CONFERENCE PROGRAMME

8th PAMCA Annual Conference & Exhibition | 2022

26th - 28th September 2022

Organized and hosted by PAMCA Rwanda Chapter

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

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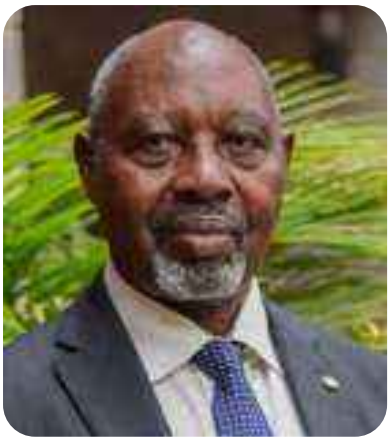
WELCOME ADDRESS

Prof. Charles Mbogo | PAMCA President



It is my distinguished honor to welcome you all to the 8th edition of the PAMCA Annual Conference and Exhibition which is being hosted from September 26-28, 2022, in Kigali, Rwanda. This 8th edition of the PAMCA Annual Conference & Exhibition is being hosted by our PAMCA Rwanda Chapter in collaboration with PAMCA Secretariat. Whereas this year's conference is going back to being fully physical, we hope that you now start feeling the local Rwanda hospitality and ambiance throughout the duration of the conference.

The PAMCA Annual Conference & Exhibition continues to provide a premier platform bringing together diverse actors in the disease vector control sphere to share experiences and lessons on vector-borne diseases, and to provide the necessary synergy towards control and elimination of these diseases in Africa. Conferences such as this provide a valuable opportunity for research scientists, industry specialists and decision-makers to share experiences. I am grateful to the many experts who have come to share their knowledge this week. I also welcome the many representatives of governments, industry associations and NGOs who have joined us.

The theme of this year's conference is, "***Harnessing local institutional and community support for the elimination of vector-borne diseases.***" This year's conference features a rich and diverse menu of scientific content, plenary discussions on topical issues in vector-borne disease control, hosted symposia, round table discussions with major financing partners in global health, and an award ceremony supported by one of our partners. Besides this, there will be diverse opportunities to network with colleagues, form new acquaintances, and forge long-term partnerships with colleagues, new and old from the virtual interactive platform. Beyond this, we shall experience other interactive sessions during the week including the African night experience and a field trip to name but a few.

All this would not be possible without the hard work of the organizers co-led by PAMCA Secretariat and the local organizing committee (LOC) of the PAMCA Rwanda Chapter, as well as the financial and material support, we have received from our sponsors and partners. I therefore heartily thank all the LOC team led by the President of the PAMCA Rwanda Chapter, Dr. Emmanuel Hakizimana. I also thank the PAMCA Secretariat for providing leadership and coordination of the entire planning and organizing process. We are also grateful to the international scientific team for the work they have done to ensure that all abstracts accepted for presentation at the conference meet the necessary rigour and scientific merit.

I continue to encourage you to join the growing network of PAMCA members from every part of the globe to contribute in a concerted manner to the efforts to alleviate humans of the scourge of vector-borne diseases.

I am sure you will have fruitful and rewarding exchanges in the next few days. I wish you every success with this important conference and I look forward to learning about the outcome.

Dr. Prosper Chaki | Executive Director, PAMCA

Honorable Minister, our chief guest, your Excellency Ambassador, Distinguished Delegates, Ladies and Gentlemen, it gives me great pleasure indeed to welcome you all to this 8th PAMCA annual Conference here in Kigali that starts today 26th to 28th September 2022. It is, indeed, an exciting moment for PAMCA to host an in-person meeting after last's virtual conference necessitated by the COVID-19 pandemic. We are happy to meet each one of you face to face.

Ladies and Gentlemen, The PAMCA Annual Conference and Exhibition, is a flagship meeting of the organization, that brings together participants from diverse fields including research and public health entomology, government agencies, non-governmental agencies, academia, private industry, affected communities, to share experiences and advances in VBDs and to adopt best practices for surveillance, control and elimination of vector-borne diseases in Africa with an anticipated 500 participants in attendance. The findings, conclusions and recommendations of this conference will contribute directly to the strategies of controlling and eventual elimination of VBDs.

I am equally happy to report that the theme of the conference is, ***"Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)."*** It is worth noting that we have several other sub-themes for the conference that include: Vector surveillance, epidemiology, disease control programs, and global health; Precision public health and innovations for VBDs elimination: AI, entomological databases, modeling, and genomic surveillance; LLINS, IRS and insecticide resistance management; Larval source management and integrated vector management; Vector biology, ecology, taxonomy and population genetics; New and re-merging arthropod-borne viruses, climate change, Neglected Tropical Diseases (NTDs) and One Health; Social sciences and gender inclusivity for VBDs.

Distinguished Ladies and Gentlemen, it is refreshing to note that out of the **300 plus** abstracts received, **270** were accepted for presentation (120 orals and 150 posters). We have one keynote speaker and seven plenary talks on different thematic areas. The conference is also hosting 8 symposia, 2 round table discussions and 12 scientific sessions. On top of this, in the past week we held 5 pre-conference workshops.

I would like to extend a special welcome to our international guests from the American Mosquito Control Association (AMCA) especially as it is the first time for them to come to this meeting. It is my sincere hope that we shall be seeing more of you in the future when you will be coming to further support building the capacity of our institutions in combatting vectors and vector borne diseases.

Further, I would like to extend my heartfelt appreciation to our funders and sponsors who have wholeheartedly been supporting PAMCA's vision and mission and have been supportive of our annual conference and many other programs at PAMCA. This meeting has exponentially been growing in all aspects, in terms of the number of participants, quality of scientific presentations and discussions even more so a networking platform. Thank you very much.

To all the PAMCA members, this is the moment we have all been craving for, let us seize the moment and make the most out of this, to realize the dream of an Africa free of Vector Borne Diseases. As I have always said before, PAMCA is a movement of people who individually and collectively believe that we can see the end to the sufferings of our people from the several vectors borne diseases. Thank you very much for all the continued support. I would, like to reiterate, on behalf of the PAMCA management it is our pleasure in having you with us and our hope that you enjoy the scientific discussions and I urge you to spare some time to out and see the beauty that Kigali presents.

Dr. Emmanuel Hakizimana | PAMCA-Rwanda, President and Chair, Local Organizing Committee (LOC)

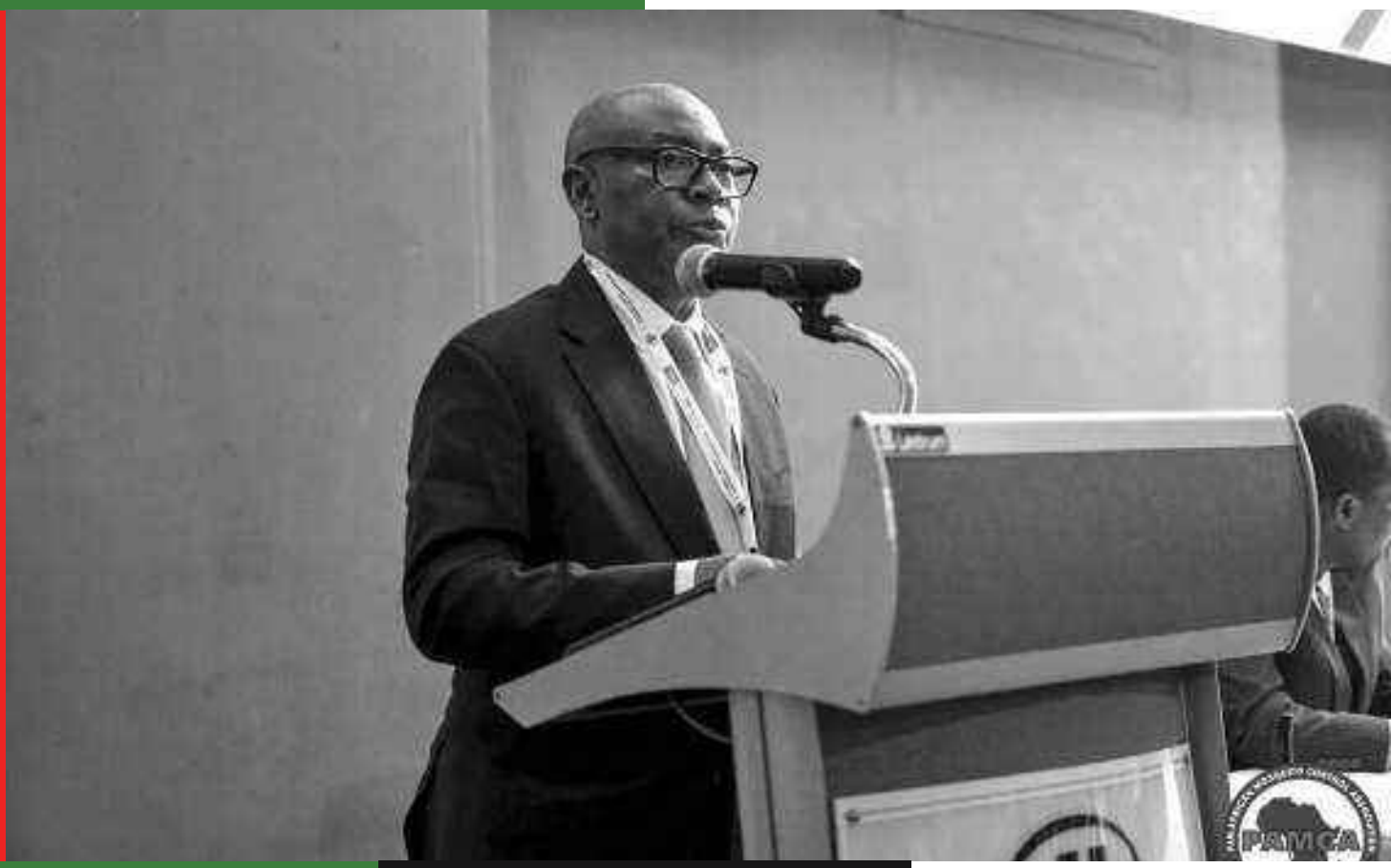
It is with great pleasure that I welcome you to this 8th annual PAMCA Conference and Exhibition held at this wonderful facility, the Kigali Convention Center. During the last two years, the COVID-19 pandemic restricted our movements, our actions against VBDs/mosquitoes, and our physical interactions and meetings. I am now delighted that we can have face-to-face meetings, enabling us active discussions for tailored strategies and actions, and build strong collaborations for effective and sustainable fight against vector-borne diseases globally and particularly in Africa. insects and other vectors, have heavy health and economic burdens imposed. Globally and particularly in Africa, they cause more than one million deaths each year. But death counts, though alarming, vastly underestimate the human misery and hardship caused by these diseases, as many people who survive infection are left permanently debilitated, disfigured, maimed, or blind.

Malaria, which is spread by mosquitoes, is the best-known, the biggest killer and burden among vector-borne diseases in Africa, but there are others. Some, like dengue, Rift Valley fever and yellow fever, etc... tend to erupt in large outbreaks that can paralyze health systems and cause considerable economic and social disruption. Many of these diseases have been historically confined to well-located geographical areas, but this situation has become more fluid due to a host of ills, including resistance to insecticides or drugs, behavioural changes in vectors, climate change, change in land use such as intensive irrigation farming, general population movements, rapid and unplanned urbanization, lack of funds and adequate skills and so forth. These changes create great opportunities for vectors and the diseases they spread to take up residence in new areas and where they were prior eliminated.

Effective controlling of VBDs requires a well-coordinated, highly trained workforce, engagement of decision makers, funders, industrial leaders, community; and then adequate tools and integrated approaches that meet international standards. The theme of this year's conference **"Harnessing local institutional & community support for**

the elimination ofNovel vector-borne diseases (VBDs)" reminds all of us that addressing the above hindrances requires another way of working, strong collaboration and engagement between all stakeholders including communities towards elimination of the above diseases in coming years for the sustainable wellbeing of our communities. On behalf of members of the LOC and PAMCA Rwanda Chapter, I would like to express my warm gratitude to the Rwanda Ministry of Health, PAMCA Secretariat, Rwanda Convention Bureau, sponsors, the event Organizer "EMS" for their tireless support to make this conference a success. In our mother language, the Kinyarwanda, we say "*Murakaza Neza*" meaning warm welcome to this conference, and I wish you all, a successful conference.

8th PAMCA Annual Conference & Exhibition | 2022



KEYNOTE SPEAKERS

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

KEYNOTE SPEAKER

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs) – ALMA's perspective

Prof. Sheila Tlou | Special Ambassador for the African Leaders Malaria Alliance (ALMA)

Prof. Sheila Tlou is Co-Chair of the Global HIV Prevention Coalition, Chancellor of Botswana Open University, Special Ambassador for the African Leaders Malaria Alliance, Champion of the Nursing Now Challenge, Trustee to the Board of the Florence Nightingale Foundation (FNF), and Advisory Board member for the Harvard Global Nursing Leadership Program.

She is former UNAIDS Regional Director and former Minister of Health of Botswana, where she led a comprehensive HIV/AIDS program that is still a model in Africa. She is Professor Emerita of the University of Botswana and former Director of the WHO Collaborating Centre for Nursing and Midwifery Development in Primary Health Care.

As UNAIDS Regional Director, Prof. Tlou provided leadership and Political Advocacy for a sustainable AIDS response in 21 African countries. She holds a PhD in Nursing Sciences from the University of Illinois at Chicago., a master's in nursing education from Columbia University, and a Master of Science in Nursing from the Catholic University of America. She has many publications on Human Rights and HIV/AIDS and has received over 30 international awards for Leadership in Global Health, among them Botswana Presidential Order of Honor, Princess Srinagarindra award from Thailand, Christianne Reimann award from International Council of Nurses, and Princess Muna Al Hussein award from American Nurses Credentialing Centre. She is United Nations Eminent Person for Women, Girls, and HIV/AIDS in Southern Africa.

PLENARY SPEAKERS

Changing malaria Epidemiology and role of data for decision making

Dr. Corine Karema | Interim CEO, RBM Partnership to End Malaria

Dr. Corine Karema is a Medical Doctor with a master's degree in Sciences in Epidemiology from the University of Rwanda. She is a global health leader and recognized malaria expert. She recently served as Special Advisor to the Board Chair of The Global Fund, a partnership designed to accelerate the end of AIDS, tuberculosis, and malaria as epidemics. Previously, she was the Malaria Senior Programme Officer at the African Leaders Malaria Alliance (ALMA) and led the malaria experts' group of the technical Panel review of the Global Fund. Before serving as an independent consultant at the National Malaria Control and Elimination Programs in Africa where she provided technical assistance, Dr. Karema was Director of the Rwanda National Malaria Control Programme (NMCP) for ten years, following five years as Head of the Malaria & Other Parasitic Diseases (Neglected Tropical Diseases) Division. During her time at the NMCP, she led the development of malaria control strategies, policies, and research, which has guided the implementation of evidence-based malaria control interventions resulting in increased coverage of key interventions and reductions in malaria morbidity and mortality in Rwanda. She has served as a member and leader of different malaria technical, scientific advisory, and steering committees of many international institutions such as WHO, RBM, MMV, ASTMH, etc. Dr. Karema has published and co-authored many scientific journals on malaria as a researcher.

Potential impacts of climate change on malaria vector control in Africa

Prof. Heather Ferguson | Professor in Medical Entomology and Disease Ecology, University of Glasgow

Professor Heather Ferguson is a vector ecologist whose work encompasses study of the ecology, behaviour and control of mosquitoes that transmit malaria and arboviruses. She is involved in the development of new tools for vector surveillance and control with partners from malaria endemic countries. Professor Ferguson has a long-term research and training partnership on malaria vector research with the Ifakara Health Institute in Tanzania, where she holds a position as a Visiting Scientist Position. She has been a Co-Chair of the World Health Organization's Vector Control Advisory Group since 2019.

Dr. Nico Govella | Senior Research Scientist, Ifakara Health Institute (IHI)

Professor Nico Govella has 18 years of experience in Malaria research, around malaria vector behaviour, ecology, surveillance, transmission, and control, including designing, leading, coordinating, managing, and capacity-building for malaria entomological studies. Prof Ovella currently serves as the Chief Research Scientist and head of department at the Ifakara Health Institute, Tanzania, and Research affiliate at the University of Glasgow. He is also an MRC African Research Leader Awardee. He has a PhD in Infectious Diseases (focus on malaria vector ecology and control) from Liverpool School of Tropical Medicine, UK. Prof. Govella developed and evaluated new malaria mosquito surveillance traps (Govella et al 2009 Malar J 8:157 and Govella et al 2010 Am J Trop Med Hyg 83: 596-600) which, for the first time offered affordable, practical and scalable method for routine programmatic surveillance of malaria transmission (Chaki et al 2012 Malar J 11:172). He also worked on novel analytical methods for optimal selection of vector control interventions, and for predicting their impacts based on measurements of key mosquito behaviours (Govella et al 2010 Am J Trop Med Hyg 83:415-19). Beyond Tanzania, these analytical approaches have since been adopted as far as Zambia, Kenya, Solomon Islands, etc. He has worked persistently over several years on several other different prototypes of a new electrocuting grid trap (METs) for measuring intervention-targetable behaviours of mosquitoes, before finally patenting models that satisfy the target product profiles (O (Ovella et al 2016 Malar J 15:465, Meza et al 2019 Malar J 18:83). More recently, he has assessed the METs as an alternative to HLC for measuring protective efficacy of repellent products. Beyond Tanzania, these METs have been piloted for the surveillance of arbovirus mosquitoes in Southeast Asia, and South America, and proved useful and effective. He has also recently developed a novel portable semi-field experiment and modelling and used it to demonstrate for the first time that the ability of African malaria vectors to bite outside of hours when people are protected by Nets is heritable.

Abstract

Potential impacts of climate change on malaria vector control in Africa

H. M. Ferguson[1,2]* and N.J. Govella[2,1]

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There has been extensive consideration of how climate change may impact the distribution and intensity of vector-borne disease transmission; with a particular focus on malaria risk in Africa. However, such analyses primarily focus on how the "malaria map" will shift in response to changes in the environmental determinants of transmission, but rarely consider the equally if not more important question of whether climate change will impact the effectiveness of vector control measures. We hypothesize that the efficacy and ability to implement malaria vector control will be significantly impacted by climate change due to direct and indirect impacts of mosquito vectors and interventions. We will highlight mechanisms through which the type of climate change expected in different regions of sub-Saharan Africa may modify, and potentially impede, the efficacy and feasibility of the major core and supplementary interventions of Insecticide Treated Nets, Indoor Residual Spraying and Larviciding. Consideration is focussed on how climate change may impact four key determinants of vector control impact: 1) mosquito vector ecology, 2) environmental determinants of product efficacy, 3) mosquito resistance strategies and 4) human behaviour and intervention use. Finally, we review potential indirect impacts of climate change on the ability to finance, implement and sustain vector control through changes in land use, urbanization, socioeconomic conditions and health systems. To better prepare and mitigate against the most negative impacts, we advocate for consideration of climate change impacts to be built into future vector control and public health planning.

LSM in operational mosquito control programs: Lessons from the past and tools for the future

Dr. Mark Latham | Retired Entomologist and Mosquito Control Program Director

Mark Latham is a retired Entomologist and Mosquito Control Program Director who has spent more than 40 years working in governmental mosquito control programs utilizing IVM approaches, most of that time in the state of Florida, USA. After graduating from the University of Cambridge in 1979 and leading the 1979 Cambridge Medical Expedition to Brazil (to study Chagas disease), Mark took a position as a graduate research assistant at the Mosquito Research and Control Unit (MRCU) in the Cayman Islands (1980). His responsibilities included conducting research on the biology and control of the Black Saltmarsh mosquito (*Aedes taeniorhynchus*) and managing teams of local staff in all aspects of Integrated Vector Management. This included a comprehensive surveillance system to detect re-introductions of *Aedes aegypti* onto the island to maintain the "eradication status" of this important disease vector.

In 1985, Mark took a position as a supervisor/entomologist with the Miami-Dade mosquito control section, responsible for the mosquito control operations protecting a population of 2.5 million residents in a mixed urban/suburban/rural area of Florida, USA. During his 9 years in Miami, he developed an interest and expertise in the science of the aerial application of mosquito control products, both larvicides and adulticides. The primary mosquito species targeted in Miami included urban container species (*Aedes aegypti* and *Culex quinquefasciatus*) and rural floodwater species (*Aedes taeniorhynchus*, *Psorophora columbiae* and many others), mostly as nuisance rather than disease vectors.

In 1994, Mark accepted the position of Director of the Manatee County Mosquito Control District on the west coast of Florida, a position he held for 26 years until his retirement in 2020. As an Independent Taxing District, in addition to his regular management responsibilities, this provided the flexibility to conduct operational research, allowing him to work with university scientists and industry members on research subjects to improve mosquito control methods and practice. This included studies on

non-target impacts, new products and formulations, pesticide resistance, optimum droplet sizing through new application equipment, canopy penetration of both larvicides and adulticides, and comparisons between different actives on multiple species.

Outside of his work managing a mosquito control district in Florida, Mark has served as an expert advisor/consultant to many other programs, most notable of which has been with WHOPES (helping develop specifications and guidelines on a number of subjects) and mosquito control applicators in northern Greece during the West Nile virus epidemic between 2009-2012. He has travelled widely to give presentations on a number of subjects at regional meetings within the US and has also been a guest speaker at conferences in Europe and Australia.

Since retiring from Manatee County MCD in 2020, Mark continues to work part-time as a consultant with IVCC and with mosquito control product manufacturers. He has also returned to work part-time at the district, helping out in the laboratory and with research projects. Mark is a member of the American Mosquito Control Association (AMCA) and the Florida Mosquito Control Association (FMCA), serving as its President in 2002. He has served on many committees and continues to teach at annual training sessions, primarily on the subjects of aerial application and the importance of correct droplet sizes for efficient pesticide targeting. Mark has been married to his wife Charlotte for 37 years, and they have three Children: Caroline 33, Peter 30 and Alex 26. They live in Bradenton, Florida, USA.

