ROBOTS AND SOCIETY

Virus-blocking mosquitoes take flight in the fight against dengue

Jacob E. Crawford*

Drone-based mosquito releases facilitate the introduction of dengue-blocking bacteria in wild mosquito populations.

Counterintuitive though it may seem, intentionally releasing mosquitoes is one of the most promising tools in the global fight against dengue. There are two approaches to dengue control that involve live mosquito releases: suppression of wild mosquito populations via sterile male mosquito releases and replacement of the disease-transmitting mosquito population by releasing modified mosquitoes with reduced viral transmission capacity. Both approaches require a series of releases covering large inhabited areas, sometimes where access can be challenging. More than half of all humans live in areas that are environmentally suitable for dengue transmission (*1*). Dengue-endemic countries include roughly 900,000 km^2 of dense urban areas (*2*) where the primary mosquito involved in transmission, *Aedes aegypti*, thrives. To realize the promise of mosquito release approaches, new technologies are needed to scale the release of mosquitoes. In a new paper, Lin *et al.* (*3*) describe a drone-mounted release device that delivers healthy mosquitoes to target areas with high uniformity and at a scale that resulted in successful replacement of wild mosquito populations with one infected with a dengue-blocking bacterium called *Wolbachia*.

A. aegypti mosquitoes typically fly only 100 to 150 m in their lifetime without help (*4*) and thus require mosquito release methods that operate at fine spatial scales to ensure full coverage of mosquitoes across an area. The simplest, and most labor-intensive, release method involves walking or driving through a release area while manually opening many small containers of live adult mosquitoes to achieve an even distribution (*5*). Recently, Crawford *et al.* (*6*) described a van-based automated adult mosquito release method that provides improved coverage and efficiency. Another approach is to distribute containers with live mosquito eggs where adults develop and distribute unassisted (*7*). All current release methods require field staff to repeatedly access target release areas, which can be challenging in some cases for safety and other concerns. Automated aerial releases provide advantages over existing methods and may become a preferred or complementary release method.

Aerial mosquito release devices must carry enough mosquitoes to cover a large area, microdose mosquitoes at designated locations, and keep mosquitoes healthy during the flight. Building on a similar device used to release sterile male mosquitoes in a smaller experiment in Brazil (*8*), Lin *et al.* (*3*) developed a compact, drone-ready device with systems to meet these specifications. Within the device, chilled and sedated mosquitoes are stored in containers at high density, with a capacity for 160,000 mosquitoes (Fig. 1A). The storage containers connect to a multistage dosing system that isolates approximately 150 mosquitoes from the tangled mass in the storage containers and readies them for exit through the release mechanism. One of the challenges of this process is that adult mosquitoes are delicate and need to remain within a range of temperature and humidity. Allowing the temperature or humidity to fluctuate beyond set points or moving adults too quickly can cause substantial physical damage and may lead to clumping. The new device includes climate control onboard and is stored in an insulated box. The authors conducted a series of tests starting in the laboratory followed by small-scale field releases in an A/B test against ground-based releases. After some adjustments and a few technical setbacks, the validation tests showed that mosquitoes were dosed at roughly the target rate, with a life span and dispersal ability at least as good as those of ground-released mosquitoes. Critically, the entire process from packing to aerial releases required one-third the number of hours compared with the ground-based release process.

The drone-mounted device was tested in releases of *Wolbachia* mosquitoes in a 2-km^2 area near the town of Nausori, Fiji (Fig. 1B). On the basis of mosquito collections from the field, the released mosquitoes were confirmed to compete in sufficiently large numbers to result in effective introduction of *Wolbachia* into the wild population. Importantly, the infection was maintained in the population, as evidenced by spot checks a year later. Whether mosquito releases are intended for population suppression or population replacement, both approaches are a numbers game requiring a consistently high density of released mosquitoes to compete for mates. The field results reported by Lin *et al.* (*3*) demonstrate that the drone release device performed well at scale for 3 months of weekly releases.

Drones have become increasingly popular for a variety of use cases over the past decade, and community acceptance varies according to a range of factors (*9*). Using drone releases in mosquito programs will require community engagement and regulatory approval from governments. Lin *et al.* (*3*) conducted substantial community engagement efforts and recorded overwhelmingly positive support for drone-based releases in a prerelease survey of households, providing a hopeful example for the implementation of this technology.

