HAWAII INVASIVE SPECIES COUNCIL
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January 17, 2016

SUBMITTAL

TO: Co-chairs and Members
Hawaii Invasive Species Council
State of Hawaii

FROM: Joshua Atwood, Program Supervisor
Hawaii Invasive Species Council

Cynthia King, Entomologist & Hawaii Mosquito Working Group Chair
Department of Land and Natural Resources, Division of Forestry and Wildlife

SUBJECT: Requesting a resolution supporting evaluation and implementation of technologies for landscape-scale control of mosquitoes, with a focus on mitigating both human and wildlife health risks

Background

Hawaii has no indigenous mosquito species, and none were present in Hawaii until the accidental introduction of *Culex quinquefaciatus* by ship in 1826. Since then eight species of mosquito have become established in Hawaii. According to the Hawaii Department of Health[1], only six of these species interact with humans and wildlife:

- *Aedes albopictus*, a day-biting mosquito found throughout the state
- *Aedes aegypti*, a day-biting mosquito established on Hawaii Island only, though individuals have been periodically intercepted at Honolulu International Airport
- *Aedes japonicus*, a day-biting mosquito found on Hawaii Island, Maui, Oahu, and Kauai,
- *Aedes vexans*, a night-biting mosquito found on Kauai, Oahu, Molokai, and Hawaii Island
- *Wyeomyia mitchelli*, a day-biting mosquito found on Hawaii Island, Oahu, and Kauai
- *Culex quinquefasciatus*, a night-biting mosquito found throughout the state.

Mosquitoes provide a pathway for the introduction and spread of a variety of vector-borne diseases. Of particular concern to Hawaii are the following diseases, all vectored by mosquitoes:

- Dengue fever, vectored by *Aedes* mosquitoes
- Zika, vectored by *Aedes* mosquitoes
- Chikungunya, vectored by *Aedes* mosquitoes
- Yellow fever, vectored by *Aedes* mosquitoes
- West Nile Virus, primarily vectored by *C. quiquefasciatus*
- Avian malaria, primarily vectored by *C. quinquefasciatus*

There are many other mosquitoes not currently present in Hawaii that could increase risk for disease transmission if they became established. Malaria, for example, is vectored by mosquitoes in the *Anopheles* genus, which is not established in Hawaii. A single individual of *Anopheles punctipennis* was, however, intercepted on Oahu in 2003[2].

In 2015 and 2016, there were a total of 262 cases of dengue fever, 10 cases of Chikungunya, and 17 cases of Zika in Hawaii[3]. To date, individuals with Chikungunya or Zika have been infected outside of Hawaii, and these viruses are not known to be circulating within the state. However, the presence of *Aedes* mosquitoes in Hawaii does present a risk for local circulation of these diseases in the future. All three of these viruses can result in fever, muscle pain, joint pain, and, in rare circumstances, death. Additionally, Zika is associated with microcephaly, a birth defect resulting in the development of a smaller than usual head and subsequent impacts on brain development and function. Yellow fever, malaria, and West Nile Virus also cause fever, muscle, and joint pain, though these have not been detected in Hawaii to date.

In addition to human impacts, Hawaii's native bird species are susceptible to some diseases that are vectored by mosquitoes. In Hawaii, avian malaria is circulated by *C. quinquefasciatus* at low elevations. As a result many native bird species are only found at higher elevations, where temperatures are suboptimal for mosquito populations. As climates change, these high elevation refugia are predicted to shrink as the warmer habitat conditions favored by mosquitoes move higher into mountainous areas. Hawaii has already seen nine bird species go extinct in the last 30 years; the remaining 24 species are at great risk as mosquito habitats expand and spread avian malaria into new locations.

Control of mosquito populations through chemical and mechanical methods is logistically challenging. While public education to reduce breeding sites (such as bromeliads or other water-collecting items) can help mitigate localized impacts, effective control over large areas currently requires the use of insecticides. However, a recent analysis of *A. aegypti* populations in Florida demonstrated an acquired resistance to pyrethroids, a class of commonly used insecticides[4]. Should currently available chemical control methods become ineffective, the development of new chemical products is unlikely to due to the high costs for research and regulatory approvals[4]. To protect Hawaii's people and wildlife from the impacts of mosquito-borne disease, researchers should be encouraged to explore non-chemical options for landscape-scale control of mosquitoes.

