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Mosquitoes, Zika Virus, and Transmission Ecology

The Zika virus is transmitted primarily by mosquitoes, and the Centers for Disease Control and Prevention (CDC) have identified some cases of human-to-human transmittal. The two species of mosquitoes most commonly associated with transmitting the virus are the yellow fever mosquito (*Aedes aegypti*, or YFM) and Asian tiger mosquito (*Aedes albopictus*, or ATM). This report will focus on the ecology of the two mosquito species and briefly discuss methods used or proposed either to control their populations or to limit their ability to transmit viruses. Control methods could require compliance with a variety of federal or state statutes and regulations; such statutes generally have special provisions regarding human health and safety. For a discussion of human health issues, see CRS Report R44368, *Zika Virus: Basics About the Disease*, and CRS Insight IN10433, *Zika Virus: Global Health Considerations*.

Mosquito Ecology

Neither mosquito is native to the Western Hemisphere. YFM is native to Africa, and ATM is from Southeast Asia. Only females bite; blood proteins are then used in egg development. After a blood meal from an infected person, a virus may be transmitted to a person bitten later. Both mosquitoes are vectors for other human viruses, including dengue fever, chikungunya, and yellow fever. As a result of their association with these major and established diseases, considerable research on their ecology has been performed. Both species are strongly associated with human habitat, particularly YFM, which is a weaker flyer and rarely travels more than a few hundred yards in its lifetime. However, both are hitchhikers and may spread via cars, planes, and boats.

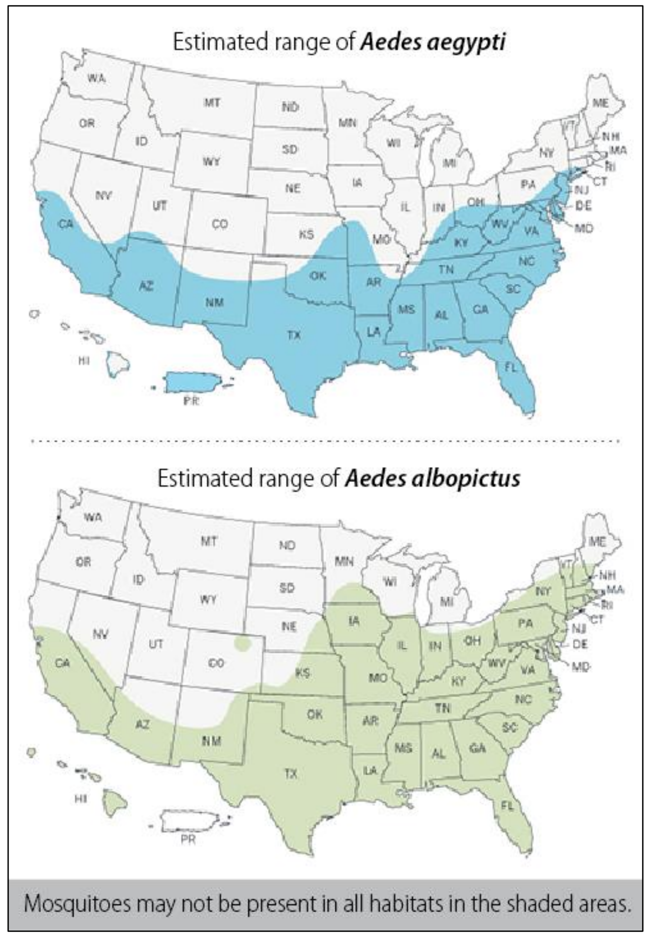
Both species are already found in suitable habitat along the U.S. Gulf Coast, and both occur sporadically in parts of California, Arizona, and New Mexico. However, ATM has adapted to cooler temperatures, allowing it to spread into higher elevations and farther north. Its range currently extends north into Pennsylvania and west to parts of Iowa and Nebraska.

Both species breed in small containers of fresh water. Breeding sites may include roadside rubbish, discarded tires, flower pots, gutters, potholes, and even bottle caps. The larvae of both are aquatic, and at the larval stage their predators include other insects. When they emerge from the larval stage, predators include dragonflies, birds, and bats. Both species are primarily diurnal (i.e., active in daytime). Both avoid biting humans who have recently used various registered repellants.

Controlling Mosquito Numbers

Control methods for the two species are varied and include elimination of breeding sites and pesticide applications, as well as screening and well-sealed homes. Issues include efficacy, cost, and human or environmental health.

Figure 1. Approximate U.S. Distribution of Zika Virus Vectors, 2016



Source: Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases, "Surveillance and Control of *Aedes aegypti* and *Aedes albopictus* in the United States," at http://www.cdc.gov/chikungunya/resources/vector-control.html.

