



## Can Biotechnology Stop Hawai‘i’s Invasive Mosquitoes?

By: Jennifer Howard (Director of Public Relations, American Bird Conservancy)

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Hawai‘i has no native species of mosquitoes, but several species have been accidentally introduced by humans.  
Photo by Isara Kaenla/Shutterstock.

One of the biggest threats to Hawai‘i’s native forest birds is also one of the tiniest. Non-native mosquitoes that spread two deadly diseases, avian malaria and avian pox, have infiltrated the main islands. The diseases, like the mosquitoes, are also non-native, and they’re decimating native bird populations already stressed by habitat loss and other introduced plants and animals.

The threat is becoming even more dangerous for Hawai‘i’s birds. For many species, global climate change is projected to increase the transmission risk as mosquitoes — and the malaria parasite — are able to survive at ever higher altitudes. A wave of extinctions could follow.

Recent advances in biotechnology could prevent this epidemic. Several techniques now exist to modify, suppress, or even eliminate mosquito populations to preclude the spread of avian diseases. Some of these approaches, including the introduction of sterile male mosquitoes and a bacteria that disrupts the reproduction of mosquitoes and pathogens, have been tested successfully and safely elsewhere. Other more controversial techniques, notably so-called gene drives, are still in the developmental stages.

None of these techniques have been shown to directly affect human health. And removing the mosquitoes could help to restore the islands’ natural state of affairs. These unwelcome insects “are not a natural part of the Hawaiian food web. No native species depends on them,” says Chris Farmer, ABC’s Hawai‘i Program Director.

Still, manipulating nature can have unintended consequences, and conservationists are approaching the matter with care. When, where, and if any of these techniques are deployed to save Hawai‘i’s birds depends not just on the state of the science, but on appropriate oversight — and, most critically, on making sure that Hawai‘i’s human population supports such an intervention to save the islands’ birds.

### Invasive Mosquitoes: Carriers of Disease

Hawai‘i has no native species of mosquitoes. The insect invaders began arriving by ship in the 19th century, carried as larval stowaways in vessels’ water supplies. Two species of mosquito, *Aedes aegypti* and *Aedes albopictus*, are the chief vectors for diseases that affect humans, including malaria, chikungunya, dengue fever, and Zika, which raised alarms around the world in 2016. Hawai‘i’s Big Island suffered an outbreak of dengue fever in 2016 that sickened more than 260 people.

For birds, a different species of mosquito, *Culex quinquefasciatus*, is the one to worry about. The insects don’t have to penetrate feathers; they aim for the skin of the legs or around the eyes. When they bite, infected mosquitoes transmit the avian pox virus or the parasite that causes avian malaria.



Non-native mosquitoes, such as the one pictured here on an Apapane, carry diseases that are deadly for Hawai'i's birds.  
Photo by Jack Jeffrey.

The consequences for the victims are ugly and often fatal. A bird infected with pox can develop large tumors on its legs and eyes and around its bill—"anywhere there's exposed skin," Farmer says. "Birds can just get so many tumors that they die."

Avian malaria, though less gruesome, is no less dire. It ruptures red blood cells, causes internal organs to swell, and infected birds become lethargic and often die from fever. If they survive, they can suffer lasting effects that make it harder for them to reproduce and live out full lifespans.

### Mosquitoes Are Decimating Hawai'i's Forest Birds

By the late 1800s, as the *Culex* mosquitoes spread, avian pox had taken hold among the islands' bird populations, contributing to a rash of extinctions around 1890. By the early 1900s, avian malaria had begun to take a noticeable toll as well, leading to many extinctions in the first half of the century and limiting the range of most remaining bird species to elevations above 4,500 feet.

Native honeycreepers such as critically endangered



Native Hawaiian birds find refuge from mosquitoes in the montane forests of Kaua'i's Alaka'i Swamp, which has a climate that is unsuitable for mosquitoes. This refuge and others like it are now in peril due to climate change — as the slopes warm, mosquitoes are able to survive at higher and higher elevations.

Photo by Jack Jeffrey.

‘Akikiki, ‘Akeke‘e, and the more widespread ‘I‘iwi are currently the biggest losers. The first two species are already on the brink of extinction — each has fewer than 1,000 individuals remaining — and increasing exposure to diseases could push them over the edge. As climate change increases temperatures and alters rainfall patterns, the mosquitoes are spreading upslope. Some population and habitat-change models suggest that without fast conservation action, many species could be wiped out as soon as 2020.

