Dengue vector habitats in Ouagadougou, Burkina Faso, 2020: an unintended consequence of the installation of public handwashing stations for COVID-19 prevention

An estimated 400 million dengue cases occur annually worldwide.[1] Burkina Faso is one of several African countries considered to be endemic for dengue,[2] having recorded outbreaks in 2013, 2016, and 2017, when the highest prevalence and incidence were recorded in Ouagadougou city.[3] As per July 1, 2023, the most recent outbreak of dengue in Burkina Faso began between Aug 7 and Aug 12, 2023, in Bobo Dioulasso, before spreading to Ouagadougou. This outbreak was an unprecedented and remarkably early appearance for dengue viruses that by the week of Nov 13–19, 2023, had already resulted in 123 804 cases and 570 deaths nationwide. The outbreak is ongoing, but these numbers already exceed the cumulative number of dengue cases and deaths reported since the outbreak in 2016. Almost simultaneously, Burkina Faso experienced its first outbreak of Chikungunya in Pouytenga (137 km east of Ouagadougou), with 214 confirmed cases.

Two studies conducted in Ouagadougou, published in 2022, highlighted discarded car tyres as the most productive larval habitat[4,5] for the dengue vector *Aedes aegypti*. However, those studies focused on larval habitats associated with households, and the relative contribution of different vector habitats in public places remains largely unexplored in west Africa, despite the documented role of such places as dengue vector proliferation hotspots elsewhere.[6,7] Our study addressed this knowledge gap by investigating the presence, abundance, and diversity of immature *A aegypti* in a range of water-holding containers in public places in Ouagadougou. As this study coincided with the COVID-19 pandemic, the water-based handwashing stations introduced into public places to reduce or prevent transmission of the SARS-CoV-2 virus were included in assessments of the relative contribution to the vector population of different containers. This study received the approval of the National Research Ethical Committee (deliberation 2020-9-209 of Sept 2, 2020) of the Ministry of Health, Burkina Faso.

A cross-sectional entomological survey was conducted between Sept 18 and Oct 16, 2020, systematically screening all water-holding containers in 61 public places of Ouagadougou (appendix p 2) to collect mosquito larvae and pupae. Each public place was visited once, and the entire yard and its accessible outbuildings were thoroughly inspected. Positive mosquito breeding containers were emptied to collect larvae and pupae for sorting, counting, and identification[4] to the genus level, and pupae were reared to the adult stage to identify the species.

The numbers of water containers and positive containers and the *A aegypti* larval and pupal densities were used in generalised linear mixed models (GLMMs) with a negative binomial link function in R (with the glmmTMB package) to explore their association with container type, material, collection site, physicochemical characteristics of water,[5] sunlight exposure, container function, the date of collection, and the breeding site identifier (as a random effect). Additional generalised linear models were used to model the effect on breeding site productivity[8] and breeding preference ratio (BPR)[5] of breeding container types, collection months, and types of public place.

Of 924 potential larval habitats inspected, the most common were the containers at handwashing stations, followed by tyres, small containers, and buckets, cans, or pots (BCPs; appendix p 3). Although the abundance of breeding containers did not vary among public places, handwashing stations and tyres were significantly more abundant than the reference container category BCP (appendix p 4). Of 660 containers positive for *A aegypti*, handwashing stations were the most common (37·4%), followed by tyres (37·3%), small containers, BCPs, drum barrel, and others (appendix p 3). The abundance of *A aegypti*-positive breeding sites varied only slightly among public places, but infested handwashing stations and tyres were significantly more abundant than the reference container category BCP (appendix p 5). *A aegypti* were the most common immature mosquitoes