References:
1. Hawaii Department of Health, Vector Control Branch, Bulletin 3. 2011. Honolulu (HI) [accessed January 6, 2017] http://health.hawaii.gov/about/files/2013/06/VCB-bulletin_03_11.pdf
2. Furumizo RT, Warashina WR, Savage HM. 2005. First collection of Anopheles (Anopheles) punctipennis (Say) on Oahu, Hawaii: implications for the potential introduction of West Nile Virus. Journal of the American Mosquito Control Association. 21(2):225-6.
3. Hawaii Department of Health, Disease Outbreak Control Division. "Mosquito-Borne Diseases." Honolulu (HI) [accessed January 6, 2017] http://health.hawaii.gov/docd/dib/disease/mosquito-borne-diseases/
4. Bunge J, McKay B. January 5, 2017. In the Fight Against Zika, Insecticides Hit a "Dead End." The Wall Street Journal [accessed January 6, 2017]. http://www.wsj.com/articles/fight-against-zika-nears-dead-end-1483621245

<u>Discussion</u>

The recent International Union for the Conservation of Nature (IUCN) World Conservation Congress (WCC) generated a number of discussions relating to mosquito impacts on both human and wildlife health, and options for landscape-scale control of mosquitoes. Experts at the University of Hawaii, the Department of Land and Natural Resources, the Department of Health, and the U.S. Fish and Wildlife Service, among others, have begun identifying safe mosquito control technologies that could be implemented in Hawaii. There are several different technologies that could potentially be used, including:

- Sterile Insect Technique (SIT): Using this method a population of mosquitoes in a laboratory is irradiated to induce sterility and then males are released into a given area to mate with wild-type mosquitoes. No offspring are produced from these pairings, reducing the number of mosquitoes in the next generation. This technique is already used in Hawaii for fruit fly suppression. This technique is non-persistent, meaning that there is no lasting impact to subsequent generations in the wild and the technique would need to be repeated periodically to continue suppressing mosquito populations.
- *Wolbachia*, or Incompatible Insect Technique (IIT): *Wolbachia* is a naturally occurring bacterium found within many arthropods. There are different strains of *Wolbachia*, and in mosquitoes two individuals with different strains of *Wolbachia* are unable to produce viable offspring. By examining the strain of *Wolbachia* found in mosquitoes in Hawaii researchers may be able to lab-rear mosquitoes with an incompatible *Wolbachia* strain. Similar to SIT, the IIT functions via the release of lab-reared male mosquitoes to mate with wild-type mosquitoes, reducing the number of mosquitoes in the next generation due to incompatible mating. Mosquitos with *Wolbachia* have been approved by the U.S. Environmental Protection Agency for use and are already being used for mosquito control in the U.S. This technique is also non-persistent and would need to be repeated periodically.
- Self-limiting genetic technique: This technique involves a genetic modification to sterilize male mosquitoes reared in a laboratory. When the lab-reared mosquitoes are released and mate with wild-type females, no viable offspring are produced in the next generation. This technique is self-limiting, as the genetic modification is not passed on to any viable offspring and effectively removes itself from the environment. Self-limiting mosquitoes have been used successfully in multiple locations around the world to suppress wild mosquito populations and has been approved by the Food and Drug Administration for use in the U.S. This technique is non-persistent and would need to be repeated periodically to achieve continued suppression of mosquito populations.
- Gene drive: Gene drive techniques are not currently available for use, but research has begun on how this approach could be safely implemented. The concept behind gene drives is to insert a genetic modification into lab-reared mosquitoes in such a way that the gene has a dominant inheritance pattern and spreads through a population over multiple generations. These modifications could, for example, result in unviable offspring, the production of solely male (non-biting) offspring, or the production of mosquitoes that are simply immune to diseases like avian malaria. This technique is persistent, meaning that it remains in the environment through subsequent generations. Research into this technology should address safeguards that minimize the risk for spread of genes beyond a desired geographical area, identify the potential for halting or reversing the spread of altered genes, and ensure that the process is transparent and acceptable to the public. Locally-confined drive systems are currently theoretical and would require extensive safety testing in laboratories before they might be available for field trials.