Abstract

Larval Source Management (LSM) is an integral part of most large, well-funded mosquito control programs in the United States. Where funding is available, it is also the primary method of mosquito control in Europe and Australia. The philosophy is that the larval mosquito population is concentrated in discreet habitats and can be effectively targeted before the adult mosquitoes disperse over much larger areas. The method is further bolstered by the availability of products that are very specific and have relatively low toxicities to humans and other non-target species, as opposed to the broad-spectrum adulticides. Larviciding and Source Reduction are often combined in an IVM approach alongside adulticiding to target important mosquito species in the most appropriate manner. However, this varies widely between different species and in different regions based on the mosquito's bionomics, the region's accepted practices, and the economic viability of the different methods. In sub-tropical Florida and the South-eastern United States, most of the mosquito problems emanate from natural habitats, primarily the coastal saltmarshes, whereas in the desert Southwest (California, Nevada, Arizona, and Utah) much of the mosquito production is man-made, from agricultural irrigation schemes and stormwater conservation/management. A common problem throughout the United States is the management of urban mosquitoes, primarily *Culex quinquefasciatus*/*Culex pipiens* and the invasive species *Aedes aegypti* and *Aedes albopictus*, which thrive in man-made containers and urban drainage systems. Unlike the NMCPs in sub-Saharan Africa, much of the mosquito control work in the US is targeted against abundant nuisance species, often multiple different species in the same location, and less against potential disease vectors due to the relatively low incidence of mosquito-borne disease.

This presentation will discuss some of the challenges and important aspects to consider for successful operational LSM implementation. These include product availability, applicability of different formulations, efficacy testing, post application monitoring, and best practices on delivery methods. Ideally, such comprehensive evaluation in an operational setting will provide evidence to guide those programs considering the implementation of LSM as part of an IVM approach where economically viable.

Using malaria genomics to accelerate Africa towards malaria elimination

Dr. Jaishree Raman | Principal Medical Scientist at the National Institute for Communicable Diseases (NICD)

Dr Jaishree Raman is a molecular biologist by training with a strong interest in malaria and public health. Jaishree currently heads the Laboratory for Antimalarial Resistance Monitoring and Malaria Operational Research (ARMMOR) at the NICD. The core focus of ARMMOR is to improve malaria diagnostic and treatment options, with the ultimate aim of assisting South Africa and Africa to eliminate malaria. To this end, ARMMOR hosts the South African National Surveillance Programme for Antimalarial Drug and Diagnostic Resistance Monitoring. This robust surveillance programme enables the near real-time tracking of emerging resistance to inform case management policy and prompt containment responses. In partnership with collaborators from other malaria endemic countries and research organizations including the Universities of Cape Town, Pretoria, Namibia and California-San Francisco, Dr Raman's laboratory is currently investigating novel techniques and technologies aimed at improving malaria case detection and treatment practices.

Abstract

The recent COVID-19 pandemic has very clearly demonstrated the value of using near real-time genomic surveillance data to enable evidence-based decision making. While other infectious diseases such as TB and HIV routinely use genomic data to inform policy decisions related to intervention selection and treatments, genomic data have been used rather sparingly by policy makers and national malaria control programs in Africa. The reasons for this are multifactorial, but include limited funding, poor infrastructure, a scarcity of the required human capacity and a limited appreciation of the utility of genomic data.

However, most of these excuses are no longer valid, as the genomic capacity landscape in Africa has been completely transformed, thanks to significant investments from organization like the Africa CDC and the Bill and Melinda Gates Foundation. If Africa is serious about eliminating malaria, it is imperative that African malaria control programs leverage this existing genomic capacity and incorporate genomic surveillance into their routine surveillance activities, as matter of urgency.

This is of course, not without challenges. But lessons learnt from COVID-19 can be used to enhance the uptake. In my talk I will discuss the challenges that I foresee and suggest possible mitigation strategies. For example, using regional hubs that do the sequencing, with data analysis done in-country as a way of reducing costs associated with building sequencing capacity in every country. Regional hubs have the potential to maximize the return on investment due to economies of scale related to the number of samples analysed while reducing costs associated with running and maintaining a next generation sequencing facility.

Generating the data is only the first step. Making sure that policy makers and national malaria control programs understand the data and are able to use the data for effective decision making is the final crucial step for impactful genomic surveillance. I will discuss a few initiatives in Africa that aim improve the understanding and utility of genomic data within national malaria control programs. If successfully, national malaria control programs will then be capacitated to use genomic data to design country-specific interventions aimed at halting the locally transmission of malaria, making a malaria-free Africa, a real possibility.

Threats to the gains in malaria control posed by the invasion of *An. stephensi*, an urban malaria transmitting mosquito

Dr. Fitsum Girma Tadesse | Biochemist/molecular biologist, Armauer Hansen Research Institute, the Ethiopian Public Health Institute, the Ethiopian Biotechnology Institute, and the National Malaria Elimination Program

Dr. Fitsum Girma Tadesse's is a biochemist/molecular biologist. His studies mainly focus on the transmission of *Plasmodium* parasites. His long-term research interest is in translational research to support an informed decision-making process for malaria elimination. His group recently demonstrated the very high permissiveness of *An. stephensi* mosquitoes that recently invaded the Horn of Africa, providing solid evidence for the risks related to the invasion of this vector in Africa. He has led the development of a five-year action plan to respond to *An. stephensi* by the Ethiopian government. He is currently supporting similar efforts in neighbouring countries in the region. Dr. Tadesse is currently leading cohort studies of *P. vivax* infected patients to explore serological markers of relapse and use these markers for targeted intervention against the dormant liver stage, hypnozoite. He is also leading studies that aim to evaluate strategies (tMDA vs RCD) and efficacy of first line and alternative second-line drugs (Pyramax) to support the elimination effort of the country. He led the establishment of the Ethiopian Malaria Genomics Epidemiology Network (EMAGEN) which aims to leverage existing capacity in four institutions in Ethiopia: The Armauer Hansen Research Institute, the Ethiopian Public Health Institute, the Ethiopian Biotechnology Institute, and the National Malaria Elimination Program. He is also leading a multi-site assessment of the distribution of parasites with *hrp2/3* gene deletion (African Center for hrp2/3 Deletion Surveillance, ACHIDES). Within less than 5 months from its start, the findings of the ACHIDES study were instrumental in the decision of the Ministry of Health of Ethiopia to switch to non-HRP2 based RDTs. Dr. Tadesse is expanding the ACHIDES to 10 more countries in Africa, the Horn, and West of Africa.

Abstract

First reported in Djibouti (2012) and Ethiopia (2016), *Anopheles stephensi,* an Asian highly efficient malaria vector, is expanding rapidly in Africa. So far, it was reported from most parts of Ethiopia, Somalia, Sudan, Yemen, and most recently Nigeria. This species thrives in urban and rural environments and persists throughout the dry season by breeding in artificial containers. In 2019, the World Health Organization issued a Vector Alert that highlighted the spread of *An. stephensi* as major potential threat to malaria control and elimination in the region. The role of *An. stephensi* to malaria transmission was not formally investigated but was epidemiologically linked in Djibouti. Since 2012, malaria cases increased sharply in Djibouti (raising from only 1,684 cases in 2013 to 72,332 in 2020). Following a recent case build-up during the dry season in Dire Dawa, one of the first cities in Ethiopia with confirmed *An. stephensi* presence, Dr. Tadesse's team investigated the role of *An. stephensi* to malaria transmission in a case control study from April – June 2022. Understanding the extent of the problem to inform where and how to respond in an effective and timely manner is essential. Prompt action is needed to delineate and monitor the extent of the invasion by *An. stephensi*, control the vector in places where it emerged – with the ultimate aim of preventing further spread and eliminating it from already invaded areas – and monitor the impact of interventions. In response to these developments, Ethiopia recently launched a national action plan that ambitiously aims to eliminate *An. stephensi*. Emphasized in this strategy is multidisciplinary approach, cross-border collaboration, and integration with surveillance and control of other relevant vectors including *Aedes aegypti.*

Introducing the WHO Evaluation of Vector Control Products: The role and mandate of Prequalification Team/Vector Control Product Assessment

Dr. Marion Law | Team Lead, WHO Prequalification Vector Control Product Assessment

Dr. Marion Law, Team Lead, WHO Prequalification Vector Control Products Team is a microbiologist with research experience in the area of antibiotic resistance. Before joining WHO to lead the newly formed Prequalification Team for Vector Control Product Assessment, Marion worked for a number of years in the pharmaceutical industry before moving to the Health Canada, Government of Canada to lead the newly established office of biotechnology drug evaluation. During her career with Health Canada, Marion has held a number of senior executive positions. These included positions responsible for leading health product science evaluation, developing regulation and science policy in the areas of pharmaceuticals, medical devices, vaccines, control drugs and substances, blood products, and biotechnology drugs as well as pesticides and pest control products. As a previous Chief Registrar of the Pest Management Regulatory Agency of Health Canada, and latterly as the Director General of the Therapeutic Products Directorate, Health Canada she has extensive knowledge and experience both nationally and internationally including as head of the Canadian delegation to NAFTA and also to the OECD where she was the Chair of the OECD Pesticide Registration Group and the Chair of the OECD Working Group on Pesticides as well as Health Canada head of delegation on numerous international committees in place to harmonize health product regulatory science requirements and processes.

Abstract

In 2018, WHO implemented a new evaluation approach for vector control products. This new approach was put in place to bring the assessment of these product in alignment with other health products evaluated by WHO and also to put in place a process which would encourage the development of new innovative tools and products which are urgently needed for populations at risk from vector borne diseases. The new evaluation approach, which involves the WHO Department of Regulation and Prequalification, Department of Neglected Tropical Diseases and the Global Malaria Programme work in collaboration to ensure access to vector control products which meet established standards for product quality, safety and efficacy and are covered by a WHO policy recommendation which signals that the product has demonstrated a public health value. The WHO presentation to PAMCA 2022, will provide an overview of the WHO evaluation approach and focus particularly on the Prequalification, Vector Control Product programme, the application process, data requirements and science assessment and also provide some information on the prequalified products, new products and tools in the WHO pipeline and some challenges and programme successes.

Harnessing innovations for the elimination of vector-borne diseases

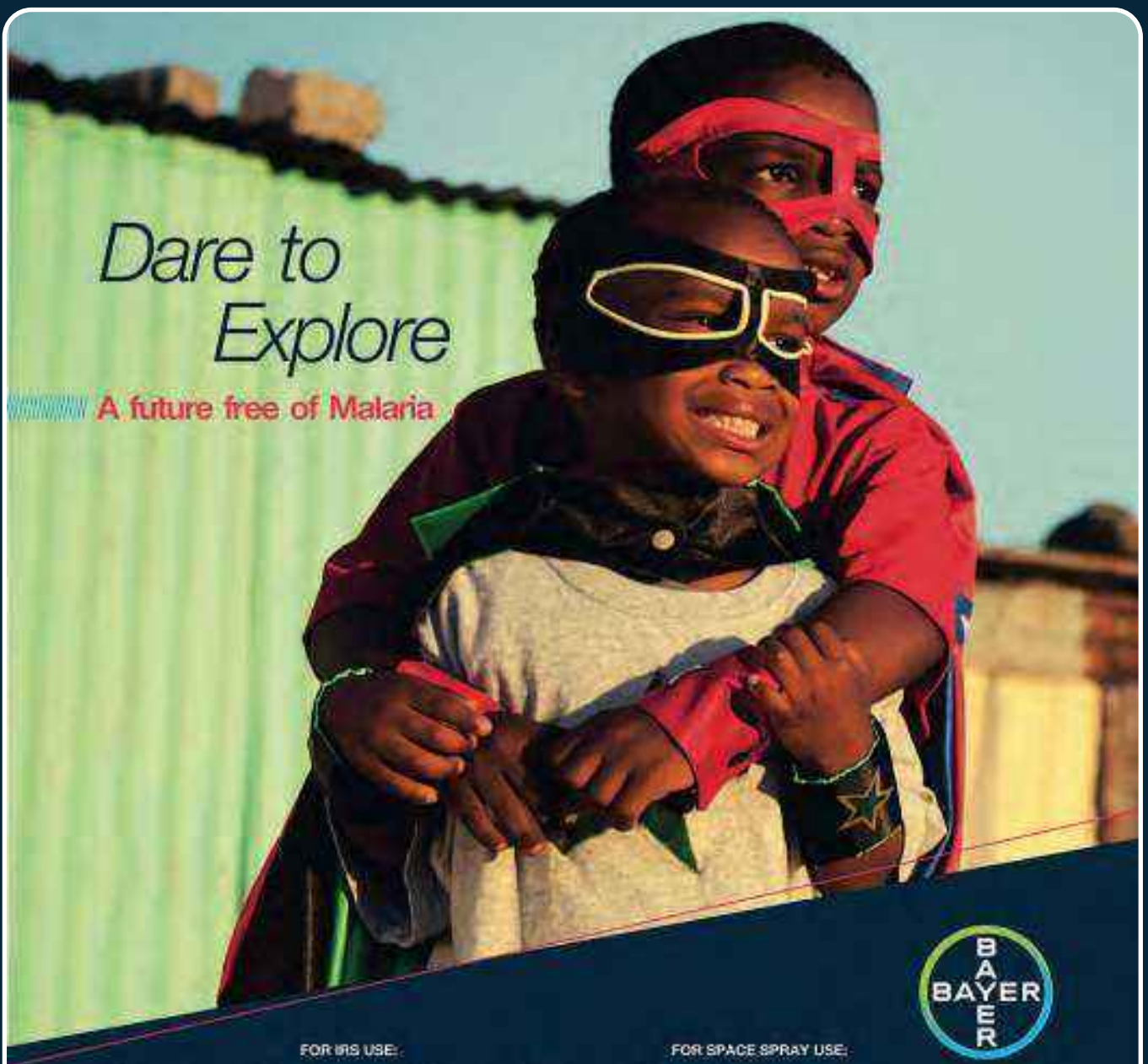
Dr. Diabate Abdoulaye | Group lead of the Vector Biology Department, Research Institute in Health Sciences (IRSS) | Director, World Bank funded Center of Excellence on Vector Borne Diseases in Burkina Faso.

Following his PhD degree in Parasitology from the University of Montpellier France, he spent four years as a postdoc fellow at the National Institute of Health United States. Diabate Abdoulaye is a vector ecologist and a leader in the fight against malaria reduction in Africa. His research areas focused on two different but complementary directions. First, it involves insecticide resistance and its management and second, it is focused on population biology, ecological studies on phenotypic variation within and between populations of mosquitoes and analyses of its genetic and environmental sources. He is particularly interested in mosquito male biology and related transgenic and sterile male's approaches to control vector diseases.

He is particularly interested in mosquito male biology and related transgenic and sterile male's approaches to control vector diseases. He has been an invited speaker in several prestigious universities including the Harvard University. He is the recipient of the Royal Society Pfizer award in 2013, laureate of the academic palms of the government of Burkina Faso in 2014, the PAMCA life achievement Award in 2019, the AAAS Newcomb Cleveland Prize in 2020 and Fellow of the African Academy of Sciences since 2021.

Abstract

Current malaria vector control strategies are heavily impaired by the widespread of insecticide resistance. There is global consensus that malaria elimination will require a diverse range of high-quality and long-lasting vector control tools. We must bring new vector control products to market rapidly and cost-efficiently and at the same time we must build a critical mass of entomologists on the ground who have the right skills to run incoming new tools. While some of the new tools on the horizon hold promise that malaria could be eliminated in the future, they may not be sufficient to reach this goal alone. A combination of various tools/methods targeting transmission dynamics and vector species will be required. Such methods include gene drive, attractive toxic sugar baits (ATSB), spatial repellents, push-pull strategy and the second generation of long-lasting insecticidal nets (LLINs) which combine 2 chemicals with different modes of action. Ironically, while the prospect of vector control is rich and diverse, Africa where these intervention tools will be most impactful may not be ready to deploy them due to insufficient local expertise and technical platform, lack of simple and robust monitoring scheme. An integrated technical platform that can operate across interventions, regions and countries, while building the necessary capacity is needed.



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Rotation is key in managing insecticide resistance, **Ficam® VC**, a bendiocarb, is an alternative in controling mosquitos. It is an **odourless** and **non staining residual** insecticide belonging to carbamate group of insecticide which will provide you an alternative for IRS use.

Together, we achieved to protect the lives of more than 250 million people from the disease in the last 10 years. Let's pursue our efforts towards a **Zero-Malaria world** and **provide healthy environments wherever people live, work and play.**

8th PAMCA Annual Conference & Exhibition | 2022

CONFERENCE PROGRAMME

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

CONFERENCE PROGRAMME

Day One: Monday September 26, 2022

Time (UTC+2)	Activity	
7:00 - 8:00	**Conference Registration at the KCC-Foyer**	
7:30 – 9:40	**Opening Ceremony** **Room:** Main Hall (MH1 & 2) **MC:** Dr. Damaris Matoke-Muhia; **Co-MC:** Dr. Jessy Goupeyou-Youmsi	
7:30 – 8:00	Entertainment	
8:00 – 8:15	Welcoming of dignitaries	MC
8:15 – 8:25	Sponsors highlight	Video
8:25 - 8:30	Welcome address	Country Chapter Chairperson
8:30 – 8:55	Opening remarks	PAMCA Executive Director
		AMCA President
		WHO Country Office
		RBM CEO
		PAMCA President
8:55–9:05	Remarks and Official opening of the conference	Chief Guest
9:05– 9:20	Group Entertainment	Cultural dance
9:20 – 9:40	Keynote Speaker	Prof. Sheila Tlou - Special Ambassador for the African Leaders Malaria Alliance (ALMA) Topic: "Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs) – ALMA's perspective
9:40– 11:00	**Coffee Break (Exhibition Hall open/ Poster Session 1 (Posters #1-50); Social Media Labs**	
11:00 – 13:00	**Scientific Sessions 1-4**	

11:00 – 13:00	**Parallel Scientific Session 1:** Vector surveillance, epidemiology, disease control programs and global health **Room:** MH1 & 2 **Session Chair:** Dr. Anne Wilson; **Co-chair:** Mr. Karisa Jonathan		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-368	Karisa Jonathan	Utility of MALDI-TOF MS for species and blood meal identification of main malaria vectors on the Kenyan coast
11:00 – 13:00	ABS-507	Yvonne Kamau	Mosquitocidal Effect and Pharmacokinetics of Different Ivermectin Dose Regimens in Preparation for Bohemia Cluster Randomized Controlled Trial
11:00 – 13:00	ABS-539	Caroline Kungu	Entomological impact of Ivermectin mass drug administration to humans and livestock: A cluster randomized controlled trial in Mopeia, Mozambique
11:00 – 13:00	ABS-324	Rock Aikpon	Increase in the malaria entomological inoculation rate following indoor residual spraying withdrawal in atacora, benin
11:00 – 13:00	ABS-344	Anne Wilson	Effect of passive and active ventilation on human comfort and malaria mosquito-house entry: an experimental study in rural Gambia
11:00 – 13:00	ABS-596	Limonty Simubali	Impact of animal enclosures on human exposure to primary vector and understudied vectors in an area targeted for malaria elimination
11:00 – 13:00	ABS-338	Sosthene Hillary	Prevalence of malaria and genetic diversity of erythrocyte binding antigen-175 in Ngali II, Centre region, Cameroon
11:00 – 13:00	ABS-478	Sarah Moore	Endpoints measured in semi-field bioassays of volatile pyrethroids and their impacts on vectorial capacity
11:00 – 13:00	ABS-572	Foko Dadji	Mosquito repellent activity of cream from essential oil of Petroselinum crispum (Apiaceae) in the city of Yaoundé Cameroon.
11:00 – 13:00	ABS-618	Coulibaly Sanata	Lamp-PCR and conventional PCR for LF xenomonitoring in endemic health districts of Burkina Faso

11:00 – 13:00	**Parallel Scientific Session 2:** Precision public health and innovations for VBD elimination: AI, entomological databases, modelling and genomic surveillance **Room:** AD10 + AD11 **Session Chair:** Dr. Eric Lucas; **Co-chair** Dr. Givemore Munhenga		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-641	Fatou Mathurin	3D infrared video tracking reveals the behavioural mode of action of permethrin-treated long-lasting insecticidal nets in the tunnel test
11:00 – 13:00	ABS-326	Dickson Lwetoijera	Infrastructure development for transgenesis research in Tanzania
11:00 – 13:00	ABS-328	Halfan Ngowo	Using Bayesian state-space models to understand the population dynamics of the dominant malaria vector, Anopheles funestus in rural Tanzania
11:00 – 13:00	ABS-416	Bazoumana Sow	An Online Platform for Real-time Age-grading and Species Determination of Malaria Vectors using Artificial Intelligence and Infrared Spectroscopy
11:00 – 13:00	ABS-501	Andrea Kipingu	Checkmate or stalemate? Modelling density-dependence and Allee effects in the malaria vector control endgame
11:00 – 13:00	ABS-523	Mauro Pazmino	Towards fast quantum cascade laser spectrometers for high-throughput and cost-effective mosquito surveillance
11:00 – 13:00	ABS-607	Eric Lucas	Genome-wide association studies and machine learning prediction reveal high predictive power of Ace-1 for pirimiphos-methyl resistance, but a highly multigenic basis for metabolic resistance
11:00 – 13:00	ABS-706	Laban Njoroge	A novel 3 in 1 mosquito trap from Kenya
11:00 – 13:00	ABS-790	Givemore Munhenga	Progress of the Sterile Insect Technique as a potential malaria vector control complimentary tool in South Africa
11:00 – 13:00	ABS-563	Mara Kont	Characterizing phenotypic resistance to insecticides in vectors: introducing a novel statistical framework for analysis of intensity bioassay data

11:00 – 13:00	**Parallel Scientific Session 3:** LLINS, IRS and Insecticide Resistance Management **Room:** AD12 **Session Chair:** Dr. Geraldine Foster; **Co-chair:** Dr. Luna Kamau		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-599	Sonhafouo Chiana	Rapid evolution of insecticide resistance and patterns of pesticides usage in agriculture in the city of Yaoundé Cameroon
11:00 – 13:00	ABS-664	Yapo Kadjo	Involvement of metabolic mechanisms in the expression of insecticide resistance in Aedes aegypti mosquitoes in Songon-Agban, southern Côte d'Ivoire
11:00 – 13:00	ABS-707	Amelie Wamba	The Cytochrome P450 CYP325A is a major driver of pyrethroid resistance in the major malaria vector Anopheles funestus in Central Africa
11:00 – 13:00	ABS-711	Aboubacar Sombie	Specific Kdr mutation haplotypes are associated to pyrethroid resistance in Aedes aegypti from Burkina Faso
11:00 – 13:00	ABS-733	Luna Kamau	Towards malaria elimination: Malaria vector species distribution and the status of insecticide resistance in selected sites in Kenya
11:00 – 13:00	ABS-741	Basiliana Emidi	Pyrethroid insecticide susceptibility status and breeding habitats preference of Aedes aegypti mosquito in the Lake zone, Tanzania
11:00 – 13:00	ABS-749	Hilary Ranson	Understanding the impact of mosquito behaviour on of the public health benefit of dual active ITNs: the ESSENTIALS project.
11:00 – 13:00	ABS-505	Sarah Moore	Experimental hut evaluation to demonstrate the non-inferiority of candidate piperonyl butoxide (PBO) Insecticide Treated Nets (ITNs) to the first in class, and enhanced mosquito mortality of
11:00 – 13:00	ABS-770	Faiza Abbas	Sociodemographic trends in malaria knowledge and implications for behavior change interventions in Zanzibar
11:00 – 13:00	ABS-561	Ngangue Siewe	Malaria transmission and insecticide susceptibility of the anopheline fauna in Njombé and Kékem, Cameroon.

