Fighting Fire With Fire:

How Science is Turning Mosquitoes Against Themselves

There is no single "silver bullet" to adequately manage mosquitoes that carry viruses such as Zika, dengue, and West Nile, but today's mosquito management toolbox contains more than it did even just a few years ago. Entomologists and pest professionals use a broad array of tactics such as habitat manipulation and chemical insecticide in their integrated pest management (IPM) programs, and they may soon have three new options at their disposal to either manage mosquito populations or interfere with disease transmission.

Fine-Tune Mosquito Genes So They Can't Breed

Scientists have developed methods to precisely alter the genomes of male mosquitoes so that they pass a gene to their offspring that prevents them from becoming adults. Male mosquitoes do not bite, but they do mate with females (the ones guilty of biting and transmitting disease). Thus, when these modified males are released in large numbers and mate with wild females, their offspring die before becoming adults. Successful application of this technique has been shown to lower mosquito populations by over 90 percent.

An important advantage of this tactic is that it can target only one species in a localized area. (In its lifetime, an *Aedes aegypti* male mosquito's range is typically just 30-100 meters). However, once the males are no longer released, the population will return. To keep populations suppressed, modified male mosquitoes must be released on a recurring basis.

> The U.S. Food and Drug Administration has conducted a thorough assessment of the risks to people and the environment of releasing genetically engineered male mosquitoes, and it published a Finding Of No Significant Impact, concluding that their use "is not expected to cause any significant adverse impacts ... beyond those caused by wild-type mosquitoes."

Infect Mosquitoes With Bacteria So They Can't Breed

While harmless to humans, the bacterium known as *Wolbachia* naturally infects more than half of all known insect species. *Wolbachia* is naturally common because it manipulates the reproduction of insect hosts: When an uninfected female mates with a *Wolbachia*-infected male, her eggs will not hatch. However, a female infected with *Wolbachia* will pass it down to her offspring after mating with any male mosquito of the same species. This natural phenomenon can be employed by entomologists to establish *Wolbachia* infections in several mosquito species, including those of medical importance.

One technique using *Wolbachia* is similar in concept to the genetic-modification method in that it relies on releasing specially raised, *Wolbachia*-infected male mosquitoes to breed with wild females causing them to produce eggs that do not hatch. The mosquito population is therefore reduced.

Although effective, this method of population reduction is sustained only through ongoing introduction of *Wolbachia*-infected males.

> In the U.S., *Wolbachia*-based methods are currently regulated by the Microbial Pesticide Branch of the Environmental Protection Agency. To date, the population replacement method has not been used in the U.S., but it has been regulated and used in Australia, Brazil, and other countries.

Infect Mosquitoes With Bacteria So They Can't Transmit Disease

Wolbachia has also been shown to interfere with the ability of mosquitoes to carry pathogens and transmit diseases by boosting the mosquito immune response or by competing for the resources available to a virus inside a mosquito. A second technique uses this *Wolbachia* trait to replace a wild mosquito population with *Wolbachia*-infected mosquitoes that have reduced capacity to transmit disease. It does, however, require that at least some of the introduced, *Wolbachia*-infected mosquitoes be females, which will bite and feed on blood.

Because mosquito offspring acquire *Wolbachia* from their mother, a *Wolbachia* infection that is established and spread into a population of mosquitoes can be maintained, meaning additional introductions of *Wolbachia*-infected mosquitoes are not required. Infected females can successfully reproduce with both infected and uninfected males; however, uninfected females can only produce offspring if they mate with uninfected males. Since uninfected males become increasingly rare over time, eventually the mosquito population will be unable to transmit viruses. This population replacement technique does not significantly reduce the number of mosquitoes, but it does interrupt disease transmission.