Native bacteria block Wolbachia from being passed to mosquito progeny

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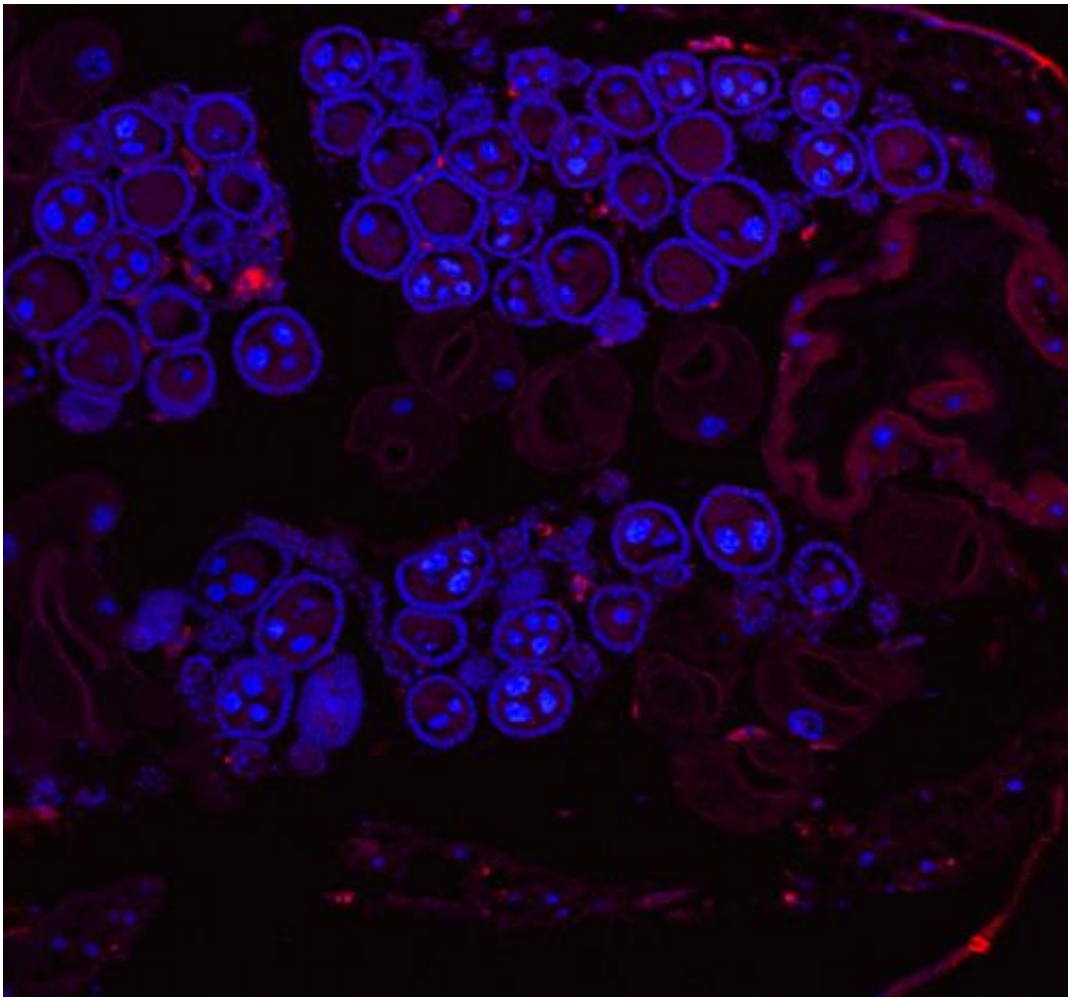

A cross-section of an Anopheles mosquito that has been injected with Wolbachia (red). The blue area represents mosquito DNA. Credit: Jason Rasgon, Penn State

Native bacteria living inside mosquitoes prevent the insects from passing *Wolbachia* bacteria—which can make the mosquitoes resistant to the malaria parasite—to their offspring, according to a team of researchers.

The team found that *Asaia*, a type of bacteria that occurs naturally in *Anopheles* mosquitoes, blocks invasion of *Wolbachia* into the mosquitoes' germlines—the cells that are passed on through successive generations of an organism—thus stopping the insects from transmitting *Wolbachia* to their offspring.

"*Wolbachia* infects up to 70 percent of all known insect species, but is notably absent from some groups, including the *Anopheles* mosquitoes that transmit malaria," said Jason Rasgon, associate professor of entomology, Penn State. "One of the big questions is, 'Why are some insect species infected with *Wolbachia* while others are not?' Our research provides a potential answer—maybe competitive interactions with *Asaia*, or other bacteria present in the insects, determine whether *Wolbachia* can infect the germline, be transmitted and invade the population, which is a desired outcome if *Wolbachia* is to be a successful control agent for malaria or other vector-borne pathogens. Both *Wolbachia* and *Asaia* are independently being evaluated as potential control agents for vector-borne pathogens; our research suggests that maybe these two strategies are not compatible."

According to Rasgon, in the insects in which it naturally occurs, *Wolbachia* is transmitted vertically from mother to offspring, but over evolutionary time it often has been transmitted horizontally between insect groups.

"No one really knows why some species are infected and why some are not, and no one really knows what governs the successful acquisition of a horizontally acquired *Wolbachia* infection," he said.

To conduct their study, the researchers injected *Wolbachia* into female *Anopheles* adults and measured transmission to offspring.

"We found that under normal circumstances, *Wolbachia* was transmitted very poorly and that *Wolbachia*-injected mosquitoes died after bloodfeeding," said Rasgon. "However, when we reared mosquitoes with antibiotics prior to *Wolbachia* injection, *Wolbachia* was transmitted much more efficiently and mosquitoes survived after bloodfeeding."

The team then used a DNA sequencing technique to identify all of the bacteria —the "microbiome"—in the antibiotic-treated and control mosquitoes. They found that *Asaia* was specifically reduced by the antibiotic treatment in two different *Anopheles* species. The scientists then generated an antibiotic-resistant *Asaia* mutant and supplemented this bacterial mutant back to the antibiotic-treated mosquitoes. They found that after they recolonized the antibiotic-treated mosquitoes with *Asaia*, *Wolbachia* was no longer transmitted to offspring and mosquitoes died faster after bloodfeeding.

The results appear in today's (August 11) issue of the *Proceedings of the National Academy of Sciences*.

"With *Asaia*, we have identified the first specific barrier to *Wolbachia* maternal transmission," said Rasgon. "We have also shown that *Wolbachia* can interact with the other members of the mosquito microbiome. Finally, we have a potential hypothesis to explain the decades-old observation of the apparent lack of *Wolbachia* infection in *Anopheles* mosquitoes." In the future, the team plans to investigate whether the phenomenon of one species of bacteria blocking maternal transmission of other species holds true across a wider range of insect species. The researchers also hope to exploit their new knowledge to more easily establish stable *Wolbachia* infections in *Anopheles* and other mosquitoes.

More information: Native microbiome impedes vertical transmission of Wolbachia in Anopheles mosquitoes, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1408888111

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