See Online for appendix

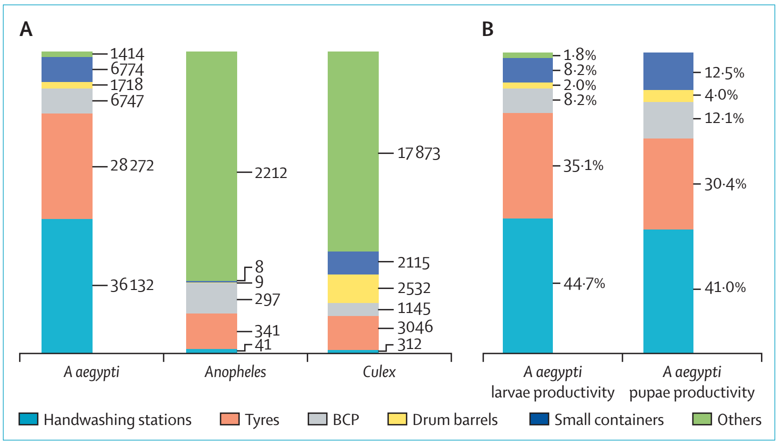

***Figure:* Abundance of immature mosquitoes in *Aedes aegypti* breeding containers**
(A) Number of *A aegypti*, *Anopheles*, and *Culex* immatures per container type. (B) Larval and pupal productivities according to breeding site container types (percentage of total counts). BCP=buckets, cans, or pots.

detected, with 81 057 larvae and pupae collected mostly from handwashing stations (44·6%) followed by tyres (34·9%; figure 1A). The GLMM analysis indicated that type of public place and container type significantly affected larval density, but that only small containers had slightly less effect than the reference BCP, whereas containers that were in use showed reduced larval density (appendix p 6). Pupal density was also negatively affected by being in use and the container pH (appendix p 7). The results clearly showed that handwashing stations and tyres in public areas were the most productive habitats for both larvae and pupae, greatly exceeding the collections from other container types (figure 1B). In terms of BPR, tyres (BPR 1·17) were significantly preferred over other container types for breeding, followed by small containers, BCPs, drum barrels, and handwashing stations, whereas the category for other containers was significantly less preferred (appendix pp 3, 8). The results show the importance of public places in the proliferation of *A aegypti*, previously uninvestigated in this region, and the ability of this robust mosquito to exploit what might appear to be entirely novel, temporary water containers that are frequently disturbed by routine use. This finding attests to the remarkable capacity of this vector to thrive in the urban environment. Many discarded or waste containers harboured *A aegypti*. Understanding the types of breeding sites in public places is important to guide the development of appropriate control strategies. Among people frequenting these locations during daytime, asymptomatic carriers of the dengue virus might serve as a viral reservoir when adult *A aegypti*—daytime feeders—are active.[9] Given that larval and pupal densities were negatively associated with the in-use state of the container,[4,10] we suggest that poorly or infrequently maintained and neglected containers favour successful oviposition and completion of immature development.

Some of the different handwashing stations had easily accessed containers where female *A aegypti* could enter and oviposit (appendix p 9). Others were designed to drain water after handwashing, either into toilets, wastewater pipes, underground, or onto vegetation (eg, grass or flowers), and represented no public health risk (appendix p 9).

The introduction of water-based handwashing stations as a risk-mitigation measure for COVID-19 created entirely novel, immature-stage habitats for dengue vectors, which indicates the importance of local-based risk assessments of proposed designs before the introduction of any device or protocol. The findings clearly show that handwashing stations are potentially as important as tyres in supporting *A aegypti* populations, and reiterate the importance of ensuring a target population has sufficient awareness of the purpose of interventions such as the handwashing stations and their correct use in public places.

AB, PJM, DW are supported by a WHO–TDR grant (WHO/TDR/RCS-KM 2015 ID235974). AB and HK are supported by AMED (JP17jm0510002h0003). AB, JZBZ, LSD are supported by the President Macky Sall Research Fund to PTR-SANTE for the project ALSO-COVID 19. MV is supported by the European Research Council under the European Union's Horizon 2020 Research and Innovation Programme (grant agreement 852957). PJM receives support from MRC-UK (MR/T001267/1) for research on peri-domestic behaviour of *Aedes aegypti*. All data underlying the findings are fully available without restrictions. All relevant data are presented in the paper and the supporting appendices. Signed informed consent was obtained from all heads or directors of services included in the study before starting the field collection. We thank the managers of the public places involved the study for accepting the prospection of breeding sites and the collection of larvae in their service places.