Reducing the Sources: Breeding Sites

Reduction of breeding sites as a mosquito-control method was most famously tested in 1904, not long after the discovery of the link between mosquitoes and disease transmission, with the building of the Panama Canal. It continues to be used, especially in the South. The method is still effective but requires broad public participation and education for success. Public funding for cleanup of roadside litter, destruction of old tires, and similar measures may be required.

Mosquitoes and Registered Pesticides

If habitat elimination or modification and other abatement approaches are not feasible or successful, requisite control strategies may require communities to rely on pesticides, particularly those used at the aquatic, larval stage. The U.S. Environmental Protection Agency (EPA) has registered a number of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) specifically for the domestic control of mosquitoes. (Some additional unregistered pesticides manufactured in the United States may be exported and used abroad but not domestically.) CDC guidelines recommend that decisions to use pesticides to control mosquitoes should be based on surveillance data and the risk of human disease. Registered pesticides include those to control mosquitoes at the larval stage (larvicides) in the breeding habitat before they can mature, ranging from bacterial insecticides, growth inhibitors, and organophosphate insecticides, to mineral oils and monomolecular films. There are also registered pesticides for controlling adult mosquitoes (adulticides), including synthetic pyrethroid insecticides and organophosphate insecticides. A more detailed list and discussion of registered pesticides are available from the National Pesticide Information Center (http://npic.orst.edu/pest/mosquito/mosqcides.html) and from the EPA (http://www.epa.gov/mosquitocontrol).

Further, an exemption process exists for circumstances in which no efficacious pesticide is currently registered. Under Section 18 of FIFRA (7 U.S.C. 136p; regulations in 40 C.F.R., Part 166), state or federal agencies may request an Emergency Public Health exemption to use a non-registered pesticide when they deem that a pest will cause a significant risk to human health. Emergency Public Health exemptions must be approved by EPA and may be authorized for up to one year. An Emergency Public Health exemption was granted for the control for ticks carrying Lyme disease, for example.

Preventing Transmission of the Virus

Alternatives to attempting to kill substantial numbers of mosquitoes directly include attempting to reduce the ability of the mosquitoes to transmit viruses or to reduce the number of viable offspring. Neither method has been fully tested in the field with respect to Zika virus.

Release of Genetically Modified Mosquitoes

Genetic engineering has been used to create mosquitoes that either are not able to carry the disease-causing pathogens or are unable to produce viable offspring. For example, researchers are genetically engineering mosquitoes to make them more resistant to the *Plasmodium* parasite that causes malaria. Other researchers are developing mosquitoes to express antimalarial peptides and enzymes that inhibit parasite development. These varieties have not been field tested and hence are not approved.

In 2002, scientists at the British firm Oxitec genetically modified some YFM so that larvae die unless they are exposed to the antibiotic tetracycline. When males are released into the wild, where tetracycline is generally absent, males mate with wild females to produce larvae that die before they reach adulthood. These genetically modified mosquitoes were field tested by the company in 2009-2011 in Grand Cayman Islands, Malaysia, and Brazil. Oxitec reported that YFM populations were significantly reduced within the test areas. Similar plans to field test these engineered mosquitoes in the Florida Keys in 2012 were halted after environmental, regulatory, and ethical issues were raised. The U.S. Food and Drug Administration's Center for Veterinary Medicine is currently reviewing the potential environmental and human health effects of a U.S field test of the mosquitoes under its Investigational New Animal Drug protocol.

Mosquito Bacteria to Suppress Virus

Another approach focuses primarily on reducing mosquitoes' ability to transmit viruses. Researchers in Australia infected YFM with a bacterium called *Wolbachia*, which naturally infects many other insect species, though not YFM. The bacterium appears to limit the multiplication of the dengue virus inside the mosquito, thus limiting the chance of transmitting dengue to the next victim. The bacterium is too big to pass through a mosquito's mouthparts into a human, but infected females pass it via their eggs into their offspring.

When *Wolbachia*-infected males mate with uninfected females, their offspring fail to hatch. But because infected females pass the bacterium on to their offspring, the bacterium eventually spreads through the entire population, both in the laboratory and in certain field trials. Field trials in Australia appeared to be successful in ending chronic dengue fever outbreaks. Further trials are continuing in Southeast Asia, and one trial began in Brazil in 2015. Because the dengue, chikungunya, and Zika viruses are similar (all RNA viruses), *Wolbachia* has been suggested as a potentially useful tool against Zika as well.

Conclusion

No single method of controlling YFM or ATM seems likely to be effective in completely eliminating transmission of Zika virus, nor in extirpating either mosquito species from the Western Hemisphere. Surveillance for the presence of YFM and ATM and public cooperation in reducing breeding sites are prerequisites for local policy choices. Multiple tools are available or being tested; in conjunction they may lessen or break transmission of the Zika virus through mosquitoes.

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