ROBOTS FOR SOCIETY

Drones against vector-borne diseases

Eric Rasmussen

Uncrewed aerial vehicles can reduce the cost of preventative measures against vector-borne diseases.

In 2018, there were more than 200 million malaria cases reported in the world and more than 400,000 malaria deaths, two-thirds of whom were children under age 5 (*1*). Malaria is an ongoing tragedy of immense proportions, with the World Health Organization aggressively targeting its global eradication within the next decade. Reducing transmission of the malaria parasite *Plasmodium*, carried by *Anopheles* mosquitoes, is an important part.

Aedes mosquitoes are a different mosquito genus that transmits the viral diseases dengue, Zika, chikungunya, and yellow fever. Each of those diseases has recently been the subject of newsworthy outbreaks, and each is worrisome as we track their expanding range. In 1970, for example, only nine countries in the world had dengue cases. Now, there are more than 100 countries with dengue (Fig. 1), and 2019 saw the largest global number of dengue cases ever reported (*2*).

Both *Aedes* and *Anopheles* mosquitoes are predicted to expand their range still further in a warming world, and regrettably, although most mosquitoes will bite anything, *Aedes* prefers to bite humans (*3*). Writing in this issue of *Science Robotics*, Bouyer *et al.* describe a new, efficient, and inexpensive technique for the release of sterile male mosquitoes from an uncrewed aerial vehicle, or drone, that will reduce field reproduction through competitive mating with wild-type female mosquitos. The resulting eggs cannot mature and the regional mosquito population falls (*4*). Bouyer's technique may have broad applicability against *Aedes*, *Anopheles*, and other insects and so may help reduce vector-borne diseases.

But there may be unforeseen impediments. While Bouyer and colleagues have been doing good work with *Aedes*, the world has been responding to a zoonotic respiratory coronavirus pandemic, and massive resources have been allocated against this infectious threat. Underneath the global response against SARS-CoV-2, however, a subtle catastrophe is likely unfolding. We are already anticipating disruptions in mosquito bednet distribution, loss of prophylaxis and simple therapies for common medical problems, and reductions in management of serious illnesses as a result of both lockdowns and of care providers focused on COVID-19 (*5*). The resulting excess mortality may be severe.

I was part of a team that worked with the Obama White House in 2014 on the global response to the Ebola virus outbreak in West Africa. What we missed then, and learned later, was the cost of that outbreak on conventional medical care in the region. Anecdotal reports in Guinea a year after Ebola showed that conventional health care had suffered severely as a result of re-directing scarce medical resources to that looming viral threat. Outpatient visits for children under age 5 at a district hospital dropped from 200 per day to a dozen per day, and patients presenting to hospital with malaria, diarrhea, and pneumonia dropped 75% from baseline (*6*). Later, a rigorous paper in *The Lancet* by Walker and colleagues modeled the malaria-specific toll taken by the loss of ordinary medical care during the Ebola crisis in Guinea, Liberia, and Sierra Leone. At the low end of their sobering findings, they estimated 2.6 million additional cases of malaria and more than 5000 excess malaria-attributable deaths, just in West Africa (*7*).

As seen in the Ebola outbreak, it is likely mosquito-borne diseases during this pandemic are going to take an outsized toll that we will not discern clearly for years and that makes the work by Bouyer and co-workers exceptionally important. Their findings may help reduce the ravages of mosquito-borne disease through the reduction in viable mosquito eggs. Although this is only one facet of vector-borne disease eradication, it is a critical part. Their work shows that we are getting closer to cheap and efficient methods to mitigate the damage done by mosquitoes, even when, like now, normal medical resources are under stress.

Bouyer and colleagues introduce a new method for dispersing sterile males from a drone-based system. Their drone technique was designed, assembled, and deployed using ordinary materials used in clever ways and tested with, among more conventional apparatus, leaf blowers designed for neighborhood lawns. The researchers also describe a new process that might allow shifting from irradiating pupae—which can result in anoxic injury and lowered viability and so reduced competitiveness in the wild—to irradiating chilled adults. Their statistics show improved survivability and, once released, improved competitiveness. The result is a surprisingly high degree of induced sterility in females after the release of the males by drone.