11:00 – 13:00	**Parallel Scientific Session 4:** Social sciences and gender inclusivity for VBDs **Room:** MH3 **Session Chair:** Prof. Frederic Tripet; **Co-chair:** Dr. Lydia Kibe		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-716	Gerard Killeen	Strategies for cultivating independent leadership cadres at African institutions
11:00 – 13:00	ABS- 506	Sarah Moore	Efficacy of the Mosquito Shield™, a passive emanator spatial repellent, against pyrethroid-resistant malaria vectors
11:00 – 13:00	ABS-726	Eve Worrall	Informing vector control product development with qualitative and quantitative information on user preferences through a discrete choice experiment
11:00 – 13:00	ABS-552	Lina Heltsche	The role of gender in malaria interventions
11:00 – 13:00	ABS-612	Frederic Tripet	Fifty years of mosquito control research: unstructured data analysis of publication records from 1971 to 2020 highlights changes in regional research priorities, gender gaps, collaborative pa
11:00 – 13:00	ABS-678	Lusungu Kayira	Different paths to reduce malaria exposure when outdoors at night by members in Rural Malawi- Chikwawa District.
11:00 – 13:00	ABS-762	Da Silva Junior	Entomological happenings: exploring collaborative design solutions for sustainable mosquito control
11:00 – 13:00	ABS-649	Adjovi Amoudji	Evaluation of the effectiveness of preventive measures on malaria prevalence among the communities of the health district of haho, Togo (west Africa)
11:00 – 13:00	ABS-628	Caroline Monteh	Prevalence and associated factors of malaria, among Internally Displaced Children in Ntouessong health area, Central Region of Cameroon.
13:00 - 14:00	**Lunch Break (Exhibition Hall open/ Poster Session 1 (Posters #1- 50)**		
	Symposia Sessions 1 - 4		

14:00 – 15:30	**Parallel Symposium 1: Household improvements for Vector Control: User-led design** **Room**: MH3 **Organizer**: Prof. Ann H. Kelly, King's College London **Speakers:** · Ann H. Kelly (King's College London, United Kingdom) · Denise Valle (Oswaldo Cruz Foundation, Brazil) · Denise Nacif Pimenta (Oswaldo Cruz Foundation, Brazil) · Ibrahim Msuya (Ifakara Health Institute, Tanzania) · Liz McCormick (University of North Caroline at Charlotte, USA)
14:00 – 15:30	**Parallel Symposium 2**: **Gene drive mosquitoes: New approaches for community engagement and agreement in vector control** **Room:** MH1 & 2 **Principal organizer**:. Samantha O'Loughlin, Imperial College London **Co-organizer:** Ana Kormos, University of California Malaria Initiative (UCMI) **Speakers:** · Aaron Roberts (McMaster): Why is gene drive different? · Dr. Silas Obukosia (NEPAD): What does regulation say about engagement? · Ana Kormos *or colleague* (UCMI): A relationship-based SE model for gene drive research · Lea Pare Toe (IRSS, Target Malaria): Learnings on community engagement from the release of sterile GM mosquitoes · Naima Sykes (Imperial College London, Target Malaria): A community agreement model for fertile (non-gene drive) GM mosquitoes
14:00 – 15:30	**Parallel Symposium 3**: **Supporting improved insect resistance management strategies – a new mode of action for Indoor Residual Spray (IRS) programmes** **Room:** AD10+AD11 **Principal organizer:** Maezawa Takeo (Mitsui Chemicals Agro, Inc.) / **Co-organizer:** Dr. Graham Small (IVCC) **Speakers:** · Dr. Janneke Snetselaar (IVCC): Implementation of insecticide resistance management by rotation of IRS products with different modes of action · Kawase Ayumi (Mitsui Chemicals Agro, Inc.): Introduction to VECTRONTM T500 · Dr. Samuel Dadzie (Noguchi Memorial Institute for Medical Research): A semi-field trial of VECTRON™ T500 against susceptible and resistant field Anopheles gambiae s.l. in Odumse, Dodowa, Southern Ghana · Dr. Steven Gowelo (University of Malawi Vector-borne disease laboratory): Malaria theme: Community trial evaluation of VECTRON™ T500 in the south-eastern region of Malawi · Dr. Hien S. Aristide (CNRST/IRSS-DRO): Community (Phase Ⅱ) trial of residual effect and efficacy of a new IRS product VECTRON™ T500 (broflanilide) against susceptible and pyrethroid-resistant Anopheles gambiae s.l. populations from rural Burkina Faso
14:00 – 15:30	**Parallel Symposium 4: The mosquito abatement district learning exchanges: Lessons from the American mosquito control model** **Room**: AD12 **Organizer**: Elijah Juma, PhD; **Co-organizer**: Samuel Rund, PhD **Speakers:** · Ary Fraji, PhD - Salt Lake Mosquito Abatement District, UT, USA · Mark Breidenbaugh – Northwest Mosquito & Vector Control District, CA, USA · Prosper Chaki, PhD – PAMCA Executive Director

15:30 – 16:30	**Turbo Talks (requested for oral but assigned poster)** **Room:** MH1&2 **Chair:** Dr. Jewelna Akorli; **Co-chair:** Ms. Rosalia Joseph
16:30 – 17:00	**Coffee Break (Exhibition Hall open/ Poster session 1 (Posters #1-50); Social Media Labs**
	Day One Ends
20:00- 22:00	**Quiz Night – PAMCA Vestergaard** **Implication of the dance gene in brain** **Room -- Fairview**

Day Two: Tuesday September 27, 2022

Time (UTC+2)	Activity		
7:00 - 8:00	**Special Meeting; Young – Senior Investigator/Mentor Breakfast Meeting**		
8:00- 8:30	**Conference Registration at the KCC-Foyer**		
8:30 – 9:50	**Plenary Talks 1-4** **Room:** Main Hall (MH1&2) **Chair:** Dr. Damaris Matoke-Muhia; **Co-Chair:** Dr. Sam Kiware		
8:30 - 8:50	**Plenary Talk 1: Dr. Corine Karema** Topic: Changing malaria Epidemiology and role of data for decision making		
8:50 – 9:10	**Plenary Talk 2: Drs. Heather Ferguson** and **Nico Govella** Topic: Potential impacts of climate change on malaria vector control in Africa		
9:10– 9:30	**Plenary Talk 3: Dr. Mark Latham** Topic: LSM in operational mosquito control programs: Lessons from the past and tools for the future		
9:30– 9:50	**Plenary Talk 4: Marion Law** Topic: Introducing the WHO Evaluation of Vector Control Products: The role and mandate of Pre-qualification Team/Vector Control Product Assessment		
9:50– 10:30	**Coffee Break (Exhibition Hall open/ Poster Session 2 (Posters #51-100);** **Social Media labs**		
	Scientific sessions 5 - 8		
10:30 – 12:30	**Parallel Scientific Session: 5:** Larval source management and integrated vector management **Room:** MH 1 & 2 **Session chair:** Dr. Silas Majambere; **Co-chair:** Dr. Antonio-Nkondjio		
	Abstract N°	**Speaker**	**Abstract Title**
10:30 – 12:30	ABS-518	Antonio-Nkondjio	High efficacy of microbial larvicides for malaria vectors control in the city of Yaounde Cameroon following a cluster randomized trial
10:30 – 12:30	ABS-367	Lenson Kariuki	Community-based Larval Source Management in Kenya
10:30 – 12:30	ABS-491	Denis Kailembo	Implementation of Community-based Larval Source Management for Enhancing Malaria Control in mainland Tanzania. A process narration.

10:30 – 12:30	ABS-594	Nkahe Diane	Fitness cost of the bio-larvicide VectoMax G on pyrethroid-resistant populations of Anopheles coluzzii; contribution to resistance management
10:30 – 12:30	ABS-327	Doumbe Belisse	Assessing malaria transmission and vector dynamic in a context of larviciding trial in the city of Yaoundé, Cameroon.
10:30 – 12:30	ABS-519	Carmène Ngadjeu	Association between house characteristics and community practices on anophelines distribution and malaria prevalence before and during a larviciding program in the city of Yaoundé-Cameroon.
10:30 – 12:30	ABS-550	Nina Yensii	Contribution of VectoMax®G, a larvicide for the control of mosquito densities and malaria transmission in some districts in the city of Yaoundé
10:30 – 12:30	ABS-617	Nnennaya Obasi Uwalaka	Chlofenapyr and clothiandian; larvicidal for control of malaria vector
10:30 – 12:30	ABS-796	Steven Gowelo	The masked contribution of Larval Source Management in malaria control in the context of high insecticide-treated bed net use
10:30 – 12:30	ABS-797	Theresia Nkya	Evaluating the impact of community-based winter larviciding on malariann transmission in countries aiming for malaria elimination in southern Africa countries: The case of Namibia and Botswana
10:30 – 12:30	**Parallel Scientific Session 6:** LLINS, IRS and Insecticide Resistance Management **Room:** MH3 **Session chair:** Prof. Charles Wondji; **Co-chair:** Ms. Rosheen Mthawanji		
	Abstract N°	**Speaker**	**Abstract Title**
10:30 – 12:30	ABS-578	Mersimine Kouamo	Allelic variation of GSTe3, GSTe4 and GSTe6 contributes to insecticide resistance in Anopheles funestus
10:30 – 12:30	ABS-600	Patrick Tungu	Long-lasting performance of pyrethroid-PBO LLINs against pyrethroid resistant mosquitoes: a post market evaluation of PermaNet® 3.0
10:30 – 12:30	ABS-622	Eggrey Kambewa	Residual efficacy testing of Actellic 300CS for Indoor Residual Spraying and vector susceptibility to insecticides in Mangochi, Malawi
10:30 – 12:30	ABS-626	Nelly Armanda	Insecticides resistance across the Sahelian, Humid savanna, Highland, Coastal and Forest eco-epidemiological settings in Cameroon

10:30 – 12:30	ABS-772	Maria Pondja	Complexity and challenges in managing insecticide resistance in the main malaria vectors in Mozambique
10:30 – 12:30	ABS-325	Rock Aikpon	Digitalized mass distribution campaign of insecticide-treated nets (itns) in the particular context of covid-19 pandemic in benin: challenges and lessons learned
10:30 – 12:30	ABS-687	Metitsi Danale	Evaluation of the effectiveness of malaria control tools prior to the distribution campaign of new long-lasting insecticide-treated nets in Southern Cameroon
10:30 – 12:30	ABS-697	Joel Odero	Countrywide entomological surveillance and insecticide resistance of Anopheles funestus mosquitoes in Tanzania
10:30 – 12:30	ABS-754	Agnes Matope	The video cone test plus system: assessing the utility of using anopheles gambiae behavioural responses to evaluate insecticide-treated bed net efficacy
10:30 – 12:30	ABS-377	Nancy Matowo	Two-year entomological surveillance results from a cluster-randomized controlled trial assessing the effectiveness of dual active ingredients Long-Lasting Insecticidal Nets (LLINs) compared to pyrethroid-only LLINs in north-western Tanzania
10:30 – 12:30	ABS-534	Barnabas Zogo	Laboratory and field experiences with SumiShieldTM 50WG, 5 years on
10:30 – 12:30	**Parallel Scientific Session 7:** New and re-emerging arthropod-borne viruses, climate change, NTDs and One Health **Room:** AD10 & 11 **Session chair:**; Dr. Joel Lutomiah **Co-chair:** Dr. Obame-Nkoghe		
	Abstract N°	**Speaker**	**Abstract Title**
10:30 – 12:30	ABS-332	Catd Colonel	Epidemiology of rift valley fever in Mali: Cases of Yelimane, Nioro, Kenieba and the hydro-agricultural areas of the Markala, Selingue and Manantali dams
10:30 – 12:30	ABS-509	Remy Hoek Spaans	Climate change Impact on malaria transmission in high-resolution climate simulations (C2mt-HighreS)
10:30 – 12:30	ABS-373	Tasneem Osman	Alteration of plant species could control arboviral disease vectors: Evidence from Kenya

10:30 – 12:30	ABS-529	Andrew Muganda	Schistosoma mansoni co-infection decelerates murine Plasmodium berghei ANKA induced inflammatory response and organ damage
10:30 – 12:30	ABS-598	Obame-Nkoghe	The Asian Tiger Mosquito invasion story in forest of Central Africa and potential consequences in a One Health perspective.
10:30 – 12:30	ABS-602	Carine Tchibozo	Longitudinal surveillance of arboviruses in Benin: Detection of Dengue virus 3 in Ae. aegypti
10:30 – 12:30	ABS-603	Gildas Hounkanrin	First detection of the invasive mosquito vector Aedes albopictus (Skuse, 1894) in Benin, West Africa, 2021
10:30 – 12:30	ABS-650	Koala Lassane	Prospects for developing efficient targets for the xenomonitoring and control of Simulium damnosum s.l., the major vectors of onchocerciasis in Africa.
10:30 – 12:30	ABS-660	Samson Konongoi	Detection of emerging and re-emerging arbovirus infections in Kenya: The KEMRI Viral Hemorrhagic Fever Laboratory Perspective
10:30 – 12:30	ABS-700	Daniel Msellemu	The use of household suitability score on prediction of Aedes mosquitoes abundance as a preventive measure to dengue outbreak.
10:30 – 12:30	**Parallel Scientific Session 8:** Vector biology, ecology, taxonomy and population genetics **Room:** AD12 **Session chair:** Dr. Agapitus Kato; **Co-chair:** Dr. Ayodele Babalola		
	Abstract N°	**Speaker**	**Abstract Title**
10:30 – 12:30	ABS-531	Agapitus Kato	Phenotypic stability of natural pigmentation trait in anopheles gambiae indicates readiness of the uganda virus research institute acl-2 facility to handle transgenic mosquitoes.
10:30 – 12:30	ABS-560	Fatoumata Seck	Genetic diversity of genes involved into Anopheles gambiae s.l fertility and vector competency in Sub-Saharan Africa
10:30 – 12:30	ABS-720	Diego Ayala	Predicting urban adaptation of Anopheles gambiae and Anopheles coluzzii, major malaria vectors, in Central Africa
10:30 – 12:30	ABS-359	Seynabou Sougoufara	High-throughput sperm tracking technique for Anopheles male mating competitiveness studies

10:30 – 12:30	ABS-369	Akpodiete	Improvement of water quality for mass anopheline rearing dynamics of larval tray bacterial communities under different water treatments revealed by 16s ribosomal RNA ultra-sequencing
10:30 – 12:30	ABS-547	Ndo Cyrille	IgG Antibody responses to Anopheles gambiae gSG6-P1 salivary peptide are induced in human populations exposed to secondary malaria vectors in forest areas in Cameroon
10:30 – 12:30	ABS-755	Romoke Jimoh	Polymorphic inversion 2la frequencies associate with ecotypes in populations of an. Gambiae across Nigeria
10:30 – 12:30	ABS-758	Ayodele Babalola	Spatial distribution and ecological niche modeling of geographical spread of *Anopheles gambiae, Anopheles coluzzii* and *Anopheles arabiensis* (Diptera: Culicidae) in Nigeria using real time data
10:30 – 12:30	ABS-769	Nadifo Ismail	Bioecology of the different species of Anopheles from Djibouti involved in the vectorial transmission of malaria
10:30 – 12:30	ABS-370	Brigid Kemei	Application of a spatially explicit sampling design to identify heterogeneities in the distribution of mosquitoes
10:30 – 12:30	ABS-795	Marianne Sinka	The Vector Atlas: An open access platform for African malaria vector data, maps and evidence-based spatial models specifically targeting mosquito control.
12:30 - 14:00	**Lunch Break/Exhibition Hall open/ Poster Session 2 (Posters #51-100)**		
14:00 – 16:30	**Roundtable Discussions 1 & 2 –** Main Hall (MH 1&2)		
14:00 – 15:00	**Roundtable Discussion 1:** Harnessing the capacity of African institutions for strengthened response against vector-borne diseases **Organizer:** Dr. Prosper Chaki; **Co-organizer:** Ms. Emma Orefuwa		
15:00 – 16:00	**Roundtable Discussion 2:** The development journeys of global women leaders in vector control and men allies **Organizer:** Dr. Damaris Matoke; **Co-organizers:** Dr. Jessy Goupeyou-Youmsi, Ms. Rosalia Joseph, Ms. Christina Sudi		
16:00 – 16:30	**Launch of PAMCA WIVC Mentorship programme**		

14:00 – 15:30	**Coffee Break/Exhibition Hall open/ Poster Session 2 (Posters #51-100); Social Media Labs**
	Day Two Ends
18:30 - 21:00	**Africa Night (African Experience)** **Room:** Kigali Cultural & Exhibition Village

Day Three: Wednesday September 28, 2022

Time (UTC+2)	Activity		
7:00-8:00	**Medical Anthropologists/ Social Scientists Meeting** **Room:** AD12		
8:00 - 8:30	**Conference Registration at the KCC Foyer**		
8:30 – 10:40	**Plenary Talks 5 – 7** **Room:** Main Hall (MH 1 &2) **Chair:** Dr. Silas Majambere; **Co-chair:** Dr. Evelyn Olanga		
8:15- 8:35	**Plenary Talk 5: Dr. Jaiyshree Raman** Topic: Using malaria genomics to accelerate Africa towards malaria elimination		
8:35 – 8:55	**Plenary Talk 6: Dr. Fitsum Girma** Topic: Threats to the gains in malaria control posed by the invasion of *An. stephensi*, an urban malaria transmitting mosquito		
8:55 – 9:15	**Plenary Talk 7: Dr Abdoulaye Diabate** Topic: Harnessing innovations for the elimination of VBDs		
9:15 – 10:40	Sponsors presentations		
10:40– 11:00	**Coffee Break/Exhibition Hall open/ Poster Session 3 (Posters #101-150),** **Social Media Lab**		
	Scientific Sessions 9-12		
11:00 – 13:00	**Parallel Scientific Session 9:** Vector surveillance, epidemiology, disease control programs and global health **Session Chair:** Dr. Diabate Abdoulaye; **Co-chair:** Dr. Mercy Opiyo **Room**: AD12		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-620	Djappi Tchamen	*Aedes* mosquito surveillance in Yaoundé, Cameroon using ovitraps, sweep nets and Biogent traps
11:00 – 13:00	ABS-643	Meshesha Balkew	Structures preferred for resting by *Anopheles arabiensis* in Ethiopia
11:00 – 13:00	ABS-654	Charles Ntege	Anopheles mosquito observatory in Uganda
11:00 – 13:00	ABS-694	Damon Roger	Rapid age-grading and species identification of natural mosquitoes for malaria surveillance

11:00 – 13:00	ABS-729	Isaac Stopard	Mechanisms affecting sporozoite prevalence in wild mosquito populations
11:00 – 13:00	ABS-730	Dulcisaria Marrenjo	Feeding behavior of malaria vectors and its implications in malaria control, Mozambique
11:00 – 13:00	ABS-363	Seline Omondi	Natural sugar feeding rates of *Anopheles* mosquitoes collected by different methods in western Kenya
11:00 – 13:00	ABS-536	Magreth Shayo	Optimisation of tunnel tests: an important bioassay for vector control product evaluation
11:00 – 13:00	ABS-553	Poumachu Yacouba	House improving as a supplemental intervention tool for reducing indoor vector densities and malaria prevalence in Emana, center Cameroon.
11:00 – 13:00	ABS-556	Mercy Opiyo	Development, piloting, and evaluation of an Entomological Adaptive Sampling Framework (EASF)
11:00 – 13:00	ABS-793	Adeogun Adedapo ,	Progress in malaria vector surveillance in combatting insecticide resistance in Nigeria: lesson learnt from the past to reach a future free of malaria
11:00 – 13:00	ABS-522	Mafalda Viana	Dissecting the impacts of interventions on mosquito fitness and population dynamics using standard entomological surveillance data
11:00 – 13:00	**Parallel Scientific Session 10:** Vector biology, ecology, taxonomy and population genetics **Session chair:** Dr. Jewelna Akorli; **Co-chair:** Dr. Etienne Bilgo **Room**: AD10 + AD11		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-346	Come Koukpo	The evolution of the genetic structure of populations of two species of the *Anopheles gambiae* s.l. complex using the *Kdr* gene before and after indoor residual spraying in some agroecological zones of Benin (West Africa)
11:00 – 13:00	ABS-476	Jackline Kosgei	Evaluation Of Different Trapping Methods for the Collection of Anopheles Mosquitoes in Western Kenya
11:00 – 13:00	ABS-569	Victor Balyesima	Life history parameters of two *Anopheles gambiae* phenotypes in target malaria ACL 2 insectaries, a proxy for rearing performance.

