15
Global mosquito alert

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An exciting recent development in citizen science has been the emergence of a variety of projects to fight disease-vector mosquitoes. These projects have shown that citizens can play an important role in alleviating the global burden of the diseases these mosquitoes transmit, but the projects are mostly limited to a handful of countries and have yet to benefit much of the world's most heavily mosquito-affected regions. The Global Mosquito Alert Consortium (GMAC) seeks to change that. The initiative is bringing diverse citizen science projects together to tackle disease-vector mosquitoes worldwide.

The problem of disease-vector mosquitoes

The re-emergence and global spread of vector-borne diseases during the past two decades has given mosquitoes a prominent place on the international public health agenda (WHO 2014). Dengue has skyrocketed, reaching 100–390 million cases annually (Castro, Wilson & Bloom 2017). Outbreaks of chikungunya and Zika since 2005 have infected millions of people, with Zika triggering a global health emergency due to its rapid expansion and its link to microcephaly and other neurological complications (Petersen & Powers 2016; Weaver & Lecuit 2015; Christofferson 2016; WHO 2016b). Malaria incidence and mortality have decreased

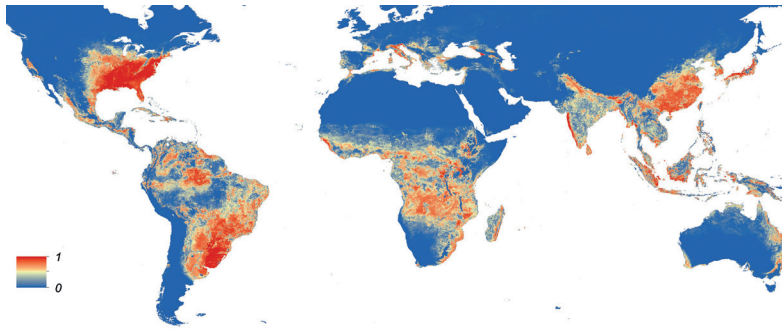

Fig. 15.1 Predicted global distribution of *Aedes albopictus*, mosquitoes that can serve as vectors for dengue, chikungunya, Zika and other viruses. Colours indicate probability of occurrence (from 0 blue to 1 red) at a spatial resolution of 5 km × 5 km. (Source: Kraemer et al. 2015, CC0)

since 2000 but the disease continues to affect enormous numbers of people, with over 200 million cases and over 400,000 deaths each year (WHO 2016a; WHO 2014). Moreover, recent upticks in malaria suggest stalled progress and the need to revitalize efforts by gathering real-time data with greater geographic precision (WHO 2017; Gates 2018).

These diseases and others, all transmitted by mosquitoes, place massive burdens on society – particularly the poor (Bhatt et al. 2013; Stanaway et al. 2016). Invasive vector species like the Asian tiger mosquito, *Aedes albopictus*, have spread quickly around the globe (see figure 15.1), and the World Health Organization has issued a strong warning that governments and development agencies must act quickly to improve vector control before this 'alarming situation' further deteriorates (WHO 2014). In contrast to treatments and vaccines aimed directly at vector-borne diseases, the WHO has concluded that targeting mosquitoes and other vectors provides an 'excellent, but underutilised opportunity' to fight these diseases and address the poverty and inequality that they cause (WHO 2014).

Citizen science as a scalable and flexible solution

Citizen science offers a highly effective strategy for tackling disease-vector mosquitoes. Traditional methods of mosquito surveillance and control are costly and often implemented in unco-ordinated patchworks at a time when public sector budgets are under increasing pressure (Hadler

et al. 2015). Citizen science, in contrast, can be highly scalable, connecting the mosquitoes' human hosts into massive, active networks. These networks can act as effective mosquito sensors across large geographic scales, providing early warning and mosquito prevalence estimates comparable in quality to those from traditional methods (Palmer et al. 2017; and see Danielsen et al. in this volume). Citizen science projects that already provide information on disease-vector mosquitoes at national or supranational scales include Mosquito Alert (http://www.mosquitoalert.com), active in the Mediterranean Region; Muggenradar (https://www.naturetoday.com/intl/nl/observations/mosquito-radar), active in the Netherlands; and Zanzamapp (http://www.zanzamapp.it), active in Italy, among many others.

