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ABSTRACT BOOK

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Institut de Recherche pour le Développement
FRANCE
French National Research Institute for Sustainable Development

DAY 1

>> Opening Ceremony

Global dengue situation and the global arbovirus initiative

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1. *Global Neglected Tropical Diseases Programme of the World Health Organization.*

Abstract

As of July 2024, over 11 million dengue cases have been reported to WHO in 2024, including over 4 million confirmed cases, over 16,000 severe cases, and over 7000 deaths. While a substantial increase in dengue cases has been reported globally in the last five years, this increase has been particularly pronounced in the Region of the Americas, where the number of cases has already exceeded ten million, surpassing the annual high of 4.6 million cases in 2023. 102 countries have known active dengue transmission in 2024, not all of which have been captured in formal reporting. In addition, many endemic countries do not have strong detection and reporting mechanisms, so the true burden of dengue globally is underestimated. Undetected cases, co-circulation of other arboviruses and misdiagnosis and also movement of people have all contributed to this steep increase., WHO has established a global dengue surveillance system with monthly reporting across all WHO regions with a new dashboard now live (https://worldhealthorg.shinyapps.io/dengue_global/). Countries' overall capacity to respond to multiple, concurrent outbreaks continues to be strained due to the global lack of resources, including shortages of dengue diagnostic kits for early disease detection, a lack of trained clinical and vector control staff, and community awareness. The risk of emergence and re-emergence of arboviruses with epidemic potential has increased as a global public health threat and will continue to do so in the years to come. The Global Arbovirus Initiative outlines an integrated approach across these viruses and disciplines that will enable optimal use of limited resources to achieve the greatest impact, particularly in areas with the heaviest arboviral burden and in areas that are at risk of emergence of arboviruses.

INOVEC: A Research and Innovation Partnership for Enhancing the Surveillance and Control of Mosquito Vectors of Emerging Arboviruses

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Abstract

Over the past 10 years, arboviral diseases (re)emerged with increasing prevalence and severity, also affecting European countries. Access to effective vaccines and treatments is limited, and preventing these diseases essentially relies on controlling mosquito vector populations. However, the recent resurgence of Aedes-borne arboviral diseases revealed the limitations of vector control worldwide. The HORIZON-MSCA-funded INOVEC project proposes the establishment of a vast pan-European, cross-sectoral and multidisciplinary network to develop, optimise and promote integrated approaches and innovative tools for the surveillance and control of mosquito vectors of emerging arboviruses. The project brings together 25 academic and non-academic institutions specialised in vector biology, mathematics, social sciences and product development to stimulate research, strengthen capacities, promote career development and facilitate knowledge transfer. In its inaugural year, through implementation of secondments, the INOVEC project made a significant contribution to research and innovation through the organization of workshops and conferences, the dissemination of scientific findings in open access, and the facilitation of knowledge transfer and career development opportunities. The ultimate goal of INOVEC is to contribute to international efforts to improve global health and well-being by reducing the burden of vector borne diseases.

Keywords: **Emerging arboviruses; research & innovation, Integrated surveillance and vector control, *Aedes* mosquitoes.**

>> Scientific Session 1: Biology and Ecology of *Aedes* Vectors

Chairs: Emmanuel Kaindoa (IHI) & Florence Fournet (IRD)

Predicting the Risk of *Aedes*-Borne Diseases in Dar es Salaam

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Abstract

Mosquitoes are important vectors for other diseases than malaria, including dengue, Zika, West Nile fever, Chikungunya, and yellow fever, transmitted by *Aedes aegypti*. While the links between housing conditions and mosquito-borne diseases are increasingly recognized, the relation between attributes of urban environments and vector-borne diseases remains understudied, decreasing the efficacy of measures to address health issues in African cities. This project will apply deep learning in the research domains of epidemiology, architecture, and remote sensing on multi-scale data, spanning from the level of the individual household to the metropolitan level to identify risk areas of mosquito-borne diseases in Dar es Salaam cities. This project will address the aforementioned knowledge gap by investigating the relationship between mosquito densities in households and architectural, ecological, and urban form variables in Dar es Salaam, Tanzania. The study includes household surveys of mosquito densities and housing conditions as well as high-resolution geospatial surveys of urban areas and conducting statistical data analyses of the links between mosquito densities in households and indicators derived from the household and neighborhood surveys. The findings will be utilized in the automated analysis of multispectral satellite remote sensing imagery based on deep learning models trained with manually delineated attributes of the urban environments to identify risk areas of mosquito-borne diseases in unprecedented detail. The predictive performance of the risk assessment model will be evaluated and the results will be used to guide policy priorities and interventions in addressing mosquito-borne diseases.

Assessing the risk of mosquito-borne diseases in Scotland and their response to environmental change

Heather M. Ferguson 1, *Emilie Pondeville 1, Georgia Kirby 1, Rebecca E. Brown 1, Meshach Lee 1, Jean-Philippe Parvy 1, Davide Dominoni, Francesco Baldini 1, Juan Morales 1, Luca Nelli 1, Jolyon Medlock 2, Alexander Vaux 2, Steven White 3, Dominic Brass 3*

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Abstract

Climate and other environmental changes are driving the expansion of mosquito vector borne diseases (VBDs) into areas of Europe previously unsuitable for transmission; with many being derived from avian populations. This presents a growing risk of VBD establishment in the United Kingdom due to presence of competent vectors and zoonotic pathogens in resident and migratory birds. Ability to detect and respond to emergence is however constrained by major gaps in national surveillance; with current activities restricted almost entirely to England and Wales. In contrast, almost no data on mosquito and avian reservoirs are available for Scotland. Here we will give an overview of the "Mosquito Scotland" project; a new multidisciplinary research programme designed to address this gap through comprehensive investigation of mosquito vectors and avian reservoir populations in Scotland. Our goal is to assess potential for VBD transmission under current and future environmental conditions through integration of entomological, pathogen and wildlife surveillance and modelling. The presentation will focus on key findings from entomological combining active and passive surveillance during the last 2 years. This will include results from a nationwide surveillance of mosquitoes at Scottish wetlands, which revealed several potential zoonotic vectors., and preliminary findings from a citizen science platform. The latter has highlighted previously undocumented hotspots of Aedes mosquito biting nuisance across the country. We will discuss how these data can be combined to increase preparedness for the emergence of zoonotic VBDs.

Assessing the Risk of Mosquito-Borne Diseases along the Tanzania-Zambia Railway Network (TAZARA)

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Abstract

Mosquito-borne diseases pose significant health risks, particularly in regions with high mosquito density and diversity. The Tanzania-Zambia Railway crosses several ecological zones, which may serve as conduits for various mosquito species. This study aims to assess the risk of mosquito-borne diseases along the TAZARA railway network, focusing on *Aedes* mosquito density and their breeding ecology, as well as surveying the perceptions of mosquito-biting risks and infections while traveling. The study was conducted at key stations along the TAZARA line, including Mlimba, Ifakara, Kisaki, and Dar es Salaam. Mosquitoes were collected using CDC light traps targeting indoors, BG sentinel traps targeting outdoors, and Prokopack aspirators targeting resting mosquitoes. Additionally, habitats were surveyed, and a questionnaire was administered to passengers and train users to gauge perceptions and awareness of mosquito-biting risks. The data revealed significant variations in mosquito density and diversity across different stations. *Anopheles gambiae* s.l. constituted 21% of the total catches at Mlimba station, while Ifakara had no catches. *Aedes aegypti* was primarily found in Dar es Salaam, 75.7% during the day and 60.1% during the night. *Culex pipiens* exhibited the highest densities with notable catches in Dar es Salaam (87.7%), Ifakara, and lowest in Kisaki (61.4%). Habitat characterization indicated that 71.2% of breeding sites were stagnant water bodies. The survey highlighted a high level of awareness only for malaria diseases, with the majority acknowledging they are at risk while travelling (94.5%). The findings underscore the need for targeted vector control interventions along the TAZARA railway network. The high mosquito density and diversity, coupled with passenger awareness, provide a strong basis for implementing comprehensive mosquito management strategies. Continued monitoring and public education campaigns are essential to mitigate the risk of mosquito-borne diseases in this region.

Keywords: Mosquito density, Breeding ecology, TAZARA railway, Vector control, Passenger Awareness.

Distribution and Abundance of Aedes aegypti and Aedes albopictus (Diptera: Culicidae) in Benin, West Africa

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Abstract

Updated information on the distribution and abundance of *Aedes aegypti* and *Aedes albopictus* is crucial to prepare African countries, such as Benin, for possible arboviral disease outbreaks. This study aims to evaluate the geographical distribution, abundance, and biting behaviour of these two vectors in Benin. Three sampling techniques were used in this study. The collection of Aedes spp. adults were made through human landing catch (HLC), immatures were captured using ovitraps, and a dipping technique was employed for the collection of Aedes spp. in 23 communes located along the North-South and East-West transects of Benin. Adult Aedes mosquitoes were collected indoors and outdoors using HLC. Mosquito eggs, larvae, and pupae were collected from containers and ovitraps. The adult mosquitoes were morphologically identified and then confirmed using polymerase chain reaction (PCR). Overall, 12,424 adult specimens of Aedes spp. were collected, out of which 76.53% (n = 9,508) were morphologically identified as *Ae. aegypti* and 19.32% (n = 2,400) as *Ae. albopictus*. Geographically, *Ae. aegypti* was

found across the North-South transect, unlike *Ae. albopictus,* which was only encountered in the southern part of the country, with a significant preponderance in Avrankou. Furthermore, exophagic behavior was observed in both vectors. This updated distribution of *Aedes* mosquito species in Benin will help accurately identify areas at risk of arboviral diseases and better plan for future vector control interventions.

Keywords: Aedes aegypti, Aedes albopictus, distribution, abundance, biting behaviour.

Response Patterns of Male Mosquitoes to Olfactory Cues of Plant and Vertebrate Origin

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Abstract

There is renewed interest in developing and implementing the sterile insect technique (SIT) for area-wide control of mosquito disease vectors. The ability to sample males involved in various life activities is particularly important to gather critical information for subsequent SIT applications. The exclusive plant-feeding behavior of male mosquitoes is well known for its essential role as a vital source of energy and has been linked to mating competitiveness. Mosquitoes commonly exploit plant semiochemicals to locate plant-based food sources. Their response to plant odors provides a strong foundation for the development of olfactory-based solutions to monitor male populations. In addition, males of some mosquito species (e.g., *Aedes aegypt*i) seek females for mating near a host, raising the possibility that males can respond strongly to vertebrate host kairomones. However, the relative importance of plant versus vertebrate-derived odors in male attraction has not been elucidated. Here, we employed a comparative approach to quantify the behavioral responses of the dengue vector *(Ae. aegypti*) and the malaria vector (*Anopheles gambiae*) to select odorants of plant and vertebrate origin, comparing their sensitivities in both male and female mosquitoes. We found sex-specific differences in responses to specific odorants, with some exhibiting high sensitivities in both sexes based on broad attractive ranges. This approach holds potential for devising improved odor-baited trapping technology for the surveillance of males in SIT and other genetic approaches.

Keywords: vector surveillance, male mosquitoes, ecology, insect behavior, host kairomones, sterile insect technique.

Interspecific Competition between Larvae of Aedes aegypti and Major African Malaria Vectors in a Semi-Field System in Tanzania.

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Abstract

Interspecific competition between mosquito larvae may influence adult life history traits such as vector competence, body size, fecundity, longevity, and flight capability, potentially reducing disease transmission risks. Despite its importance in altering key biological traits that influence vectorial capacity, knowledge of interspecific competition between *Ae. aegypti* and major malaria vectors are limited. This study examined the effects of interspecific competition on individual fitness between *Ae. aegypti* with *An. arabiensis, Ae. aegypti* with *An. gambiae s.s., and Ae. aegypti with An. funestus* at the larval stage in semi-field settings. The experiments were set up with interspecific and intraspecific (as a control) competition under three species density combinations, with and without food: 100:100, 200:0, 0:200 (*Ae. aegypti: Anopheles*). Two habitat sizes (basins) were used: small (8.5 cm height × 15 cm diameter) with 0.5 liters of water and medium (15 cm height × 35 cm diameter) with 1 liter of water. The first group was treated with Tetramin fish food (0.02 g) twice per day, whereas the second group was not given food. Each of the 12 treatments was replicated six times, making a total of 72 larval habitats for one experiment and 216 larval habitats for three experiments. Interspecific competition had significant effects on both genera, but these effects were more pronounced in Anopheles species than *Ae. aegypti.* Survival rates decreased, and developmental time was delayed when Anopheles larvae were mixed with *Ae. aegypti*. Additionally, larger adults developed from single populations compared to mixed populations for both genera. Cannibalism and predation were observed in both experimental groups. *Ae. aegypti* showed prolonged survival in the absence of food compared to Anopheles species, although none survived to adulthood. Overall, the study highlights the importance of understanding interspecific competition for effective vector control, especially considering the potential risks associated with increased exposure to *Aedes*-transmitted diseases.

Keywords: interspecific competition, Aedes aegypti, major African malaria vectors, predation, cannibalism.

Characterization of Total and Cultivable Aedes aegypti Mycobiome and the Antiviral Effect of the Fungus Candida guilliermondii

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Abstract

Arboviruses that cause human diseases such as dengue, chikungunya, and Zika represent a significant challenge to global public health. These viruses are transmitted by the *Aedes aegypti* mosquito, and their transmission is influenced by interactions with the vector and its microbiota. While the role played by bacteria in insect arbovirus transmission is well established, knowledge regarding the influence of fungal microbiota remains scarce. Nonetheless, certain fungal species are known to significantly impact insect vector competence. Our research group aimed to study the *Aedes aegypti* mycobiota (both cultivable and total). Forty cultivable fungal isolates were identified as belonging to the species *Candida guilliermondii*, *C. intermedia*, *C. metapsilosis*, *Rhodotorula mucilaginosa*, and *Penicillium citrinum*. Sequencing of the fungal ITS gene from insects subjected to three different sugar sources revealed a complex community dependent upon ingested carbohydrates, with C. guilliermondii and *R. mucilaginosa* being the most prevalent. In vitro experiments (Aag2 cell infection) revealed a particular *C. guilliermondii* isolate with significant activity against the Zika virus. Metabolite analyses were conducted to identify secreted fungal molecules responsible for the observed antiviral effect. The *C. guilliermondii* secretome revealed the following molecules: fucose, cadaverine, putrescine, xylitol, uracil, palmitic acid, arginine, fumaric acid, maleic acid, acetoacetic acid, and glutaric acid. Given fucose's established antiviral activity against dengue virus, experiments were specifically conducted with this compound. Regrettably, purified fucose did not exhibit inhibitory effects on Zika virus infection in Aag2 mosquito cells. Other compounds are currently being tested in the lab. Identifying the fungal mycobiome of *Aedes aegypti* and the tripartite interactions among mosquito, fungus, and arbovirus may lead to the development of new technologies for interrupting arbovirus transmission.

Keywords: Aedes aegypti, mycobiota, dengue virus.

Dynamics of Aedes aegypti Populations in Bobo-Dioulasso City from 2021-2022: Perspectives for Sterile Insect Technique Implementation in Burkina Faso.

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Abstract

In the last decade, Burkina Faso has experienced a series of dengue outbreaks involving the circulation of four serotypes of the dengue virus (DENV1, DENV2, DENV3, DENV4). Vector control remains the primary action for response strategies and is mainly based on the use of insecticides for indoor and space spraying interventions. Similar to malaria vectors, *Aedes aegypti*, the major vector transmitting dengue in Burkina Faso, has developed resistance to the main insecticides used, which limits the effectiveness of control efforts. This raises the crucial need to investigate alternative and/or complementary strategies, among which the Sterile Insect Technique (SIT) is a promising integrated vector control tool. In the perspective of SIT, longitudinal entomological surveys were conducted to follow the population dynamics of *Aedes aegypti* in Bobo-Dioulasso for pilot interventions. Entomological surveys were carried out in three sites—Secteur 5, Pétit-Paris, and Dogona—selected as pilot sites for SIT purposes in Bobo-Dioulasso. From September 2021 to September 2022, adult mosquitoes were collected monthly over four consecutive days using BG traps and Prokopack aspirators. Larvae of *Aedes aegypti* were collected from containers holding water and reared to adulthood in the IRSS insectary. Mosquitoes were morphologically identified, and the main entomological indices were estimated according to World Health Organization criteria for arbovirus risk. A total of 39,652 adult mosquitoes, including six different species, were collected, with *Culex quinquefasciatus* and *Aedes aegypti* being the most abundant at 82.73% and 15.58%, respectively. The *Aedes aegypti* population was most abundant during the rainy season, with abundance increasing alongside rainfall intensity. A total of 5,955 larvae of *Aedes aegypti* were collected from 775 containers. The House Index and Container Index were higher, reaching up to 20 and 40, respectively, during the rainy season, with similar indices observed across survey sites. This study demonstrated that larval indices exceeded the risk level for arbovirus outbreaks in all surveyed sites and highlighted the need for an active entomological surveillance system. It also provided baseline data for future SIT interventions.