Kaua‘i, with its lower elevations, has been especially hard hit. "Most of Kaua‘i's endemic birds are crashing pretty hard," says Farmer, with some species suffering population declines of more than 90 percent in recent years.

Too many have already vanished. Only 17 species of native forest honeycreeper remain, down from 39, according to Joshua Fisher, an invasive species biologist with the U.S. Fish & Wildlife Service. Avian malaria is one of the main culprits. "Our birds have been dealing with this for decades, and we're in critical numbers now," Fisher says. The remaining birds have been restricted to higher-elevation stands of forest that remain mosquito-free. But as temperatures warm and rainfall patterns change, mosquitoes will invade those refuges as well.

Fisher coordinates an avian malaria working group in Hawai‘i that has brought together scientists and conservationists from federal and state agencies, universities, and NGOs, including ABC. Their goal: to assess an array of different biotech solutions that could resolve this crisis and provide more habitat for the birds — if the science and public opinion agree.

### End of the Line for Some Mosquitoes?

The simplest way to reduce or eliminate mosquitoes is to make sure they don't reproduce. Under an approach called Sterile Insect Technique (SIT), for instance, sterilized male insects are released into the wild in large numbers. Female mosquitoes, overwhelmed by the influx of sterile males, are unable to produce offspring. Release enough sterile insects, and the population crashes.



Honeycreepers, such as the 'Akikiki, are among the most vulnerable to mosquitoes. Photo by Jack Jeffrey.

SIT, which doesn't affect other species or the environment, has been around for decades. It has a record of success in the United States and beyond, having been used effectively for more than 40 years against agricultural pests in California, Florida, and other states, and to eradicate screwworm from the U.S. and Central America.

Kenneth Kaneshiro is Director of the Center for Conservation Research and Training at the University of Hawai'i at Mānoa. He was central to a SIT program in Japan, where the technique succeeded in ridding the Okinawa archipelago of two non-native species of fruit fly with no damage to public health or the native ecosystem. In September 2016, during the IUCN World Conservation Congress in Hawai'i, Kaneshiro convened a two-day workshop to discuss the feasibility of a mosquito-free Hawai'i.

Everybody involved in these ongoing conversations agrees on one thing: Public approval is critical before biotech can be brought to bear on Hawai'i's mosquitoes. "We need to be sure that the general public will accept any mosquito eradication program that's adopted in the Hawaiian Islands," Kaneshiro says.

A group called Revive & Restore, which promotes the "genetic rescue" of endangered or extinct species, has been active in these discussions. Ryan Phelan is Revive & Restore's Co-founder and Executive Director. Among the techniques she believes "could be really effective at knocking down mosquito populations even in remote areas" is a naturally occurring bacterium called *Wolbachia*. This parasite can affect mosquitoes in a variety of ways, including female sterility and a reduced ability to transmit agents of disease.

*Wolbachia* has been used for some time in agricul-

ture as a sort of natural pesticide against a range of insects, and some people find it an attractive solution because it does not require genetic manipulation. Using it in Hawai'i, she says, might "give the birds a chance."

### Genetic Interventions May Help Control or Eliminate Mosquitoes

Many conservationists also have high hopes for a technique that involves mosquitoes genetically edited to be unable to breed successfully. It's a type of modified SIT: release enough of the altered insects, and mosquito populations plummet. A firm called Oxitec has pioneered this approach in Brazil and elsewhere against dengue and Zika, with Florida next on the list. That work doesn't involve the *Culex* mosquito — yet — but the technique could be applied to that species for the benefit of birds.

A completely different approach that has grabbed headlines lately is so-called gene drive technology. It involves altering an organism's genome in order to "drive" a trait through a population. For instance, *Culex* mosquitoes could be modified in order to derail their ability to breed. Although many researchers are at work on gene drive techniques, they are controversial and many years away from being field-ready. The National Academy of Sciences, among others, has made it clear that policy and regulatory safeguards have to catch up with the science before the techniques leave the lab.

In the meantime, Hawai'i's birds could still benefit from the enormous efforts being made to reduce mosquito-borne threats to humans. "All this energy, all this momentum, all this funding is going into eliminating the mosquito as a vector," Phelan says. "Conservation has a unique opportunity right now to capitalize on the investment being made in human health."