11:00 – 13:00	ABS-573	Gift Mwaanga	Monitoring species diversity, abundance, composition and parasite infections of *Anopheles* mosquitoes in a malaria-endemic area of Luampa District, Western Province, Zambia.
11:00 – 13:00	ABS-577	Samuel Akporh	Assessing the effectiveness of powdered beans, maize, and dried herrings as alternative feed on the larval development of *Anopheles gambiae s.l* mosquito
11:00 – 13:00	ABS-597	Esinam Akorli	Bacterial products from mosquito midgut microbiota negatively impact parasite burden of P. falciparum in Anopheles gambiae.
11:00 – 13:00	ABS-611	Rosine Wolie	Impact of a "lethal house lure" intervention on malaria transmission intensity and Anopheles mosquito vector diversity during a cluster randomized controlled trial in central Côte d'Ivoire
11:00 – 13:00	ABS-635	Etienne Bilgo	Molecular basis of immune response of combining Wolbachia and entomopathogenic fungi for Dengue Control in Burkina Faso
11:00 – 13:00	ABS-668	Hyacinthe Toe	Longitudinal survey on Aedes aegypti larval ecology in urban and peri-urban sites of Burkina Faso: implication for dengue control
11:00 – 13:00	ABS-688	Honorine Kabore	Study of the polymorphism of the fruitless gene in Anopheles coluzzii in 9 African countries
11:00 – 13:00	**Parallel Scientific Session 11:** Precision public health and innovations for VBD elimination: AI, entomological databases, modelling and genomic surveillance **Session Chair:** Dr. Samson Kiware; **Co-chair:** Jeanne Lemant **Room**: MH3		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-568	Jeanne Lemant	Validating the modelled impact of vector control interventions using randomised controlled trials
11:00 – 13:00	ABS-604	Tristan Ford	Expanding vector surveillance capabilities with a system for rapid training and deployment of deep learning techniques for automated identification, counting, and digitization of mosquito vectors

11:00 – 13:00	ABS-613	Lakamy Sylla	Genetically modified mosquito technologies in malaria control. Where are we in Mali?
11:00 – 13:00	ABS-639	Edith Madumla	A mixed methods evaluation of factors associated with discarding of long-lasting insecticidal nets in Bagamoyo, Tanzania
11:00 – 13:00	ABS-658	Innocent Tia	Efficacy of a 'lethal house lure' against Culex quinquefasciatus from Bouaké, central Côte d'Ivoire
11:00 – 13:00	ABS-496	Abdoulaye Niang	The development of target spraying technology: bioassay test shows potential impact of the swarm-killing in Anopheles gambiae s.l. malaria vectors
11:00 – 13:00	ABS-546	Lalasoa Felamboa	Irradiation Dose Optimisation of A Colonised Anopheles Funestus Strain
11:00 – 13:00	ABS-585	Frederik Seelig	The Global Vector Hub - building entomological capacity worldwide and improving epidemic preparedness
11:00 – 13:00	ABS-646	Mamadou Diallo	Genomic surveillance of Pfcsp, the RTS,S/AS01 malaria vaccine target antigens in Senegalese parasiteS
11:00 – 13:00	ABS-702	Tania Gbenou	Spatial distribution and modeling of the ecological niche of vectors and the pathogen of lymphatic filariasis (Wuchereria bancrofti (cobbold, 1877) in the context of climatic and global chain
11:00 – 13:00	**Parallel Scientific session 12:** LLINS, IRS and Insecticide Resistance Management **Room:** MH1 &2 **Session Chair:** Dr. David Weetman; **Co-chair:** Dr. Leon Mugenzi		
	Abstract N°	**Speaker**	**Abstract Title**
11:00 – 13:00	ABS-498	Thomas Syme	Assessing the entomological performance of next-generation chlorfenapyr-treated nets in the presence of pyrethroid-piperonyl butoxide (PBO) insecticide-treated nets
11:00 – 13:00	ABS-499	Jackline Martin	Bio-efficacy and durability (insecticidal and physical) of next generation insecticide-treated bed nets against pyrethroid resistant malaria vectors in Tanzania.

11:00 – 13:00	ABS-510	Eliud Lukole	Textile durability and protective efficacy against malaria of a PBO-pyrethroid synergist-treated nets Olyset® Plus, over 3-year in Tanzania
11:00 – 13:00	ABS-565	David Weetman	Comparative effectiveness of single and dual-treated bednets on malaria prevalence at antenatal clinics in Sud Ubangi, Democratic Republic of Congo
11:00 – 13:00	ABS-586	Yadouleton Anges	Susceptibility profiles of Aedes aegypty to different families of insecticide in three ecological zones in Benin
11:00 – 13:00	ABS-588	Leon Mugenzi	Impacts of a 4.3kb structural variant on Gene Expression and insecticide resistance phenotype in the malaria vector An. funestus s.s.
11:00 – 13:00	ABS-621	Beatus Cyubahiro	Residual efficacy and entomological impact of new generation insecticides, Actellic® 300CS (Pirimiphos-methyl) and Fludora® Fusion WP-SB 56.25 in two Districts of Rwanda
11:00 – 13:00	ABS-662	Isaac Namango	Timing of infective anopheline biting and human behaviour under high indoor residual spraying (IRS) and insecticide treated net (ITN) use in Ulanga, Tanzania
11:00 – 13:00	ABS-759	Luc Djougbenou	Impact of exposure to insecticide-treated nets on host-seeking behaviour and life-history traits in *Anopheles. gambiae* s.l using a baited box bioassay
11:00 – 13:00	ABS-339	Benjamin Menze	Experimental hut trials reveal that CYP6P9a/b P450 alleles are reducing the efficacy of pyrethroid-only Olyset net against the malaria vector Anopheles funestus but PBO-based Olyset Plus net
11:00 – 13:00	ABS-320	Heather Ferguson	Potential impacts of climate change on malaria vector control in Africa
13:00 - 14:00	**Lunch Break (Exhibition Hall open/ Poster Session 3 (Posters #101-150)**		
14:00 – 15:30	**Symposia Sessions 5-8**		

14:00 -15:30	**Parallel Symposium 5**: **Strengthening the nexus between parasite and vector genomics to accelerate malaria elimination in Africa** **Room:** AD12 **Organizer**: Isabella Oyier, PhD; **Co-organizer**: Elijah Juma, PhD **Speakers:** · Alistair Miles, PhD (PAMCA-MalariaGEN Vector Genomics Surveillance Program) · Deus Ishengoma, PhD (PAMCA-MalariaGEN Vector Genomics Surveillance Program) · Isabella Oyier, PhD (East Africa Malaria Molecular Surveillance Network)
14:00-15:30	**Parallel Symposium 6**: **Presenting the ATSB® (Attractive Targeted Sugar Bait); a novel outdoor intervention** **Room**: MH3 **Co-organizers**: Mathias Mondy (IVCC) / Dave Malone (BMGF) **Speakers:** · Prof. Woody Foster (The Ohio State University): Mosquitoes Sugar Feeding Biology · Michal Elias Gez (Westham): Westham Story · Nick Yalla (KEMRI): Assessing attractiveness of [Westham] ATSBs compared with local flora in the semi-field system · Mohamad Traore (Bamako university) / Eric Ochomo (KEMRI): Entomological & Epidemiological Trials · Javan Chanda (PATH/Zambia): Product Acceptance -Field & community insights
14:00-15:30	**Parallel Symposium 7**: **Regulating the use of genetically modified mosquitoes for malaria control in Africa** **Room:** AD10&11 **Co-organizers**: Wolfgang Richard Mukabana (AFIDEP) / Dr. Rose Oronje (AFIDEP) **Speakers:** · Charles Mbogo (KEMRI-Wellcome Trust Research Programme): Novel approaches for malaria vector control in Africa · Moussa Savadogo (AUDA – NEPAD): Strengthening regulatory capacity on genetic based vector control in Africa · Rufus Ebegba (National Biosafety Management Agency, Nigeria): Issues in the regulation of Genetically Modified Mosquitoes in Africa · Hennie Groenewald (Biosafety South Africa), The sensible governance of induced genetic variation

14:00-15:30	**Parallel Symposium 8: Strengthening entomological surveillance capacity towards malaria elimination in sub-Saharan** Africa **Room:** MH1&2 **Principal organizer:** Pan-African Mosquito Control Association (PAMCA), Kenya **Co-organizers**: Ifakara Health Institute (IHI), Tanzania; Centre for Research in Infectious Diseases (CRID), Cameroon; Institut de Recherche en Sciences de la Santé (IRSS), Burkina Faso **Speakers:** · Emma Orefuwa (PAMCA): Strengthening local capacity for malaria surveillance and elimination in sub-Saharan Africa: An overview of the surveillance program · Ghislaine Ouedraogo-Ametchie (PAMCA): Landscaping of malaria vector control and surveillance in Burkina Faso, Cameroon and Tanzania. · Betwel John Msugupakulya (IHI); Emmanuel Elanga (CRID); Abdoulaye Niang (IRSS): Improving vector surveillance capabilities in Tanzania, Cameroon and Burkina Faso: Updates from Centres of Excellence **Panel discussion:** Experiences from the field: Impact and lessons learnt from the district entomology training program in PAMCA's 3 regional centres of excellence in Burkina Faso, Cameroon and Tanzania · Fuh Adangwa Donatien: Ministry of public health, Regional Delegation for South West, Cameroon · Souimbou Sanon: District Sanitaire de Dandé, Ministère de la Santé, Burkina Faso · Rosemary Nshama: Ministry of Health, Community Development, Gender, Elderly & Children, Tanzania	
15:30 – 16:00	**Coffee break; (Exhibition Hall open/ Poster session 3 (Posters #101-150);** **Social Media Labs**	
16:00 – 16:30	**Closing Ceremony – Main Hall** **MC:** Dr. Damaris Matoke-Muhia; **Co-MC:** Dr. Jessy Goupeyou-Youmsi	
16:00 - 16:10	WIVC Awards	Introduction of WIVC Awards ceremony recognition of sponsors
16:10 – 16:20	Closing remarks	Country Chapter President
		Executive Director
		PAMCA President
16:20 – 16:25	Vote of thanks and Announcement of next conference host	Ag. PAMCA DSP
16:25 – 16:30	**Coffee break; (Exhibition Hall open/ Poster Session 3 (Posters #101-150)**	
16:30 - 18:00	**PAMCA MEMBER BUSINESS MEETING**	

Day Four : September 29, 2022

Event	Venue	Time
Field Visit/Demo	Mareba Entomology Sentinel Site	9:00-12:00 pm
Policy Workshop	KCC-AD9	9:00 – 4:00 pm

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SYMPOSIA

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

SYMPOSIA

Parallel Symposium 1

Household improvements for Vector Control: User-led design

Organizer: Prof. Ann H. Kelly, King's College London

Speakers

Ann H. Kelly (King's College London, United Kingdom)

Denise Valle (Oswaldo Cruz Foundation, Brazil)

Denise Nacif Pimenta (Oswaldo Cruz Foundation, Brazil)

Ibrahim Msuya (Ifakara Health Institute, Tanzania)

Liz McCormick (University of North Caroline at Charlotte, USA)

Description and Justification

Improving the quality of the built environment is one of the most effective measures against mosquito-borne diseases. Yet this protection needs to be extended to particularly vulnerable populations and, critically, to those living in rural communities, where the risk of disease is compounded by those posed extreme weather events such as heat waves, drought, and food shortages. Efforts to make housing more protective often leads to dwellings with reduced air transmission, substandard air quality and low levels of interior comfort. Additionally, residents can be sceptical of substantial interventions to their built environment, particularly those that affect domestic space, if they do not have a direct say in design decisions. Despite best intentions, outside developers often rely on the regional aesthetic, while overtly vernacular styles may reinstate stigmas of poverty in communities that seek modern buildings.

This symposium will discuss the role that buildings play as an exposure pathway for mosquito-borne disease within the context of a rapidly changing climate, particularly in low-resource settings. Bringing together social scientists, entomologists, architects and engineers, the symposium will explore these questions with a particular focus on the potential of user-led innovation to embed public health concerns in the improvement of the building stock. At a time when the conventional tools for malaria control and prevention – Indoor Residual Spraying (IRS) and Insecticide-Treated Nets (ITNs) – are reaching the limit of their efficacy, cross-cutting methodologies that elicit and capitalize on local expertise are urgently needed.

Presenting a diverse set of experiences working in global health and sustainable development, this symposium seeks to consider new avenues in household design and catalyse a broader discussion on frugal and locally appropriate approaches to global health innovation. The symposium will also present examples of carbon neutral building envelope technologies currently under development through a collaboration between the University of North Carolina at Charlotte School of Architecture, King's College London Department of Global Health & Social Medicine, the Ifakara Health Institute in Tanzania, and the Oswaldo Cruz Foundation in Brazil.

Parallel Symposium 2

Gene drive mosquitoes: New approaches for community engagement and agreement in vector control

Principal organizer: Samantha O'Loughlin, Imperial College London

Co-organizer: Ana Kormos, University of California Malaria Initiative (UCMI)

Speakers

Aaron Roberts (McMaster): Why is gene drive different?

Dr Silas Obukosia (NEPAD): What does regulation say about engagement?

Ana Kormos *or colleague* (UCMI): A relationship-based SE model for gene drive research

Lea Pare Toe (IRSS, Target Malaria): Learnings on community engagement from the release of sterile GM mosquitoes

Naima Sykes (Imperial College London, Target Malaria): A community agreement model for fertile (non-gene drive) GM mosquitoes

Description

Effective community engagement has long been recognised as important to the success of vector control programs. Although still at a research stage, gene drive mosquitoes are a promising new tool for vector control. As an area-wide intervention using ground-breaking technology, gene drive mosquitoes raise new ethical questions surrounding engagement. The aim of this symposium will be to bring these questions to an audience of vector control researchers and practitioners. The symposium will consist of a five-minute introduction by the moderator, followed by 15-minute talks by five speakers, then 40 minutes for questions and discussion. The first speaker will be an ethics specialist to introduce how stakeholder engagement for gene drive differs from that of conventional vector control methods. Secondly, a regulatory expert will outline the existing regulatory framework regarding public consultation and community engagement for living modified organisms, including gene drives. The third speaker will describe a potential model for stakeholder engagement for gene drive research, and the fourth will describe learnings from the experience of the first experimental release of genetically modified mosquitoes in Africa. The final speaker will present a proposed model for community agreement for the release of fertile non gene drive GM mosquitoes in Africa. During the discussion, the thoughts and opinions of the audience will be sought to provide insights and synergies between the stakeholder engagement and vector control communities.

Justification

Gene drive mosquitoes are showing great promise as a novel tool for vector control. They have been recognised in the Lancet report as a promising transformative tool for malaria elimination (Feachem et al., 2019). Harnessing innovation to end malaria was WHO's World Malaria Day theme showing how critical the issue is for the malaria community. At this occasion, gene drive mosquitoes were featured as one of the potentially transformative tools. Over the last few years, discussions have taken place about ethical considerations, community engagement strategies, and questions surrounding community participation in the decision-making process. The WHO guidance on ethics for vector-borne diseases showed that, while a lot of attention has been driven by future gene drive applications, these discussions are relevant for the whole vector control sector. As such it is important to take the opportunity of PAMCA to share the work done on community engagement around gene drive mosquitoes.

Parallel Symposium 3

Supporting improved insect resistance management strategies – A new mode of action for Indoor Residual Spray (IRS) programmes

Principal organizer: Maezawa Takeo, Mitsui Chemicals Agro, Inc., takeo.maezawa@mitsuichemicals.com

Co-organizer: Dr. Graham Small, IVCC, graham.small@ivcc.com

Speakers:

Dr. Janneke Snetselaar (IVCC, janneke.snetselaar@ivcc.com): Implementation of insecticide resistance management by rotation of IRS products with different modes of action

Kawase Ayumi (Mitsui Chemicals Agro, Inc., ayumi.kawase@mitsuichemicals.com): Introduction to VECTRONTM T500

Dr. Samuel Dadzie (Noguchi Memorial Institute for Medical Research, sdadzie@noguchi.ug.edu.gh): A semi-field trial of VECTRON™ T500 against susceptible and resistant field Anopheles gambiae s.l. in Odumse, Dodowa, Southern Ghana

Dr. Steven Gowelo (University of Malawi Vector-borne disease laboratory, gowellsteve@gmail.com): Malaria theme: Community trial evaluation of VECTRON™ T500 in the south-eastern region of Malawi

Dr. Hien S. Aristide (Chargé de Recherche en Entomologie médicale CNRST/IRSS-DRO, aristide.hien@yahoo.fr): Community (Phase ☒) trial of residual effect and efficacy of a new IRS product VECTRON™ T500 (broflanilide) against susceptible and pyrethroid-resistant Anopheles gambiae s.l. populations from rural Burkina Faso

Description

The effectiveness of interventions such as IRS and LLINs which, since the turn of the century, has halved malaria deaths, are being increasingly threatened by the development and spread of insecticide resistance. New chemistries are urgently needed to support the rotation of insecticides in line with best practice Insecticide Resistance Management (IRM).

VECTRON™ T500 is a new indoor residual spray product containing broflanilide, a meta-diamide insecticide, discovered and named TENEBENAL™ by Mitsui Chemicals Agro, Inc. With a unique Mode of Action, it has shown good performance against susceptible and resistant mosquitoes.☒Laboratory and small-scale experimental hut studies have confirmed the good residual efficacy of this formulation and, more recently, data have been gathered from larger-scale community trials conducted in some African countries showing excellent performance and long residual efficacy across a range of different wall substrates. In this symposium, we will introduce VECTRONTM T500's key properties as a new tool which can support IRM best practice for IRS in national malaria control programmes. The symposium will also present the results of trials conducted recently in Malawi, Ghana and Burkina Faso demonstrating the long residuality of VECTRON™ T500.

Justification

Insecticide resistance in malaria transmitting mosquitoes is becoming widespread in Africa. The modes of action of IRS products are currently limited, and malaria control will become increasingly difficult if resistance continues to spread. New insecticides are urgently needed, and their rotation is essential to avoid further resistance development and to prolong their effectiveness. To address this challenging situation, Mitsui has developed a new IRS formulation containing a novel active ingredient called TENEBENALTM. Unlike other chemistries which have been repurposed from agriculture, TENEBENALTM has not previously been used to control, thus reducing the possibility of resistance to this insecticide. The new IRS product VECTRONTM T500, which contains TENEBENAL™, has a novel mode of action, and has demonstrated a long residuality against both susceptible and resistant mosquitoes. This symposium shares information on VECTRONTM T500 and provides an opportunity for NMCPs to consider how it can be integrated into their malaria eradication programmes.

Parallel Symposium 4

The mosquito abatement district learning exchanges: Lessons from the American mosquito control model

Organizer: Elijah Juma, PhD; **Co-organizer**: Samuel Rund, PhD

Speakers

Ary Fraji, PhD – Salt Lake Mosquito Abatement District, UT, USA

Mark Breidenbaugh – Northwest Mosquito & Vector Control District, CA, USA

Prosper Chaki, PhD – PAMCA Executive Director

Description and Justification

Vector control remains the gold standard method for prevention and control of vector-borne diseases (VBDs) in Africa and globally. The efficacy of the primary vector control interventions, namely long-lasting insecticide treated nets (LLINs) and indoor residual spraying (IRS) are declining rapidly due to multiple factors, including changes in vector and human behaviour and insecticide resistance - resulting in significant gaps in protection. Most of the research in the pipeline still target optimization of these two major interventions, such as development of new LLINs with dual active ingredients (dual AI), and iterations of the chemicals used in IRS with longer residual efficacy. The major limitations of mosquito control operations in most vector-borne disease-endemic countries in sub-Saharan Africa is that the two major interventions target the adult mosquitoes, which is the most expensive and the most logistically challenging stage of the mosquito to target in mosquito surveillance and control operations.

In the past two years since 2021, PAMCA has had the opportunity to send three delegations of its members to different mosquito abatement districts in the United States. A total of twelve districts in were visited encompassing five different states, were visited. The districts visited represented an array of diversity in terms of climate and geography, mosquito species composition and vector-borne disease risk, and district governance and management, among others. The delegations from PAMCA were drawn from 11 vector-borne disease endemic countries in sub-Saharan Africa and included public health entomologists, researchers, students, and senior personnel from the national malaria control programs. The primary objective of the exchange tours was to expose the delegations, particularly those drawn from the national programs, to learn about the mosquito abatement district model of mosquito surveillance operations, and to document its essential attributes that can be piloted in Africa to improve mosquito surveillance and control operations in the continent. These learning tours have served a dual purpose in strengthening the cooperation between the PAMCA and the American Mosquito Control Association (AMCA); leveraging its many decades of advances and experience in mosquito control operations. In addition, it has opened doors for PAMCA and its affiliate membership to strike new partnership with individual mosquito abatement districts in the US for long-term cooperation.