Keywords: Aedes aegypti, surveys, larval indices, Bobo-Dioulasso, SIT.

Genomic Surveillance and Data Science: Advancing Control of Vector-Borne Infections.

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Abstract

Vector-borne diseases like malaria, chikungunya, dengue, yellow fever, Zika, and West Nile virus transmitted by mosquitoes remain a significant global health challenge. Most of the epidemiologically significant mosquito-borne viruses pose a major threat to approximately 3.9 billion individuals across more than 120 countries worldwide (Shragai et al., 2017). While some mosquitoes transmit well-known pathogens posing constant threats, others are emerging and present a significant risk of precipitating unprecedented epidemics. These are of considerable public health concern due to disease outbreaks, overwhelmed health systems during epidemics, and high morbidity and mortality rates in endemic regions (Freitas et al., 2012). The threat posed by mosquito-borne diseases continues to escalate, and current countermeasures are inadequate, necessitating urgent implementation of novel and efficient measures against these diseases. This paper explores the transformative potential of genomic science and machine learning in enhancing surveillance and control strategies for vector-borne infections. Genomic surveillance and

machine learning play crucial roles in the control of vector-borne diseases (VBDs) (Javaid et al., 2023). Genomic surveillance and data science provide rich insights into vector biology, pathogen diversity, and transmission dynamics. Whole genome sequencing (WGS) data and machine learning models like convolutional neural networks can predict the geographic origin of infections, aiding in disease control, predicting disease outbreaks, modeling vector population dynamics, and identifying genetic markers associated with drug resistance. Such predictive analytics enable early intervention strategies, optimize resource allocation, and guide targeted public health interventions. Furthermore, establishing cutting-edge molecular surveillance systems for proactive detection of new virus diseases is vital for tropical countries like Africa, where VBDs pose a significant public health threat. Integrating genomic surveillance with machine learning techniques not only enhances disease prediction accuracy but also enables timely interventions and targeted control strategies (Deelder et al., 2023).

Keywords: vector biology, genomics, machine learning, vector control, technology.

A Survey of Aedes Mosquito Bionomics, Insecticide Susceptibility, and Sero-Epidemiology of Dengue in the Lake Zone, Tanzania.

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Abstract

The emergence of arboviruses such as dengue, chikungunya, yellow fever, and Zika, spread by *Aedes* mosquitoes, poses a significant global challenge. These mosquitoes thrive in human-made breeding sites, which have increased due to rapid urbanization, particularly in developing economies. By 2025, over half of Africa's population is projected to live in cities, exacerbating the transmission risk of these diseases. *Aedes aegypti* and *Anopheles stephensi* are prominent disease vectors in urban environments, spreading arboviral diseases and malaria, respectively. In Tanzania, Dar es Salaam has experienced recurrent dengue outbreaks, but arbovirus assessments in regions like the Lake Zone are limited. This study aimed to investigate *Aedes* mosquito bionomics, insecticide susceptibility, and the sero-epidemiology of dengue in urban, semi-urban, and rural areas of Tanzania's Lake Zone. The presence of dengue and other arboviruses in mosquitoes was also examined. A four-month cross-sectional survey (October-January 2023) was conducted across six sites representing different settings. The study involved collecting entomological data, characterizing breeding sites, assessing insecticide resistance, and detecting arboviruses in mosquitoes. Additionally, human exposure to the dengue virus was gauged using serology surveys with rapid diagnostic tests (RDTs) and ELISA. A total of 180 houses and 503 containers were inspected, revealing 973 immature *Aedes aegypti* mosquitoes, primarily breeding in discarded containers and used tires filled with turbid water and plant debris. The container index was highest in urban areas (57.4%), followed by semi-urban (33.5%) and lowest in rural areas (23.7%). Of 800 individuals tested, 24 were positive for dengue, and 16 showed past exposure (7 with DENV IgM antibodies and 9 with DENV IgG antibodies). Approximately 75% of dengue exposures were in urban settings.

Keywords: Aedes mosquito, bionomics, insecticide susceptibility, sero-epidemiology, dengue, Lake Zone, Tanzania.

Insecticide Resistance Monitoring in Aedes aegypti from Brazil

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Abstract

Insecticide Resistance Monitoring (IRM) has been a routine practice for chemical control surveillance against the *Aedes aegypti* vector in Brazil since the late 1990s. Between 1990 and 2013, the network known as Morenaa biannually analyzed between 70 and 120 populations of *Ae. aegypti* distributed throughout the country. Standardized WHO bioassays were employed for larvicides and adulticides, utilizing bottle or impregnated paper assays. In many cases, dose-response assays were conducted to calculate resistance ratios. Simulated field and field assays were also performed for resistant populations. During this period, widespread resistance was identified, particularly to the larvicide temephos and pyrethroid-class adulticides. Resistance mechanisms were detected through enzymatic assays and genotyping of kdr mutations. Following the dissolution of the network, the LBCVIV laboratory (IOC/FIOCRUZ) conducted bioassays (2017/2018 and 2022/2023) upon request from the Ministry of Health (MoH). These studies identified resistance to the larvicide pyriproxyfen in a few populations, complete susceptibility to spinosad, but widespread resistance to the adulticide malathion. We have exercised caution in interpreting results for new combined neonicotinoid + pyrethroid adulticides, which we anticipate discussing at this event. The kdr mutations continue to expand and increase in frequency, despite the MoH campaigns no longer using them, reinforcing evidence of selective pressure from domestic insecticide use. Currently, we are in discussions with the MoH regarding the implementation of IRM for *Ae. albopictus* and advancements in IRM for *Anopheles darlingi*, the primary malaria vector in the Brazilian Amazon.

Keywords: insecticide resistance monitoring, bioassays, kdr genotyping, surveillance

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Insecticide Resistance in Aedes aegypti Mosquitoes: Possible Detection of kdr F1534C, S989P, and V1016G Triple Mutation in Benin, West Africa

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Abstract

Epidemics of arboviruses in general, and dengue fever in particular, are an increasing threat in areas where *Aedes* (Ae.) *aegypti* is present. The effectiveness of chemical control of *Ae. aegypti* is jeopardized by the increasing frequency of insecticide resistance. The aim of this study was to determine the susceptibility status of *Ae. aegypti* to public health insecticides and assess the underlying mechanisms driving insecticide resistance. *Ae. aegypti* eggs were collected in two study sites in the vicinity of houses for two weeks using gravid *Aedes* traps (GATs). After rearing the mosquitoes to adulthood, female *Ae. aegypti* were exposed to diagnostic doses of permethrin, deltamethrin and bendiocarb, using Centers for Disease Control and Prevention (CDC) bottle bioassays. Unexposed, un-engorged female *Ae. aegypti* were tested individually for mixed-function oxidase (MFO), glutathione-S-transferase (GST) and esterase activities. Finally, allele-specific PCR (AS-PCR) was used to detect possible kdr mutations (F1534C, S989P, and V1016G) in the voltage-gated sodium channel gene in insecticide-exposed *Ae. aegypti*. Most traps were oviposition positive; 93.2% and 97% of traps contained *Ae. aegypti* eggs in the 10th arrondissement of Cotonou and in Godomey-Togoudo, respectively. Insecticide bioassays detected resistance to permethrin and deltamethrin in both study sites and complete susceptibility to bendiocarb. By comparison to the insecticide-susceptible Rockefeller strain, field *Ae. aegypti* populations had significantly higher levels of GSTs and significantly lower levels of α and β esterases; there was no significant difference between levels of MFOs. AS-PCR genotyping re-vealed the possible presence of 3 kdr mutations (F1534C, S989P, and V1016G) at high frequencies; 80.9% (228/282) of the *Ae. aegypti* tested had at least 1 mutation, while the simultaneous presence of all 3 kdr mutations was identified in 13 resistant individuals. Study findings demonstrated phenotypic pyrethroid resistance, the over-expression of key detoxification enzymes, and the possible presence of several kdr mutations in *Ae. aegypti* populations, emphasizing the urgent need to implement vector control strategies targeting arbovirus vector species in Benin.

Keywords: Aedes aegypti; pyrethroid resistance; kdr mutations; detoxification enzymes, Benin

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48-Hour Surveillance of Aedes aegypti Activity along an Urbanization Gradient Reveals Substantial Nocturnal and Outdoor Biting in Burkina Faso

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Abstract

Aedes aegypti plays a role in the transmission of several arboviruses, including dengue, whose prevalence is on the rise. The bionomics of *Ae. aegypti* are understudied in sub-Saharan Africa, gaining interest over the past decades in response to increased dengue cases in the region. As evidence on *Ae. aegypti* behavior is required to guide disease control, we investigated its biting patterns along an urbanization gradient in Burkina Faso to assess daily variation in

blood-feeding and the locations where biting activity of this species occurs. In 2023, we evaluated biting rates using Human Landing Catches. The study was conducted for three months during the rainy season in three localities representing urban, peri-urban, and rural areas. We collected data weekly around the clock for 48 hours, both indoors and outdoors, in each locality. A total of 4,684 *Ae. aegypti* were caught over 144 days across sites and localities. Their distribution varied between indoor and outdoor sites, as well as day and night periods, depending on the location. The number of bites per person peaked at approximately 1,000 every 48 hours in the urban locality outdoors and decreased to a minimum of approximately 100 bites indoors. Contrary to the paradigm that *Ae. aegypti* activity is only diurnal, we found biting occurred continuously throughout the 24-hour period with two peaks: one between 5 AM and 9 AM in the morning and another between 4 PM and 7 PM in the evening. Moving from urban to rural localities, we observed a progressive decrease in biting rates and a change in daily biting patterns. The evening biting peak remained consistent across localities, but the morning peak vanished in the rural locality. To understand the reasons behind these unusual and varying behaviors, further investigations are needed. We are currently exploring whether there is a connection between genomic variants and behavioral differences.

Keywords: Aedes aegypti, dengue, nighttime, outdoor biting.

>> Turbo Talk Poster Session

Chairs: *Zawadi M Mboma (IHI) & Paulo Ribolla (Unesp)*

House Modifications Using Insecticide-Treated Screening of Eaves and Windows as Vector Control Tools: Evidence from a Semi-Field System in Tanzania and Simulated Epidemiological Impact.

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Abstract

Despite the extensive use of available vector control tools, the burden of malaria and dengue continues to increase throughout sub-Saharan Africa. Gaps in house structures, particularly in eaves and windows, allow vector entry and facilitate indoor vector biting, contributing to disease burden. Simple house screening tools that target these structures have the potential to reduce human exposure to bites in the home. This study assessed the performance of insecticide-treated screening (ITS) comprising eave nets and window screens, incorporated with deltamethrin and piperonyl butoxide (PBO), in Tanzania. A randomized Latin square (4 x 4) design study was conducted in four experimental huts built in a semi-field system (SFS). Four treatment arms were evaluated: 1) new ITS; 2) 12-month naturally aged ITS; 3) estimated 12 months field-used Olyset® Plus ITNs (those used as standard-of-care in Tanzania); and 4) no treatment. The study was performed over 32 nights using a minimum of 30 mosquitoes per strain per night. Four laboratory-reared strains were used: vectors of malaria (*Anopheles arabiensis* and *An. funestus*) and dengue infection (*Aedes aegypti*) as well as nuisance biting (*Culex quinquefasciatus*). Recaptured mosquitoes were assessed for mortality at 72 hours (M72), blood feeding, and hut entry. New ITS induced higher M72 than field-used ITNs against all mosquito species tested [OR: 2.25 (95% CI: 1.65-3.06), $p < 0.0001$], while M72 was similar between aged ITS and field-used ITNs [OR: 0.80 (95% CI: 0.59-1.08), $p = 0.141$]. ITS reduced mosquito blood feeding and hut entry more effectively than field-used ITNs for all mosquito species tested ($p < 0.0001$). ITS is an efficacious tool for controlling vectors transmitting malaria and dengue, as well as those mosquitoes known for nuisance biting, as assessed in a semi-field setting. Given the intervention's simplicity, it should be considered as an additional (or stand-alone) tool alongside behavioral change educational efforts to encourage the repurposing of old ITNs for house screening.

Keywords: insecticide-treated screening (ITS), insecticide-treated nets (ITNs), malaria, dengue, semi-field system.

Entomological parameters of vector species Aedes albopictus and Aedes aegypti and risk of Arbovirus transmission in the city-province of Kinshasa, DR. Congo

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Abstract

Households located in rural areas that have been declared epicenters of arbovirus epidemics in the past, and households located in areas where the level of urbanization presents a high risk of arbovirus transmission, were subjected to an entomological evaluation regarding the risk of arbovirus transmission by *Aedes* mosquitoes for the purpose of developing effective vector control strategies in the city-province of Kinshasa (DR. Congo). Repeated cross-sectional household surveys were carried out over 12 months of 2023, including the dry and rainy seasons. Mosquitoes were collected using four sampling techniques including the Human landing catches, Prokopack, BG-Sentinel 2 trap and larva collection. Biological tests were carried out with adult *Aedes* mosquitoes from

field-collected larvae. The *Aedes tested*, especially *Aedes aegypti* and *Ae. albopictus* were found to be susceptible to insecticides 24 hours after exposure. Both Aedes vectors were found in urban and rural areas, *Ae. aegypti* was dominant in urban areas, while *Ae. albopictus* was dominant in rural areas throughout the study period. On the basis of Entomological index, the results obtained indicate a high epidemic risk in rural areas

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Geographic Expansion of the Introduced Aedes albopictus and Other Native Aedes Species in the Democratic Republic of the Congo.

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Abstract

Aedes albopictus has been reported in several Central African countries, including the Democratic Republic of the Congo (DRC). The establishment of this mosquito species poses a serious threat as a vector of various infectious diseases. Although *Ae. albopictus* has been reported in the western region of the DRC, information about its distribution is still scarce in the country. The aim of this study was to investigate the current nationwide distribution of the invasive *Ae. albopictus*, as well as other native *Aedes* mosquitoes, in the DRC and to identify suitable areas for its future expansion. Two entomological surveys were conducted in 2017-2019 and 2022. Based on the occurrence sites of *Ae. albopictus*, important environmental variables were identified. Geographical areas suitable for *Ae. albopictus* establishment was determined using the maximum entropy model. The distribution and abundance of *Ae. albopictus* were also compared with those of the major native *Aedes* species. *Aedes albopictus* was found in the western, northern, central, and eastern regions of the DRC, but it was not found in the southeastern region. The maximum entropy model predicted that most parts of the DRC are suitable for the establishment of this mosquito. The unsuitable areas encompassed the eastern highlands, known for their low temperatures, and the southeastern highlands, which experience both low temperatures and a long dry season. The native Aedes species found were *Aedes aegypti, Aedes simpsoni, Aedes africanus*, and *Aedes vittatus. Aedes albopictus* dominated in the western and northern regions, while *Ae. aegypti* was more prevalent in other regions. *Aedes albopictus* has been well established in the western and northern regions of the DRC. This mosquito is expanding its distribution while replacing the native *Aedes* species. Most of the country is suitable for the establishment of this mosquito species, except for the highlands of the eastern and southeastern regions.

Keywords: Aedes mosquitoes, arbovirus vectors, invasion, distribution, MaxEnt.

Aedes Mosquito Distribution along a Transect from Rural to Urban Settings in Yaoundé, Cameroon.

