Urbanization changes shape of mosquitoes' wings

January 23 2019

Research shows that rapid urbanization in São Paulo City, Brazil, is influencing wing morphology in the mosquitoes that transmit dengue and malaria . Credit: Pest and Diseases Image Library, Bugwood.org

The mosquito Aedes aegypti is the main transmission vector of dengue, Zika, yellow fever and chikungunya in Brazil. It is highly adapted to urban environments and rarely found in forested areas. The mosquito Anopheles cruzii is the primary vector of Plasmodium, the protozoan parasite that causes malaria in humans. It mostly inhabits the countryside and is infrequent in urban areas.

Mosquito population control is considered the best strategy for combating these diseases. Understanding mosquito population dynamics is vital to the development of more effective vector control programs. Researchers in Brazil and the United States are working on a project to investigate A. aegypti and A. cruzii populations in São Paulo City.

Microevolutionary changes occurring within species or populations over time can be perceived as variations in the genomes or phenotypes of the insects concerned.

In two recent studies, researchers affiliated with the University of São Paulo in Brazil and the University of Miami in the US set out to modulate the population structures of these two mosquitoes based on morphology and genetics and to find out how they are affected by different levels of urbanization.

"In other words, we wanted to understand more about the ecology of these mosquitoes and their relations with the environmental changes produced by human action," said Mauro Toledo Marrelli, a professor in the Epidemiology Department of the University of São Paulo's Public Health School (FSP-USP).

Marrelli is one of the researchers responsible for both studies, alongside André Barretto Bruno Wilke, affiliated with the Department of Public Health Sciences at the University of Miami's Miller School of Medicine (UMMSM).

The results of their research on A. aegypti, which was supported by FAPESP—São Paulo Research Foundation, are published in BMC Parasites and Vectors.

"By pinpointing the genetic and morphological differences and similarities between members of the same species inhabiting a specific

area, we wanted to identify possible variabilities in these mosquitoes triggered by environmental pressures such as chemical control, which may lead to the selection of insecticide-resistant phenotypes. This is cause for concern, as chemical control with insecticides is the main weapon used by public health workers to combat mosquitoes," Marrelli said.

Between 2012 and 2015, the researchers collected 308 specimens of A. aegypti from 11 sites in three areas of São Paulo City with different levels of urbanization, defined as conserved, intermediate, and urbanized.

The conserved area comprised five municipal parks (Anhanguera, Eucaliptos, Independência, Previdência and Piqueri). The intermediate area was the University of São Paulo's campus in the city's Butantã neighborhood. The urbanized area was Pinheiros, the neighborhood in which FSP-USP and the same university's Medical School (FM-USP) are located.

Biologist Ramon Wilk da Silva removed the right wings from the female specimens, photographed them and digitized the photographs. He analyzed the geometric morphometry of the wings, recorded the comparative data, and fed the data into advanced statistical analysis programs.

The results showed significant correlations between the population structure of A. aegypti and the different degrees of urbanization in the selected areas. Wilk da Silva is currently a Ph.D. researcher at the University of São Paulo Institute of Tropical Medicine (IMT-USP) with a scholarship from FAPESP.

"Microevolutionary processes can be triggered in mosquitoes by man-made changes to the environment and give rise to a previously unknown

population structuring pattern of major epidemiological importance," Marrelli said.

The environmental pressure undergone by these mosquitoes owing to urbanization, he explained, leads to the selection of certain phenotypes that are better adapted to the prevailing conditions. "Wing shape variability is a sign of this selection. The results agreed with those of a genetic study we had conducted previously, using microsatellite markers," he said.

Malaria vector

Analysis of wing morphometry is a low-cost method for studying mosquito population dynamics. Insects are captured and mounted on slides, and their wings are examined under an optical microscope. Wing size and shape are important, but 18 key points of wing veins are also measured to identify different species and varieties.

The wing morphometric study of A. cruzii was performed by biologist Laura Cristina Multini, focusing on wing veins. The study was supported by a scholarship from FAPESP and was part of a broader research project for which Marrelli is principal investigator.

A. cruzii is the main vector of malaria in the Atlantic Rainforest biome. The analysis of the wings of A. cruzii began with the capture of 500 specimens using traps between 2015 and 2017 in the Capivari-Monos Municipal Environmental Protection Area, which is located in the subdistrict of Parelheiros, on the southernmost edge of São Paulo City. The specimens were collected in three different environments: forest (remnants of Atlantic Rainforest on private property), periurban (an area of transition between forest remnants and a cattle farm), and urban (Engenheiro Marsilac, a neighborhood in the Parelheiros subdistrict).

In contrast to the study of A. aegypti, which focused on wing vein morphometry, the study of A. cruzii focused on wing size and shape.

"We found considerable variation in both wing shape and size in A. cruzii populations over the three-year period, suggesting rapid microevolutionary changes that probably resulted from strong selective pressures," Marrelli said. "It's likely that the mosquito's biology has evolved in response to disturbances in its natural habitat, as noted in this study in terms of wing shape variability."

There are no natural barriers between the A. cruzii populations analyzed in the study, possibly indicating different forms of adaptation to the three collection sites. "Local selection may be producing different phenotypes, and mechanisms such as genetic assimilation and genetic accommodation may be causing real differentiation," Marrelli said.

"Knowledge of the morphological differences between the various populations of A. aegypti and A. cruzii can serve as the basis for an efficient and rapid method whereby public health workers, for example, could recognize whether a variety of these insects is more or less resistant to a particular insecticide and take appropriate action."

More information: Ramon Wilk-da-Silva et al, Wing morphometric variability in Aedes aegypti (Diptera: Culicidae) from different urban built environments, *Parasites & Vectors* (2018). DOI: 10.1186/s13071-018-3154-4

Provided by FAPESP