The purpose of this open forum discussion will be to highlight the lessons documented from the mosquito abatement district tours, and provide an opportunity for open discourse about the utility of some of the key features of the abatement district model to mosquito surveillance and control operations in Africa.

Parallel Symposium 5

Strengthening the nexus between parasite and vector genomics to accelerate malaria elimination in Africa

Elijah Juma[1], Alistair Miles[1], Nsa Dada[1], Luc Djogbenou[1], Damaris Matoke-Muhia[1], Celine Mandara[2], Isabella Oyier[2], Fitsum Girma[2], Bosco Agaba[2], Isaack Ssewanyana[2], Samuel L. Nsobya[2], Corine Karema[2], Deus S. Ishengoma

[1] *PAMCA-MalariaGEN Vector Genomics Surveillance Program*

[2] *East Africa Malaria Molecular Surveillance Network*

Organizer: Isabella Oyier, PhD; **Co-organizer**: Elijah Juma, PhD

Speakers:

Alistair Miles, PhD

Deus Ishengoma, PhD

Isabella Oyier, PhD

Abstract

Serious threats to malaria control and elimination in sub-saharan Africa (SSA) in particular, include emergence of insecticide resistance in the major malaria vectors, artemisinin partial resistance, *hrp2/3* gene deletions mediating false negative rapid diagnostic tests for malaria (mRDTs) and re- emergence of *Plasmodium* species in some areas where malaria incidences had declined. Occurrence and spread of *Anopheles stephensi,* an urban malaria vector radiating from the Horn of Africa to the hinterlands is another threat already being reported in other countries, as far as Nigeria, with potential devastating impacts on progress towards malaria elimination.

Advances in the next generation sequencing technologies provide new opportunities to peer into the vector and the parasite at the molecular level for genetic signatures that can be used to answer important questions on the biology and ecology of the parasites and their host vectors relevant to the design of their control and elimination strategies. Therefore, molecular surveillance systems are an essential tool in the malaria control and elimination toolbox, serving as a monitoring and early warning systems to guarantee long-term efficacy of the conventional and new interventions being deployed.

This symposium will highlight some of the efforts being undertaken to scale up the use parasite and vector genomics for malaria surveillance SSA. Case-studies will be presented on pathogen genomic surveillance initiatives underway in East African countries under the ambit of the of the East Africa Malaria Molecular Surveillance Network, and the PAMCA-MalariaGEN Vector Genomics Surveillance Program. This symposium will also underscore the significance of interfacing the pathogen genomics initiatives with the vector genomics initiatives to synergize and accelerate the malaria elimination efforts in Africa.

Parallel Symposium 6

Presenting the ATSB® (Attractive Targeted Sugar Bait); a novel outdoor intervention

Co-organizers: Mathias Mondy (Director of Business Development and Strategy, IVCC) / Dave Malone (BMGF)

Speakers

Prof. Woody Foster (Professor at the Dept. of Evolution, Ecology & Organismal Biology and Dept. of Entomology, The Ohio State University): Mosquitoes Sugar Feeding Biology

Michal Elias Gez (VP Business Development, Westham): Westham Story

Nick Yalla, MSc. (Research Scientist, KEMRI): Assessing attractiveness of [Westham] ATSBs compared with local flora in the semi-field system -

Mohamad Traore (Bamako university) / Eric Ochomo (Senior Research Scientist and Principal Investigator of the ATSB study in Kenya, Kenya Medical Research Institute, KEMRI): Entomological & Epidemiological Trials

Javan Chanda (Senior Routine and Entomological Surveillance Officer at PATH/Zambia): Product Acceptance -Field & community insights

Description

ATSB® is a potential new vector control product class developed by Westham to control outdoor malaria transmission in a peri-domestic environment by reducing biting incidence. Continuous exposure to ATSB® will prevent the mosquito population from maturing, thereby limiting their vectorial capacity. Supported by the Bill & Melinda Gates Foundation, Westham finalized the product design in 2021 and developed a high-quality manufacturing line. Large-scale entomological and epidemiological studies are currently being conducted by IVCC with partners in Kenya, Mali and Zambia, to establish ATSB®' 's public health value for malaria control as part of WHO-PQ regulatory and policy requirements.

Justification

The malaria community worldwide is urgently needing vector control tools to prevent outdoor transmission. The ambitious ATSB® project looks to address this urgent need especially following the recognition that broad coverage of IRS and LLIN would not alone be sufficient for malaria elimination. We believe that introducing the growing challenge of outdoor transmission and the ATSB® tool to PAMCA participants will be of great interest and benefit to the malaria community. Sharing the progress made so far, presenting the evidence from the field, discussing operational and access questions for sub–Saharan African countries and the challenges we face could be a great opportunity to create a meaningful discussion and exchange of ideas.

Parallel Symposium 7

Regulating the use of genetically modified mosquitoes for malaria control in Africa

Co-organizers: Wolfgang Richard Mukabana (Senior Policy and Research Analyst, African Institute for Development Policy – AFIDEP, richard.mukabana@afidep.org , Dr. Rose Oronje (Director Public Policy and Knowledge Translation & Head of Kenya Office, AFIDEP, rose.oronje@afidep.org)

Speakers

Charles Mbogo (Head, Vector Public Health Unit, KEMRI-Wellcome Trust Research Programme, P.O. Box 43640 – 00100, Nairobi, Kenya, cmbogo@kemri-wellcome.org): Novel approaches for malaria vector control in Africa

Moussa Savadogo (AUDA NEAPD's IVM Programme, Principal Program Officer, AUDA - NEPAD, Ouaga 2000, 06 BP 9884, Ouagadougou 06, Burkina Faso, moussas@nepad.org): Strengthening regulatory capacity on genetic based vector control in Africa

Rufus Ebegb (Director General, National Biosafety Management Agency, National Park Service Office, Airport Road, Abuja, Nigeria, rebegba@hotmail.com): Issues in the regulation of Genetically Modified Mosquitoes in Africa

Hennie Groenewald (Executive Manager, Biosafety South Africa, De Beers Avenue, Somerset West, Cape Town 7130, South Africa, hennie@biosafety.org.za): The sensible governance of induced genetic variation

Description and Justification

The idea of using gene drive mosquitoes to control and eliminate in Africa is gaining momentum. This technology is still under development and will take about a decade or so before it is available for use in the continent. This prospect is however curtailed by the many controversies surrounding the deployment and use of genetically modified organisms. The regulation of this technology needs to borrow from precedents set in biosafety, biocontrol and field trials. African regulators and policy makers need to prepare befitting frameworks to facilitate the testing and evaluation of this technology. The symposium aims to deliberate on the legal and regulatory framework requirements for the ongoing preparatory research and the planned future testing of gene drive mosquitoes to control and eliminate malaria in Africa. The objectives are threefold: (a) Create awareness and increase understanding of gene drives and their potential for malaria control and elimination in Africa, (b) Identify the legal and regulatory frameworks for the current research and future use of genetically modified mosquitoes for malaria control in Africa, and (c) Enhance the understanding of African policy makers on the ongoing efforts to develop guidelines to facilitate the ongoing and planned research on gene drives for malaria control and elimination.

Parallel Symposium 8

Strengthening entomological surveillance capacity towards malaria elimination in sub-Saharan Africa

Principal organizer: Pan-African Mosquito Control Association (PAMCA). KEMRI Headquarters, Off Mbagathi Way, P. O. Box 44455 -00100, Nairobi, Kenya; info@pamca.org

Co-organizers: Ifakara Health Institute (IHI), Tanzania; Centre for Research in Infectious Diseases (CRID), Cameroon; Institut de Recherche en Sciences de la Santé (IRSS), Burkina Faso

Speakers

Emma Orefuwa (PAMCA; emma.orefuwa@pamca.org): Strengthening local capacity for malaria surveillance and elimination in sub-Saharan Africa: An overview of the surveillance program

Ghislaine Ouedraogo-Ametchie (Social Science Consultant, PAMCA; oghislaine@gmail.com): Landscaping of malaria vector control and surveillance in Burkina Faso, Cameroon and Tanzania.

Betwel John Msugupakulya (IHI; jbetwel@ihi.or.tz); Emmanuel Elanga (CRID; emmanuel.elanga@crid-cam.net); Abdoulaye Niang (IRSS; bband79@yahoo.fr): Improving vector surveillance capabilities in Tanzania, Cameroon and Burkina Faso: Updates from Centres of Excellence

Panel discussion:

Experiences from the field: Impact and lessons learnt from the district entomology training program in PAMCA's 3 regional centres of excellence in Burkina Faso, Cameroon and Tanzania

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Souimbou Sanon: District Sanitaire de Dandé, Ministère de la Santé, Burkina Faso: sanonsouimbou.84@gmail.com

Rosemary Nshama: Ministry of Health, Community Development, Gender, Elderly & Children, Tanzania: nshamarosemary@gmail.com

Description

Vector-borne diseases (VBD) disproportionately affect the communities in the low-income countries (LIC), especially in sub-Saharan Africa (SSA). To effectively address the burden of VBDs in the endemic settings in SSA require putting in place vector-borne disease surveillance systems that address practical barriers to their control and elimination. Vector control has been the gold standard method for prevention and control of VBDs for over 100 years and remains highly effective, when applied comprehensively and sustainably. However, for most VBD-endemic countries in SSA, vector control is generally under-funded with limited resources allocated to support building adequate capacity for effective entomological surveillance at national vector-borne disease programs. Vector surveillance systems remain weak, fragmented, and lack proper coordination mechanisms at the national vector-borne disease control programs where such systems are urgently needed.

Justification

The SSA countries require a growing pool of adequately trained, entomology professionals at all levels; from the entomology technicians at the district unit, to the highest level policy formulators and disease control implementers. This critical mass of entomologists should be equipped with the technical capacity to study vector biology, conduct entomological surveillance, process, analyse and interpret entomological data to guide planning, targeting and implementation of vector control and elimination interventions. Although in the recent years there has been progress in increasing the pool of well-trained entomologists within research and academic institutions in SSA countries, their skills and research outputs have not been adequately harnessed to the direct benefit of the national vector-borne disease programs. Additionally, a lot of training focus has been at the higher graduate levels (master and PhDs) and this has created a gap in skills development at the in the low- to mid-level training of the district entomology technicians which is a critical capacity for supporting evidence-based decision making on effective vector control interventions.

Objectives

The main objectives of this symposium are:

- To give an update on the progress made with PAMCA's initiative to strengthen entomology capacity at national VBD programs in three regional centres of excellence
- To understand malaria vector control funding and implementation pathways in Burkina Faso, Cameroon and Tanzania
- To learn about the successes and challenges of the district entomology training program from beneficiaries and stakeholders at PAMCA's three centres of excellence in Burkina Faso, Cameroon and Tanzania.

ROUNDTABLE DISCUSSIONS

Roundtable Discussion 1

Harnessing the capacity of African Institutions for strengthened response against vector-borne diseases

Organizer: Prosper Chaki; prosper.chaki.@pamca.org

Co-organizer: Emma Orefuwa; emma.orefuwa.@pamca.org

Stronger communities of professionals with relevant expertise based at locally owned and governed institutions has been a subject for intense discussion in recent years and is critical if vector control is to achieve maximum impact across Africa. Indeed, strong capacity for evidence-based decision-making, based on expert analysis and interpretation of monitoring, evaluation and research data, is central to the health and wellbeing of African all countries but is typically weakest in the low-and-middle income countries (LMICs) that need it most.

While greater local ownership and leadership of evidence-based decision-making in Africa has been prioritized by several health sector funders for many years, for several reasons, progress has been far too slow and as such the agenda setting for health development in most African countries is mostly externally driven. Local institutions and indigenous experts in Africa have been slow to embrace knowledge based technical leadership skills that are considered relevant to vector control/elimination. Moreover, the successful delivery of high-quality technical support, science and innovation to enable improved vector control across Africa will require a complex and vibrant community of technical experts with complementary roles, skill sets at the institutional level.

In this session we will capture perspectives from various experts in global health on how independent leadership cadres at African institutions could be more effectively cultivated and sustained going forward.

The overall goal of such targeted leadership cultivation strategies would be to enable African institutions to push past the tipping points in their development trajectories, beyond which they can achieve an unprecedented surge of sustainable growth through collective learning processes that pivot around the survival, successes, and failures of their established and emerging leadership cadres.

While many of the experiences and potential solutions shared will be familiar to members of relevant expert communities across Africa, we nevertheless hope that the considerations and perspectives outlined may provide useful food for thought and action.

Invited Panellists:

- Prof Charles Mgone, Professor Charles Mgone - Chair of the AREF Strategy Board
- Prof Gerry Killeen: AXA chair in applied pathogen ecology, University of Cork, Ireland
- Dr Corine Karema: Interim CEO, Roll Back Malaria
- Dr Hiwot Solomon: Director Disease Prevention and Control Directorate Federal Ministry of Health, Ethiopia
- Prof Abdoulaye Diabate: Head of Medical Entomology and Parasitology at the Research Institute in Health Sciences (Institut de Recherche en Science de la Santé (IRSS) /Centre Muraz) in Bobo-Dioulasso, Burkina Faso

Roundtable Discussion 2:

The development journeys of global women leaders in vector control and men allies

Organizer: Damaris Matoke-Muhia (damaris.matoke@pamca.org)

Co-organizers: Jessy Goupeyou-Youmsi (jessy.goupeyou@pamca.org) , Rosalia Joseph (rosalia.joseph@pamca.org), Christina Sudi (christina.Sudi@pamca.org)

Introduction: In recognition of the critical role women play in achieving parity in health and well-being of the society, PAMCA is committed to building the capacity of women leaders in the vector-borne disease (VBD) control in Africa. Specifically, PAMCA aims to achieve these goals through specific action plans including: strengthening the role of women in VBD control through policy and advocacy; promoting gender equality in women in the field of VBD control; building women's capacity through targeted training programs, effective science communication, and confidence building initiatives; advancing women's role in VBD leadership through structured mentorship; and promoting the active engagement of non-professional women within grassroot communities in VBD control and elimination efforts.

PAMCA proposes to host a round table discussion that focusses on learnings, experiences, and challenges of leadership of Women in Vector Borne Diseases in Africa.

Objectives: The overall objective is to share and learn from experiences, insights, and development journeys of global women leaders in to support of career development of women professional in vector borne disease control

The specific objectives are:

1. To discuss the strategies of confidence building as part of personal development
2. To highlight leadership and organizational skills through personal experiences
3. To launch of the PAMCA WIVC mentorship programme

Expected outcomes:

- Shared information on leadership and pathways of success
- Understanding the journey of women in managerial positions in Vector control activities
- Hearing of the men's view and how to work together as allies
- Launch of the PAMCA WIVC mentorship programme

Time	Activity	Facilitator
3:00 - 3:05	Welcome remarks, PAMCA WIVC overview and workshop objectives & expectations	Jessy
3:05 – 3:45	The experiences, successes, Challenges and recommendations • Prof. Sheila Tlou - ALMA Special Ambassador • Dr. Corine Karema – Interim CEO RBM • Prof. Corine Ngufour – Prof. LSHTM • Prof. Heather Ferguson – Prof. UoG • Dr. Evelyn Olanga – PMI Kinga Malaria • Prof. Charles Wondji – Executive Director CRID & Prof. LSTM	Damaris & Emma
3:45 – 3:55	Participants Q&A	Christina
3:55 – 4:25	**Launch of Mentorship Programme**	Damaris & Emma
4:25 – 4:30	Wrap up	Rosalia

8th PAMCA Annual Conference & Exhibition | 2022

ORAL ABSTRACTS

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

ORAL ABSTRACTS

PARALLEL SCIENTIFIC SESSIONS

Parallel Scientific Session 1.
Vector surveillance, epidemiology, disease control programs and global health

ABS-368

Utility of MALDI-TOF MS for species and blood meal identification of main malaria vectors on the Kenyan coast

Jonathan Karisa[1,2*], Kelly Ominde[2], Brian Bartilol[2], Mercy Tuwei[2], Zedekiah Ondieki[2], Caroline Wanjiku[2], Lawrence Babu[2], Martin Rono[2], Mumin Eminov[6], Philip Bejon[2,5], Joseph Mwangangi[2], Maureen Laroche[4], Marta Maia[2,5]

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Background information: Protein analysis using matrix-assisted laser desorption/ionization time-of-flight mass-spectrometry (MALDI-TOF MS) represents a promising tool for entomological surveillance. Studies on various arthropod vectors have shown its ability to accurately identify species, blood meal source as well as pathogen infection. In this study we tested the discriminative power of this tool in distinguishing between the main Afrotropical malaria vectors from coastal Kenya and their blood sources.

Materials and Methods: Mosquito collections were conducted along the coastal region of Kenya in November 2019 and June 2021 respectively. MALDI-TOF spectra were obtained from each individual mosquito's cephalothorax as well as the abdomens of blood-engorged mosquitoes. The same mosquitoes were also processed using gold standard tests: polymerase chain reaction (PCR) for species identification and enzyme linked immunosorbent assay (ELISA) for blood meal source identification and detection of malaria parasites.

Results and Discussion: A total of 426 spectra from *An. gambiae s.l.*, 856 spectra from *An. funestus* s.l. cephalothoraxes were obtained, and 198 spectra from blood-engorged abdomens. MALDI-TOF MS was able to accurately distinguish between different members of the *An. gambiae* complex (95.3% accuracy) and *An. funestus* complex (97.9% accuracy) with an overall sensitivity and specificity of 97.8% and 83.3% respectively. Furthermore, MALDI TOF MS also provided accurate identification of blood host sources across all species (94.5% accuracy).

Conclusion: This study provides further evidence of the discriminative power of MALDI-TOF MS to identify sibling species, and blood meal source of Afrotropical malaria vectors further supporting its utility in entomological surveillance. The low cost per sample (<0.2USD) and high throughput nature of the method represents a cost-effective alternative to molecular methods and could enable programs to increase the number of samples analyzed and therewith improve the data generated from surveillance activities.

ABS-507

Mosquitocidal Effect and Pharmacokinetics of Different Ivermectin Dose Regimens in Preparation for Bohemia Cluster Randomized Controlled Trial

Yvonne Kamau[1] **Mercy Tuwei**[1] **Kelly** Ominde [1] Jonathan Karisa[1] Mwanajuma Ngama[1] **Frida Lewa**[1] **Lawrence Babu**[1] **Festus Mure**[1] Mwaganyuma Mwatasa[1] **Martha Muturi**[1] Jane Adetifa[1] **Felix** Hammann [3,4] Urs Duthaler[3] **Carlos** Chaccour [5] **Regina** Rabinovich [5,6] **Marta Maia**[1,2]

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Background. Ivermectin (IVM) is an endectocide currently being considered for malaria vector control through mass drug administration (MDA) campaigns. Its mode of action is independent of vector behavior or insecticide resistance therefore having the potential to directly address residual malaria transmission. Several trials using different IVM dose regimens are underway. Evidence from IVERMAL study indicates that 300mcgIVM/Kg given once a day for three days results in a significant reduction in mosquito survival up to 28 days. However, MDA strategies may operationally struggle to deliver high coverage and adherence rates using a 3-day long regimen. For this reason, we designed an open-label randomized controlled trial (RCT) to compare the pharmacokinetics (PK) and mosquitocidal effect of single high-dose of IVM 400mcg/Kg to the 3-day regimen of 300mcg/Kg of IVM. Furthermore, we investigated the mosquitocidal activity of albendazole as a potential comparator for future trials.

Methods. Healthy participants were randomized to receive either 1) Single-dose oral IVM 400 mcg/Kg; 2) Oral IVM 300 mcg/Kg given once a day for three consecutive days; 3) single-dose oral 400mg albendazole; or 4) no treatment. Participants were followed-up for 28-days post-treatment with blood samples drawn at regular intervals and fed through a membrane to *Anopheles gambiae* s.l. which were observed for mortality for 28-days. Plasma concentrations of IVM at each timepoint were determined using HPLC.

Results. Trial is ongoing with results expected by September. Data will be presented in form of Kaplan-Meier curves. Survival rates between groups will be compared using log rank tests. PK parameters will be derived using observed data (Cmax, Tmax) and non-compartmental analysis of the concentration-time profiles.

Conclusion. The results will inform the design of IVM MDA interventional trials and implementation strategies. The PK results could form estimates of the expected impact of ivermectin on mosquito populations and malaria transmission using mathematical models.

ABS-539

Entomological impact of Ivermectin mass drug administration to humans and livestock: A cluster randomized controlled trial in Mopeia, Mozambique

Caroline Wanjiku[1], Caroline Kiuru[2,3], Jonathan Karisa[1], Kelly Ominde[1], Luis Constantino[2], Gildo Cole[2], Eldo Elobolobo[2], Romário Armazia[2], Claida Alves[2], Paula Ruiz-Castillo[3], Regina Rabinovich[3], Carlos Chaccour[3], Francisco Saúte[2], Marta Maia[1]

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Background: Conventional vector control tools (long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS)) have had significant impact in reducing malaria transmission across Sub-Saharan Africa. However, these tools were designed to be used indoors and, therefore, have limited utility against outdoor mosquitoes which contribute to residual malaria transmission. The endectocidal drug ivermectin (IVM), when given to a community, has the potential to address residual transmission as its mode of action is independent of mosquito's host-seeking behaviour. When mosquitoes bite an ivermectin-treated host, their survival and reproduction fitness is significantly reduced. The BOHEMIA (Broad One Health Endectocide-based Malaria Intervention in Africa) study aims to evaluate the impact of IVM mass drug administration (MDA) on malaria vector populations and consequently, on malaria transmission.