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Abstract

The surveillance of mosquito vectors is crucial for the control of arboviral diseases worldwide. Detailed information on the bionomics and distribution of their main vectors, *Aedes aegypti* and *Aedes albopictus*, is essential for assessing disease transmission risk and for better planning of control interventions. Entomological surveys were conducted from November 2019 to November 2020 in six localities of Yaoundé city, following a transect from urban to rural settings: two urban (Obili, Mvan), two peri-urban (Simbock, Ahala), and two rural areas (Lendom, Elig-essomballa) during the rainy and dry seasons. All water containers were inspected. The abundance of *Aedes* mosquitoes, species distribution, and seasonal distribution patterns were compared using generalized linear models. Stegomyia indices were estimated to determine the risk of arbovirus transmission. A total of 6,332 mosquito larvae were collected (2,342 in urban areas, 1,694 in peri-urban areas, and 2,296 in rural sites). The *Aedes* species recorded included *Ae. albopictus, Ae. aegypti, Ae. simpsoni*, and Aedes spp. High mosquito abundance was registered in the rainy season (4,706) compared to the dry season (1,626) ($p < 0.0001$). *Ae. albopictus* was the most abundant *Aedes* species in urban (96.89%) and peri-urban (95.09%) sites, whereas *Ae. aegypti* was more prevalent in rural sites (68.56%) ($p < 0.0001$). Both species were found together in 71 larval habitats. *Ae. albopictus* was primarily found in discarded tires (42.51%), whereas *Ae. aegypti* was more prevalent in plastic containers used for storing water (65.87%). The majority of *Aedes* mosquitoes' breeding sites were located close to human dwellings (0-10 m). Uncontrolled urbanization appears to greatly favor the presence of *Aedes* mosquito species around human dwellings in Yaoundé. Controlling *Aedes* mosquito distribution is becoming urgent to reduce the risk of arbovirus outbreaks in the city.

Keywords: Aedes species, ecology, transect, Yaoundé, Cameroon.

Insecticide resistance of Aedes aegypti mosquitoes: Co-occurrence of multiple kdr mutations in the Abomey-Calavi district.

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Abstract

Aedes aegypti is the main epidemic vector of arboviruses in Africa. A better understanding of the current *Ae. aegypti* susceptibility status to insecticide and relevant resistance mechanisms involved are needed for the implementation of effective vector control strategies. This study aimed to evaluate the susceptibility of *Aedes aegypti* to deltamethrin, as well as the frequency of kdr mutations and the expression of detoxification enzymes in the Abomey- Calavi arrondissement. *Aedes aegypti* is the main epidemic vector of arboviruses in Africa. A better understanding of the current *Ae. aegypti* susceptibility status to insecticide and relevant resistance mechanisms involved are needed for the implementation of effective vector control strategies. This study aimed to evaluate the susceptibility of *Aedes aegypti* to deltamethrin, as well as the frequency of kdr mutations and the expression of detoxification enzymes in the Abomey- Calavi arrondissement. *Aedes* eggs were collected using gravid *Aedes* traps in two districts of the Abomey-Calavi arrondissement for which no data are available, close to houses. After rearing the mosquitoes to adulthood, *Ae. aegypti* females were exposed to diagnostic doses of Deltamethrin (0.05%) using the OMS tube test procedure. Unexposed, non-engorged *Aedes aegypti* females were analyzed individually to assess the expression of detoxification enzyme AS-PCR was used to detect kdr mutations on the voltage-gated sodium channel gene in exposed *Aedes aegypti* females. The traps were highly positive. Deltamethrin resistance of 86.53% in Zoundja and 88.95% in Zoca was observed. PCR genotyping of female *Aedes* DNA revealed the presence of kdr mutation. A frequency of 64.28% for the S989P mutation was observed in Zoundja and 61.11% in Zoca. The frequency of F1534C mutations was 56.25% in Zoundja and 59.72% in Zoca. For the V1016G mutation, the frequency was 37.50% in Zoundja and 45.16% in Zoca. We detected the co-occurrence of two or three mutations in 23 resistant *Aedes aegypti*.Compared with the insecticide-sensitive Rockefeller strain, *Ae. aegypti* populations in the field had significantly higher levels of glutathione s-transferases (GSTs) and oxidase. The detection of deltamethrin resistance, several kdr mutations and overexpression of glutathione s-transferases and oxidases underscores the urgency of implementing alternative control strategies against *Aedes* mosquitoes. For successful vector control campaigns, it is essential to detect kdr mutations and characterize their frequency and distribution.

Keyword: Aedes aegypti; deltamethrin resistance; kdr co-occurrence; detoxification enzymes,Abomey-Calavi.

Evaluation of Aedes aegypti Larval Indices and Eco-Bio-Social Determinants and Fludora Co-Max Efficacy Against Insecticide-Resistant Adult Populations in Côte d'Ivoire.

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5. *Environmental Science, Bayer AG Crop Science Division, Bayer, Nairobi, Kenya*
6. *Environmental Science, Bayer AG Crop Science Division, Bayer, Monheim, Germany*

Abstract

Most cities in sub-Saharan Africa are increasingly facing multiple outbreaks of *Aedes* mosquito-borne arboviral diseases (e.g., dengue, yellow fever, chikungunya, Zika). However, our ability to manage these outbreaks is still limited due to the ecological plasticity of *Aedes* mosquitoes and their resistance to insecticides. Thus, we evaluated *Aedes aegypti* larval indices, breeding eco-bio-social determinants, and the space spray efficacy of Fludora Co-Max EW (a combination of flupyradifurone and transfluthrin) against wild insecticide-resistant adult populations in Côte d'Ivoire. We sampled *Ae. aegypti* larvae and breeding sites, as well as household socio-ecological data in arboviral foci in southern Côte d'Ivoire from June to December 2020. We collected *Aedes* mosquito samples in two rubber tree areas (Koffikro and Samo), two oil palm areas (Ehania and Agbaou), and two urban neighborhoods in the city of Abidjan (Bingerville and Cocody). *Aedes* larval indices (container index: CI, household index: HI, and Breteau index: BI) were determined. Additionally, we tested Fludora Co-Max and K-Othrine against encaged adult females derived from larvae collected in the field in Abidjan. Space spraying tests were conducted outdoors (10, 25, 50, 75, and 100 m) and indoors (ceiling, mid-height, and floor) using ultra-low volume fogging (ULV) and thermal fogging (TF). Mortality was recorded and compared by treatment. The most productive breeding sites for *Ae. aegypt*i were tires, discarded cans, water storage containers, and rubber latex collection cups in both private and public spaces. Larval indices were highest in urban areas, followed by rubber areas and oil palm areas, with HI values of 98.3, 81.2, and 67.8; CI values of 69.7, 57.3, and 29.5; and BI values of 99.7, 65.9, and 13.8, respectively. Larval infestation was correlated with local community behaviors, including poor water storage and solid waste management practices. Breeding site positivity was associated with unmanaged solid waste, water supply interruptions, and water storage duration. Overall, *Ae. aegypti* mortality with Fludora Co-Max (90-100% mortality) was higher compared to K-Othrine (40-100% mortality). Fludora Co-Max mortality exceeded 90% with ULV outdoors up to 100 m. Indoors, Fludora Co-Max EW achieved 100% mortality at ceiling, mid-height, and floor levels with both ULV and TF. In Côte d'Ivoire, *Ae. aegypti* larval indices and arbovirus transmission risk were high and correlated with socio-ecological factors associated with poor management of solid waste and water in urban areas. However, local *Ae. aegypti* adults in urban areas exhibited high mortality against the new space spray Fludora Co-Max insecticide, which performed better than K-Othrine. The presence of flupyradifurone and transfluthrin may have broadened its killing capacity. Fludora Co-Max is thus an effective adulticide and a promising tool for controlling arboviral outbreaks.

Keywords: Aedes aegypti, insecticide resistance, Fludora Co-Max, larval indices, Côte d'Ivoire.

>> Doctoral Students Session

Chairs: *Anne Poinsignon (IRD) & Halfan Ngowo (IHI)*

Detection of F1534C, V410 and V1016I kdr Mutations and Association with Pyrethroid Resistance in Aedes aegypti from Cameroon.

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Abstract

Many studies in Cameroon have reported the development of insecticide resistance in *Aedes*. However, little is known about the mechanisms involved in this resistance. This study aims to update the resistance profile of *Ae. aegypti* and *Ae. albopictus* and assess the implication of known kdr mutations in the phenotypic resistance observed in *Aedes* mosquitoes in Cameroon. Immature stages of *Aedes* were collected in 2022 in five localities in Cameroon and reared to adult stages. Adult bioassays and piperonyl butoxide (PBO) synergist assays were conducted following World Health Organization recommendations. Dead and alive mosquitoes resulting from susceptibility tests to deltamethrin and permethrin were used for genotyping F1534C, V1016I, and V410L mutations and assessing their association with the observed resistance using real-time melting curve qPCR analyses. Fisher's exact test was used to compare allele frequencies. Overall, high resistance was observed in *Ae. aegypti* to all the insecticides tested. Mortality rates ranged from 0% to alphacypermethrin 0.05% in Douala to 68.31% to bendiocarb 0.1% in Garoua. The level of resistance in *Ae. albopictus* was moderate, with mortality rates ranging from 63.97% to alphacypermethrin 0.05% in Douala to 96.82% to bendiocarb 0.1% in Meiganga. Both species were fully susceptible to fenitrothion 1% and pirimiphos-methyl 0.25%. The partial or full recovery of mortality with PBO preexposure suggests the implication of cytochrome P450 genes in the resistance observed, but other mechanisms may be involved. The F1534C, V1016I, and V410L mutations were detected in alive and dead mosquitoes in Douala, Yaoundé, and Bertoua. F1534C tends to be fixed (> 96%), while V1016I and V410L mutations have a high frequency in the alive compared to dead mosquitoes, suggesting an association between pyrethroid resistance and these mutations. These findings provide relevant information that should be capitalized on in implementing arbovirus vector control strategies and insecticide resistance management in Cameroon.

Keywords: Aedes aegypti, insecticide resistance, kdr mutation, arbovirus, Cameroon.

Understanding Aedes aegypti Mosquito Ecology to Reduce Dengue Transmission in Tanzania.

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Abstract

In the past half-century, dengue has increased by 30-fold. Climate change and inter-continental trade are driving the spread of the disease. The financial capital of Tanzania, Dar es Salaam, is now experiencing dengue outbreaks nearly every year. Therefore, this study intended to determine the primary characteristics and dengue transmission risk of *Aedes aegypti* mosquitoes in the Ilala, Kinondoni, and Temeke districts of Dar es Salaam city. A two-year longitudinal survey was conducted in Ilala, Kinondoni, and Temeke districts to sample *Aedes aegypti* mosquitoes using four mosquito sampling methods: i) mosquito dipper, ii) Prokopack aspiration, iii) Ovitraps, and iv) Biogent Sentinel trap. The collected *Aedes aegypti* mosquitoes were pooled into 10 individuals and tested for DENV1-4 serotypes using qPCR. Field larvae were reared to F1 and tested for phenotypic resistance to public health-used insecticides using the WHO tube tests and genotypic resistance profile using qPCR. In total, 83,530 mosquitoes were collected, and 7.3% (n=6,070) were *Aedes aegypti*. Temeke district accounted for 51.5% (n=3,129) of all collected *Ae. aegypti* mosquitoes, followed by Ilala 25.9% (n=1,573) and Kinondoni 22.5% (n=1,368). There was no variation in captured mosquitoes by month or season. 4,030 mosquito pools of 10 individuals per pool were obtained, 168, 103, and 132 pools from Temeke, Ilala, and Kinondoni districts, respectively. Temeke and Kinondoni districts were positive for DENV-2 serotype, 2/168 and 1/132 respectively, with Temeke district demonstrating a higher infection rate (11.9). *Aedes aegypti* from all three districts showed resistance to pyrethroids and organochlorines (<20% mortality) and were susceptible to carbamates. Also, mosquitoes from all districts showed the F1534C mutation. In Dar es Salaam City, Temeke district is at high risk of dengue outbreaks due to high *Aedes aegypti* mosquito density and dengue infection rate. Carbamates are a suitable insecticide class for *Aedes aegypti* control that we recommend using in fumigation and space sprays in the city.

Keywords: dengue, Aedes aegypti, traps, longitudinal survey, serotypes, Dar es Salaam.

Bionomics of Aedes Mosquito Species in Three Eco-epidemiological Settings of Cameroon and Their Susceptibility Profiles to Insecticides

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Abstract

Arboviruses represent a serious concern in tropical/subtropical countries. In Cameroon, port cities and cities surrounded by forests constitute the main hotspots of dengue and yellow fever. To date, little is known about the bionomics of their main vectors, *Aedes aegypti* and *Aedes albopictus*, in such environments. This study aims to assess the bioecology, distribution, and susceptibility profiles to insecticides of these vectors in three cities of Cameroon. Entomological surveys were undertaken from September 2021 to October 2022 in Bertoua (savanna area), Kribi (port city), and Sangmelima (forested area). Immature stages of Aedes spp. were collected by dipping, and Stegomyia indices were estimated. After emergence and morphological identification, F0 and F1 progeny of *Aedes aegypti* and *Aedes albopictus* will be used to assess the current phenotypic resistance status to commonly used insecticides using WHO bioassays. A total of 475 breeding sites were identified in Sangmelima (41.47%), Kribi (33.47%), and Bertoua (25.05%). Tires and plastic containers were most abundant. A total of 2,364 mosquitoes belonging to 4 genera and 9 species were collected. *Aedes* species recorded (1,864) included *Ae. albopictus* (72%), *Ae. aegypti* (25.91%), and *Aedes* spp. (2.09%). *Ae. albopictus* was predominant in Sangmelima and Kribi, while *Ae. aegypti* was mostly found in Bertoua. According to house indices, the transmission of dengue and yellow fever was high in Kribi and Bertoua. *Ae. aegypti* across study sites were found to be resistant to permethrin, deltamethrin, and DDT, while *Ae. albopictus* was resistant to bendiocarb in Kribi and Bertoua. However, all these species were susceptible to malathion. To effectively control arboviruses, a targeted approach is needed to limit the spread of these vectors in our environment. This work contributes to vector control using ecological and susceptibility parameters, aiming to prevent a possible arbovirus epidemic in Cameroon.

Keywords: bionomics, arboviruses, Aedes, resistance, Cameroon.

Surveillance of dengue and other arboviruses in mosquitoes from Dar es Salaam, Tanzania.

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Abstract

In 2023, over 5 million cases and over 5,000 dengue-related deaths have been reported worldwide while the actual numbers of dengue cases are largely under reported. In Tanzania, too, dengue (DENV) caused several epidemics over the past years with the most recent epidemic in 2019 that affected several thousand people alone in Dar es Salaam, the largest city in Tanzania. Despite the impact of dengue in Tanzania, there is a lack of knowledge about its epidemiology. Our aim is to identify the different sero- and genotypes of DENV and other flavi- and alphaviruses circulating in the mosquito population in Dar es Saalam. In 2022, we carried out a one year longitudinal sampling of wild mosquitoes using Prokopack aspiration, Biogents Gravid *Aedes* Traps and Biogents Sentinel traps. We collected almost 30,000 Culex and *Aedes* specimens and pooled them by 10 individuals of the same species and sampling event. Currently, we are screening the pools for flavi- and alphavirus families using endpoint PCRs while identifying the species in the pools by Sanger sequencing. So far, we have 800 pools processed and identified one DENV serotype 2 and some mosquito-specific flaviviruses. Using a DENV-2 specific amplicon panel, we amplified the whole genome of the present virus and sequenced it on a GridION using a Flongle flowcell. We were able to assemble the complete genome from the reads, and a phylogenetic analysis classified it as a cosmopolitan genotype closely related to the DENV 2 viruses found in Kenya and India.

Keywords: Genotypes, whole genome sequencing, phylogenetic analysis

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Monitoring Aedes Populations for Arboviruses, Wolbachia, Insecticide Resistance and Its Mechanisms in Various Agroecosystems in Benin.

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Abstract

Aedes-borne arboviral diseases like dengue, yellow fever, and chikungunya are significant public health issues in Benin and other African countries. Recent outbreaks of dengue and chikungunya have increased the public health burden, impeding poverty reduction and sustainable development. Strengthening *Aedes* surveillance in Benin is essential to formulate effective vector control strategies and predict arboviral disease outbreaks. The present study monitored the species composition, arboviruses, Wolbachia symbiont status, and *Aedes* populations' phenotypic and molecular insecticide resistance profile from three agroecosystems. The immature stages of *Aedes* mosquitoes were collected using oviposition traps, and adults were collected directly from the field using a Human Decoy Trap from April to October 2021 in three agroecosystems across Benin: palm, banana, and in-house garden sites. Phenotypical assessment of insecticide resistance was conducted by exposing adults (F0) to permethrin (0.75%) using WHO bioassay protocols. TaqMan (RT)-qPCR assays were employed to assess major kdr mutations and the expression levels of eight detoxification genes. Additionally, molecular identification of *Aedes* species, as well as *Wolbachia spp.* screening was carried out using qPCR. The study found that *Ae. aegypti* mosquitoes were the most common (93.9%) in the three agroecosystems studied, followed by *Ae. albopictus* mosquitoes (6.1%). Although no arboviruses were detected in these mosquitoes, the study found that naturally occurring Wolbachia symbionts (20%) were present in all three agroecosystems. Further analysis revealed that individual kdr mutations F1534C and V1016G/I were detected in most populations of *Ae. aegypti.* Additionally, double mutant (F1534C + V1016G/I) mosquitoes were found in some populations, and in one case, triple mutant (F1534C + V1016G/I + S989P) mosquitoes were detected. Finally, the study found that three P450 genes were overexpressed in the mosquitoes studied. Our study provides information that could be used to strategize future vector control strategies and highlights the importance of continuing vector surveillance in Benin.