Whatever the decision, it needs to be made soon. "The window is definitely closing on these birds," says ABC's Farmer. "We don't have a ton of time. Doing nothing — whether through indecision, lack of awareness, or any other reason — will lead to further extinctions."

ABC hasn't endorsed any one approach but is staying abreast of the science and is actively involved in the



discussions. “Some of these techniques are controversial, but the technologies are so different from one another that it's like comparing a paper plane to a jet engine,” says Mike Parr, ABC's President. “You don't throw them all out just because one is especially contentious.”

Regardless, Parr says, it's critical that the public has every chance to weigh in on the policy- and decision-making. “This is a community decision, and not something a single organization or agency can decide.”

If invasive mosquitoes were safely controlled or eliminated, the benefits to Hawai'i's birds would be immense. Species now confined to small patches of moun-

tain habitat could expand their ranges again if lower elevations were mosquito-free. “The birds we have left are the most robust species,” ABC's Farmer says. “They survived this long. And if we give them a little bit of help, they can survive for future generations.”



The 'I'iwi is one of several Hawaiian honeycreeper species that are vulnerable to mosquito-borne diseases. Photo by Robby Kohley.

## New egg at Hawai'i State Art Museum

By: Keith Swindle (Resident Agent in Charge, U.S. Fish and Wildlife Service)

There appears to be good news for Honolulu's most famous pair of white terns: a new fuzzy chick at a much more convenient perch. Earlier this year, Honolulu residents were presented the headline: “Nesting native bird delays multimillion-dollar project in downtown Honolulu” when a pair of white terns chose to lay an egg (for at least a third time) on a piece of faulty railing on the picturesque balcony on an upper floor of the stately Hawaii State Art Museum. While the media chose to pitch the situation as conservation versus progress, Museum staff actually viewed it more like conservation versus convenience and they, rightly, chose conservation.

A month later, we learned the sad news that this pair lost its egg somehow. Only a few of the Museum's staff had access to the balcony and those that did were fiercely protective of “their terns”. The flat and relatively smooth metal corner of the railing was not the best spot for a round egg and it is likely that one or

both of the parents knocked the egg off during an incubation duty exchange. Or perhaps, a mischievous myna bird may have knocked it off, if it were left briefly unattended. The museum was advised by the USFWS to take advantage of the pair's misfortune and they quickly erected bird excluding wires.

Precluding the birds from re-nesting at the spot would serve two purposes. First, it enabled the museum to get on with their plans for renovation and schedule the necessary restorative projects of this iconic building. Second, it would encourage the terns to find an alternate nest spot. Several weeks later it appeared that the strategy paid off on both counts. A pair of white terns laid an egg on the closest tree branch to the balcony just dozens of feet away. While we can't know for sure that it's the same pair, the timing of the re-nest attempt and the conspicuous proximity to their old (and rundown!) nest site, causes us to to



The “famous” White Tern incubating the egg on the corner of the Hawaii State Art Museum rail. Photo by Cathy Young.



Pair of White Terns that recently laid an egg on the State Art Museum railing. Photo by Cathy Young.



The museum was advised by the USFWS to take advantage of the pair's misfortune and they quickly erected bird excluding wires. Photo by KHON2.

be pretty certain it is them. The fact that this is the first time white terns have been seen nesting in this particular spot increases our confidence that is the same persistent pair.

With the exception of this pair, Honolulu's Manu O Ku lay their eggs exclusively in trees. However, this pair is the exception that disproves the rule, because we know that elsewhere, white terns will lay their eggs seemingly anywhere. At Midway Atoll National Wildlife Refuge speckled eggs followed by a fuzzy chick are frequently found on buildings, rocks, piers, wooden railings, water spigot handles, piping, and even on golf carts and bicycle seats when parked "too long".

So, why then do virtually all of Honolulu's 700+ breeding pairs (minus one!) lay their eggs in trees and not elsewhere, like on buildings or even sidewalks? It's likely due to a process of elimination, possibly combined with some learning within tern society. Unlike at some of the most remote refuges like Midway Atoll and Baker Island, Honolulu is full of ground dwelling predators that would make a meal out of a tern egg, chick or nesting adult, including rats, cats, mongooses, dogs and even cattle egrets. Some of these might take eggs or small chicks, but others could easily kill and consume the incubating adult terns too.