Two specific findings in this paper were especially interesting to this physician who leads disaster response teams into the aftermaths of cyclones. One was the finding of similar competitiveness between ground release and drone release. That naturally leads to a recognition that this drone methodology, as they describe late in the paper, will allow a remote preparation of the drone canisters, loading and transport to an affected region, and then a release over an area where local preparation of such canisters would not normally be feasible. That may reduce the intensity of later disease outbreaks by reducing the number of viable mosquito eggs deposited in standing water.

The second important finding here, beyond the clever mechanical engineering to reduce damage to the fragile legs and delicate wings of the insects, is the estimated 20-fold reduction in cost for sterile-insect-technique (SIT) release studies using this new drone modality. If tried in an appropriate subset of the other 34 *Aedes* SIT studies now in process globally, we might be able to expand the power of those trials without altering their budgets.

Medical care in a tropical region of the world can easily be broken by an outbreak or a climate disaster. Even without disruptive events, public health resources are often so poor that no local capability exists for mosquito eradication at scale. This new drone technique

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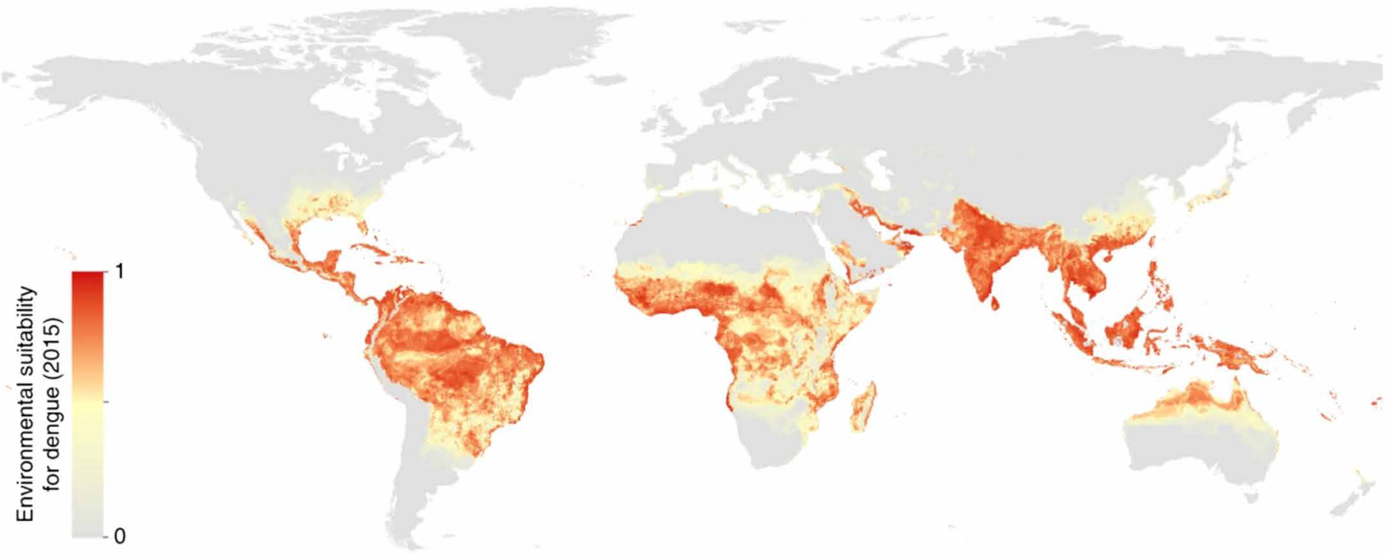

Fig. 1. Probability of occurrence of dengue in 2015 (gray, low; red, high). Taken from figure 1 of Messina *et al.* (*3*).

for sterile release, though, is cheap enough to allow a reduction in the misery of mosquito-borne diseases almost anywhere. That is exciting news.

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Acknowledgments

Competing interests: E.R. is CEO, Infinitum Humanitarian Systems; Chief Medical Officer, Briotech Inc.; Chair, Board of Directors, InSTEDD; President and Chairman of the Board, iRespond; Team Lead, Global Disaster Response Team, The Roddenberry Foundation; Research Professor, Environmental Security and Global Medicine, San Diego State University, San Diego, CA; Senior Fellow, GeoTech Center, The Atlantic Council; and Senior Fellow, Florida Institute for Human-Machine Cognition, Pensacola, FL.

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