Keywords: Aedes species, insecticide resistance, vector control, knock-down resistance, Wolbachia.

Spatiotemporal distribution and bionomics of Anopheles stephensi in different eco-epidemiological settings in Ethiopia

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Abstract

The incidence of malaria could worsen with the spread of the invasive vector *Anopheles stephensi* in Ethiopia. This study aimed to provide updates on the distribution of *An. stephensi* and the likely household exposure in Ethiopia. Entomological surveillance was performed in 26 urban settings in Ethiopia from 2021 to 2023. A kilometer-by-kilometer quadrant was established per town, and approximately 20 structures per quadrant were surveyed every three months. Additional extensive sampling was conducted in 50 randomly selected structures in four urban centers to assess household exposure to *An. stephensi*. Prokopack aspirators and CDC light traps were used to collect adult mosquitoes, while standard dippers were employed to collect immature stages. The collected mosquitoes were identified to species level using morphological keys and molecular methods. PCR assays were utilized to assess Plasmodium infection and mosquito blood meal sources. Catches of adult *An. stephensi* were generally low (mean: 0.15 per trap), with eight positive sites among the 26 surveyed. This mosquito species was reported for the first time in Assosa, western Ethiopia. *Anopheles stephensi* was the predominant species in four of the eight positive sites, accounting for 75–100% of the adult Anopheles catches. Household-level exposure, defined as the percentage of households with a peridomestic presence of *An. stephensi*, ranged from 18% in Metehara to 30% in Danan. *Anopheles arabiensis* was the predominant species in 20 of the 26 sites, accounting for 42.9–100% of the Anopheles catches. The bovine blood index, ovine blood index, and human blood index values were 69.2%, 32.3%, and 24.6%, respectively, for *An. stephensi,* and 65.4%, 46.7%, and 35.8%, respectively, for *An. arabiensis.* None of the 197 *An. stephensi* mosquitoes were tested positive for *Plasmodium* sporozoites, while of the 1,434 *An. arabiensis* mosquitoes tested, 62 were positive for *Plasmodium* (10 for *P. falciparum* and 52 for *P. vivax*). This study indicates that the geographical range of *An. stephensi* has expanded to western Ethiopia. Its strongly zoophagic behavior, coupled with low adult catches, may explain the absence of Plasmodium infection. The level of household exposure to *An. stephensi* varied across positive sites, highlighting the need for further research to better understand the bionomics and contribution of *An. stephensi* to malaria transmission.

Keywords: Anopheles stephensi, mosquito ecology, malaria transmission, household exposure, Ethiopia.

High efficacy of VectoMax-G® larvicide against Aedes aegypti and Aedes albopictus species under semi-natural conditions in Yaoundé, Cameroon.

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Abstract
Background: Arboviruses represent a major public health problem in Cameroon, where the number of cases is increasing throughout the country. Indeed, vector control remains the main strategy to protect human populations and prevent epidemics. With this in mind, we evaluated the efficacy of larval control using a bacterial larvicide (VectoMax®G) in the control of two major arbovirosis vectors: *Aedes aegypti* and *Aedes albopictus*. Methodology: This study was conducted from May 2019 to August 2021 under semi-natural conditions in the Biyem-Assi Lycée district of Yaoundé. The efficacy and persistence of different doses of larvicides were evaluated in three types of containers containing Aedes mosquitoes for their larval development (tyres, plastic and metal containers) following the standard WHO protocol (2005). The results of these tests were compared by container type and by species. Results: The results showed that regardless of the dose of VectoMax®G applied in the containers, maximum mortality (100%) was obtained 24 hours after the first treatments against *Ae. aegypti* and *Ae. albopictus* larvae. In addition, the time of efficacy of the larvicide was longer in the tyres than in the plastic and metal containers. This time could go beyond 28 days in the tyres for supranormal doses. Furthermore, a high efficacy of VectoMax®G and a long residual effect on *Aedes aegypti* larvae were noted. Conclusion: The study showed good efficacy of VectoMax®G larvicide against *Aedes aegypti* and *Aedes albopictus* larvae. However, the residual effect varied significantly depending on the concentration of the larvicide in the species and abiotic factors. This effectiveness varies more under the influence of certain abiotic factors such as the temperature and pH of the water in the container.
Keywords: Arboviroses, Aedes aegypti, Aedes albopictus, larvicide, VectoMax®G

DAY 2

>> **Session:** Integrated Approaches to Vector Control

***Chairs**: Marcia de Freitas (Fiocruz) & Roch Dabiré (IRSS)*

Communities and publics in the control of invasive vector species

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Abstract
Most of our knowledge of community participation in vector control efforts stems from contexts where vector-borne diseases are endemic. How much of that experience can be applied to invasive species and/or emerging risks is an open question. This presentation will review some of the basic principles of community action against endemic vectors, and review their applicability to invasive threats. Secondly, it will discuss how forms of community action that are arising in contexts where vector threats are relatively novel could renew our approach to public health interventions against endemic problems.

Vector Cloud: A web-based application for improving malaria vector surveillance using MALDI TOF MS

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Abstract

MALDI-TOF MS (matrix-assisted laser desorption/ionization time-of-flight) has revolutionised clinical microbiology with accurate, rapid, and inexpensive identification of microorganisms. Several machines are readily available in multiple sub-Saharan African centres for microbiology. Recently, MALDI-TOF MS has emerged as a valuable tool in entomology and is part of the European Centre for Disease Control guidelines (ECDC) for entomological surveillance of invasive mosquito species. MALDI-TOF Biotyper (MBT) users usually rely on libraries of spectra made available by the machine manufacturer. Online databases are available such as MicrobeNet hosted by CDC however these are not yet available for mosquitoes. KEMRI Wellcome Trust in collaboration with Bruker Daltonics have developed an online platform called MBT Vector Cloud with purpose of sharing MALDI TOF MS libraries for species identification of the main Anopheles complex including *Anopheles stephensi*. The libraries provide accurate identification (>95% accuracy) of both adult and larval stages and will be made available at no cost to users. The MBT Vector Cloud will offer the possibility to connect multiple users and improve accuracy and species representation with quality assurance provided by the industry partner Bruker Daltonics. The platform is currently at beta version stage but will be made available in the near future to external pilot labs. MALDI-TOF MS offers a cost-effective and high throughput platform. The ease of execution, rapid results turnaround, and modest cost per-sample (0.2 USD) render this methodology highly advantageous for mosquito surveillance whereby costs and time often limit data collection possibilities. MALDI-TOF MS has the potential to revolutionise routine entomological surveillance, akin to the paradigm shift witnessed in the field of microbiology. A cloud-based library will greatly facilitate the dissemination of the technology.

Surveillance and control of Arboviruses in Burkina Faso using a global approach (ArboFaso)

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Abstract

Context and rationale: Arbovirus surveillance in Burkina Faso faces several challenges. The number of arboviruses under surveillance is very limited. In addition to yellow fever and dengue, only two other arboviruses are tested in

samples of suspected cases of arbovirus infection at the National Reference Laboratory for Viral Haemorrhagic Fevers (NRL-VHF): Chikungunya and Zika. There is also a limited number of laboratories equipped for the biological diagnosis of arboviruses. In fact, there is only one laboratory (NRL-VHF) which carries out arbovirus surveillance for the whole country. An integrated surveillance of arboviruses that takes into account climatic data, information on vectors, potential animal reservoirs and humans would make it possible to identify the risk at an early stage and anticipate epidemics. Objective: The overall objective of this project is to assess and monitor arboviral risk in Burkina Faso using a global health approach by integrating studies in humans, domestic (horses and poultry) and wild animals (birds and bats) as well as vectors (mosquitoes). Methods: This will be a descriptive cross-sectional study with prospective collection which will take place over 3 years, from December 2023 to November 2026. The study will be carried out in urban areas: Ouagadougou and Bobo-Dioulasso and semi-urban: Banfora, Houndé, Ziniaré and Koudougou. Our study population will consist of patients who consult health centers for fever, as well as sheep, horses, domestic birds, wild birds, mosquitoes, and people living near animal sample collection sites. Patient samples will be collected in health centers, while samples from healthy individuals will be collected in homes in the vicinity of pet sample collection sites. As Burkina Faso has 2 seasons: a rainy season (June to October) and a dry season (November to May), samples will be collected during each season to see the dynamics of arbovirus circulation as a function of the seasons. Patient, animal and mosquito samples will be analyzed by RT-PCR for arboviruses (pan-flavivirus, pan-alphavirus and pathogen-specific PCR). For RT-PCR-positive samples, sequencing analyses will be carried out to identify the virus strain. Samples from healthy individuals and animals will be serologically tested using enzyme-linked immunosorbent assays to detect antibodies against the same viruses, using pan-flavivirus Elisa kits and tests specific to the virus in question. Serum neutralization tests will be carried out to confirm the specificity of antibodies identified in Elisa-positive samples. Expected results: The results of our work will undoubtedly have an impact on the surveillance of arboviruses in Burkina Faso and will thus make it possible to anticipate the occurrence of potential epidemics due to arboviruses. At the end of our study, we will have more detailed information on the arboviruses circulating in Burkina Faso and their impact on the health of the population. We will also have an overview of the level of immunization of the population in relation to the arboviruses studied. At the end of this study, we will be able to identify the animals involved as reservoirs in the circulation of arboviruses and thus propose the use of these animals as sentinels in the surveillance of arboviruses in Burkina Faso. The results obtained on mosquitoes will enable us to identify the vectors involved in the transmission of arboviruses in Burkina Faso and to propose guidelines for vector control. An arboviral risk map will be drawn up and could serve as a reference for the authorities in the fight against arboviruses. Finally, a technical note will be sent to the Burkina Faso Ministry of Health with proposals for improving the surveillance and control of arboviruses in Burkina Faso.

Keywords: Surveillance, Control, Arbovirus, Burkina Faso, Global Approach

Risk of Aedes-Borne Diseases in and Around the Tanzanian Seaport of Tanga Despite Community Members Being More Concerned with Malaria.

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Abstract

Increased global trade exacerbates *Aedes* mosquito-borne diseases despite the significant economic benefits of facilitating their movement. Yet, in sub-Saharan Africa, key *Aedes*-transmitted diseases remain under study, as the majority of research and implementation activities focus on malaria. Assessing disease risk at seaports is crucial due to heightened international activity. This study aimed to compare the risks of disease-transmitting mosquitoes within and around the Tanga port along the Indian Ocean. Between June and December 2023, a grid-based system with 200 m x 200 m grids was established to survey mosquitoes in the port and surrounding areas. Breeding habitats were characterized, and insecticide susceptibility tests were conducted on *Aedes aegypti*. Adult mosquitoes were collected using CDC light traps and BG sentinel traps, while larval collections were done using dippers. Port users and residents were surveyed to assess perceptions of mosquito biting and disease risks. Aquatic habitat surveys in the study area identified 2,931 breeding sites, with 60.8% positive for *Aedes* larvae. The Container Index peaked at 66.2% within the port, dropping to 44.6% at a distance of 5 km, while the Breteaux Index was higher in surrounding areas (30.3-45.7%). *Ae. aegypti* predominantly breeds in artificial containers and tyres. Adult surveys yielded 20,449 mosquitoes, with *Ae. aegypti* is significantly more abundant in the port area. Insecticide susceptibility tests indicated susceptibility to bendiocarb and DDT but resistance to permethrin. High malaria awareness contrasted with limited knowledge of other diseases and inadequate personal protection measures, despite acknowledged mosquito bite risks. This study highlights the elevated risk of *Ae. aegypti* and associated diseases in the Tanga port area, where effective control was confirmed with bendiocarb and DDT. Targeted interventions and public health campaigns are essential to address these risks in port areas.

Keywords: Aedes aegypti, habitat characterization, insecticide susceptibility, Tanga port, Tanzania.

Antibodies to Aedes Salivary Proteins: A Suitable Tool to Measure Exposure to Mosquito Bites in Northern Tanzania

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Abstract

The continued expansion of arboviral diseases, such as dengue, Zika, and chikungunya, poses a serious threat to public health globally. With the use of biomarkers for exposure to mosquito bites, such as antibodies against the *Aedes* Nterm-34 kDa protein, as a proxy for the risk of *Aedes*-borne diseases, determining the risk of exposure to arboviral infections has lately attracted attention. The objective of this study was to assess whether IgG antibodies against the Nterm-34 kDa peptide were associated with the level of human exposure to *Aedes* mosquito bites and the risk of arboviral infection. Three longitudinal surveys were conducted during the rainy season (June 2021), dry season (September 2021), and short rainy season (January 2022) in three villages in Bondo, Tanga. The study included children aged between 2-10 years and adolescents/adults aged 11-70 years. Face-to-face interviews were conducted using a pre-tested questionnaire to collect information regarding demographic characteristics and mosquito bite prevention measures. The questionnaire was uploaded into the system, and data was collected electronically using the Open Data Kit (ODK) application. Collected blood samples were tested for the presence of IgG antibodies against the *Aedes* Nterm-34 kDa protein using an ELISA test. Results showed that the medians of specific IgG antibody levels were significantly different in the three seasons ($p = 0.009$; Kruskal-Wallis test). Dengue-positive participants presented a higher level of anti-salivary IgG compared to dengue-negatives ($p = 0.02$; non-parametric Mann–Whitney test). Anti-Nterm-34 kDa IgG antibodies are an important correlate of human exposure to *Aedes* mosquito bites, and thus the antibodies are an important indicator for measuring the risk of arboviral infections. As arboviral diseases continue to expand, the application of these biomarkers can contribute to more targeted and effective interventions to protect public health.

Keywords: arboviral diseases, mosquito bites, Aedes Nterm-34 kDa, dengue infection.

Leveraging Technology to Enhance Vector-Borne Disease Surveillance in Uganda

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Abstract

Uganda utilizes the WHO-developed Integrated Disease Surveillance and Response (IDSR) strategy for disease outbreak detection and control. The electronic version, eIDSR, facilitates real-time data collection, analysis, and reporting. However, limitations exist, including reliance on manual microscopy for diagnosis. This presentation explores how advancements in vector surveillance technologies can strengthen Uganda's disease control efforts. Mobile point-of-care devices with automated blood smear analysis for diseases like malaria hold promise for faster

and more accurate diagnoses, particularly in remote areas with limited access to technicians. Furthermore, integrating Artificial Intelligence (AI) into existing platforms like eIDSR offers exciting possibilities. AI-powered disease surveillance systems can analyze vast amounts of data, including environmental factors, to predict and track outbreaks in real-time. This would enable more targeted interventions and resource allocation, ultimately leading to improved public health outcomes.

Keywords: vector-borne disease, disease surveillance, Uganda, eIDSR, mobile diagnostics, AI, real-time data analysis.

Stakeholder Mapping to Support Pilot Trials of Digital Tools for Citizen Engagement in Mosquito Surveillance

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Abstract

The recent (re)emergence of arboviral infections transmitted by *Aedes* vectors, including Zika, chikungunya, and dengue, is a significant international concern. There is no vaccine for Zika and chikungunya, and no specific treatment is available for any of these three arboviruses. Although vector control is the most comprehensive solution available, it is not always effective. The success of vector control programs is greatly enhanced through community engagement, which is essential for both the implementation of these programs and community empowerment. Mosquito Alert is a mobile application that enables citizens to report on mosquitoes, bites, and breeding sites. It is an efficient tool for surveying invasive *Aedes* species in Europe. In INOVEC, we aim to test the efficacy and acceptability of Mosquito Alert in regions with endemic arbovirus transmission, such as Tanzania and Burkina Faso. To support the local implementation of Mosquito Alert, we have identified and mapped the different stakeholders that need to be engaged in this process in Tanzania and Burkina Faso. Here, we present the analysis that evaluated the potential contributions of these stakeholders to Mosquito Alert's implementation and the benefits they could derive from the project. Additionally, we pinpointed the optimal timing for their involvement and assessed the advantages and risks associated with their participation. The level of involvement, impact, and influence of each stakeholder is expected to vary; some will be crucial for obtaining approval for Mosquito Alert's local use, others will play important roles in supporting and enhancing trials in the field, and some may utilize the information acquired. This analysis will support pilot trials for the implementation of this tool in Tanzania, aiming to

improve the control of arboviral diseases and monitor mosquito dynamics and the arrival of exotic species of concern, such as *Anopheles stephensi*.