If a tern pair is repeatedly harassed off of their egg or chick or if they perennially lose their egg or chick, then they are less likely to use the same egg-laying spot (I hesitate to say "nest" given that they don't

build one!) in the future. But if a pair are successful at raising a chick at a location, they are more likely to use the same spot again in the future, or so we think. Additionally, 99.9% or so of the white terns born and raised in Honolulu called a tree their home and spent their formative days gazing down from a tree branch. When it is their turn to lay an egg, why not do what seems familiar?

Another factor may be nest site availability. At Midway Atoll NWR, white terns way outnumber the trees, so terns may be more apt to be creative in choosing nest sites. While we have a lot of terns in Honolulu we also have a lot of trees with a lot of suitable branches. But even here, there is some subtle discerning going on. For example, terns need some temperature control in the form of shade or wind. Also, we see that our terns don't just nest in any old tree, they clearly prefer trees that are "open" with easy access to the interior branches. White terns rarely nest in city trees that are very bushy and dense with foliage, unless they can access the branches from beneath the canopy, such as is the case with monkey pods and their umbrella shape. White terns can access a monkeypod's branches by flying beneath the edge of the "umbrella" where there are no leaves or small branches precluding their access to the larger limbs. In fact, that's just what our famous pair of Hawaii State Art Museum terns has done, when they re-nested in the monkeypod on a branch nearest to their old railing. Avid tern watcher, Miriam Swann reported on June 5 that the egg hatched! With luck, the chick will fledge in the middle of August --90 days or so after egg laying or about 55 days after hatching. All's well that ends well--thanks to the staff at the Museum for preserving Honolulu's unique pieces of art, indeed!



White tern nesting on piping at Midway Atoll National Wildlife Refuge. Photo by USFWS.

# Progress Report from 2016 Hawai‘i Audubon Society Research Grant Recipient, Carmen Antaky

By: Carman Antaky (2016 HAS Research Grant Winner)



Carmen Antaky presenting research on the Band-rumped Storm Petrel at Aiea High School, 11<sup>th</sup>/12<sup>th</sup> grade Geography Class.

Since receiving the Hawaii Audubon Society Research Grant, Carmen has started her Masters research at the University of Hawai'i at Mānoa on the Band-rumped Storm Petrel (*Oceandroma castro*), which became listed as federally endangered in October 2016. To raise awareness about the endangered species, Carmen has lectured at local high schools, presented her proposal in the Student Research Symposium at University of Hawai'i, and published her own project

website, <http://bandrumpedstormpetrel.weebly.com>. Carmen has received blood and feather samples previously collected from six birds on Hawaii Island by the Center for Environmental Management at Pōhakuloa Training Area (PTA) and twelve birds on Kauai by the Kauai Endangered Seabird Recovery Program. She is currently working in the ToBo lab at Hawai'i Institute of Marine Biology to sequence the samples to determine structuring among populations. Furthermore, she has purchased a Garmin eTrex GPS, using the supporting Hawaii Audubon Society grant funds, in preparation for this summer's fieldwork. Carmen will be joining Nicole Galase, Seabird Project Leader at PTA, during the height of *O. castro* nesting activity (July-August 2017) to research nesting ecology and nest-site selection of the Band-rumped Storm Petrel.

## ‘Elepaio Submission Guidelines

Hawai‘i Audubon Society has released submission guidelines for the ‘Elepaio. To review the full guidelines please visit: [www.hawaii-audubon.org/elepaio-submission-guidelines](http://www.hawaii-audubon.org/elepaio-submission-guidelines)

**Submitting to the ‘Elepaio:** The Hawaii Audubon Society is a nonprofit membership organization committed to fostering community values that result in the protection and restoration of native ecosystems and conservation of natural resources through education, science and advocacy in Hawaii and the Pacific.

**Instructions for Authors:** The ‘Elepaio welcomes submissions that relate to our mission as stated above.

**Word Limits:** Word count includes all text from the first word of the Abstract through the last word in Literature Cited. It does not include legends for tables and figures or the body of tables. Manuscripts that substantially exceed the word limits specified below will not be sent for review.