*Wendegoudi M Ouédraogo, Nicolas Zanré, Noah H Rose, Julien Z B Zahouli, Luc S Djogbenou, Mafalda Viana, Hirotaka Kanuka, David Weetman, Philip J McCall, *Athanase Badolo*
a.badolo@gmail.com

Laboratoire d'Entomologie Fondamentale et Appliquée, Université Joseph Ki-Zerbo, 03 BP 7021 Ouagadougou, Burkina Faso (WMO, NZ, AB); Programme National de Lutte contre les Maladies Tropicales Négligées, Ministère de la Santé, Burkina Faso (WMO); Department of Ecology, Behavior, and Evolution, School of Biological Sciences, University of California, San Diego, CA, USA (NHR); Centre d'Entomologie Médicale et Vétérinaire, Université Alassane Ouattara, Bouaké, Côte d'Ivoire (JZBZ); Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire (JZBZ); Swiss Tropical and Public Health Institute, Basel, Switzerland (JZBZ); Tropical Infectious Diseases Research Centre (TIDRC), University of Abomey-Calavi, Cotonou, Benin (LSD); School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, Glasgow, UK (MV); Department of Tropical Medicine, The Jikei University School of Medicine, Tokyo, Japan (HK); Department of Vector Biology, Liverpool School of Tropical Medicine, Liverpool, UK (DW, PJM)

1 Bhatt S, W. Gething P, Brady OJ, et al. The global distribution and burden of dengue. *HHS Public Access* 2013;**496:** 504–07.
2 Weetman D, Kamgang B, Badolo A, et al. Aedes mosquitoes and *Aedes*-borne arboviruses in Africa: current and future threats. *Int J Environ Res Public Health* 2018; **15:** 1–20.
3 Im J, Balasubramanian R, Ouedraogo M, et al. The epidemiology of dengue outbreaks in 2016 and 2017 in Ouagadougou, Burkina Faso. *Heliyon* 2020; **6:** e04389.
4 Badolo A, Sombié A, Yaméogo F, et al. First comprehensive analysis of *Aedes aegypti* bionomics during an arbovirus outbreak in west Africa: dengue in Ouagadougou, Burkina Faso, 2016–2017. *PLoS Negl Trop Dis* 2022; **16:** e0010059.
5 Ouédraogo WM, Toé KH, Sombié A, et al. Impact of physicochemical parameters of *Aedes aegypti* breeding habitats on mosquito productivity and the size of emerged adult mosquitoes in Ouagadougou city, Burkina Faso. *Parasit Vectors* 2022; **15:** 478.
6 Kampango A, Furu P, Sarath DL, et al. Risk factors for occurrence and abundance of *Aedes aegypti* and *Aedes bromeliae* at hotel compounds in Zanzibar. *Parasit Vectors* 2021; **14:** 544.
7 Abe M, McCall PJ, Lenhart A, Villegas E, Kroeger A. The Buen Pastor cemetery in Trujillo, Venezuela: measuring dengue vector output from a public area. *Trop Med Int Health* 2005; **10:** 597–603.
8 WHO, TDR. Operational guide for assessing the productivity of *Aedes aegypti* breeding sites. Geneva: World Health Organization, 2011.
9 Guzman MG, Gubler DJ, Izquierdo A, Martinez E, Halstead SB. Dengue infection. *Nat Rev Dis Primers* 2016; **2:** 16055.
10 Getachew D, Tekie H, Gebre-Michael T, Balkew M, Mesfin A. Breeding sites of *Aedes aegypti*: potential dengue vectors in Dire Dawa, east Ethiopia. *Interdiscip Perspect Infect Dis* 2015; **2015:** 706276.