Keywords: citizen science, community engagement, stakeholders, vector monitoring, Mosquito Alert.

The potential use of detection dogs for the surveillance of the Asian tiger mosquito

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Abstract

The Asian tiger mosquito, *Aedes albopictus*, is one of the most invasive species worldwide and is spreading across Switzerland. It is an aggressive biter and poses a public health threat due to its vector competence for viruses such as dengue, chikungunya or Zika. A key challenge is early detection of infested areas in order to implement targeted vector control measures promptly. Known for their ability to locate mammals and plants, detection dogs have had promising use in insect location. In the present study we assessed whether detection dogs could potentially be deployed to identify *Ae. albopictus* breeding sites. We trained 6 detection dogs in differentiating odours from *Ae. albopictus*-contaminated water from other scents using an automated training system. The automated training system had 7 holes through which the dogs could sample an odour. In a round, one hole presented the odour of water containing *Ae. albopictus* larvae, while the other 6 holes presented odours from water containing either no larvae or larvae of other mosquito species. The experiment was fully automated and double-blinded; neither the dog guide nor the experimenter knew in which hole the odour from the *Ae. albopictus* larvae was. The training consisted of three blocks of increasing difficulty. Block three comprised an in-lab field simulation using watering cans. Across the 6 dogs, the final success rates were 84.7%, 82.7% and 55.6% for blocks 1, 2 and 3, respectively, while the individual success rates varied consistently between the dogs. We conclude that detection dogs can be trained to identify *Ae. albopictus* larvae within the lab environment but further training needs to be conducted to achieve consistent success in identifying *Ae. albopictus* larvae in the field context.

Keywords: Aedes albopictus, detection dogs, vector surveillance, detection dog training system, breeding site identification

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Implementation of traps (ovitraps) for surveillance and guidance of control actions of Aedes in Brazil

José Bento Pereira Lima 1, *Ademir J. Martins 1, Diogo F. Bellinato 1, and Ricardo Passos 2.*

Affiliation

1. *Instituto Oswaldo Cruz, FIOCRUZ, Rio de Janeiro, Brazil*
2. *Ministry of Health, Brazil*

Abstract

The Asian tiger mosquito, *Aedes albopictus*, is one of the most invasive species worldwide and is spreading across Switzerland. It is an aggressive biter and poses a public health threat due to its vector competence for viruses such as dengue, chikungunya or Zika. A key challenge is early detection of infested areas in order to implement targeted vector control measures promptly. Known for their ability to locate mammals and plants, detection dogs have had promising use in insect location. In the present study we assessed whether detection dogs could potentially be deployed to identify *Ae. albopictus* breeding sites. We trained 6 detection dogs in differentiating odours from *Ae. albopictus*-contaminated water from other scents using an automated training system. The automated training system had 7 holes through which the dogs could sample an odour. In a round, one hole presented the odour of water containing *Ae. albopictus* larvae, while the other 6 holes presented odours from water containing either no larvae or larvae of other mosquito species. The experiment was fully automated and double-blinded; neither the dog guide nor the experimenter knew in which hole the odour from the *Ae. albopictus* larvae was. The training consisted of three blocks of increasing difficulty. Block three comprised an in-lab field simulation using watering cans. Across the 6 dogs, the final success rates were 84.7%, 82.7% and 55.6% for blocks 1, 2 and 3, respectively, while the individual success rates varied consistently between the dogs. We conclude that detection dogs can be trained to identify *Ae. albopictus* larvae within the lab environment but further training needs to be conducted to achieve consistent success in identifying *Ae. albopictus* larvae in the field context.

Keywords: Aedes albopictus, detection dogs, vector surveillance, detection dog training system, breeding site identification

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The MTego Trap: A Potential Tool for Monitoring and Control of Malaria and Arbovirus Vectors.

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Abstract

Odour-baited traps are useful for vector surveillance and control. However, most existing traps have shown inconsistent recapture rates across different mosquito species, necessitating the need for more effective and efficient traps. The MTego trap with integrated thermal stimuli has been developed as an alternative. Therefore, this study was undertaken to determine and compare the efficacy of the MTego trap relative to the Modular Biogents Pro (BGP) trap for sampling different mosquito species in a semi-field system. Fully balanced Latin square design experiments (No-choice and dual-choice) were conducted in the semi-field chambers using laboratory-reared species of female *Anopheles gambiae* sensu stricto, *An. funestus*, *An. arabiensis*, *Culex quinquefasciatus* and *Aedes aegypti*. Sixteen replicates and 50 mosquitoes of each species were released in each

chamber per replicate. Traps evaluated were MTego trap baited with PM6 (MT-PM6), MTego baited with BG-lure (MT-BGL) and BGP baited with BG-lure (BGP-BGL). In the no-choice test, the MT-BGL and BGP-BGL traps captured a similar proportion of *An. gambiae* (31% versus 29%, P-value = 0.519) and An. funestus (32% vs 33%, P = 0.520). The MT-PM6 and BGP-BGL traps also showed no significant difference in capturing *Ae. aegypti* (33% vs 31%, P = 0.324). However, the BGP-BGL caught more An. arabiensis and Cx. quinquefasciatus mosquitoes than the other traps (P <0.0001). In the dual-choice test of MT-PM6 vs BGP-BGL, a similar proportion of An. funestus (25% vs 27%, P = 0.473) and *Aedes aegypti* (29% vs 25%, P = 0.264) were captured in either trap, while the BGP-BGL captured more *An. gambiae*, *An. arabiensis* and *Cx. quinquefasciatus* mosquitoes than MT-PM6 (P <0.0001). The study demonstrated that the MTego trap is a potential tool that can be used interchangeably with the BGP trap for sampling anthropophilic mosquitoes including African malaria vectors *An. gambiae* and An. funestus and the principal arbovirus vector *Ae. aegypti*.

Keywords: odour-baited trap, mosquito, Anopheles, Culex, Aedes.

Entomofavela: Popular Vector Surveillance in a Vulnerable Territory.

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Affiliation

1. *Oswaldo Cruz Foundation, Rio de Janeiro, Brazil*
2. *Oswaldo Cruz Institute, Rio de Janeiro, Brazil*

Abstract

In Brazil, the arboviruses transmitted by *Aedes aegypti* include dengue, chikungunya, and Zika. In 2024, the country experienced the worst dengue epidemic in the last 40 years, with approximately 5 million cases and more than 3,000 deaths reported by May (MS, 2024). According to the 2022 demographic census, Brazil has 11,403 favelas, home to approximately 16 million people (IBGE, 2022), who are permanently exposed to *Ae. aegypti*. Vertically planned vector control strategies are often detached from the realities of the favelas, contributing to the endemicity of arboviruses in large cities. In many of these areas, there are considerable obstacles to the implementation of traditional vector control methods (Wermelinger et al., 2023), such as a lack of sanitation, inaccessible properties, and a routine of violence caused by the increasing territorialization of armed criminal groups (Fernandes et al., 2008). Is it possible to evaluate alternative methods of controlling *Aedes aegypti* in favelas, relying on the participation of local agents? Would these agents have better access to the territory? These questions guided the proposal of Entomofavela—a pilot project in Maré, a neighborhood composed of 16 favelas with 150,000 inhabitants in Rio de Janeiro. The three most densely populated favelas were selected for *Aedes* surveillance. Young locals from these areas were trained at the Oswaldo Cruz Institute/Fiocruz to carry out the project, which consists of mapping the areas, defining the samples, distributing ovitraps, identifying *Aedes* species, surveying vector density, and assessing the socio-environmental determinants related to mosquito reproduction. The importance of the role of popular agents for vector control in vulnerable territories will be evaluated. Surveillance data will be discussed with community organizations and partner institutions to drive feasible control and preventive measures in the context of the climatic crisis and its effects on local health.

Keywords: vector surveillance, community participation, Aedes, vulnerable territory, Entomofavela.

Development of a System to Support Community-Based Surveillance of Disease-Transmitting Mosquitoes in Resource-Constrained Settings

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1. *Ifakara Health Institute, Dar es Salaam, United Republic of Tanzania*

Abstract

The identification and tracking of disease-transmitting mosquito populations are crucial for understanding their geographical distribution, behavior, and species composition. Furthermore, understanding the dynamics of these mosquito populations is essential for guiding vector control interventions to improve their effectiveness and identify areas that require attention. Given the high burden of mosquito-borne diseases, particularly in resource-limited settings, and the limitations of traditional surveillance methods, there is a need for an innovative solution. To address this, we have developed a system to facilitate community-based surveillance of disease-transmitting mosquitoes. The system architecture comprises three main components: the user interface layer, the data processing layer, and the feedback and reporting layer. The user interface layer includes a mobile and web application that serves as the primary point of contact for users, allowing community members to submit mosquito data. The data processing layer manages the secure transmission, storage, validation, and trust assessment of the data, ensuring its integrity and reliability. The feedback and reporting layer provides necessary feedback to community members, generates comprehensive reports based on validated data, and manages compensation, thereby fostering wider community engagement. This system allows for the timely and efficient tracking of mosquito populations, significantly improving public health response capabilities across diverse geographic settings. By streamlining data collection and making it accessible to a wider audience, the system enhances the quality of surveillance data and enables targeted public health interventions. This system supports the tracking of disease-transmitting mosquito populations while simultaneously enhancing healthcare quality over the long term by informing public health practices.

Keywords: community-based surveillance, resource-constrained settings, mosquito-borne diseases.

Citizen Action for Sustainable Control of Dengue Vectors in Abidjan, Côte d'Ivoire

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2. *University of Basel, Basel, Switzerland*
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4. *Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire*
5. *Université Alassane Ouattara, Bouaké, Côte d'Ivoire*
6. *The International Society for Urban Health, New York, USA.*

Abstract

Transmitted by day-biting, highly anthropophilic invasive *Aedes* mosquitoes, dengue is a life-threatening disease that has dramatically increased in incidence globally in recent years. While vector control interventions are the mainstay in dengue control programs, such programs in sub-Saharan Africa are largely nonexistent or primarily follow a top-down approach with sporadic insecticide spray campaigns targeting adult mosquitoes. However, these interventions have only a very limited, short-term impact and are environmentally unsustainable since *Aedes* mosquitoes breed in small water containers that are ubiquitous in urban areas. Together with local residents, we designed a community-based intervention to reduce *Aedes* breeding sites in Abidjan, the largest city in Côte d'Ivoire. To measure the intervention's efficacy, we implemented a cluster-randomized controlled trial. In the trial, we are also testing whether mass trapping with simple traps targeting egg-laying females reduces mosquito densities, either alone or in combination with community-based larval source management. At the meeting, we will present the study design and preliminary results from the baseline study.

Keywords: Aedes aegypti, cluster-randomized trial, community-based intervention, mass trapping, larval source management.

>> Round Table: Are we losing the battle against urban mosquito-borne diseases in Africa?

Challenges and opportunities in controlling the spread of Anopheles stephensi and Aedes spp mosquitoes

Chair: *Daniel Msellemu (IHI), Senior research scientist*

Strengthening Aedes-Borne Arbovirus Surveillance in West Africa: The Role of the West African Aedes Surveillance Network (WAASuN)

Samuel K. Dadzie, *WAASuN Members.*

Affiliation

1. *Noguchi Memorial Institute for Medical Research, University of Ghana, Accra, Ghana*

Abstract

Aedes-borne arboviruses are emerging in Africa, with recent outbreaks of dengue, yellow fever, Zika, and chikungunya reported in many West African countries. These viral diseases contribute to an increased public health burden, impeding poverty reduction and sustainable development. However, the capacity for *Aedes* surveillance and control in West Africa, which is key to reducing the prevalence of arboviral infections, needs to be strengthened to provide essential information for formulating effective vector control strategies and predicting arboviral disease outbreaks. In line with this objective, the West African *Aedes* Surveillance Network (WAASuN) was created in 2017 during a meeting held in Sierra Leone, with participants primarily comprising entomologists working on *Aedes* mosquitoes in West Africa. The first meeting of the network was held in July 2019 in Accra, Ghana, and since then, the network has convened three additional meetings in Ghana, Côte d'Ivoire, and recently in Cabo Verde. The purpose of these meetings was to bring together core members of WAASuN to receive updates

from countries on *Aedes* surveillance activities and discuss major topics related to *Aedes* surveillance in West Africa.
This presentation will showcase the activities of WAASuN since its inception and discuss the major bottlenecks to surveillance activities in West Africa.
Keywords: Aedes aegypti, Aedes albopictus, arboviruses, surveillance, West Africa, WAASuN

Threats of Anopheles stephensi in Urban Africa

Nicodemus Govella

Affiliation

1. *Population Services International, Tanzania*

Anopheles stephensi, traditionally known as an urban malaria vector in South Asia and the Middle East, has recently emerged as a significant threat in Africa. Its invasion poses a critical challenge to malaria control efforts on the continent, which has primarily focused on rural vectors like *Anopheles gambiae*. *An. stephensi*'s adaptability to urban environments, coupled with its ability to breed in various water sources, increases the risk of malaria transmission in rapidly growing African cities. Here we review the current distribution of *An. stephensi* in Africa, predicted cities at high risk and behavioral characteristics, and the potential strategies for effective response.

>> Industry Session: Developing public-private partnership for success

***Chairs**: José Bento Lima (Fiocruz) & Jennifer Stevenson (Swiss TPH)*

VCPPP: A professional placement opportunity for African researchers and manufacturers of vector control tools to exchange knowledge and best practices and to contribute to the development of global health interventions

***Arianna Braccioni**, Angus Spiers*

Affiliation

1. *Innovation to Impact (I2I)*

Abstract

Innovation to Impact (I2I), a global partnership aimed at transforming the development and delivery of vector control products, works closely with over 30 stakeholders, to find consensus on shared challenges and to catalyse solutions. The I2I Vector Control Professional Placement Programme, funded by the Gates Foundation, aims to identify and place qualified researchers already working in vector control at African research institutes within established vector control manufacturers to offer hands-on experience in all aspects of product development from design to launch. This experience will confer an understanding of the process and mindset of product interventions, developing cross-sectorial relationships and information sharing. Researchers will be seconded to the industry partner and will complete funded placements of 12 months for the opportunity to develop in-demand skills in vector control product development, business planning, quality assurance, regulatory affairs as well as soft skills,

networking and the two-way sharing of knowledge with local and international researchers. Industry hosts will gain awareness of the regulatory, safety and manufacturing issues that must be considered by product developers. Researchers returning to their home institute will enable knowledge transfer, helping African institutes increase their existing capacity to contribute to malaria and vector control discovery and produce development initiatives. ***Keywords: Product development, Capacity building, Professional placements, Industry engagement, Knowledge exchange.***

The Nexus of Innovative and Integrated Vector Control: Solutions for Effective Dengue and Malaria Management

Laetitia Leroy

Affiliation

1. *Clarke, USA*

Abstract

Integrated vector control is a multifaceted approach that requires a deep understanding of species biology and habitat variability for optimized impact. Larval control is one pillar of an integrated approach, and has long been a core strategy for managing *Aedes* mosquitoes and the related dengue disease burden. In the global pursuit for innovative malaria intervention strategies, and in response to the emergence and spread of *Anopheles stephensi*, a competent malaria vector with biological and habitat patterns more likened to *Aedes* than native African Anopheles vectors, larval control practices bring significant potential to the fight against malaria transmission. The best practices established for dengue control offer a framework for adopting larval source management in malaria programs, particularly when targeting *Anopheles stephensi*. Clarke's innovative Natular portfolio of larvicides, formulated with the active ingredient Qalcova® Spinosad, is widely deployed in global dengue control programs. Derived from the naturally occurring soil bacterium *Saccharopolyspora spinosa, Qalcova Spinosad* provides vector control programs a unique mode of action for insecticide resistance management, a wide range of formulation types for different habitats, a favorable environmental profile, and established stewardship guidelines and technical support. This presentation will focus on the innovative and integrated vector control benefits of larval control, with a spotlight on the Natular G30 and DT formulations and their successful deployment in core dengue markets like Brazil for *Aedes* control, and their emerging use in India for *Anopheles stephensi*, based on recent Phase III trials completed in country.