Due to our limited space, regardless of the category, we are unable to print manuscripts beyond 3,000 words in length. If you have several images and/or figures we ask that you limit your word count to 2,000. We encourage authors who are uncertain whether their manuscript is appropriate to send a title and abstract for preliminary evaluation.

**Manuscript Submission:** All submissions should be sent in a word document directly to Hawaii Audubon Society's email: [hiaudsoc@pixi.com](mailto:hiaudsoc@pixi.com)

**Review Process:** If the editor determines the manuscript topic is appropriate for the journal and meets standards of content and presentation, then the Society's board of directors will review it. When the manuscript has been approved it is sent to the scientific editor who finds appropriate reviewers. The scientific editor will be in touch for revisions.



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Photo by Mitch Walters.

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### EVENTS

#### Hawai'i Island Festival of Birds

Where: Kailua-Kona, Hawaii (Big Island)

When: September 15-17, 2017

Description: Celebrate Hawai'i's unique blend of birds – from native honeycreepers found nowhere else in the world to common backyard birds from five continents. The annual Hawai'i Island Festival of Birds supports the Hawai'i Island Coast to Coast Birding Trail and the Hawai'i Wildlife Center.

Information & Tickets: <http://birdfesthawaii.org/>

### FIELD TRIPS

#### Low-Low Tide: Paikō Lagoon Wildlife Sanctuary

When: June 24, 2017 8:30am – approximately noon, East Honolulu

Leader: Alice Roberts (HAS Board Member)

Description: Explore the lagoon while learning about Hawaii's visiting shorebirds. We may see some shorebirds (Kōlea, Ruddy Turnstone, Wandering Tattler) as well as a resident pair of Hawaiian Stilts, year round 'Iwa, Egrets & Herons, lots of urban birds & ducks.

RSVP: Please RSVP to Alice Roberts with your name and phone number at 808-864-8122.

#### Nature Hike to Kahuku Point & Wetlands at Turtle Bay

When: July 29<sup>th</sup>, 2017; meet outside the Helipad at 8:45am

Leader: Angela Huntemer

Description: Due to the popularity of this hike, we are offering another date. Be prepared to see Hawaiian monk seals, turtle nest sites, endangered and endemic plants, Endangered Hawaiian bee nesting areas, sea birds, endangered water birds, possibly nene and who knows what else. Folks can either join us for the 4-mile round trip walk to Kahuku Point (1.5 hours or do the 5-mile loop which would include seeing waterbirds (3 hours).

RSVP: Please RSVP to Angela at, [ahuntemer@aol.com](mailto:ahuntemer@aol.com) or 808-224-3101 - with the number in your party and cell phone numbers. More details emailed a few days before the 29th.

#### Service Trip at Mount Ka'ala

When: August 26, 2017 7:30am – 4:00pm, at Mount Ka'ala

Leader: Wendy Kuntz (HAS Board Member)

Description: Work with Natural Area Reserve (NAR) staff to remove non-native species on the top of Waianae mountain range Mount Ka'ala is home to many of Hawai'i's rare and endemic species. Work can be strenuous.

RSVP: Space is limited. RSVP to Wendy Kuntz ([wkuntz@hawaii.edu](mailto:wkuntz@hawaii.edu)) for reservations and instructions.

#### Welcome Home to Shorebirds: Paikō Lagoon Wildlife Sanctuary

When: September 16th, 2017 6:30am - approximately 8:00am, East Honolulu

Leader: Alice Roberts (HAS Board Member)

Description: Enjoy fall at Paikō! Let's welcome our unique and beautiful migratory shorebirds as they return from their extensive travel to enjoy the Hawaiian Islands for the fall and winter months.

RSVP: Please RSVP to Alice Roberts with your name and phone number at 808-864-8122.

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[www.hawaiiaudubon.org/programs](http://www.hawaiiaudubon.org/programs)

**NEXT DEADLINE:** October 1<sup>st</sup>, 2017 for winter/spring grants



**Ryan Lam**

“Conserve and Manage Habitat for Kauai’s Endemic Endangered Birds Using High-Resolution Imagery to Develop Species Distribution Models and Establish Critical Habitat Areas”



**Rachael Graham**

“Variation in the reproductive ecology of *Dubautia menziesii* (Asteraceae) along an elevation and climatic gradient on Haleakala volcano”

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