Methods: The study is a three-arm cluster randomised controlled trial ongoing in Mopeia district, Mozambique. The trial consists of 102 clusters randomized to one of three treatment arms: 1) Ivermectin MDA to humans, 2) Ivermectin MDA to humans and livestock or 3) Albendazole MDA to humans (control), given monthly for three rounds during the peak malaria transmission season. Entomological monitoring is done through bi-weekly indoor and outdoor CDC light trap mosquito collections in five

randomly selected clusters per arm and paired human double-net collections (HDN) in two houses per treatment arm once a month. Additionally, susceptibility of local vector populations is being evaluated by exposing field-caught vectors to ivermectin using a bio-efficacy assay (See poster Ominde et al).

Results: Entomological impact of the MDA will be measured by comparing mosquito densities, survival rates, parity rates, and biting patterns across treatment arms. Data will be analysed using generalized linear mixed-effects models.

Conclusions: These results are expected to contribute to the body of evidence for a WHO policy recommendation on IVM use as a first-in-class endectocide for reduction of malaria transmission.

ABS-324

Increase in the malaria entomological inoculation rate following indoor residual spraying withdrawal in Atacora, Benin

Rock Aïkpon[1*], Cyriaque Affoukou[1], Gil Padonou[2], Patrick Condo[3], Ahmed Saadani Hassani[4], Aurore Ogouyemi Hounto[1], Martin Akogbéto[2]

Background: The National Malaria Control Program withdrew indoor residual spraying from the Atacora department in northern Benin after six consecutive years (2011 to 2016) of implementation in the region. This was done with the expectation that past IRS campaigns significantly suppressed the seasonal malaria transmission in Atacora. An IRS withdrawal strategy, comprised of enhanced surveillance, reinforced case management, and availability of insecticide-treated bednets (ITNs) through continuous channels, was also done to maintain suppression of malaria transmission. This study assessed the entomological inoculation rate (EIR) after the IRS withdrawal.

Method: Monthly mosquito collections by human landing captures (HLCs) were done in two Atacora districts (Natitingou and Toukountouna). Entomological monitoring occurred during the last IRS campaign year (2016) and two years after the IRS withdrawal (2018), both times from January to December. Technical constraints prevented entomological assessment in 2017. Malaria vectors were tested for the presence of *Plasmodium falciparum* sporozoites by ELISA.

Results: Two years after IRS withdrawal, the average EIR increased in the two survey districts. In 2016, the cumulative EIR ranged from 17.2 infected bites/year in Natitingou to 24.8 infected bites/year in Toukountouna. In 2018, the EIR range significantly increased ($p<0.0001$) to 94.9 infected bites/year in Natitingou to 129.2 infected bites/year in Toukountouna.

Conclusions: While the EIR increased significantly after IRS withdrawal, it's not clear if mitigation measures were insufficient in this seasonal malaria transmission setting or other factors, such as rainfall, accounted for the increase EIR. Additional analysis or investigation should be done establish if IRS withdrawal led to increased EIR. Nonetheless, robust epidemiological and entomological monitoring is needed before IRS is withdrawn, and appropriate mitigation efforts should be in place to maintain the gains by IRS and monitor transmission trends to avoid any rebound of transmission.

Keywords. IRS; disruption; malaria; Benin

ABS-344

Effect of passive and active ventilation on human comfort and malaria mosquito-house entry: an experimental study in rural Gambia

Anne Wilson

Introduction. Insecticide-treated nets (ITN) are the principal malaria control tool in sub-Saharan Africa, however, they are often not used when it is too hot. Designing cheap ways to ventilate and cool a house should increase ITN compliance. Here we assess whether passive or active ventilation methods can cool a bedroom at night and reduce house entry of malaria mosquitoes in rural Gambia.

Methods. Two identical metal-roofed experimental houses with badly-fitting doors and screened windows were used: one ventilated and one unventilated, serving as a reference. In the passive ventilation experiment, a transparent solar chimney was fitted to the external wall of the house. Heated by sunlight, warm air rises up the chimney pulling in cooler air from within the house, creating a cooling air current indoors. In the active ventilation experiment, an electric-ceiling fan was installed in both houses, with only one used each night. In each house, two men slept under separate ITNs. Measurements were made for four

nights each week, with house treatments changed weekly for eight weeks (n=32 nights). Indoor evaporation, temperature, relative humidity, carbon dioxide and wind speed were monitored and mosquitoes collected using light traps.

Findings. *Anopheles gambiae* s.l. house entry declined by 26 % (95 % CI 20-31) with a solar chimney and by 91 % (95 % CI 90-92) with a ceiling fan compared to the reference houses. Number of *Mansonia* spp., however, increased in a house with a solar chimney, but not an operating fan, compared with the reference house. Although there were no differences in indoor nightly temperature between intervention and control house, nightly evaporation in a house with the solar chimney was 61 % higher (95 % CI 61 to 61%) and a house with a fan operating 319 % higher (95 % CI 319 to 319) than a reference house. Solar chimneys reduced indoor carbon dioxide levels by 28 % (95 % CI 18 to 36) and ceiling fans by 19 % (95% CI 11 to 27) from 00.00-07.00 h compared with the reference house.

Discussion. Passive and active ventilation reduced female *An. gambiae* house entry, by increasing airflow in the house, which reduces dioxide levels indoors making it more difficult for a female mosquito to locate a blood meal from outside a house. Improved ventilation in houses may make it more likely that people will use a bednet at night and reduce house entry by malaria vectors, helping to reduce malaria transmission.

ABS-596

Impact of animal enclosures on human exposure to primary vector and understudied vectors in an area targeted for malaria elimination

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Background: Enhanced coverage of households with long-lasting insecticidal nets (LLINs) and indoor residual spray (IRS) has significantly reduced the abundance of *endophagic Anopheles* mosquitoes in Macha, Choma District and prior studies have shown that exophagic *Anopheles* species are likely contributing to malaria transmission. In the Macha catchment area, individuals live in close proximity with animals (especially cattle, goats, and pigs) which serve as a source of potential blood meals. These animals emit more CO2 and stronger cues from skin odors, possibly attracting more anophelines of greater species diversity. These animals may protect individuals from infectious mosquito bites by diverting the anophelines from humans, or contribute to malaria risk by supporting populations of zoophilic species which may harbor sporozoites. This study assessed the abundance and diversity of anophelines in association with animal enclosures on human exposure to both vector and non-vectors.

Method: Twenty-five clusters of 12 households were surveyed along a transect from Mutama River to Kariba Dam in Southern Province of Zambia from May 2018 to September 2018. The clusters were located 5 kilometers apart. Standard CDC light traps were used to collect adult mosquitoes indoors near people sleeping and outdoors near animal enclosures.

Results: A total of 5,706 *Anopheles* mosquitoes were collected; 93% (n=5335) were collected outdoors and 7% (n=371) were collected indoors. The most abundant species were *An. rufipes* and *An. pretoriensis* which accounted for 53% of collections, while *An. gambiae* s.l. comprised only 5% of collections. In *Anopheles*-positive households, a mean of 4.1 anophelines were captured in HH with animal enclosures compared to a mean of 2.7 in HH with no animal enclosures. Only 1/4070 (0.02%) sample was found with circumsporozoite protein (CSP) by ELISA, which was an *An. rufipes* caught from an animal enclosure. Four hundred and one visibly blood-fed samples were run on multiplexed blood meal PCR. Of those captured in animal pens, 13% had human blood, while 2% had both human and animal blood and 56% were blood-fed from animals exclusively.

Conclusion: In the Macha area, the primary indoor vector *An. arabiensis* remains endophagic and anthropophilic. In this study, abundant understudied anopheline species were caught outdoors next to animal shelters which are not targeted by any current interventions. The detection of CSP in these understudied, exophagic species implies that these vectors may be critical for maintaining transmission in this pre-elimination zone. Additionally, *Anopheles* abundance inside households which owned animals was roughly 50% higher than those without, suggesting that animal ownership might contribute to disease risk by

attracting larger numbers of mosquitoes to the household. More detailed studies are required to describe their behaviors and assess their relative roles in diseases transmission.

ABS-338

Prevalence of malaria and genetic diversity of *erythrocyte binding antigen*-175 in ngali II, Centre region, Cameroon

Hillary S. M. Tene[1,2]., Loic T. J. Keumo[1,2]., Livo F. Esemu[2,3],. Didien Meyahwi[2]., Francis Zeukeng[2,4], Crespo'o Mbencho[2]., Jude D. Bigoga[1,2]. Rose Leke[2]

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Introduction: In spite the strategies put into effect to curb malaria burden, prevalence has increased recently. The development of an effective vaccine against *Plasmodium falciparum* is imperative to induce lasting protective immunity. Vaccine candidates such as *Erythrocyte Binding Antigen-175* (EBA-175), ligand for erythrocytic invasion by merozoites have been proposed. However, the polymorphism of *EBA-175* causes the distribution of many genotypes and hinders the development of an effective vaccine. To contribute to a better understanding of the extent of *eba-175* genetic polymorphism, a cross-sectional study was conducted at Ngali II, an endemic malaria zone, Centre region of Cameroon.

Methods: A total of 107 asymptomatic children aged between 3-15 years were examined. Venous blood was collected to determine plasmodial parasitemia and hemoglobin levels. Plasmodial DNA was extracted to identify plasmodial species using the nested PCR technique. The alleles frequencies were determined by percentage.

Results: The prevalence of malaria was 87.85%. Three plasmodia species including *P. falciparum* (60.74%), *P. malaria* (37.38%) and *P. Ovale* (16.82%) were detected. Two known alleles, FCR3 (37.3%) and CAMP (15.3%) were identified by genotyping the eba-175 gene, with 47.5% of mixed distributions (FCR3-CAMP). No new alleles were detected. The multiplicity of infection and the heterozygous index were 1.47 and 1.02, respectively. About a quarter (25.23%) of children were anemic and there was an association between anemia and the F allele.

Conclusion:The extensive genetic diversity of eba-175 as presented in this study may compromise the efficacy of EBA-175 based vaccines in the community of Ngali II.

Impact of the study: The results obtained constitutes an important database for the development of innovative vaccine strategies for the fight against malaria.

Keywords: *EBA-175* gene, genetic diversity, malaria, Ngali, vaccine candidate.

ABS-478

Endpoints measured in semi-field bioassays of volatile pyrethroids and their impacts on vectorial capacity

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Background. Vector control tools such as volatile pyrethroids (VP) are often evaluated under semi-field conditions using laboratory-reared mosquitoes before field testing. However, when using the semi-field system, not all exposed mosquitoes are recovered. Poor recapture rates lead to conservative estimates of VP impact toward the null. Therefore, a large ambient chamber test (I-LACT) to improve recapture was developed to accurately assess multiple endpoints of transfluthrin VP used in a simulated "outdoor" setting. Outputs from this analysis can be used to model the possible impact of the intervention on vectoral capacity.

Method. I-LACT chambers, measuring 5x5x2 meters, were used in a dose-response experiment to measure the efficacy of transfluthrin passive emanator against susceptible *Anopheles gambiae* s.s, and pyrethroid-resistant *An. arabiensis* and *An. funestus*. Two volunteers were assigned to transfluthrin or control and rotated each day, for 16 days. Mosquitoes were either 1) collected by human landing catch or 2) allowed to feed on volunteers in the I-LACT for one hour. Mosquitoes were collected and sorted then alive unfed mosquitoes were offered blood and all mosquitoes were observed for 24- and 72-hour mortality and egg laying. Data were analyzed using generalized linear mixed-effects regressions. Additionally, the impact of interventions was predicted using the individual-based transmission model, Open Malaria.

Results. There was > 95% recapture of the released mosquitoes. For susceptible and resistant Anopheles, dose dependence was seen in protective efficacy. As dose increases transluthrin induces 1) reduced feeding, 2) increased disarming, 3) increased mortality, and 4) decreased egg laying. Transfluthrin at high doses can induce substantial mortality, particularly at longer holding times, but pyrethroid resistance does impact efficacy. Modelling shows that VP could contribute to reduction in vectoral capacity and shows species differences.

Conclusions: I-LACT is an excellent assay for measuring effects of VP beyond repellency. Modelling can translate bioassay endpoints into estimated impact on vectorial capacity and clinical malaria incidence. VP may provide community as well as individual level protection in the peridomestic space.

ABS-572

Mosquito repellent activity of cream from essential oil of *Petroselinum crispum* (Apiaceae) in the city of Yaoundé Cameroon.

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Background : Malaria still remains a major public health problem in Cameroon. While Long Lasting Insecticidal Nets remain the first line tool for vector control, personal protection methods including the application of repellents to escape from mosquito bites are encouraged. In view of the increased interest in developing botanical repellents as a substitute to chemical repellents, this study assessed the mosquito repellent activity of cream from essential oils of *Petroselinum crispum* in field conditions.

Material and Methods : Essential oils from fresh leaves of *Petroselinum crispum* were extracted by hydrodistillation. For the cream repellent preparation, the ingredients were weighed and mixed in a Pyrex glass vessel, melt in water bath and let cold at room temperature. The mixture was poured into a different container and stirred slowly with a silicone spatula, then put in a plastic container. The repellent effect of the cream was assessed through human landing catches. In each study site, a trial comparing a treated group (9 people) to the control (9 people) was implemented. Mosquito collection was done from 19h pm to 06h am. The Mulla formula was used to calculate the reduction rate of mosquito biting densities.

Results: A total of 3,936 mosquitoes belonging to the genera *Culex* and *Anopheles* were collected. The genus *Culex* was far more abundant with 92% (n=3,632) of the total collection. Globally, using the 0.9% cream from essential oil of *Petroselinum crispum* was associated with over 61% reduction of mosquito biting density. The reduction rate was 52.24% for anopheles biting density and 62.21% for culex biting density. No important change in the mosquito biting cycle was recorded.

Conclusion: The study suggested a high potential of cream from essential oils of *Petroselinum crispum* as mosquito repellents against both *Culex* spp. and *Anopheles* spp..

Keywords: Repellent, Essential oil, *Petroselinum crispum, Anopheles, Culex,* Yaoundé

ABS-618

Lamp-PCR and conventional PCR for LF xenomonitoring in endemic health distrcits of Burkina Faso

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Since 2001, Burkina Faso had adopted a community-based treatment of lymphatic filariasis (LF) with annual mass drug administration (MDA) of Ivermectin-Abendazole. Therefore, in the elimination perspectives toward 2030, it is crucial to validate a diagnostic approach to assess the prevalence of *Wuchereria bancrofti* especially in vector populations for surveillance prospects. For the validation of diagnostic tool, we used samples from previous parasitological and entomological surveys conducted in august 2014 and September 2015 in hotspots where the transmission was still active. Mosquitoes were collected by human landing catches and indoor spraying collection methods. Based on molecular techniques using DNA of pooled mosquitoes successfully tested in other countries, we tried to validate such protocols from specimens collected during the previous surveys. The results confirmed the *W. bancrofti* infection in human populations as revealed by parasitological tests and also in vector populations tested for the first time by the conventional PCR in all health districts. Within the *An. gambiae* s.l. populations, only *An. coluzzii* was found infected by *W. bancrofti* in Ouargaye, Koupéla and Fada N'gourma health districts, whereas *An. nili* was the most infected in the Diébougou health district. Some specimens of *An. funestus* were tested positive to *W. bancrofti* with the Lamp-PCR but failed to be confirmed by the conventional PCR. Our preliminary data confirmed the validity of molecular technique to detect *W. bancrofti* infection within vector populations even additional calibration is still needed. In the South West, surprisingly *An. nili* was found positive to *W. bancrofti* infection by the two molecular techniques extending the list of LF potential vectors in the country. It raised the evidence that Lamp-PCR and PCR conventional are crucial to better define endpoints for the national LF elimination program.

Keywords: *Wuchereria bancrofti*, Prevalence, Mosquitoes, Burkina Faso

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Parallel Scientific Session 2:

Precision public health and innovations for VBD elimination: AI, entomological databases, modelling and genomic surveillance

ABS-641

3D infrared video tracking reveals the behavioural mode of action of permethrin-treated long-lasting insecticidal nets in the tunnel test

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The efficacy of long-lasting insecticidal nets (LLIN) is measured in the World Health Organization (WHO) cone bioassay. However, the cone bioassay may under- or overestimate the net's efficacy if the mosquitoes' behaviour is affected when interacting with the net such as being excito-repelled. In this situation, the WHO guidelines recommend measuring mortality together with blood-feeding inhibition in the tunnel test. In the tunnel test, mosquitoes are released at one end, while a guinea pig is restrained as a bait at the other end of the tunnel. To reach the bait, the mosquitoes have to pass through a holed piece of net. The mosquitoes and guinea pig are left for 12 hours after which the number of dead and blood-fed mosquitoes are scored. Unfortunately, the tunnel test provides no insight into how the mosquitoes actually interact with the LLIN. Yet, knowing how mosquitoes interact with an LLIN would be most desirable because the net's behavioural mode of action could be highly informative as to why an LLIN is failing and could then be exploited to improve formulations and the delivery of insecticides. To overcome this shortcoming, we developed a set up to measure the behaviour of host-seeking mosquitoes in the tunnel test with a real-time 3D infrared video camera system. We tracked mosquito flight paths of *Anopheles gambiae* at 50 fps as they moved in the tunnel and interacted with an untreated or a permethrin-treated net. While the permethrin-treated net reduced blood-feeding, we found the mosquitoes passing the permethrin-treated net more frequently than the untreated net and having an equal amount of contact with the two nets. We conclude that the permethrin treatment has little or no direct repellent effect and that 3D infrared video tracking in combination with the tunnel test is a powerful tool to understand LLINs' behavioural mode of actions.

ABS-326

Infrastructure development for transgenesis research in Tanzania

Dickson Lwetoijera

Ifakara Health Institute in collaboration with Imperial College London, are establishing infrastructures necessary to assess the utility of gene drive technology in Tanzania's wild mosquito populations. These infrastructures are "Mobile Portable Laboratory Containment Level 3 (MPL CL3), a state-of the-art facility designed for conducting laboratory transmission studies using genetically modified *A. gambiae* mosquitoes and *P. falciparum* parasites. The biosafety level 3 (BLS-3) system field system (SFS), represent another facility recommended for containment of mosquito's studies that involve genetic element. The BLS-3 SFS is equipped with negative pressure zone in the corridor, air blower at the main entry, an intact net with mesh to prevent a mosquito penetration, as well as brush off- curtains on doors of each SFS chambers, all these to ensure that no mosquitoes escape from the system. The MPL CL3 and BLS-3 facilities have all the necessary safety measures for managing risks associated with transgenesis activities, as specified in Global framework for testing transgenic mosquitoes and in Tanzania national guideline for handling genetically modified organisms. Institutionally, the MPL CL3 and BLS-3 represent a strategic investment and offers competitive capabilities in conducting transgenesis research for malaria control in Tanzania and across the region.

ABS-328

Using Bayesian state-space models to understand the population dynamics of the dominant malaria vector, Anopheles *funestus* in rural Tanzania

Halfan Ngowo

Background: It is often assumed that the population dynamics of the malaria vector *Anopheles funestus*, its role in malaria transmission and the way it responds to interventions are similar to the more elaborately characterized *An. gambiae*. However, *An. funestus* has several unique ecological features that could generate distinct transmission dynamics and responsiveness to interventions. The objectives of this work were to develop a model which will; 1) reconstruct the population dynamics, survival, and fecundity of wild *An. funestus* populations in southern Tanzania, 2) quantify impacts of density dependence on the dynamics, and 3) assess seasonal fluctuations in *An. funestus* demography. Through quantifying the population dynamics of *An. funestus*, this model will enable analysis of how their stability and response to interventions may differ from that of *An. gambiae* s.l.

Methods: A Bayesian State Space Model (SSM) based on mosquito life history was fit to time series data on the abundance of female *An. funestus* s.s. collected over 2 years in southern Tanzania. Prior values of fitness and demography were incorporated from empirical data on larval development, adult survival and fecundity from laboratory-reared first generation progeny of wild caught *An. funestus*. The model was structured to allow larval and adult fitness traits to vary seasonally in response to environmental covariates (i.e. temperature and rainfall), and for density dependency in larvae. We measured the effects of density dependence and seasonality through counterfactual examination of model fit with or without these covariates.

Results: The model accurately reconstructed the seasonal population dynamics of *An. funestus* and generated biologically-plausible values of their survival larval, development and fecundity in the wild. This model suggests that *An. funestus* survival and fecundity annual pattern was highly variable across the year, but did not show consistent seasonal trends either rainfall or temperature. While the model fit was somewhat improved by inclusion of density dependence, this was a relatively minor effect and suggests that this process is not as important for *An. funestus* as it is for *An. gambiae* populations.

Conclusion: The model's ability to accurately reconstruct the dynamics and demography of *An. funestus* could potentially be useful in simulating the response of these populations to vector control techniques deployed separately or in combination. The observed and simulated dynamics also suggests that *An. funestus* could be playing a role in year-round malaria transmission, with any apparent seasonality attributed to other vector species.

Keywords: *Anopheles funestus,* State space model, population dynamic, seasonality, abundance, density dependence.

ABS-416

An Online Platform for Real-time Age-grading and Species Determination of Malaria Vectors using Artificial Intelligence and Infrared Spectroscopy

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Background: Accurate monitoring and estimation of age structures and species distribution of mosquito populations helps to evaluate and improve malaria vector control interventions. These parameters provide vital information on the intensity of malaria transmission. Unfortunately current laboratory procedures, which involve dissection to assess parity rate and PCR (polymerase chain reactions), or Ovary dissections are expensive, inaccurate and time consuming. Mid-infrared spectroscopy (MIRS) has emerged as a cheap and time efficient (less than one minute) technology for age-grading and species determination in Anopheles mosquitoes. We present a web-based platform that provides users with the functionality to upload and make

predictions using MIRS data. Specifically, the web application makes use of previously published machine learning models to simultaneously determine species and age in malaria vectors.