Interactive Visualization of the Spatial-Temporal Trends of Insecticide Resistance in Aedes aegypti and Aedes albopictus

Duncan K. Athinya 1, *Stephen Okeyo 1, Seline A. Omondi 2, Eric O. Ochomo 2, Rinki Deb 3, Melinda Hadi 3*

Affiliation

1. *Vestergaard Frandsen (EA) Limited, Nairobi, Kenya*
2. *Kenya Medical Research Institute, Kisumu, Kenya*

3. *Vestergaard SA, Lausanne, Switzerland*

Abstract

Aedes aegypti and *Aedes albopictus* are the primary vectors of arboviral infections such as chikungunya, dengue, and Zika. Preventing the spread and controlling these viral diseases relies heavily on effective vector control. Insecticidal vector control plays a major role, particularly during epidemics. However, insecticide resistance poses a significant risk to these control efforts. Understanding the spatial-temporal spread of insecticide resistance in *Aedes aegypti* and *Aedes albopictus* can aid in selecting appropriate insecticidal tools. IR Mapper was launched in 2012 to collate and visualize reports of insecticide resistance in malaria vectors from peer-reviewed articles and reports. In 2016, an *Aedes* map was included to visualize reports of resistance in *Aedes aegypti* and *Aedes albopictus*. Enhancements were made in 2024 to improve data visualization. As of July 16, 2024, the Aedes map contained 10,191 unique fields of insecticide resistance data, with 7,846 (77%) related to *Aedes aegypti* and 2,345 (23%) to *Aedes albopictus*. The Americas accounted for the highest reported data on *Aedes aegypti* (59%), while Asia had the highest reported data on *Aedes albopictus* (83%). Africa accounted for 5% of the data on *Aedes aegypti* and 6% on *Aedes albopictus*, highlighting the need for investigations into insecticide resistance as *Aedes albopictus* expands into the continent.The highest reports of confirmed resistance were to organochlorines for both *Aedes aegypti* (88% of tests) and *Aedes albopictus* (75% of tests). All tests of benzoylureas, juvenile hormone analogs, pyriproxyfen, and spinosyns showed susceptibility. The resistance mechanisms investigated included 20 variants of knockdown resistance mutations, point mutations of the acetylcholinesterase gene, and overexpression of oxidases, esterases, and glutathione S-transferases. IR Mapper serves as a valuable resource for visualizing up-to-date data on insecticide resistance, informing the deployment of insecticidal vector control tools. The recent update ensures a more user-friendly interface.

Keywords: Aedes aegypti, Aedes albopictus, insecticide resistance, vector control, IR Mapper, spatial-temporal trends.

SC Johnson Healthier World Initiative and overview of spatial repellent program

Thomas Mascari

Affiliation

1. *SC Johnson, USA*

Abstract

SC Johnson has committed $80MM+ to prevent insect-borne disease for the world's most vulnerable people, at no cost to the end user and no profit to SC Johnson. The SC Johnson Healthier World Initiative has developed spatial repellents (SC Johnson Guardian™ and SC Johnson Mosquito Shield™) as a new public health intervention to prevent insect-borne diseases including malaria, dengue, and leishmaniasis. The SC Johnson Healthier World Initiative collaborates with a network of global health partners across multiple sectors to achieve impact. Spatial repellent clinical trials have generated evidence demonstrating disease prevention to support potential policy recommendation from WHO GMP and NTD. Spatial repellents have been identified as a complementary intervention for mosquito control by WHO WASH + UNICEF and have received emergency use authorization from

US EPA against dengue in Puerto Rico. Guardian and Mosquito Shield have been implemented in real-world programmatic and humanitarian settings across 17 countries. Guardian and Mosquito Shield are purposefully designed and manufactured to be sustainable throughout the entire product lifecycle, and sustainability areas of focus to date include raw material selection, manufacturing process, product duration, and product collection. SC Johnson currently manufactures Guardian in Nairobi, Kenya, and has commenced efforts to establish manufacturing of Guardian in Pilar, Argentina.

Monitoring of Aedes albopictus with BG-GAT and BG-Pro Traps, and Integrated Control in Fürth, Germany

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Affiliation

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Abstract

With the expansion of mosquito vectors due to global warming and increasing globalization, it is becoming increasingly important to have effective control and monitoring tools. For the monitoring of container-inhabiting *Aedes albopictus*, ovitraps have often been used to detect the presence of adult *Aedes* mosquitoes. In this study, we utilized the passive BG-GAT trap and the suction trap BG-Pro to collect gravid females as well as host-seeking females. Control measures were performed by a pest control company through an integrated approach. The *Aedes albopictus* population is increasing in some parts of Germany, and further expansion is expected. At the end of 2019, several specimens of *Aedes albopictus* from the Franconian city of Fürth were sent to the citizen science project “Mückenatlas.” The municipality hired Biogents to initiate a monitoring program, which began in May 2020 and has been ongoing since. BG-GAT monitoring traps were in use continuously from May to November, with visits every two weeks. BG-Pro traps operated every two weeks for a period of 24 hours, utilizing CO2 and BG-Lure (human skin attractants). In the first year of monitoring, a large and established population of tiger mosquitoes was identified in Fürth. Hotspots were found in allotment gardens and the surrounding residential neighborhoods. Consequently, the municipality hired a pest control company, APC, to initiate control measures. Control efforts included the removal of breeding sites, treatment of rain barrels and sewage systems with Bacillus thuringiensis israelensis (Bti), covering rain barrels with gauze, and mass deployment of BG-GAT traps. Monitoring revealed a reduction in the tiger mosquito population following the application of control measures. This presentation highlights the importance of adult monitoring during intervention measures to control tiger mosquitoes in urban areas. The trap collections provide fast and reliable information about the spatial and temporal dynamics of mosquito populations. Hotspots of mosquito abundance can be detected in time to apply control measures.

Keywords: Aedes albopictus, mosquito monitoring, BG-GAT trap, integrated control, urban vector management.

DAY 3

>> Scientific Session: Innovation in Vector Control

Chairs: *Vincent Corbel (IRD/Fiocruz) & Dr. Mgeni Tambwe (IHI)*

Scaling up the Wolbachia method to prevent dengue outbreaks in endemic areas

Jérémie Gilles

Affiliation

1. *World Mosquito Program, France*

Abstract

As climate change, globalisation, and urbanisation accelerate the speed in which mosquito-borne diseases move across regions, it's more important than ever to act now. Mosquito-borne diseases kill more than one million people and infect up to 700 million each year — almost one in ten people. 2024 is the worst year for dengue on record. There have been more than 11 million cases reported from 80 countries. The fastest spreading mosquito-borne disease in the world shows no sign of relenting. The World Mosquito Program (WMP)'s groundbreaking Wolbachia method is playing a vital role in helping fight mosquito-borne diseases and protect communities across the world. Our evidence-based, safe and one-time (non-GMO) intervention has been rolled out in 14 countries over the past decade, protecting more than 11.4 million people, and its effectiveness for dengue control has been demonstrated in multiple field trials. Wolbachia mosquitoes have a reduced ability to transmit viruses to people, decreasing the risk of dengue, Zika, chikungunya and yellow fever outbreaks. Recent results from the Aburrá Valley in Colombia and from our first fully protected Brazilian city, Niteròi, show the lowest number of dengue cases in more than 20 years. Our vision is to bring an end to the pain and suffering caused by mosquito-borne diseases across the world, and make a difference in the fight against one of the biggest global health threats of the 21st century.

The Vector Control Pipeline for *Aedes:* From Pre-20th Century Practices to Future Innovations

Jennifer C. Stevenson

Affiliation

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2. *Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Allschwil, Switzerland*

Abstract

The control of *Aedes* mosquitoes has advanced from early practices like removing stagnant water and using oils and smoke to modern integrated strategies. With the recognition of *Aedes* as arboviral vectors, the early 20th century

saw significant control efforts, particularly in the Americas. Brazil spearheaded a continent-wide campaigns using inspections, larval oiling, and DDT in 1947. By the 1960s, *Ae. aegypti* was eradicated from 22 South American countries. However, reduced political support and insecticide resistance led to re-invasion. The 1980s' urbanization and globalization worsened outbreaks, rendering DDT inadequate and, combined with environmental concerns, prompted re-evaluation of chemical methods. The late 20th and early 21st centuries introduced new tools for controlling *Aedes* mosquitoes, integrating various methodologies. Source reduction through chemical, biological, and environmental management remains crucial. Depending on the context, methods like insecticidal sprays, treated materials, household screening, and personal protection are valuable in limiting mosquito exposure. Novel trapping methods with attractants and killing agents also help reduce vector populations. However, robust evaluations of many interventions particularly against disease remains insufficient. The establishment of global bodies like WHOPES in the 20tth century and more recently WHO VCAG and the prequalification team now offer systematic efficacy and safety assessments. Recent randomized trials of spatial repellents are under WHO review. Trials have confirmed Wolbachia's effectiveness against dengue, with various strains—including genetically modified ones—reducing transmission through sterilization, shorter mosquito lifespan, altered feeding behaviour, and pathogen interference. Future innovations are focusing on genetic control, particularly modified mosquitoes, to produce population suppression or replacement effects. Pilot studies releasing *Aedes* males carrying self-limiting genes have been conducted in Brazil, Panama, and parts of the USA, with further studies planned in Djibouti and the Republic of the Marshall Islands. Population replacement, introducing genetic constructs in mosquitoes that target pathogens are in early research and developmental stages. These anti-pathogenic mosquitoes show promise for future control strategies. Despite advances, robust evaluations of *Aedes* control measures in Africa remains limited, despite the origin of the vector within the continent and its current significant arboviral burden. Adapting control strategies to local contexts and continued innovation are essential for combating vector-borne diseases and addressing emerging challenges.

Overview of innovative Aedes tools under VCAG review: applicability in Africa and beyond

Audrey Lenhart

Affiliation

1. US Center for Disease Control, Atlanta, USA

Abstract
Missing

Efficacy of a Spatial Repellent for Control of Aedes-Borne Virus Transmission: A Cluster Randomized Trial in Iquitos, Peru

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Abstract

Over half the world's population is at risk for viruses transmitted by *Aedes* mosquitoes,such as dengue and Zika. The primary vector, *Aedes aegypti,* thrives in urban environments. Despite decades of effort, the cases and geographic range of *Aedes*-borne viruses (ABVs) continue to expand. Rigorously proven vector control interventions that measure protective efficacy against ABV diseases are limited to Wolbachia in a single trial in Indonesia and do not include any chemical intervention. Spatial repellents, a new option for efficient deployment, are designed to decrease human exposure to ABVs by releasing active ingredients into the air that disrupt mosquito-human contact. A parallel, cluster-randomized controlled trial was conducted in Iquitos, Peru, to quantify the impact of a transfluthrin-based spatial repellent on human ABV infection. From 2,907 households across 26 clusters (13 per arm), 1,578 participants were assessed for seroconversion (primary endpoint) by survival analysis. The incidence of acute disease was calculated among 16,683 participants (secondary endpoint). Adult mosquito collections were conducted to compare *Ae. aegypti* abundance, blood-fed rate, and parity status through mixed-effect difference-in-difference analyses. The spatial repellent significantly reduced ABV infection by 34.1% (one-sided 95% CI lower limit, 6.9%; one-sided p-value = 0.0236, z = 1.98). *Aedes aegypti* abundance and blood-fed rates were significantly reduced by 28.6% (95% CI 24.1%, ∞; z = -9.11) and 12.4% (95% CI 4.2%, ∞; z = -2.43), respectively.

Our trial provides the first conclusive statistical evidence from a pre-planned cluster-randomized controlled clinical trial with a pre-defined effect size on the primary endpoint that was appropriately powered to prospectively quantify and statistically test for a difference in the impact of a chemical intervention, in this case, a spatial repellent, to reduce the risk of ABV transmission compared to a placebo. A second trial is now underway in Colombo, Sri Lanka.

Keywords: Spatial repellents, Aedes aegypti, vector control, dengue, Zika.

Overview of the progress of the Sterile Insect Technique (SIT) and boosted SIT against Aedes invasive species at the world level

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Abstract

According to the World Health Organization (WHO), alternative methods to insecticides are urgently needed to control mosquitoes, particularly invasive *Aedes* species, vectors of arboviruses. Among these alternative methods, the Sterile Insect Technique (SIT) is under rapid development and numerous pilot trials are ongoing at the world scale. Boosted SIT is a variant of SIT where the sterile males are also used as vectors of biocides to the females and larval sites, in addition to inducing sterility, which may be used at the beginning of a suppression effort and followed by standard SIT. I will present the principles of SIT and boosted SIT as well as the most important scientific breakthroughs that allowed its upscale, particularly automated sex-sorting and drone release. I will then present a phase conditional approach used to classify the stage of progress of each project, and the current status of 36 field projects, as well as their evolution in the last 5 years. I will conclude that many projects demonstrated that SIT and boosted SIT can effectively suppress *Aedes* populations and even reduce dengue incidence and provide some recommendations to avoid failures.

Mass Trapping of Arboviral Vectors: Results from Asia and an Outlook for Africa

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Abstract

The globalization of trade and travel, combined with climate change, has resulted in the geographical expansion of mosquito-borne diseases. Moreover, over-reliance on chemical pesticides to control mosquitoes has led to resistance, threatening the management of disease risk. We demonstrate, with examples from the Maldives and the Philippines, that mosquito traps (BG-Mosquitaire CO2 traps) baited with human odors, in combination with controlling mosquito larvae in breeding sites, resulted in the successful elimination of mosquito populations on some islands and over 90% population reduction in other settings. The levels of control achieved are comparable to current genetic control methods that are far more costly and impractical for implementation on small islands. The approach presented here offers the first alternative in decades to manage mosquito-borne disease risk on small (tropical) islands in an affordable and environmentally friendly manner. Expanding this approach to larger areas poses challenges that require adapted strategies to prevent reinvasion. Additionally, resource-poor settings without electricity to operate traps present further challenges. Options for arboviral vector control, including *Anopheles stephensi*, in Africa will be discussed.

Keywords: Aedes, Anopheles stephensi, mass trapping, elimination.

Comparison of Trapping Efficacy of Locally Modified Gravid Aedes Trap and Autocidal Gravid Ovitrap for the Monitoring and Surveillance of Aedes aegypti Mosquitoes in Tanzania.

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Abstract

Monitoring and surveillance of *Aedes* mosquitoes is an essential requirement of proactive vector control. However, the high cost and low efficiency of traps remain challenging. The study assessed the trapping efficacy of locally-modified 1) Gravid *Aedes* Trap (GAT) lined with insecticide-treated net (ITN) as a killing agent, and 2) Autocidal Gravid Ovitrap (AGO) with sticky board in the semi-field system (SFS) and field setting. Fully-balanced Latin square experiments were conducted to compare GAT lined with ITN vs AGO, both with either yeast or grass infusion. Biogents-Sentinel (BGS) with BG-Lure and no CO2 was used as the standard trap for *Aedes* mosquitoes. In the SFS, GAT outperformed AGO in collecting both nulliparous (65% vs 49%, OR = 2.22, [95% CI: 1.89–2.60], $p < 0.001$) and gravid mosquitoes (73% vs 64%, OR = 1.67, [95% CI: 1.41–1.97], $p < 0.001$). Similar differences were observed in the field. Yeast and grass infusion did not significantly differ in trapping gravid mosquitoes (OR = 0.91, [95% CI: 0.77–1.07], $p = 0.250$). The use of ITN improved mosquito recapture from 11% to 70% in the SFS. The same trend was observed in the field. Yeast was chosen for further evaluation in the optimized GAT due to its convenience, and bifenthrin net for its resistance management properties. Mosquito density collected when using 4× GATs relative to BGS-captured gravid mosquitoes was 64 vs 58 (IRR = 0.82, [95% CI: 0.35–1.95], $p = 0.658$) and showed no density dependence. Deployment of multiple yeast-baited GAT lined with bifenthrin net is cost-effective (single GAT < $8) compared to other traps such as BGS ($160).

Keywords: Aedes aegypti, Bio-Gents Sentinel trap, Gravid Aedes Trap, Autocidal Gravid Ovitrap, Tanzania.

