DAILY COMMENT

COULD GENETICALLY MODIFIED MOSQUITOES SAVE HAWAII'S ENDANGERED BIRDS?

By Michael Specter September 9, 2016

Genetically modified mosquitoes could be the solution to Hawaii's quickly disappearing avian population, including the island's famous honeycreepers.

Every four years, thousands of environmentalists gather at the World Conservation Congress to assess the state of the planet, and to consider what might be done to protect it. This year's meeting ends Saturday, and the news this past week, with a few exceptions, has not been cheerful. Four of the six great-ape species are critically endangered, which means they are one step from extinction, according to the International Union for Conservation of Nature, which organizes the congress. So are thousands of other species. The eastern gorilla—the world's largest living primate—is in particular jeopardy.

The 2016 congress has been held in Hawaii, which is fitting, since the state is often referred to as the endangered-species capital of the world. President Barack Obama, who was born in Hawaii, addressed the conference as it began, shortly after signing a proclamation to create the world's largest ecological preserve. The act will protect an area of the ocean surrounding the Northwestern Hawaiian Islands that is twice the size of Texas. Nonetheless, nearly ninety per cent of the Hawaiian native plants that the I.U.C.N. has assessed so far are threatened with extinction, and the avian population is quickly disappearing, too—including the island's famous, melodious, and brightly colored species of honeycreepers. Climate change has played a role, and so have feral cats, invasive rats, and other non-native species. But mosquitoes, which carry avian malaria, are a principal reason that just forty-two of more than a hundred species of native Hawaiian birds remain. Most of them are endangered.

There were no mosquitoes on the Hawaiian islands until early in the nineteenth century, when they arrived on whaling ships. That meant that native birds had no exposure to the diseases that mosquitoes carry, and therefore no immunity. One way to protect the birds from malaria has been to kill mosquitoes with chemicals. But mosquitoes can breed in less than a teaspoon of water, and can do so nearly anywhere in Hawaii; their eggs are often inaccessible, hidden in rocks, caves, and the hollows of trees. Poison that can kill mosquitoes frequently also kills the plants and animals that surround them.

Science may offer a solution, however. There are now genetic technologies that, at least in theory, are environmentally benign, but could wipe out the mosquitoes that have decimated the birds of Hawaii—and those that endanger human health as well. That has many conservation ecologists tremendously excited. "These species are on the verge of extinction, and there may be a way to save them," Ryan Phelan, the executive director of Revive & Restore, said. The group, based in California, seeks to apply genomic solutions to conserving endangered species. At the congress, Revive & Restore held two heavily attended workshops on issues of "genetic rescue." "It is entirely up to the local community to decide whether these tools might be appropriate, but it's important to remember the consequences of doing nothing," Phelan said.

Any sentence that includes both the words "genetic" and "modify" causes controversy—often, as is the case with bird preservation in Hawaii, even before the facts are discussed. Many Hawaiians are particularly sensitive to what they see as the abuses of biotechnology. Critics argue that altering genes to save birds could cause extinctions and other unknown effects, and yet this technology may present the first genuine opportunity to protect these vanishing species.

There are essentially three genetic approaches that might save the birds of Hawaii. The first would be to introduce mosquitoes that have been genetically modified to become sterile, or are programmed to die quickly. This technique is not new: I wrote about the technology for this magazine in 2012, when the British company Oxitec, which stands for Oxford Insect Technology, embarked on an attempt in Brazil, among other places, to eliminate *Aedes aegypti*, the mosquito species that carries the viruses that cause dengue fever, yellow fever, Chikungunya, and Zika. The data from Brazil demonstrated clearly that, after the release of millions of sterile males, the number of mosquitoes capable of transmitting dengue fever fell markedly. (Only females bite; if they mate with sterile males, their eggs will never mature.)

A related approach involves deploying Wolbachia bacteria, which can prevent viruses from entering the salivary glands of mosquitoes. The third approach is by far the most controversial, and the least likely to be used anytime soon: gene-drive technology. I have written about gene drives in the past, and described them this way: they work by overriding the traditional rules of genetic inheritance. Normally, the progeny of any organism that reproduces sexually receives half its genome from each parent. Some genetic elements are “selŻsh,” however: evolution has bestowed on them a better-than- Żfty-per-cent chance of being inherited. But, until scientists began to work with CRISPR, which permits DNA to be edited with uncanny ease, they lacked the tools to insure that speciŻc genes have a similar advantage.

That has all changed. Now, by attaching a gene drive to a desired DNA sequence with CRISPR, you could permanently alter the genetic destiny of a species. That’s because, with CRISPR, a change made on one chromosome would copy itself in every successive generation, so that nearly all descendants would inherit the change, dispensing with the random selection involved in sexual reproduction. A mutation that blocked the parasite responsible for malaria, for instance, could be engineered into a mosquito and passed down whenever it reproduced. Within a year or two, none of the original mosquito’s offspring would be able to transmit the infection. And if gene drives work for malaria they ought to work for other mosquito-borne diseases, such as dengue, yellow fever, and Zika. (Different forms of malaria affect humans and birds, and the same species of mosquitoes do not always carry the respective pathogens, but the principle remains the same.)

There has never been a biological tool with more power, and no scientist I am aware of plans to use this technology now, other than in controlled laboratory experiments. Only society, collectively, should be able to deploy such a tool. But anti-technology activists, such as Vandana Shiva, whom I have written about for this magazine, are already trying to prevent even basic gene-drive research. This is how a consortium of opponents, including Shiva, characterized the issue in a position paper titled "Reckless Driving: Gene Drives and the End of Nature":

> Imagine that by releasing a single fly into the wild you could genetically alter all the flies on the planet—causing them all to turn yellow, carry a toxin, or go extinct. This is the terrifyingly powerful premise behind gene drives: a new and controversial genetic engineering technology that can permanently alter an entire species by releasing one bioengineered individual.

Or one could just as easily write: Imagine that by releasing a single mosquito into the wild you could cause all mosquitoes that transmit malaria and other deadly diseases to become harmless. This is the *thrilling* premise behind gene drives.

Advanced technologies offer tremendous opportunities and daunting risks. With gene drive, the stakes are particularly high, and we need to discuss them carefully—to decide as an informed society how we want to proceed. That will require caution, collaboration, and plenty of debate. Perhaps people will conclude in good faith that the price of saving birds from extinction—or saving the hundreds of thousands of children who die from diseases transmitted by mosquito bite each year—is too high, and that the risks are not worth the effort. Or they might conclude that it would be callous not to try. That is a choice that will affect us all, and it should not be left to scientists or journalists or a small coterie of single-minded activists who speak only in the language of fear.

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