Further, engaging the public in vector monitoring through citizen science has numerous benefits beyond enhanced data collection. Participation in citizen science often leads to enhanced topical knowledge or knowledge of the scientific process (Edwards et al. in this volume). In

Fig. 15.2 Tiger mosquito photograph submitted by an anonymous participant through Mosquito Alert. CC BY 4.0. Participants in many mosquito-related projects may submit photographs along with their reports of mosquito detections to help researchers validate the reports. Other projects allow participants to submit specimens.

disease vector–monitoring, citizen science may also help motivate and improve co-ordination between individuals and families, so that they can implement effective protective and preventive measures such as interventions on mosquito-infested private property that public authorities cannot easily access (Oltra, Palmer & Bartumeus 2016).

Citizen science is also flexible, encompassing a wide array of approaches. Different approaches may be better suited to particular regions, depending on social, economic and ecological factors. Citizen science can easily adapt to offer this variety. The mosquito-centred citizen science projects that have been emerging across the globe are unique in terms of goals and methods (Kampen et al. 2015; Vogels et al. 2015; Waterhouse et al. 2017; Yong 2017; Mukundarajan et al. 2017), though many share common practices like the collection of photographs or specimens as vouchers for species identification (figure 15.2).

Global Mosquito Alert

Despite the apparent scalability of networked citizen science, existing mosquito-related projects are mostly limited to a handful of countries. This appears to result from two basic challenges. First, the need to communicate effectively with participants and work closely with local public health and vector control authorities adds an inherently local aspect to vector-mosquito citizen science. Specific vectors, especially invasive species, will differ from one municipality to another, as will the authorities responsible for vector monitoring, management and control. Second, projects have struggled, thus far, to find funding sources that are sufficiently large and sustainable to create the infrastructure needed for both long-term local implementation and global interoperability.

The GMAC initiative took shape as a way to address these challenges. After initial discussions between existing projects, the initiative was launched at an international workshop in Geneva, convened by the European Citizen Science Association (ECSA), the Woodrow Wilson International Center for Scholars, and the United Nations Environment Programme (UNEP) in April 2017. The workshop brought together experts and the heads of vector-mosquito citizen science projects from around the world. It quickly became clear that the diversity of approaches should be embraced through the formation of a consortium to serve as a global hub of resources and an engine for mobilising funding for locally customised projects at the country or region level.

The workshop participants agreed on the following vision:

> The Global Mosquito Alert Consortium is a new citizen science initiative that aims to leverage networks of scientists and volunteers for the global surveillance and control of the mosquito species known to carry the following diseases: Zika, yellow fever, chikungunya, dengue, malaria and the West Nile virus. Global Mosquito Alert Consortium will be an open, common set of protocols and a toolkit that is augmented with modular components created to meet both global and local research and management needs.
>
> (Tyson et al. 2018)

The GMAC will start by focusing on four canonical protocols that reflect the goals of existing projects: (1) Real-time surveillance of adult vector mosquitoes; (2) investigation of larvae and breeding sites; (3) tracking of biting and nuisance; and (4) mosquito biodiversity approaches involving specimens and DNA identification techniques. Each protocol is designed with a small set of common, core elements and common metadata documentation and data policies to facilitate interoperability (see also Williams et al. in this volume). These include a common set of data-validation processes and supporting tools, complemented by a directory of experts that can help local projects develop; a common process of data analysis and visualisation; four sets of open, canonical Android and iPhone mobile applications that may be customised for local use (e.g., the Mosquito Alert app has already been translated into Spanish and Cantonese for local pilot deployments in Colombia, Mexico, Puerto Rico and Hong Kong). Common data policies include compatible open source licences for software and open-access licences for data, privacy protections for participants and a set of user agreements.

Looking forward

For GMAC and other citizen science initiatives to realise their promises, policymakers and regulators, in collaboration with technologists, should have an ambitious conversation about global data commons. They need to address the question of how open and resilient big data architectures should be, in particular those used for monitoring vital public health and environmental factors. Experts will also need to consider the challenge and cost of ensuring accuracy when dealing with environmental samples, especially biological and genomics samples. The potential of monitoring

for disease-vectors is enormous but methods are needed to validate data and address liability issues.

This is why, throughout this process, GMAC will be working with UNEP to develop a global portal on UNEP's open-access web platform, Environment Live, where both data and techniques can be shared, assessed and improved. In an increasingly interconnected world, GMAC aims to give citizens the tools to make a growing contribution to combatting disease-vector mosquitoes at a scale never previously achieved, regardless of where they live and work.