Better Methods, Better Data: Landscaping the Priorities for Enhanced Methodologies in Mosquito Surveillance and Control

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Abstract

Innovation to Impact (I2I) seeks to improve the development landscape for vector control products (VCPs), through enhanced evaluation, sustained quality, and judicious use, with a focus on shortening time to market. The I2I Methods Validation team works to improve evaluation methods, streamlining robust data generation, analysis, and interpretation to accelerate registration and uptake of new tools. The decision to deploy new vector control tools should be supported by robust entomological evidence, comprising data collected using appropriate and validated

methods. To facilitate effective choice, use, and monitoring of new tools, it is crucial that appropriate methods are validated and widely available to measure efficacy with sufficient accuracy, sensitivity, and reproducibility. We have developed a standardized framework for validating methods and a process for establishing consensus standard operating procedures (SOPs) to help empower the vector control community to confidently use methods optimized for specific purposes. Our 'Methods Landscape' for evaluating VCPs and in vector control more generally, is a living online document and a decision-making tool for selecting the best methods to generate the right data to answer a given question. Methods Reports collate evidence from literature, data, and expert interviews, explaining how best to interpret and use the data methods generated. Methods are characterized considering factors including context (test item, chemistry, mode of action, stage of the product's life cycle), endpoints and their significance (speed of action, relevance to personal or community protection), key testing parameters (mosquito population, exposure times, controls), and factors relevant to method choice (accessibility, cost). The Landscape is also a call to arms to invest in priority research questions and method development and validation for new tools. Phase one of the Methods Landscape explores methods for evaluating insecticide-treated nets (ITNs) and indoor residual spraying (IRS) against malaria vectors. We are seeking opportunities to expand to methods relevant to surveillance and control of *Aedes* vectors.

Keywords: methods, standardization, validation, data collection, interpretation of results.

The iDEM Trial (Intervention for Dengue Epidemiology in Malaysia) to Measure the Effectiveness of Integrated Vector Management on the Incidence of Dengue in Urban Malaysia: A Cluster Randomized Controlled Trial

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Abstract

Efficient vector control (VC) is the most effective preventive strategy to reduce the burden of dengue and other *Aedes*-borne diseases. However, current VC efforts primarily rely on reactive approaches such as fogging and mosquito breeding source reduction once a dengue case is identified. We present the outcome of a proactive Integrated Vector Management (IVM) program. This cluster randomized controlled trial was conducted in the Federal Territory of Kuala Lumpur and Putrajaya, Malaysia, to investigate the impact of a proactive IVM strategy on dengue incidence. In total, 280 localities were randomized either to the control group, which received routine VC activities, or to an IVM strategy consisting of targeted outdoor residual spraying with K-Othrine Polyzone (TORS), auto-dissemination devices with active ingredients pyriproxyfen and Beauveria bassiana (ADDs), and active community engagement. The primary outcome was the incidence of dengue reported to the e-Dengue national surveillance system. Entomological outcomes were measured in 12 localities in each arm. The effect of the intervention was estimated by the rate ratio (RR) with its 95% confidence interval. The baseline population of the trial comprised 23% of Kuala Lumpur's population. From June 2020 to September 2022, 834 TORS spray cycles were performed, and 6,942 ADDs were deployed. Overall, 1,921 and 2,145 dengue cases were recorded in the intervention and control arms, respectively. We observed a 14% decrease in the dengue incidence rate in the intervention arm. The intervention's impact reached statistical significance in the last two (post-COVID) periods in 2022. Post-hoc analysis showed a significant decrease in the number of dengue cases by 29% during outbreaks and by 43% in hotspot clusters in the intervention compared to the control arm. Despite the challenges posed by the COVID-19 pandemic, which affected the outcome of the intervention, we provide evidence of the effectiveness of proactive VC on dengue incidence, especially in hotspot areas.

Keywords: Aedes aegypti, dengue, proactive Integrated Vector Management, outdoor residual spray, auto-dissemination device.

Current and Future Opportunities of Autodissemination of Pyriproxyfen for Malaria Vector Control in Rural and Urban Africa

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Abstract

Despite the progress made in reducing the malaria burden, new strategies to address the emerging threats of insecticide resistance and the spread of *Anopheles stephensi* in Africa are urgently needed. While African countries are adopting larviciding as a supplementary intervention, the autodissemination approach has the potential to overcome barriers associated with the identification and treatment of prolific habitats that impede conventional larviciding methods in rural settings. The autodissemination technology, as a “lure and release” strategy, works by exploiting the resting behavior of gravid mosquitoes to transfer lethal concentrations of biological or chemical

insecticides, such as pyriproxyfen (PPF), an insect growth regulator (IGR), to their oviposition sites, resulting in reduced adult emergence. Despite evidence supporting the autodissemination approach for controlling *Aedes*-borne diseases, there is growing and promising evidence for its use in controlling malaria vectors in Africa, highlighting the significant research that needs to be sustained. This article reviews the efficacy of the autodissemination approach using PPF and discusses its potential as an efficient and affordable complementary malaria vector control intervention in Africa. Previous studies conducted in controlled semi-field environments demonstrated that autodissemination with PPF effectively reduced the densities of captive populations of malaria vectors such as *Anopheles gambiae* and *Anopheles arabiensis*. Importantly, empirical evidence and biology-informed mathematical models to demonstrate the utility of the autodissemination approach for controlling wild populations of malaria vectors in field environments, either alone or in combination with other tools, are underway. Key determining factors for the future introduction of this approach at scale include the development of scalable autodissemination devices, optimized PPF formulations, assessment of its integration with existing conventional larviciding methods, and community perception and acceptance of the autodissemination approach.
Keywords: Autodissemination, pyriproxyfen, malaria, larval source management.

Entomological and sociological assessments of hessian fabric transfluthrin vapour emanators for protecting against *Aedes* mosquitoes in urban Tanzania and Haiti

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Abstract

A treated hessian fabric device for emanating the volatile pyrethroid transfluthrin was recently developed in Tanzania that protected against night-biting Anopheles and Culex mosquitoes for several months. Here these same emanator devices were assessed in the coastal tropical cities of Dar es Salaam in Tanzania and Port-au-Prince in Haiti, as a means of protection against day biting *Aedes* vectors of human arboviruses. Under semi-field conditions in large cages in Tanzania, 50 to 60% reductions of landing rates of *Ae. aegypti* were observed, regardless of which transfluthrin dose, capture method, emanator placement position, or source of mosquitoes (mildly pyrethroid resistant wild caught *Ae. aegypti* or pyrethroid-susceptible colonies of *Ae. aegypti* and *An. gambiae*) was used. Gas chromatography-mass spectrometry indicated that air samples collected in Tanzania immediately downwind from an emanator treated with the highest transfluthrin dose (15g) contained 12 to 19 µg/m3 transfluthrin vapour, which might be high enough to be a cause for concern. Also, several different full field experiments across Tanzania and Haiti with a variety of emanator designs, transfluthrin formulations and use practices consistently indicated negligible reduction of human landing rates by wild *Aedes*, largely *Ae. aegypti*. On the other hand, however, many community end users in Haiti, who were provided with these devices for their own use, viewed emanators positively and several outlined various advantages over current alternatives, although some expressed concerns about smell, health hazards, bulkiness, unattractiveness and future cost. Most participants expressed moderate to high satisfaction with protection against mosquitoes, especially indoors. Diverse use practices were reported, some of which probably targeted nocturnal Culex resting indoors, rather than *Aedes* attacking them outdoors during daylight hours. Some participants considered emanators superior to fans, bedsheets, sprays and coils, but it is concerning that several preferred them to bed nets and consequently stopped using the latter. These perspectives shared by Haitian end-users are consistent with those from similar studies in Brazil and recent epidemiological evidence from Peru that other transfluthrin emanator products can protect against arbovirus infection. While these encouraging sociological observations contrast starkly with the entomological evidence of essentially negligible effects upon *Aedes* landing rates from parallel entomological assessments across Haiti, Tanzania, Brazil and Peru, no other reason to doubt the generally encouraging views expressed herein by Haitian end users could be identified.

Microsporidia MB: A Novel Malaria Transmission-Blocking Strategy - Community Acceptance and Potential to Control Malaria Transmitted by Anopheles stephensi

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Abstract

Microsporidia MB is a naturally occurring symbiont in *Anopheles arabiensis*. It inhibits the development of Plasmodium, is transmitted vertically from mother to offspring and horizontally through mating without any fitness consequences. These characteristics form the basis of developing a Microsporidia MB-based transmission-blocking strategy. A rapid assessment of public health concerns, awareness of malaria, malaria control practices, and willingness to accept and participate in this novel control strategy was carried out in local communities of Ahero, Western Kenya. Considering the spread of *An. stephensi* across Africa, larvae and adults were collected in Dire Dawa, Ethiopia to determine the feasibility of Microsporidia MB to control malaria transmitted by *An. stephensi*. The assessment involved administering a questionnaire to household heads. There was an overall high level of willingness to accept (81%) and participate in the implementation of the strategy (96%). Although the willingness to accept was similar in both communities, the Ombeyi community was more willing to participate (OR 22, 95% CI 13-36). Women were less willing to accept (OR 0.8, 95% CI 0.7-0.9) due to fear of increased mosquito bites near homes. Household heads with incomplete primary education were more willing to accept (OR 1.6, 95% CI 01.2-2.2) compared to those educated to primary level or higher. Perceiving malaria as a moderate or low public health issue was also associated with a lower willingness to accept and participate. Experience of > 3 malaria cases in the family over the last six months and knowledge that malaria is transmitted only by mosquito bites increased willingness to accept but reduced the willingness to participate. There is a high level of willingness to accept and participate in a Microsporidia MB-based strategy, which is influenced by community, disease risk perception, gender, education level, knowledge, and experience of malaria. The *An. stephensi* collection is currently being processed.

Keywords: transmission blocking, symbiont, malaria, Anopheles stephensi, community.

Bioinsecticides Based on Interfering RNA to Control Aedes Mosquitoes

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Abstract

Aedes aegypti and *Aedes albopictus* are mosquito species that serve as important vectors of serious diseases such as dengue, Zika, yellow fever, and chikungunya. The control of these mosquitoes presents a significant challenge for public health worldwide, exacerbated by the emergence of resistance to conventional chemical insecticides. Therefore, new approaches to controlling these mosquitoes are necessary. The use of RNA interference technologies, such as short-hairpin RNAs (shRNAs), has the potential to disrupt the expression of essential genes in mosquitoes, leading to their death, and has shown promise for vector control. The present study aims to develop a specific bioinsecticide for *Aedes aegypti* and *Aedes albopictus* using shRNAs. The chosen vector for the production and delivery of shRNA is the yeast Saccharomyces cerevisiae, which has proven to be an efficient and safe system for the production of RNA interference. Two target genes have been selected: 1) Semaphorin (SEMA1A), important for the neural development of mosquitoes, and 2) Serotonin receptor 1 (5-HTR1), which expresses receptors that regulate numerous intracellular signaling cascades essential for mosquitoes. shRNAs were designed to silence these genes. The specific sequences for shRNA expression were inserted into plasmids, which were cloned in E. coli and subsequently transformed into yeast, which transcribes the specific shRNAs before being inactivated. The shRNAs, along with the inactivated yeast, are then tested on live mosquitoes in laboratory assays and subsequently in the

field to evaluate aspects such as mortality, survival, and phenotypic changes. The results of laboratory assays thus far have demonstrated that the consumption of SEMA1A yeast results in highly significant mortality rates in *Aedes* spp. mosquito larvae. Future studies aimed at optimizing the large-scale production of yeast expressing insecticidal shRNA could facilitate field tests to better evaluate this new and promising mosquito control intervention.

Keywords: Aedes mosquitoes, vector control, RNA interference (RNAi), bioinsecticides, Saccharomyces cerevisiae

>> POSTER PRESENTATIONS

INOVEC: A Research and Innovation Partnership for Enhancing the Surveillance and Control of Mosquito Vectors of Emerging Arboviruses

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Abstract

Over the past 10 years, arboviral diseases such as dengue, Zika, chikungunya, and yellow fever have (re)emerged with increasing prevalence and severity. In the absence of effective vaccines and treatments, preventing these diseases on a global scale continues to depend largely on controlling mosquito vector populations, interrupting human–vector contact, or both. Unfortunately, the recent resurgence of *Aedes*-transmitted arboviral diseases worldwide highlights the limitations of current vector control efforts to prevent epidemics and reduce disease incidence. New, affordable, scalable, and community-based vector control measures are urgently needed to prevent the introduction, spread, and establishment of *Aedes*-borne diseases. The INOVEC project aims to improve and promote scientific and technical knowledge for the surveillance and control of invasive *Aedes* mosquitoes by gathering a large international multidisciplinary and cross-sectoral network of partners specializing in vector research, social sciences, and product development. The project will develop, optimize, and promote integrated approaches, innovative tools, and technologies for the surveillance and control of mosquito vectors of emerging arboviruses, facilitating the transfer of knowledge and technologies to countries at increasing risk of arboviral diseases. INOVEC is committed to coordinating and integrating sectors to maximize impact, raise awareness among policymakers and stakeholders, and enhance the potential for innovation at a global level. By contributing to international efforts to improve global health and human well-being, INOVEC aims to reduce the burden of vector-borne diseases.

Keywords: Aedes, arboviruses, vector control, surveillance

Field Evaluation of Breath Biomarkers for Zika Virus Diagnosis in Coastal Kenya.

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Abstract

Zika virus is a mosquito-borne virus that is primarily transmitted to humans through the bite of infected *Aedes* mosquitoes. It can also be transmitted through sexual contact, blood transfusion, and from mother to child during pregnancy. There is currently no ideal diagnostic technique for Zika virus, as all currently available options have limitations and they are all based on blood tests. We used state-of-the-art mass spectrometric techniques to identify volatile organic compounds (VOCs) produced by cultured *Aedes* mosquitoes. Several of these compounds are known mosquito attractants, called terpenes. In a recent pilot study in Lilongwe, Malawi, we found that similar compounds, including terpenes, are present in the exhaled breath of children with Zika virus. Using just six breath biomarkers, we can classify children with or without Zika virus with over 82% accuracy. Based on our key proof-of-concept pilot study, we hypothesize that candidate biomarkers characterize the exhaled breath of Zika virus-infected children. To advance this approach, our immediate objectives are to determine the reproducible changes in breath composition in response to Zika virus infection, viral loads, and virus developmental stages. These compounds can then be explored as novel biomarkers of Zika virus infection and could then form the basis of future non-invasive Zika virus diagnostic devices. Zika virus remains a critical global health concern that affects hundreds of millions of people each year. There is an urgent need for rapid, accurate, field-deployable, and low-cost Zika virus diagnostic methods. Our proposed studies will advance the development of novel Zika virus diagnostics based on detection of Zika virus-specific compounds from exhaled breath. We will also determine whether breath VOCs correlate with virus numbers or life cycle, as this information will have utility in Zika virus elimination efforts, to reduce human reservoirs of Zika virus transmission through "test-and-prevent" public health interventions.

Keywords: breath biomarkers, diagnostic, volatile organic compounds, Zika virus

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Integrated Vector Control Strategies in The Gambia

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Abstract

Due to the complex nature of vectors, there is a need to employ more than one vector control strategy to effectively curb their effects on human populations. Based on this fact, the National Malaria Control Program (NMCP) in The Gambia employs two vector control strategies, especially in high endemic zones where malaria transmission is highest, such as the Upper River Region (URR) and Central River Region (CRR). The two strategies used in these areas are insecticide-treated nets (ITNs) and indoor residual spraying (IRS).

IRS is conducted once every year at the beginning of the rainy season, while ITN distribution occurs in two phases: as part of a campaign and through routine distribution.

Keywords: integrated vector control, NMCP Gambia, insecticide-treated nets, indoor residual spraying, malaria transmission.

Semi-field Evaluation of Aquatic Predators for the Control of Anopheles funestus in Rural South-Eastern Tanzania.

