Science News

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Global warming may limit spread of dengue fever, new research finds

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Summary: Infection with dengue virus makes mosquitoes more sensitive to warmer temperatures, according to new research. The team also found that infection with the bacterium Wolbachia, which has recently been used to control viral infections in mosquitoes, also increases the thermal sensitivity of the insects. The findings suggest that global warming could limit the spread of dengue fever but could also limit the effectiveness of Wolbachia as a biological control agent.

FULL STORY

Infection with dengue virus makes mosquitoes more sensitive to warmer temperatures, according to new research led by Penn State researchers. The team also found that infection with the bacterium Wolbachia, which has recently been used to control viral infections in mosquitoes, also increases the thermal sensitivity of the insects. The findings suggest that global warming could limit the spread of dengue fever but could also limit the effectiveness of Wolbachia as a biological control agent.

"Dengue fever, a potentially lethal disease for which no treatment exists, is caused by a virus, spread by the bite of the mosquito *Aedes aegypti*. This mosquito is also responsible for transmitting a number of disease-causing viruses, including Zika, chikungunya and yellow fever," said Elizabeth McGraw, professor and head of the Department of Biology, Penn State. "Aided by increasing urbanization and climate change, this mosquito's range is expected to overlap with 50% of the world's population by 2050, dramatically increasing the number of people who could potentially be exposed to these viruses."

In recent years, research groups around the world have attempted to control these viruses by infecting *Ae. aegypti* with the bacterium *Wolbachia pipientis* and then releasing the mosquitoes into the environment, McGraw explained.

"Wolbachia have been shown to prevent viruses, including dengue, from replicating inside mosquitoes," she said. "Importantly, Wolbachia are passed down to the mosquitoes' offspring, making them a self-propagating and lower-maintenance approach to disease control in the field."

McGraw noted that both dengue virus and Wolbachia infect a variety of tissues throughout a mosquito's body, and although they are not toxic, they do evoke an immune stress response.

"Since mosquitoes that are infected with dengue virus and/or Wolbachia are already suffering a stress response, we thought that they would be less well equipped to deal with an additional stressor, such as heat," she said.

To investigate the effects of heat on dengue and Wolbachia-infected mosquitoes, the team placed infected mosquitoes in sealed vials and then submerged the vials into a water bath heated to 42°C -- a realistic temperature extreme that a mosquito might encounter in the wild. The researchers then measured how long it took for the mosquitoes to become immobilized and compared the time to uninfected control mosquitoes. Their findings appear today (July 22) in the journal *PLOS Neglected Tropical Diseases*.

"After a lot of trial and error, we were successfully able to adapt a heat-based physiological assay commonly used in Drosophila [a model fruit fly species] to our mosquito species to examine the impact of both dengue virus and Wolbachia infections on thermal sensitivity," said Fhallon Ware-Gilmore, graduate student in the Department of Entomology and Center for infectious Disease Dynamics at Penn State who led the project.

The team found that mosquitoes infected with dengue virus showed greater sensitivity to heat; they became immobilized almost three times faster than uninfected mosquitoes when placed in the hot water bath. Similarly, mosquitoes infected with Wolbachia became immobilized four times faster than uninfected mosquitoes.

Interestingly, Ware-Gilmore said, the two agents -- dengue virus and Wolbachia bacteria -- did not have an additive effect on mosquito thermal tolerance.

"You might expect that mosquitoes infected with both dengue virus and Wolbachia might become immobilized even faster than mosquitoes infected with only one or the other microbe, but we did not find an additive effect," she said. "We are, however, the first to show that viral infection can affect mosquito thermal tolerance, specifically by reducing mosquito survival during exposure to high heat. And, while there are some known interactions between heat and Wolbachia, particularly in immature stages, this is also the first study to show that adult infected-mosquitoes have reduced survival during heat stress."

Ware-Gilmore noted that future climate models point to increasing frequencies of extreme temperature events, making short exposures to high temperatures a threat to the survival of dengue and Wolbachia infected mosquitoes.

"At lower temperatures, we know that dengue virus may fail to replicate fast enough to make it through the mosquito body and be transmitted, thereby reducing transmission risk," she said. "At higher temperatures, while the virus may replicate faster, our work suggests that a corresponding reduction in mosquito thermal tolerance may act as a counterforce on mosquito survival that could help to reduce transmission and potentially human disease incidence in hotter, more climate-variable regions. Similarly, our work suggests that Wolbachia may fail to work as a biocontrol agent in hotter regions given its effect on mosquito survival."

Other Penn State authors on the paper include Heverton Dutra, postdoctoral scholar in entomology; Matthew Jones, research assistant, Huck Institutes of the Life Sciences; and Katriona Shea, professor of biology and Alumni Professor in the Biological Sciences. Also on the paper are Carla Sgrò, professor of biological sciences, and Matthew Hall, senior lecturer in biological sciences, Monash University; Zhiyong Xi, professor of microbiology and molecular genetics, Michigan State University; and Matthew Thomas, director and professor, York Environmental Sustainability Institute, University of York.

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Journal Reference:

1. Fhallon Ware-Gilmore, Carla M. Sgrò, Zhiyong Xi, Heverton L. C. Dutra, Matthew J. Jones, Katriona Shea, Matthew D. Hall, Matthew B. Thomas, Elizabeth A. McGraw. **Microbes increase thermal sensitivity in the mosquito Aedes aegypti, with the potential to change disease distributions**. *PLOS Neglected Tropical Diseases*, 2021; 15 (7): e0009548 DOI: 10.1371/journal.pntd.0009548

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