Automated devices are exceptionally useful when a task is repetitive or when access is difficult. Releasing mosquitoes across thousands of square kilometers to combat dengue fits both of these descriptions. Provided that government approval and public trust can be obtained, we now have a critical new tool to enable the introduction of the disease-blocking bacterium *Wolbachia* in wild populations of dengue-transmitting mosquitoes. Innovation and new technologies like this aerial release

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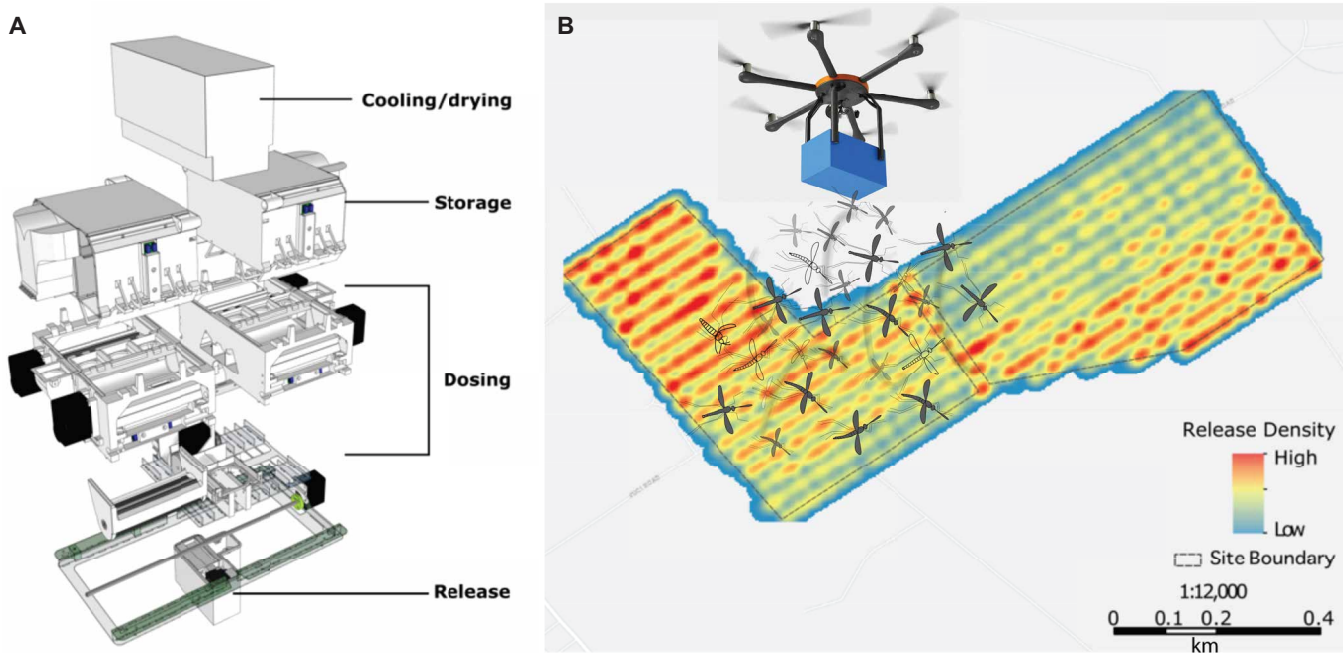

Fig. 1. Drone-mounted device for releasing dengue-blocking adult mosquitoes. (**A**) Schematic illustration of release device components. (**B**) The drone-mounted device successfully distributes mosquitoes across the target area.

device are essential to improve capabilities and capacity in our integrated fight to reduce dengue transmission on a global scale.

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Acknowledgments

Competing interests: J.E.C. reports employment and equity ownership at Verily Life Sciences LLC. The opinions/research expressed in this article are those of the individual author and do not reflect those of the author's employer (Verily Life Sciences LLC).

10.1126/scirobotics.adr0224

Science Robotics

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Sci. Robot. **9** (92), eadr0224. DOI: 10.1126/scirobotics.adr0224

Science Robotics (ISSN 2470-9476) is published by the American Association for the Advancement of Science. 1200 New York Avenue NW, Washington, DC 20005. The title *Science Robotics* is a registered trademark of AAAS.