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Abstract

Biological control is a promising alternative or complementary approach for controlling vector populations in response to the spread of insecticide resistance in malaria vectors. This study evaluated the efficacy of three selected potential predators on the density and fitness parameters of *Anopheles funestus* larvae in rural Tanzania. Common predator families *Aeshnidae* (dragonflies), *Coenagrionidae* (damselflies), and *Notonectidae* (backswimmers) and *An. funestus* group larvae were collected from natural aquatic habitats in rural south-eastern Tanzania. Predators were starved for 12 hours while *An. funestus* larvae were given fish food before starting the experiment. *Anopheles funestus* larvae were placed into artificial habitats containing predators, exposing them to potential predation. The number of surviving *An. funestus* larvae was counted every 24 hours. An emergence trap was placed at the top of artificial habitats to capture emerging mosquitoes. Emerged mosquitoes were monitored until they died. Female wings were measured and used as a proxy for body size. Generalized linear mixed models (GLMM) with binomial variates at 95% CI and Cox proportional hazard models were used to assess the proportion of dead mosquitoes and the daily survival determined. There were significant differences in the number of emerged mosquitoes between the treatment and control groups ($p<0.001$). Thus, all predator species played a significant role in reducing the density of *An. funestus* mosquitoes ($p<0.001$). Furthermore, these predators had notable effects on the fitness parameters and survival of emerged mosquitoes ($p<0.001$). Among the three predators studied, *Coenagrionidae* (damselflies) were most efficient, followed by *Notonectidae* (backswimmers), with *Aeshnidae* (dragonflies) being the least efficient. Selected aquatic predators have the potential to reduce the survival and density of *Anopheles funestus* larvae. They might eventually be included within an integrated malaria vector control strategy, ultimately leading to a reduction in malaria transmission.

Keywords: Anopheles funestus, predators, aquatic habitats, efficacy, biological control, malaria transmission.

Effects of Sample Preservation Methods and Duration of Storage on the Performance of Mid-Infrared Spectroscopy for Predicting the Age of Malaria Vectors.

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Abstract

Monitoring the biological attributes of mosquitoes is critical for understanding pathogen transmission and estimating the impacts of vector control interventions. Infrared spectroscopy and machine learning techniques are increasingly being tested for this purpose, as they can accurately predict the age, species, blood-meal sources, and pathogen infections in Anopheles and *Aedes* mosquitoes. Since these techniques are still in early-stage development, there are no standardized procedures for handling mosquito samples. We assessed the effects of different preservation methods and storage duration on the performance of mid-infrared spectroscopy for age-grading malaria-transmitting mosquitoes. Laboratory-reared *Anopheles arabiensis* (N=3,681) were collected as 5- or 17-day-olds, killed with ethanol, and preserved using either silica desiccant at 5°C, freezing at -20°C, or absolute ethanol at room temperature. For each preservation method, the mosquitoes were divided into three groups and stored for 1, 4, or 8 weeks, then scanned using an attenuated total reflection-Fourier transform infrared spectrometer at mid-infrared wavelengths. Supervised machine learning classifiers were trained with the infrared spectra and used to predict the mosquito ages. The best-performing classifier for age-grading mosquitoes was the support vector machine (SVM). The classification of mosquito ages (as 5- or 17-day-olds) was most accurate when the samples used to train the SVM model (training samples) and the samples being tested (test samples) were preserved in the same way or stored for equal durations. However, when the test and training samples were handled differently, the classification accuracies declined significantly. When using mid-infrared spectroscopy and supervised machine learning to age-grade mosquitoes, the highest accuracies are achieved when the training and test samples are preserved in the same way and stored for similar durations. Protocols for infrared-based entomological studies should therefore emphasize standardized sample-handling procedures and possibly incorporate additional statistical methods, such as transfer learning, for greater accuracy.

Keywords: Anopheles arabiensis, mid-infrared spectroscopy, machine learning, age-grading, biological control, malaria transmission.

Malaria Vector Bionomics and Transmission Patterns in Olama, an Equatorial Forest Region of South Cameroon

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Abstract

In rural areas of the equatorial forest region, the wide range of available breeding sites generally favors vector diversity and high densities. Malaria is perennial and is transmitted by local vectors such as *Anopheles moucheti* and *An. gambiae s.l*., which are responsible for high malaria transmission. However, recent environmental changes resulting from intensified human activities, including deforestation, urbanization, and agriculture, have promoted the proliferation of these highly anthropophilic vector species, leading to serious consequences for malaria epidemiology in this area. Based on these observations, this study aimed to investigate vector bionomics and malaria transmission patterns in Olama. Adult mosquitoes were captured using human landing catches and CDC light traps in Olama from January to December 2023. Malaria vectors were morphologically identified and analyzed for Plasmodium falciparum circumsporozoite protein detection using the ELISA method, along with molecular identification of *Anopheles gambiae* species using PCR. A total of 8,240 mosquitoes were collected, identifying seven Anopheles species. A predominance of *An. moucheti* was observed, accounting for 98.32% (4,757/4,838) of the Anopheles mosquitoes. Of the 107 *An. gambiae* s.l. processed by PCR, 50.46% (54/107) were *An. coluzzii* and 24.29% (26/107) were *An. gambiae s.s*. The infection rate by P. falciparum was 0.52% (11/2,122 mosquitoes processed), with an entomological inoculation rate of 2.21 infective bites per man per night. The human biting rate was 117.54 bites per man per night. Malaria transmission risk was not significantly higher indoors (122.42 ib/m/n) compared to outdoors (112.67 ib/m/n) (X=0.427; P=0.51). *Anopheles moucheti* remained the main malaria vector species. In Olama, mosquitoes are now predominantly found to bite indoors. Although a decrease in malaria transmission intensity has been reported, this level is still far from the target of the national malaria control program.

Keywords: Anopheles moucheti, malaria, vector, Cameroon, forest region.

First Report on the Molecular Phylogenetics and Population Genetics of Aedes aegypti in Iran.

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Abstract

Aedes aegypti, the primary vector of various human arboviral diseases, poses a significant public health threat. *Aedes aegypti* was detected in Iran in 2018 in Hormozgan province, but comprehensive information regarding its genetic diversity and origin within the country remains scarce. This study aimed to determine the origin and genetic diversity of *Ae. aegypti* in southern Iran.Methods: *Aedes aegypt*i mosquitoes were collected from Bandar Abbas City, Hormozgan Province, southern Iran, between May and July 2022. Specimens were morphologically identified. The origin and genetic diversity were assessed based on the mitochondrial DNA-encoded cytochrome c oxidase subunit I (mtDNA-COI) gene. BLAST (Basic Local Alignment Search Tool) analysis confirmed the accuracy of the morphological identification of all specimens as *Ae. aegypti,* with 100% similarity to GenBank sequences. Calculated variance and haplotype diversity were 0.502 and 0.00157, respectively. Among the 604 examined nucleotide sequences, only a single site was non-synonymous. Total nucleotide diversity and average pairwise nucleotides were determined as 0.00083 and 0.502, respectively. Fu and Li's D test values were not statistically significant. Strobeck's S statistic value was 0.487, and Tajima's D value was 1.53395; both were not statistically significant ($p > 0.10$). Phylogenetic analysis revealed two distinct clades with minimal nucleotide differences and low haplotype diversity, suggesting the recent establishment of *Ae. aegypti* in the southern region of Iran. The phylogenetic analysis also indicated an association between *Ae. aegypti* populations and mosquitoes from Saudi Arabia and Pakistan.

Keywords: Aedes aegypti, molecular phylogenetics, population genetics, Iran, arboviral.

Optimization of Antimalarial Drug Delivery and Evaluating Their Effects on the Survival and Fecundity of Laboratory-Reared Anopheles gambiae Mosquitoes

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Abstract

The WHO global technical strategy for malaria control aims to reduce malaria cases by 90% by 2030. Recent studies have demonstrated the potential of using standard antimalarials to block the development and transmission of

pre-erythrocytic stages within the mosquito. However, further studies are warranted to optimize drug delivery into the vector, as well as to determine tolerable doses and the fecundity of treated Anopheles mosquito vectors. This study aimed to determine the maximal tolerable doses and the efficacy of the antimalarial drugs (artemether, lumefantrine, primaquine, and tafenoquine) on the fecundity of reared *An. gambiae s.s.* mosquitoes. *An. gambiae s.s.* (Kisumu strain) were reared in the insectary under standard conditions. The study utilized an artificial membrane feeding system to feed human blood to the insectary mosquitoes, and soaked cotton balls were used to administer the antimalarial drugs. Fifty 3–5-day-old starved mosquitoes were introduced into ten labeled paper cups. Eight doses consisting of serial dilutions of each antimalarial drug in a 10% glucose solution were prepared. Mosquitoes were allowed to feed on cotton wool soaked in different concentrations of antimalarials, and mortality was monitored for ten days. To assess fecundity, a fresh batch of mosquitoes was fed with human blood and subjected to the tolerable drug doses. The number of eggs laid was monitored over an 8-day period, with controls fed 10% glucose. Kaplan–Meier survival analysis was performed to estimate the tolerable drug doses, while the Chi-square method was used to assess the efficacy of antimalarial drugs on the fecundity of Anopheles mosquitoes. The maximum tolerable doses were determined to be 0.01 ng/ml for artemether and lumefantrine, and 1.5 ng/ml for tafenoquine and primaquine. The number of eggs laid did not differ significantly between the mosquitoes exposed to the different drugs and the control groups. These doses can be recommended for future use as transmission-blocking doses.

Keywords: Anopheles gambiae, malaria, transmission blocking, antimalarial, fecundity, mortality

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Mosquitocidal Activity of Steinernema abbasi on Anopheles gambiae Mosquitoes

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Abstract

The marsh mosquito, *Anopheles gambiae*, is of crucial concern to public health due to its role as a vector in the transmission of malaria, which is the leading cause of morbidity and mortality, particularly in tropical and subtropical regions. Over the past decades, entomopathogenic nematodes (EPNs) have been utilized to control important agricultural insects and pests, demonstrating effectiveness against mosquitoes as well. This study aimed to investigate the mosquitocidal effect of Steinernema abbasi on *Anopheles gambiae*. Methodologically, colonies of *Anopheles gambiae* were collected and reared at KALRO Kandara, Kenya, under standard laboratory conditions. Nematode propagation was conducted using the method described by Liao et al. (2001). S. abbasi was produced by passing through the larvae of a wax moth (*Galleria melonella*) (Kaya and Stock, 1997). The infected juveniles (IJs) of S. abbasi were cultured and applied to mosquito larvae breeding sites. The infected assay was described as per Beresky and Hall (1977). Briefly, larval mortality rates were recorded at specific time intervals post-application against the concentration of nematodes (IJs/mL). Additionally, the impact of S. abbasi on adult *An. gambiae* mosquitoes was evaluated through exposure bioassays. Mortality rates, reproductive potential, and behavioral changes in surviving mosquitoes were assessed. Distilled water and *S. carpocapsae* were used as controls. Overall, this study will contribute valuable information to the development of novel and environmentally friendly strategies for controlling mosquito populations and reducing the burden of mosquito-borne diseases like malaria.

Keywords: Anopheles gambiae, entomopathogenic nematodes, Steinernema abbasi, mosquitocidal activity, malaria control.

Monoterpenes-based nanohydrogels for potential application as repellents against Aedes aegypti

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Abstract

Aedes mosquito-borne diseases still represent a significant global health threat, demanding effective control strategies. In this study, we introduce monoterpenes-based nanohydrogels designed for potential application as repellents against *Aedes aegypti* the main dengue vector worldwide. Using cymene and myrcene-based nanoemulsions, we formulated hydrogels incorporating different polymers: chitosan, carboxymethylcellulose (CMC), and carbopol. After evaluating these polymers' rheological texture and bioadhesive properties, we identified CMC hydrogel as the most promising polymer for topical application. CMC hydrogels demonstrated sustained release of monoterpenes over 12 hours, and low skin permeation and retention in stratum corneum. When used as mosquito repellents, this retention in the skin's outer layer enhances the monoterpene-based hydrogels' (NH) protection time. To assess their repellent efficacy, females of *Ae. aegypti* were tested in a membrane-feeding essay. The myrcene-loaded CMC hydrogel exhibited superior performance, with 57% of mosquitoes avoiding blood feeding compared to 47% in the cymene group. Although not optimal, these findings suggest the potential repellency of these nanohydrogels against females of *Aedes aegypti.* Molecular docking studies unveiled interactions between myrcene and an essential amino acid (Ile116) in the *Ae. aegypti* odorant binding protein 22 (AeOBP22), corroborating its higher repellent efficiency than cymene. In conclusion, our monoterpenes-based nanohydrogels, particularly the myrcene-loaded CMC hydrogel, represent a promising, minimally invasive alternative strategy for personal protection against *Ae. aegypti*. Further investigations are needed to find optimal concentrations of monoterpenes-based nanohydrogels for application in vector control.

Influence of Sugarcane Irrigation on Anopheles Mosquito Species Abundance and Diversity in Areas Surrounding Illovo Sugar Estate in Dwangwa, Nkhotakota District, Malawi.

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Abstract

Malawi is undergoing unprecedented expansion in sugarcane irrigation farming. This can increase Anopheles mosquito population, putting surrounding communities at risk of malaria. This study investigated the effects of

sugarcane irrigation on Anopheles mosquito abundance and diversity, specifically: 1) Assessing the effects of sugarcane irrigation on mosquito abundance in areas surrounding irrigated farms, and 2) Comparing Anopheles species diversity and abundance in sugarcane irrigated and non-irrigated areas. Adult mosquitoes were collected from December to January 2021-2022 from 8 pm to 6 am using CDC light traps in two sites surrounding Illovo sugar estate. The collected Anopheles mosquitoes were sorted using morphological keys and the aid of a dissecting microscope. Data was analyzed using Excel, SPSS, and Past. t-tests and Shannon diversity indices were used to compare the abundance and species diversity between the two sites. Overall, 513 mosquitoes were collected in both sites, with 354 (69%) mosquitoes from the irrigated site and 159 (31%) from the non-irrigated site. About 64 (12.67%) mosquitoes were of the genus Anopheles, comprising three species: *Anopheles funestus* (n=38, 60%), *An. gambiae* (n=25, 38%), and *An. arabiensis* (n= 1, 2%). Approximately 47 (74%) of the Anopheles mosquitoes were from the non-irrigated site, and 17 (26.15%) were from the irrigated site. Both general mosquito abundance and Anopheles mosquito abundance from the two sites were not significantly different (p-value = 0.2963). Anopheles mosquito diversity was higher in the non-irrigated site (0.7744) than in the irrigated site (0.5456). Sugarcane irrigation resulted in very little mosquito abundance and diversity due to proper management and regular maintenance of irrigation canals, reducing the risk of malaria in the surrounding communities. *An. funestus* was higher than other Anopheles species in sugarcane fields due to the shaded breeding sites created by sugarcane plants, which are favorable for its breeding.

Keywords: Anopheles, mosquito, irrigation, impact, abundance.

Persistence of anti-yellow fever virus immunoglobulin M antibodies post-vaccination and its reactivity to the Envelope domain III antigen of the yellow fever virus

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Abstract

Yellow fever (YF) is an arboviral mosquito-borne infection endemic to tropical and subtropical regions of South America and Africa where a live attenuated YF vaccine is routinely administered to children at 9-12 months of age. If a vaccinated child develops fever and jaundice years post-vaccination and anti-YF IgM antibodies are detected in their serum, it becomes unclear what these results represent. Whether the detected IgM suggests a recent natural YF virus infection indicating vaccine failure or the persistence of YF-IgM antibodies years post-vaccination remains unknown. To better understand YF IgM sero-positivity in children post-vaccination, archived plasma/sera collected from children enrolled from birth in 3 hospitals in Cameroon and received the YF vaccine at 9-12 months of age were tested. These samples were collected prior YF vaccination, at 2-6 months and 1-2years post-vaccination and, tested using the CDC YF IgM antibody capture 72hrs ELISA. We found that at 2-6 months post-YF vaccination, 30/352(8.5%) of infants had anti-YF IgM antibodies while, 10/433 (2.3%) of infants still had anti-YF IgM antibodies by 1-2 years post-vaccination. Our results indicate that, anti YF IgM is rare by 6 months post-vaccination in infants who receive the YF vaccine at 9-12 months. However, IgM persistence years post YF vaccination could be observed

in a minute proportion of infants. To further maximize the insight we could obtain from these samples, we assessed and compared the reactivity of YF IgM-positive vaccinee sera and YF natural infection sera to 3 recombinant YF virus antigens (Envelope protein, Envelope Domain III protein (EDIII), non-structural protein 1) using the multiplex immunoassay (Luminex). The IgM antibodies from both sera groups exhibited stronger reactions to the YFV DIII envelope protein compared to other proteins, hence could serve as a more specific and sensitive diagnostic marker for detecting IgM in both cases.