Methods: This online platform will allow user to signup, log in or log out; store locations (longitude and latitude) where mosquito have been collected; collect and store relevant metadata (type of machine, wave numbers, spectral resolution, storage and collection temperature, humidity, location name, sex and insecticide resistance status); upload and filter spectra (data cleansing to compensate for atmospheric water and CO2 interference bands); make predictions using deep learning algorithms.

Results: For the targeted Anopheles gambiae s.l. complex (An .gambiae, An. coluzzi and An. arabiensis) the user will be able to upload their dataset and obtain age and species predictions using supervised machine learning and deep learning (convolutional neural networks). Results will be visualized using confusion matrices and demographic tables (age and species) and printable for the user's future report.

Conclusions: Our online platform will provide an easy-to-use tool for age and species classification of Anopheles gambiae s.l mosquitoes based on MIRS spectra. More broadly, these processes could be applicable to the others Anopheles mosquitoes, as well as Culex and Aedes upon calibrating new predicting models.

ABS-501

Checkmate or Stalemate? Modelling Density-dependence and Allee Effects in the Malaria Vector Control Endgame

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Background: Understanding the interplay between vector control and malaria mosquito population dynamics is critical to assess and improve vector control. Mosquito populations are regulated through a range of biotic and abiotic mechanisms, and among them, density-dependence is thought to be widespread. Density-dependence means per capita growth rate should be fastest when density is very low, for instance through competition for larval habitat that is alleviated as population size goes down. Evidence for this comes mostly from laboratory experiments with *Anopheles gambiae* showing that competition for resources at the larval stage is the major source of density-dependence affecting population densities. However, an opposing scenario is also possible where small mosquito populations experience Allee effects, defined as positive density-dependence, in which per capita growth rate reduces as population declines. Here, we aim to identify the trade-offs between density-dependence and Allee effects, and how they might be impacted by interventions such as larvicides. Learning how to exploit this trade-off could make the difference between extinction or persistence (checkmate or stalemate).

Methods: We developed a deterministic-stochastic simulation based on a stage-structured population model. The model follows a mosquito life cycle stages with life history traits such as adult and larval survival and fecundity defined as a function of density, larvicides and environmental variables. We included density-dependence as a predictor of larval stage and Allee effects as a predictor of adult mosquito fecundity rate.

Results: With density-dependence and Allee effects at levels that lead to a stable population, results indicate that there is at least 56% and 21% decline in average number of adult mosquitoes at a 100% and 50% coverage of larvicides respectively. However, if density-dependence increases by 50% and the intervention is short termed, the mosquito population bounces back to similar or higher levels than before. In contrast, if Allee effects are increased by only 36%, the population will decline 3 times faster. This indicates that density-dependence and Allee effects could be used to drive the population to extinction when used in combination to larvicides as an intervention.

Conclusion: Mosquito population regulatory processes, that is density-dependence and allee effects have shown a significant decline in mosquito population when used in combination with larvicidal control by increasing the efficacy of the control intervention towards malaria vector elimination.

Key words: Anopheles mosquitoes, larvicides, density-dependence, allee effects, population density and vector control.

ABS-523

Towards fast quantum cascade laser spectrometers for high-throughput and cost-effective mosquito surveillance

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Background. Fourier transform infrared (FTIR) spectroscopy with machine learning analysis can classify mosquito samples into species and different age groups with high speed and accuracy. However, current FTIR instruments use low power light sources to produce infrared light, which limits the measurement of complex biological samples, such as specific mosquito tissues. Moreover, portability of these systems is lacking, which is needed in the field. To overcome these issues, spectrometers using quantum cascade lasers (QCLs) have become an attractive alternative to build fast and portable systems due to its high power, small size, and potential to be low cost. Therefore, here we present a prototype of a spectrometer that is aimed for large-scale, low-cost, field-based mosquito surveillance.

Methods. A spectrometer was built using a QCL chip with the range of 950 - 1100 cm^{-1} using an external cavity configuration. Measurements of calibrated polymers were done in transmission mode to test stability, wavelength accuracy and speed measurement. Furthermore, samples of females *Anopheles gambiae* were prepared into pellets with Potassium Bromide (KBr) to facilitate measurement in transmission mode and compared to commercial FTIR spectrometers.

Results. A working prototype using QCL chip was successfully built. The prototype can collect infrared spectra of mosquito samples in transmission mode at speeds of 100 spectrum per second. Higher speeds up to 500 spectrum per second were achieved with some loses on the range of the laser. High spectral agreement between our system and a commercial FTIR was obtained at speed of 100 spectrum per second with different samples

Conclusions. Our results highlight how QCLs-based spectrometers can be build and used to obtained infrared data from mosquitoes. The high speeds, the small size already achieved of this prototype with little optimization compared to FTIRs shows the great potential these lasers have. QCLs are already changing how infrared spectra is collected in the industry and they can become the next generation of spectrometers in vector surveillance.

ABS-607

Genome-wide association studies and machine learning prediction reveal high predictive power of Ace-1 for pirimiphos-methyl resistance, but a highly multigenic basis for metabolic resistance in *Anopheles gambiae* s.l.

Eric Lukas

Background: Genomic surveillance of insecticide resistance offers the prospects of large scale, reproduceable monitoring of the evolutionary dynamics and spread of insecticide resistance in malaria mosquitoes. The two main aims of genomic studies are to discover novel resistance-conferring mutations, and to estimate the resistance phenotype of a population. Both of these goals require large numbers of phenotyped and genotyped mosquitoes, yet such datasets have so far been lacking.

Methods: The Genomics of African Anopheles Resistance Diagnostics (GAARD) project has collected phenotyped *Anopheles gambiae* s.l. from six African countries, performing WHO tube assays with pirimiphos-methyl (PM) and deltamethrin. Collections from Bénin, Ghana, Côte d'Ivoire and Togo were submitted to the Vector Observatory for whole-genome sequencing, allowing genome-wide association studies and machine-learning based prediction of phenotype.

Results: We found strong association between resistance to PM and the Ace-1 locus, despite very high frequencies of the documented CNV in Ace-1. The Ace-1 locus alone provides over 75% accuracy in predicting resistance phenotype. Alongside this dominant signal, several metabolic loci are also highlighted by the analysis, including Gste and carboxylesterase gene clusters, while signals in previously unassociated loci (eg: GPRMTH7) point to areas for further investigation. In contrast, there is little association between resistance to deltamethrin and the kdr locus, due to susceptible genotypes at this locus having largely disappeared in the study areas. Signals in metabolic gene clusters such as Cyp6 and Cyp9k1, some of which are linked to CNVs in these genes, and novel loci (COE22933) provide directions for further research, but the predictive power provided by these loci is low.

Conclusions: The low predictive power of genomic data from metabolic genes, combined with metabolic signals being population specific, suggests that metabolic resistance in *An. gambiae* may be highly multiallelic, requiring new approaches to genetically quantify the broad spectrum of resistance markers.

ABS-706

A novel 3 in 1 mosquito trap from Kenya

Laban Njoroge,

National Museum of Kenya

A new trap that operates as an odor-baited trap, a light trap and a gravid trap for mosquitoes has been developed in Kenya. The patent pending prototype has shown high potential for outdoor sampling of both host-seeking and gravid mosquitoes. A unique feature of the trap is its ability to substitute baits as well as an optional use of light and heat depending on the target mosquito species. Preliminary data has shown high potential for collection of the common mosquito genera namely Anopheles, Aedes, and Culex to which major disease vectors belong. The very first test run of the trap collected 11 different mosquito species in a single night in Lamu, coastal Kenya. Other non-mosquito species appearing in the trap in considerable numbers include the black flies (Simuliidae) and moth flies (Psychodidae). Weighing less than 4 kilograms, this trap has potential for sampling arboreal mosquito species such as those responsible for yellow fever transmission. Possible applications of this trap include vector surveillance, mass mosquito trappings for control as well as estimation of entomological inoculation rates. Its utilisation of easily available attractants as well as solar charged batteries makes it suitable for use even in the remotest of places.

ABS-790

Progress of the Sterile Insect Technique as a potential malaria vector control complimentary tool in South Africa

Givemore Munhenga, Thabo Mashatola, Maria Kaiser, Leonard C Dandalo, Oliver R Wood, Leanne N Lobb, Jeremy Gilles, Hanano Yamada, Jeremy Bouyer, Kobus Slabbert, Alan Kemp, Pinky N Manana, Michael Samuel, Malibongwe Zulu, Eunice Jamesboy, Nonhlanhla Ntoyi, Fortunate Moletsane, Dumsani M Dlamini, Nondumiso Mabaso, Jan Rijn Zeevaart[6], Basil D Brooke, and Lizette L Koekemoer A

South Africa has begun initiatives to eliminate malaria transmission within its borders. Some malaria-affected districts have a malaria case incidence of <1/1000 population, meeting the World Health Organization (WHO) criteria for pre-elimination and suggesting that control initiatives can be shifted towards elimination. However, malaria control activities, particularly current vector control interventions using indoor residual spraying (IRS) though effective, are insufficient to achieve the government malaria elimination agenda. Given this, a group of multisector stakeholders identified and set a mandate to eliminate local malaria transmission within the near future. It was found that additional vector control interventions to supplement existing malaria control programmes are necessary. The use of the sterile insect technique (SIT) was proposed, culminating in a multi-year plan for testing the feasibility of the SIT for malaria control in South Africa. The strategic plan is being implemented in three main phases whose advancement to the next Phase is dependent on significant progress in the preceding stage. Phase I was the pre-feasibility Phase which aimed to provide scientific arguments and baseline information for using the SIT as a complementary malaria vector strategy. This Phase included identifying a pilot release site and intensive baseline vector surveillance at the release and control sites that yielded critical information concerning the population dynamics of the targeted *Anopheles arabiensis* population. Phase II involved refinement of Phase I findings, development of a genetic sexing strain, irradiation/sterilization studies, community engagement including knowledge, attitude and practices (KAP) survey, development of the capacity to mass rear mosquitoes and technical feasibility assessment of the technology. The project is now in Phase III. This Phase aims to demonstrate the applicability of SIT through field pilot trials on a small scale. The purpose of this presentation is to discuss the experience and knowledge gained in developing the SIT as a malaria vector control tool in South Africa, focusing on the challenges and status of the project. We also provide insight into the next steps, including the ongoing pilot sterile male releases.

ABS-563

Characterising phenotypic resistance to insecticides in vectors: introducing a novel statistical framework for analysis of intensity bioassay data

Mara D Kont, Ben Lambert, Antoine Sanou, Jessica Williams, Hilary Ranson, Rosemary Lees, Thomas S Churcher

Background. Insecticide resistance is a growing problem that threatens the success of vector-borne disease control interventions across the world, particularly in sub-saharan africa. Historically, phenotypic resistance was monitored by discriminating dose bioassays. The who now recommends intensity bioassays (ib) to measure the level of resistance in regions where the discriminatory concentration indicates its presence. However, mosquito data can be highly variable and it is unclear how ib data should be analysed, which metrics can be reported and what these represent. Here, a novel statistical framework for analysis of ib data is introduced.

Methods. A bayesian binomial framework using a flexible logistic function is developed. This framework is tested on data from susceptible and resistant laboratory mosquito colonies with defined genetic background, as well as highly resistant wild mosquitoes collected in burkina faso. A base model is developed, quantifying the amount of background mortality, the median lethal concentration (lc_{50}), the heterogeneity in mortality and within-assay variability in mortality. The model is then extended to add a time covariate to explore temporal variation in insecticide resistance.

Results. The framework developed is suitable for the analysis of intensity bioassay mortality data in laboratory colonies as well as field samples. Whilst observed mortality is more heterogeneous in resistant strains, the framework captures both susceptible and resistant trends suitably. Within- and between-assay variability can be quantified, providing an indication of which species, insecticides or locations produce more heterogeneous results. The time model enables the characterisation and quantification of temporal changes in resistance, with the potential to be extended to other covariates of interest.

Conclusions. The model introduced here provides a framework for the analysis of intensity bioassay data as well as insights

into novel ways of describing phenotypic insecticide resistance. This framework is highly adaptable and describes vector resistance more precisely than traditional statistical models.

Parallel Scientific Session 3 : LLINS, IRS and Insecticide Resistance Management

ABS-599

Rapid evolution of insecticide resistance and patterns of pesticides usage in agriculture in the city of Yaoundé Cameroon

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Background: The practice of agriculture in urban settings is considered to contribute importantly to the rapid expansion of insecticide resistance in malaria vectors. However, there is still not enough information on pesticide usage in most urban settings. The present study aims to assess the evolution of *An. gambiae* s.l. population susceptibility to insecticides and patterns of pesticide usage in agriculture in the city of Yaoundé Cameroon.

Methods: WHO susceptibility tests and synergist PBO bioassays were conducted on adults *An. gambiae* s.l. mosquitoes aged 3 to 5 days emerging from larvae collected from the field. Seven insecticides (deltamethrin, permethrin, DDT, bendiocarb, propoxur, fenitrothion and malathion) were evaluated. The presence of target site mutation conferring knock down (*kdr*) resistance was investigated using TaqMan assay and mosquito species were identified using SINE-PCR. Surveys on 81 retailers and 232 farmers were conducted to assess general knowledge and practices regarding agricultural pesticides usage.

Results: High resistance intensity to pyrethroids was observed with a high frequency of the *kdr* allele 1014F and low frequency of the *kdr* 1014S allele. The level of susceptibility of *An. gambiae* s.l. to pyrethroids and carbamates was found to decrease with time (from ⊠34% in 2017 to < 23% in 2019 for deltamethrin and permethrin and from 97% in 2017 to < 86% in 2019 for bendiocarb). Both *An. gambiae* s.s. and *An. coluzzii* were recorded. Over 150 pesticides and fertilizers were sold by retailers for agricultural purposes in the city of Yaoundé. The majority of farmers do not respect safety practices. Poor practices including extensive and inappropriate application of pesticides, poor management of perished pesticides and empty pesticide containers were also documented.

Conclusions: The study indicated rapid evolution of insecticide resistance and uncontrolled usage of pesticides by farmers in agriculture. There is an urgent need to address these gaps in order to improve the management of insecticide resistance.

Keywords: Vector control, *Anopheles gambiae*, insecticide resistance, pesticide management, Yaoundé, Cameroon

ABS-664

Involvement of metabolic mechanisms in the expression of insecticide resistance in *Aedes aegypti* mosquitoes in Songon-Agban, southern Côte d'Ivoire

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Background. The intensive use of the insecticides in agriculture affects vector susceptibility to insecticides and represents a threat for vector control. We assessed the insecticide susceptibility status and the role of detoxification enzymes in the resistance of *Aedes aegypti* from a vegetable-growing area in Côte d'Ivoire.

Methods. Social behavior of farmers about the use of insecticides and sampling of *Aedes* egg sampling using the World Organization Health (WHO) ovitrap method were carried out from March to August 2019 in Songon-Agban, a vegetable growing area. Adult 3-5 day-old females of *Ae. Aegypti* reared from ovitrap eggs were tested against 0.05% deltamethrin, 0.05% lambda-cyhalothrin, 4% Dichloro-Diphényl-Trichlorohexane DDT and 0.4% chlorpyrifos-methyl using WHO susceptibility test kits. Synergist assays using 4% piperonyl butoxide (PBO) were conducted on pyrethroids and DDT resistant populations. Biochemical assays were performed to detect increased activity level in mixed-function oxidases, non-specific esterases and gluthation S-Tranférases.

Results. Pyrethroids and organophosphates-based products were the most used in Songon-agban. *Ae. Aegypti* was resistant to all insecticides tested with a mortality rate of 68% for deltamethrin, 57% for lambda-cyhalothrin, 41% for DDT, and 82% for chlorpyrifos-methyl. Partial restoration of the susceptibility to pyrethroids and DDT (all p⊠0.05) was associated with an overexpression of α-esterase activity (32.08 nanomol α-naphthol/min/mg protein) in *Ae. aegypti* at Songon-Agban.

Conclusion. This study showed for the first time the involvement of metabolic mechanisms (α-esterases) in insecticide resistance within *Ae. aegypti* populations in Côte d'Ivoire. It is therefore necessary to take into account agricultural practices in the management of resistance of dengue vectors.

Keys words: *Aedes aegypti*, Insecticide resistance, Metabolics mechanisms, Côte d'Ivoire.

ABS-707

The Cytochrome P450 CYP325A is a major driver of pyrethroid resistance in the major malaria vector *Anopheles funestus* in Central Africa

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The overexpression and overactivity of key cytochrome P450s (CYP450) genes are major drivers of metabolic resistance to insecticides in African malaria vectors such as *Anopheles funestus* s.s. Previous RNAseq-based transcription analyses revealed an elevated expression of the *CYP325A* specifically in Central African populations but no validation of its role in resistance has so far been achieved. In this study, RT-qPCR consistently confirmed that *CYP325A* is highly over-expressed (fold change > 50; $P < 0.01$) in pyrethroid-resistant *An. funestus* from Cameroon, compared with the control, unexposed. Synergist bioassay with PBO significantly recovered susceptibility for permethrin (Mortality= 29%, $\chi^2 = 106.34$, $p<0.00001$) and deltamethrin (Mortality

= 17%, χ^2 = 130.56, p<0.00001) implicating P450s. Polymorphism analyses of the full-length 1512bp cDNA of *CYP325A* Africa-wide detected a high polymorphism with no evidence of an allelic variation mechanism associated with pyrethroid resistance. The *in silico* homology modelling and molecular docking simulations predicted *CYP325A* model to bind and metabolise type I (4.91Å) and type II (4.45Å) pyrethroids and potentially carbamates (4.33Å). Heterologous expression of recombinant *CYP325A* and metabolic assays confirmed that this gene metabolises both type I (permethrin: percentage depletion = 77% ± 0.6) and type II (deltamethrin: percentage depletion = 59% ± 0.3) pyrethroids. The establishment of *CYP325A* as a pyrethroid-resistance gene explained the observed permethrin and deltamethrin resistance in field mosquitoes from Central Africa and confirms RNAseq patterns. Analysis of the 1kb fragment of the promoter region revealed a reduced diversity in resistant mosquitoes compared to susceptible ones, revealing an ongoing selection on this gene. These findings provide evidence implicating *CYP325A* in field mosquitoes as a major driver of pyrethroid resistance in *An. funestus* mosquitoes across Central Africa and should facilitate future efforts to detect the causative resistance markers to design field applicable DNA-based diagnostic tools.

Keywords: *Anopheles funestus*, malaria, pyrethroids, metabolic resistance, cytochrome P450, *CYP325A,* Central Africa

ABS-711

Specific Kdr mutation haplotypes are associated to pyrethroid resistance in *Aedes aegypti* from Burkina Faso

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Background: Previous studies in Burkina Faso reported *Aedes aegypti* resistance to pyrethroid insecticides, associated to F1534C and V1016I *kdr* mutations. Larval of *Ae. aegypti* were collected from three health districts of Ouagadougou in 2018.

Methods: The resistance status of *Ae. aegypti* to pyrethroid was assessed using CDC-bottle and WHO-tube bioassays. *Aedes aegypti* females from all study sites were resistant to permethrin and deltamethrin (<80% mortality) but were fully susceptible to malathion (>98% mortality). The V410L, 1534C and 1016I *kdr* mutations were reported using a multiplex AS-PCR, and the results compared to TaqMan and sequencing.

Results: The F1534C *kdr* allele was almost fixed while V1016I and V410L *kdr* allele varied from 0.5 to 0.7 within the three localities. The V1016I and V410L allele frequencies varied significantly across localities. The 1534C/1016I/410L haplotype was correlated to permethrin resistance at Nongrmasson (OR: 3.18, CI95%: 1.38-7.37, χ2=7.818, p<0.01) and Bogodogo (OR: 9.46, CI95%: 3.48-25.71, χ2=25.111, p<0.001) but not associated to deltamethrin resistance in the three localities (OR: 1.59, CI95%: 0.63-4.07, χ2= 0.982, p=0.322).

Conclusion: Specific kdr mutation haplotypes associated to spatial variation of mutations frequencies drive pyrethroid resistance in *Aedes aegypti* populations from Burkina Faso.

Keywords: *Aedes aegypti*, pyrethroid, malathion, sequencing, multiplex PCR, *kdr*, V410L, F1534C, V1016I, Burkina Faso, bioassays

ABS-733

Towards malaria elimination: Malaria vector species distribution and the status of insecticide resistance in selected sites in Kenya.

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Background. Although time-tested key vector control interventions namely Long-lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) have resulted in significant declines in malaria incidence and mortality in many countries, malaria elimination remains elusive. This study explored malaria vector species distribution and diversity and the status of insecticide resistance in selected sites in Kenya toward understanding malaria transmission dynamics.

Methods. Anopheles mosquitoes were sampled between 2019 and 2020 from Kwale, Busia, Kirinyaga, Turkana and Kiambu, representing different malaria endemicities and identified based on morphology. Mosquitoes were sampled as larvae and as adults from indoors and outdoors using aspiration and CDC light traps. Standard insecticide resistance intensity bioassays were performed for selected insecticides. Presence of malaria parasites in mosquitoes was also determined.

Results. A rich repertoire of Anopheles species was found, 13 in total, although *Anopheles gambiae* s.l. and *An. funestus* remained predominant, accounting for over 64% of samples identified in most sites. *An. rufipes, An. pretoriensis and An. ziemenni* were the next most abundant species accounting for over 12% in at least one site. Malaria vectors were also identified from zones with no history of malaria transmission. Malaria parasite rates were however low (less than 1%) among the samples analysed. High levels of resistance were observed for deltamethrin, alpha-cypermethrin and pirimiphos-methyl whereas mosquitoes were susceptible to clothianidin and chlorfenapyr.

Conclusions. Despite the low parasite rates observed, these results suggest that insecticide resistance remains a real threat to malaria control. The significant densities of secondary vectors and presence of malaria vectors in new distribution ranges may further challenge the malaria elimination goal especially when existing core malaria vector control interventions fail to reach these vectors. Vector surveillance in line with the WHO Global Vector Control Response 2017–2030 strategy will improve understanding of vector dynamics and contribute towards malaria elimination.

