Nanoparticles prove effective against the yellow fever mosquito

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Aedes aegypti mosquito larvae. Credit: NIAID (CC BY 2.0, 2016)

Before being accidentally introduced to the New World by the 16th century slave trade, the yellow fever mosquito was a species native only to Africa. Highly adaptable, it has since become an invasive species in North America, but researchers at The Ohio State University may have found a way to squash the pesky population in its juvenile stages.

Recently published in the journal *Insects*, a new paper describes how mosquitoes have evolved a natural resistance to some chemical insecticides, and offers an alternative called carbon black, a type of carbon-based nanoparticles, or CNPs.

Study co-author and an associate professor of entomology at Ohio State, Peter Piermarini described CNPs as "microscopic" materials made out of organic elements. The study used a modified version of carbon black called Emperor 1800, which is often used to coat automobiles black. While CNPs are a relatively new scientific development, they have been considered as new tools to control various insect and pest infestations, he said.

"If we can learn more about how carbon black works and how to use it safely, we could design a commercially available nanoparticle that is highly effective against insecticide-resistant mosquitoes," Piermarini said.

The yellow fever mosquito, or Aedes aegypti, is a species of mosquito known for spreading not just yellow fever, but also diseases like the Zika virus, dengue fever and chikungunya fever. Adults rarely fly more than a few hundred meters from where they emerge, but their abundance leads to steady transmission of diseases—enough to claim tens of thousands of lives every year and hospitalize hundreds of thousands more people.

Because of this, the mosquito is considered to be one of the deadliest animals on the planet. For this study, the researchers' goal was to figure out how toxic these nanomaterials could be to mosquito larvae, or the immature form of the insect.

Contrary to popular belief, not all mosquitoes set their sights on turning our blood into their latest meal. Male mosquitoes subsist only on flower nectar; it's the females that will consume both flower nectar and blood in

a bid to provide their eggs with enough protein to grow.

When female mosquitoes are ready to lay their eggs, they return to standing pools of water, like lakes or birdbaths, to release them. After they hatch, these larvae will stay in the water for about a week until they reach adulthood, and take wing.

To test whether Emperor 1800 would be effective in stopping that process, researchers worked with two different strains of the yellow fever mosquito inside the lab, one extremely susceptible to typical chemical insecticides, and the other, extremely resistant to them.

By applying the carbon black nanomaterials to the water during the earliest stages of the mosquito's life cycle and checking in 48 hours later, they were able to determine that CNPs kill mosquito larvae both quickly and efficiently.

"Given the properties of carbon black, it has the most potential for killing larvae because it can be suspended in water," Piermarini said. Their findings showed that the material seemed to accumulate on the mosquito larvae's head, abdomen, and even in its gut, meaning that at some point, the larvae were ingesting smaller particles of carbon black.

"Our hypothesis is that these materials may be physically obstructing their ability to perform basic biological functions. It could be blocking their digestion, or might be interfering with their ability to breathe," said Piermarini.

However, there was one thing that Piermarini found particularly surprising.

When first suspended in water, carbon black appeared equally toxic to larvae of insecticide-resistant and insecticide-susceptible mosquitoes, but

the longer the carbon black was suspended in water before treating them, it became more toxic to the insecticide-resistant larvae.

"When you first apply the CNP solution it has similar toxicity against both strains," Piermarini said. "But when you let the suspension age for a few weeks, it tends to become more potent against the resistant strain of mosquitoes."

Although they couldn't determine the reason behind the time-lapsed deaths, the study concluded that these new nanomaterials could be extremely beneficial to controlling the species when applied as a preventive treatment to mosquito breeding grounds.

But before it can be utilized by the public, Piermarini said, carbon black needs to undergo rigorous testing to ensure it won't harm humans and the environment as a whole.

Co-authors were Erick Martinez Rodriguez, a visiting scholar currently in the Ohio State Entomology Graduate program, Parker Evans, a previous Ph.D. student in the Ohio State Translational Plant Sciences Graduate program, and Megha Kalsi, a previous postdoctoral researcher in entomology.

More information: Erick J. Martínez Rodríguez et al, Larvicidal Activity of Carbon Black against the Yellow Fever Mosquito Aedes aegypti, *Insects* (2022). DOI: 10.3390/insects13030307

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