Technologies that reduce the use of insecticide, reduce response costs, and safely control mosquitoes on the landscape scale should be a priority for development in Hawaii. To maximize the impact and cost-effectiveness of research and development, human and wildlife health experts should work together on projects that provide outcomes for mitigating the spread of both human and wildlife diseases.

Legal Authority

- HRS 194-2 authorizes the HISC to advise and coordinate invasive species-related efforts with and between state, federal, international, and private programs.

Recommendations

That the Hawaii Invasive Species Council (HISC) adopt a resolution, in substantially the same form as attached to this submittal, that:

1. Recognizes landscape-scale control of mosquitoes to be an important, cross-sector invasive species goal
2. Supports evaluation of technologies for landscape-scale control of mosquitoes in Hawaii, including sterile insect technique, incompatible insect technique, and genetic tools
3. Encourages researchers to take a cross-sector approach to evaluating technologies and wherever possible pursue research that benefits both human health and the health of native wildlife
4. Supports implementing evaluated technologies that are scientifically demonstrated as safe, effective control methods for mosquitoes

Attachments

1. Draft HISC Resolution 17-2: Supporting evaluation and implementation of technologies for landscape-scale control of mosquitoes, with a focus on mitigating both human and wildlife health risks

Attachment 1: Draft HISC Resolution 17-2: Supporting evaluation and implementation of technologies for landscape-scale control of mosquitoes, with a focus on mitigating both human and wildlife health risks

DRAFT RESOLUTION 17-2

SUPPORTING EVALUATION AND IMPLEMENTATION OF TECHNOLOGIES FOR LANDSCAPE-SCALE CONTROL OF MOSQUITOES, WITH A FOCUS ON MITIGATING BOTH HUMAN AND WILDLIFE HEALTH RISKS

WHEREAS, there are no mosquitoes native to Hawaii; and

WHEREAS, mosquitoes present in Hawaii are capable of vectoring diseases that negatively impact human health, the health of native wildlife, and our tourism industry; and

WHEREAS, control of mosquitoes in Hawaii may require tools and methods beyond use of insecticides; and

WHEREAS, there technologies are being developed to address mosquitoes on the landscape scale, including sterile insect technique, incompatible insect technique, and genetic tool; and

WHEREAS, Chapter 194, Hawaii Revised Statutes, authorizes the Hawaii Invasive Species Council to advise and coordinate invasive species-related efforts with and between state, federal, international, and private programs, and to coordinate the State's position on issues with regard to invasive species; now, therefore

BE IT RESOLVED that the Hawaii Invasive Species Council recognizes landscape-scale control of mosquitoes to be an important, cross-sector invasive species goal; and

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council supports evaluation and implementation of technologies for landscape-scale control of mosquitoes in Hawaii, including sterile insect technique, incompatible insect technique, and genetic tools; and

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council encourages researchers and management agencies to take a cross-sector approach to evaluating technologies and wherever possible pursue research that benefits both human health, the health of native wildlife, and our tourism industry; and

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council supports implementing evaluated technologies that are scientifically demonstrated as safe, effective control methods for mosquitoes; and

BE IT FURTHER RESOLVED that certified copies of this Resolution be transmitted to the Governor of Hawaii, the President of the State Senate, the Speaker of the State House of Representatives, and to the directors or chairpersons of each HISC agency.

Adopted by the Hawaii Invasive Species Council on the following date: January 17, 2017

Suzanne D. Case, Department of Land & Natural Resources	Scott Enright, Department of Agriculture
Keith Kawaoka, Department of Health	David Rodriguez, Department of Transportation
Leo Asuncion, Office of Planning, Department of Business, Economic Development, and Tourism	Rachel Novotny, Ph.D., University of Hawaii