ABS-741

Pyrethroid insecticide susceptibility status and breeding habitats preference of *Aedes aegypti* mosquito in the Lake zone, Tanzania

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Background: In recent years, Tanzania has experience outbreaks of dengue fever in the cities of Dar es Salaam and Tanga. The main vectors of the dengue virus in Tanzania are *Ae. aegypti* mosquitoes which are available in rural and urban settings. The control of this mosquito vector in based insecticide and yet the insecticide susceptibility of this species is not well known in many places in Tanzania particularly in the lake zone districts. On the other hand, the breeding habitats mostly preferred by this species is not well documented. Therefore, the present study aimed to determine the pyrethroid insecticide susceptibility status and breeding habitats preference of *Aedes aegypti* mosquito.

Methods: The study was conducted in the three sites from three districts of the Lake zone, Tanzania which were Bwiru street (Ilemela municipal council), Igekemaja village (Magu district) and Mwagagala (Misungwi district). The *Ae. aegypti* mosquito larvae were collected from different breeding sites and brought to the insectary for rearing. Emerged F1 of day three to five were tested to the three pyrethroid insecticides. Insecticides tested were Permethrin (0.75%), Alphacypermethrin (0.05%) and Deltamethrin (0.05%). The assessment of *Ae. aegypti* mosquito 24 hours % mortality was based on WHO criteria.

Results: A total of 850 *Ae. aegypti* were exposed to three pyrethroid insecticides. At Bwiru site, all Ae. Aegypti were susceptible

to Permethrin (0.75%), Alphacypermethrin (0.05%) and Deltamethrin (0.05%) each with 100% 24 hours mortality. At Igekemaja site, *Ae. aegypti* were resistant to all the three pyrethroid insecticides tested. The 24hours % mortality to Permethrin (0.75%), Alphacypermethrin (0.05%) and Deltamethrin (0.05%) in this site were 84%, 72% and 86%, respectively. In Mwagagala sites, the species was also resistant to all insecticides tested whereby the 24 hours % mortality were 79%, 86% and 60%, respectively. Regarding the breeding habitats preference, the *Aedes aegypti* mosquito prefer to breed in abandoned old tires in urban area and in small containers and water storage containers in rural setting.

Conclusion: Our findings have revealed that, all *Ae. aegypti* were resistance to all insecticides tested in Igekemaja and Mwagagala sites and susceptible in Bwiru site. The breeding habitats of *Aedes aegypti* mosquito were abandoned old tires in urban area and in small containers and the uncovered water storage containers in rural setting. These findings, call for close monitoring and management of insecticide resistance and community education on proper storage of domestic water.

ABS-749

Understanding the impact of mosquito behaviour on of the public health benefit of dual active ITNs: the ESSENTIALS project.

Ranson H, Sanou A, Emidi, B, Akoton R, Bandason E, Jones J, Matope A, Guelbago M, Manjurano A, Mzilahowa T, N'Fale S, Djogbenou, L, Towers DT, McCall PJ, Churcher T, Foster GM

Insecticide treated nets (ITNs) are essential for sustainable reduction and eventual elimination of malaria in sub-Saharan Africa but are losing efficacy as pyrethroid resistance increases. With the introduction of dual active ingredient ITNs into pilot deployments and randomised control trials, methods to characterise the efficacy of differing modes of action on disparate vector populations are urgently required. We have developed a suite of bioassays capable of capturing diverse modes of action that are suitable for screening ITNs during development from early stage screening for insecticidal effects to evaluating performance of the ITN *in situ* at affected communities in Africa. This behavioural test suite avoids forced contact, instead simulating exposure under more natural conditions, usually with the inclusion of a human host attractant. There are three systems, Video Cone Test Assay (ViCTA), Baited Box test and Room-scale Video Tracking, each permitting characterisation at different levels of detail from rapid screening for repellent or irritant effects, to characterisation of late stage host seeking at the human-ITN interface, to visualisation of vector activity around the entire host-net environment. We have implemented these systems in four African locations where dual active nets have been deployed in Benin, Burkina Faso, Malawi, and Tanzania, alongside experimental hut trials and with extended monitoring to capture downstream delayed or sub-lethal effects *e.g.* refeeding ability, oviposition and hatching rates, and longevity until natural death which allows harmonisation of data between laboratory and semi-field experiments. Outputs are entered into malaria transmission models to identify entomological predictors of epidemiological efficacy. These test outputs greatly improve evidence-based predictions regarding the likely success of new ITN products against specific vector populations, increasingly important for decision-makers as the choice of net types grows.

ABS-505

Experimental hut evaluation to demonstrate the non-inferiority of candidate piperonyl butoxide (PBO) Insecticide Treated Nets (ITNs) to the first in class, and enhanced mosquito mortality of PBO ITNs.

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Background: Pyrethroid-PBO nets were given WHO policy recommendation as a new class based on impact on malaria from epidemiological trials conducted with Olyset Plus. In addition to Olyset Plus, there are four other pyrethroid-PBO nets prequalified by WHO that differ from Olyset Plus in terms of their design specifications, which might affect their field performance. Therefore, a study was undertaken to generate evidence on the relative entomological efficacy of pyrethroid-PBO nets and whether they are non-inferior (NI) or not to Olyset Plus.

Methods: A partially randomized, double blind experimental hut trial (EHT) was conducted to assess the NI of candidate nets PermaNet 3.0, Tsara Boost and Veeralin (pyrethroid-PBO), against the first-in-class Pyrethroid-PBO ITN: Olyset Plus. A pyrethroid-only net, Olyset, was used to demonstrate whether Pyrethroid-PBO nets are superior to pyrethroid-only nets. A negative control (untreated polyester net) was used to check study quality. For each product, unwashed and 20-times-washed nets were evaluated. The six treatment arms were evaluated over 36 nights in 24 huts near Ifakara, Tanzania. Primary endpoints were 1) proportion of mosquitoes dead after 24 hr (M24), and 2) proportion blood fed (BF). The dominant species was *Anopheles arabiensis*.

Results: For M24, all of the candidate PBO nets (washed and unwashed) were NI to Olyset Plus and superior to Olyset. Odds ratios were in the direction of higher M24 for candidate nets. All nets reduced BF to <5% and none of the candidate nets were shown to be NI to Olyset Plus; all confidence intervals crossed the NI margin. Relative to the untreated net, both the pyrethroid and the pyrethroid-PBO arms reduced BF by >70%.

Conclusions: The trial demonstrated evidence of NI of candidate PBO nets to the first in class, and enhanced mosquito mortality in all PBO arms, supporting the conclusion of public health value based on epidemiological trials of PBO nets.

ABS-770

Sociodemographic trends in malaria knowledge and implications for behaviour change in Zanzibar

Faiza Abbas

Background: Zanzibar is among the few places within East Africa that has documented significant reduction of malaria morbidity and mortality. Despite tremendous gains over the past decade, malaria transmission still persists in Zanzibar. This study aimed at understanding levels of malaria knowledge to provide recommendations that can be used to reinforce and scale up targeted malaria social and behaviour change interventions.

Methods: A descriptive cross-sectional survey was conducted through an administered questionnaire to 431 households selected randomly. The interviewees were the heads of household or representative adults above 18 years. This study investigated the levels of knowledge about the causes, symptoms, and prevention of malaria in areas with high (> 1.9 per 1,000) and low (<1 per 1000) incidence of local malaria cases. The Principal Component Analysis (PCA) was used to compute the composite variable of each category. Descriptive statistics were calculated to understand variables of interest between low and high transmission areas. Multinomial logistic regression model was used to compare knowledge on malaria based on key variables.

Results: A total of 431 heads of household were interviewed. Respondent age, education level and wealth status were significantly associated with variations in level of malaria knowledge. Old age was found to be significantly associated with low knowledge in malaria (P<0.001). Majority of study participants who had secondary and higher education levels had good knowledge of malaria (P<0.006). Participants characterized as middle-income had good knowledge compared to those characterized as low-income (P<0.001).

Page Break

Conclusion: The study identified existing gaps in malaria knowledge in low and high transmission areas. Low levels of malaria knowledge were documented among elderly and populations with lower education and income levels. There is a need to extend mobilization, advocacy, and expand channels of communication to reach all community members. The reported gaps in knowledge are important to consider when designing strategies to engage communities in malaria elimination in Zanzibar. Tailored social and behavioral change interventions aiming to increase malaria knowledge could enhance the uptake of malaria prevention services in the community.

Keywords: Knowledge on Malaria, local malaria transmission, Incidence, Zanzibar, Tailored SBC, intervention

ABS-561

Malaria transmission and insecticide susceptibility of the anophelian fauna in Njombé and Kékem, Cameroon.

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Malaria remains a major threat in Cameroon. However, there is still a lack of data on malaria situation and susceptibility profile of its vectors in many places across the country. In the present study we report data from entomological and household survey conducted in the localities of Njombé and Kékem in Cameroon. The study took place in 2021. Adult mosquitoes were collected using HLC and CDC method and identified using morphological and molecular techniques. *Anopheles gambiae* s.l. larvae were sampled from stagnant water and reared to generate F1 adults. The presence of *Plasmodium falciparum* CSP antigen was detected in the heads and thoraces of adult mosquitoes using ELISA. *An. gambiae* s.l. population were tested to deltamethrin, permethrin, bendiocarb and carbamate using WHO protocol. Population's Knowledge and practices concerning malaria was recorded using a questionnaire. About 3,694 mosquitoes belonging to 3 genera (*Anopheles, Aedes, Culex*) were collected. *Culex* spp., was the predominant species (54.04%) followed by *An. gambiae* s.l., and *An. funestus* s.l. *An. coluzzii* was the only species of the *An. gambiae* s.l. complex found. Amongst the 1,550 *Anopheles* screened by ELISA, 14 (0.90%) were found infected by *P. falciparum* 08 (0.52%) in Njombé and 06 (0.39%) in Kékem. The EIR was 0.27 ib/m/n in Njombé and 0.16 ib/m/n in Kékem. In Njombé, *An. gambiae* s.l. where resistant to perm 0.75; 3.75, delta 0.05 and 0.25% while they were more resistance to all insecticides in Kekem. Two hundred households were surveyed and over 85% of respondents attributed malaria transmission to mosquito bites. LLIN was the main tools use to prevent mosquito bites. The study reveals that population in Njombé are exposed to high malaria transmission than in Kékem and this transmission was sustained by *An. coluzzii.* Mosquito population of Kékem were more resistance to all insecticides than those of Njombé.

Key words: Anopheles, Malaria, Resistance, LLINs, Njombé, Kékem.

Parallel Scientific Session 4 :
Social sciences and gender inclusivity for VBDs

ABS-716

Strategies for cultivating independent leadership cadres at African institutions

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The successful delivery of high-quality technical support, science and innovation to enable improved vector control across Africa will rely on a complex and vibrant community of technical experts with complementary roles, skill sets and institutional bases. While all the actors in such a synergistic ecosystem of expertise are vital to its overall functionality, it is essential to recognize the pivotal leadership role played by the small minority of individual experts who ensure the sustainability and growth of the community as a whole. A simple rule of thumb within the scientific community is that the vast majority of all the many technicians and scientists required to generate new insights and innovations are highly dependent upon the small minority who are independently capable of securing funding and influencing funding policy. Furthermore, these are the only individuals advanced enough to train, mentor and manage the leadership cadres required to secure the sustainability of teams, departments, institutions and entire communities over the long term, so their cultivation and retention at African institutions is of paramount importance to the future of the continent.

In this presentation I will outline a personal perspective on how independent leadership cadres at African institutions could be more effectively cultivated going forward. The overall goal of such targeted leadership cultivation strategies would be to enable African institutions to push past the tipping points in their development trajectories, beyond which they can achieve an unprecedented surge of sustainable growth through collective learning processes that pivot around the survival, successes and failures of their established and emerging leadership cadres. While many of the experiences and potential solutions shared will be familiar to members of relevant expert communities across Africa, I nevertheless hope that the considerations and perspectives outlined may provide useful food for thought and action.

ABS-506

Efficacy of the Mosquito Shield™, a passive emanator spatial repellent, against pyrethroid-resistant malaria vectors

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Background: Spatial repellents create airborne concentrations of an active ingredient (AI) within a space, disrupting mosquito behaviours in ways that ultimately lead to a reduction in human-vector contact. The purpose of this study was to assess the efficacy of Mosquito Shield, a transfluthrin passive emanator spatial repellent, against wild, free-flying, pyrethroid-resistant *Anopheles arabiensis* mosquitoes in Tanzania

Methods: This study was partially randomized with two treatment arms: 1) Mosquito Shield and 2) negative control (no treatment). A total of 24 experimental huts were used to run two concurrent experiments: the Human Landing Catch (HLC) experiment to measure mosquito landing and a classic experimental hut experiment used for testing Insecticide Treated Nets (ITNs) to measure blood feeding inhibition and 24-hour mortality. The product was evaluated for its efficacy over 1 month.

Results: Two measures of protective efficacy (PE) for Mosquito Shield over 30 days were obtained. In the HLC experiment, PE of envelope 67%(95%CI:63-70%) based on the reduction in human landings. In the hut experiment, PE was 73%(95%CI:(62-84%) based on the reduction in the proportion of blood-fed females. The interaction between the treatment and the method used was tested using negative binomial regression, resulting in a non-significant Rate Ratio of 0.98(95%CI:0.53-1.82;p=0.958) indicating that both methods measured the same PE. Control corrected mortality was 30%(95%CI:22-38%). Logistic regression showed a significantly higher 24-hour mortality in the treatment huts with an OR of 2.94(95%CI:2.18-3.97;p<0.0001).

Conclusions: The placement of transfluthrin Mosquito Shield indoors successfully reduced the landing and blood-feeding rate of wild *Anopheles arabiensis* mosquitoes for 30 days. Mosquito Shield induced significant mortality among pyrethroid resistant mosquitoes. HLC is a good proxy of feeding inhibition for evaluation of volatile insecticides under field conditions. Evaluating volatile insecticides using the methodology used for ITNs it is possible to additionally evaluate induced mortality, which has a major impact on vectorial capacity.

ABS-726

Informing vector control product development with qualitative and quantitative information on user preferences through a discrete choice experiment

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Background: Malaria transmission remains high despite regular distribution of insecticide-treated bednets (ITNs) by the Programme National de Lutte Contre le Paludisme (PNLP). A trial conducted in Cote d'Ivoire in 2018 by Sternberg *et al* compared ITNs combined with Eave Tubes (ET) and non-insecticide treated window screens (WS) to ITNs alone on households in Cote d'Ivoire. Malaria incidence in children was significantly lower in the intervention group compared to the control group. However, intervention costs were high and equally split between untreated WS and ET, which suggests that a simplified intervention which delivered similar impact, could be more cost-effective.

Methods: We explored consumer preferences for WS using a Discrete Choice Experiment (DCE) to elicit respondents' preferences by asking them to choose between pairs of hypothetical products with different attributes. Data collection took place from May to August 2022 in the Gbéké region, Cote d'Ivoire, where the previous trial was conducted. Firstly, qualitative data on the important characteristics of WS were collected through focus group discussions. Secondly, a Discrete Choice Experiment (DCE) was conducted with 400 participants who were asked to state which WS they preferred between multiple different pairs of products with and without insecticide, with differences in price and other characteristics. We used a mixed logit model to identify what product attributes matter the most participants as well as their willingness to pay for different WS; and performed a latent class analysis to highlight heterogeneity between participants' categories (based on gender, age etc.).

Results: The DCE results provide a foundation for developing a target product profile, to guide product research and development into a product which best suits end-user preferences.

Conclusion: DCE provide a useful approach to identifying and quantifying user preferences which could be more widely applied to improve the acceptability and demand for vector control tools.

ABS-552

The role of gender in malaria interventions

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Background: The control and elimination of malaria remains one of the biggest public health challenges. Malaria transmission and control heavily intersects with gender-specific vulnerabilities, yet gender is often overlooked during implementation, monitoring and evaluation. The objective was to identify to what extent there are differences between women and men in malaria control interventions in endemic regions in sub-Sahara Africa.

Methods: A scoping review was conducted guided by a conceptual framework that considered the differences in use, access and exposure in vector control, preventative therapies and case management – between men and women. A literature search was implemented in PubMed/MEDLINE, Web of Science and Google Scholar. Key informant interviews were conducted with stakeholders to gain further insight.

Results: 24 papers investigated gender differences in vector control, preventive antimalarial drugs and case management. The majority addressed vector control, specifically the use and access of insecticide-treated nets (54%), others fell under preventive antimalarial drugs (4%), case management (16%) and many publications covered more than one intervention category (24%). Recurring themes of gender dynamics were identified in different publications and similar across the different intervention categories. Access to interventions is in many cases dependent on financial resources and on the decision-making power within the household. Additionally, gender-specific activities and social norms play an important role in many settings, where women and men have to conform to the standards set by the society in which they live. Access and exposure to vector control interventions are heavily influenced by information channels and understanding.

Conclusion: When implementing malaria control interventions, gender-specific approaches should be considered, depending on the societal context, to ensure equality in use and access of malaria control interventions, and ultimately equality in the reduction in malaria burden.

ABS-612

Fifty years of mosquito control research: unstructured data analysis of publication records from 1971 to 2020 highlights changes in regional research priorities, gender gaps, collaborative patterns and funding inequities

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Background. Strategic decisions informing disease control programmes and control interventions crucially depend on evidence-based research. In the past, global research funding sources often went to institutions and individuals in high-income countries, even for work done in low-income countries leading to knowledge inequities and perpetuating cycles of capacity deficits. More so, funding bodies not applying the gender lens in resource allocation. Understanding long term patterns of access to knowledge, capacity deficits, gender inclusivity and funding patterns is complicated by the lack of comprehensive records spanning relevant timespans.

Methods. Here, we compiled the publication records of fifty years of research focusing on mosquito research (1971-2020) from Medline and Web-of-Science resulting in a database of ~25,000 outputs. Using unstructured data analysis on publication title and abstracts, we extracted information on changes in research productivity focus and questions in relation to time and regions. Author information was used to identify the gender of 1st and senior authors and allowed us to highlight changes in research participation and leadership. Furthermore, we used the publication authors address records to study changes in collaboration patterns and access to funding overtime.

Results. Our analysis highlights broad difference and changes in disease control priorities and research focus and innovations in relation to regions and time. Long term North-South disparities in productivity, the importance of collaborations and progress in research capacities and leadership in Southern regions are underlined. Progress in narrowing the gender gap and increasing female leadership in science are also highlighted.

Conclusions. This study underlines the power of unstructured data analysis to generate quantitative comparisons from digital libraries of text records. The data from 50 years of mosquito control research highlights important positive changes in access to and participation in science and leadership. However, there remains important disparities and capacity deficits in cycles perpetuated by funding inequities.

ABS-678

Different paths to reduce malaria exposure when outdoors at night by members in Rural Malawi-Chikwawa District.

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Background. Malaria infection rates in Malawi remain high with the prevalence at 24%. Insecticide Treated Nets (ITNs) and Indoor Residual Spraying (IRS) represent the main domestic tool for vector control in Malawi. However, the popular interventions provide 100% protection to individuals from exposure to malaria transmission when under the bednet; leaving individuals who outdoors during Anopheles feeding times of 6pm and 6am exposed to malaria transmission. Using a qualitative and in-depth lens, this work presents findings on ways people employ when outside the protection of a bednet outdoors to prevent malaria.

Methods. Participant observation and in-depth interviews and focus group discussions were conducted between November and December for one week and for 9 weeks between August and December of 2021in Chikwawa, Chikwansa Village.

Results. The study showed that members of the community interacted with malaria vectors outdoors due to different reasons. Women and children were exposed to malaria vectors at the same time, whilst mothers cooked and could not place the child under a bednet, as family members ate and chatted before going indoors; men were exposed outdoors-away-from-home at the local bar; open spaces playing local games; as well as community member taking part in community activities such as initiation ceremonies and funerals.

To prevent malaria transmission during times that limit bednet usage, individuals take a different approach to reduce human-vector interaction. Cloth chasing was the most mentioned and observed strategy used by mothers to protect themselves and younger children from being bitten by mosquitoes as they remained outdoors. Additionally, participants used: covering themselves with a cloth; men wearing body covering materials when going outdoors; burning cattle dung and neem leaves to repel mosquitoes; chasing away mosquitoes using neem branches; and using coils when money was available.

Conclusion. Though ITNs and IRS recognised and accepted by users as the main vector control intervention in malaria prevention; individuals are unable to use them when outdoors taking part in different activities where a bednet cannot be used even when available. Therefore, looking into interventions which accommodate the factors which limit bednet usage provides a window of opportunity in the development of integrated and sustainable vector control strategies whish respond to the needs of the users.

Keywords: ITNs; malaria prevention; outdoor; vector control interventions

ABS-762

Entomological happenings: exploring collaborative design solutions for sustainable mosquito control

Denise Valle, Paulo Roberto Da Silva Júnior, Denise Nacif Pimenta, Ann Kelly, Braulio Silva Chaves, Brunah Schall, Claudia Gomes França, Javier Lezaun, Tiago Filizzola Lima, Yasmine Paula Evaristo

Background & Objective: The improvement of vector control programs depends on the commitment of people from affected communities, whose involvement and engagement around the efforts to eliminate mosquitoes are themselves prime conditions to understand and positively impact such highly dynamic local contexts. The "Entomological Happenings" project responds to that imperative, intending to experiment with a new form of collaborative design, which we call *happening*. The project aims to build solutions of collaborative design for vigilance, prevention, and sustainable control of *Aedes Aegypti* in Brazil.

Materials & Method: Interactions among social agents from two different groups: current or former students (whatever their genre or sex) of the Professional Master's in Vigilance and Control of Vectors from FIOCRUZ (PGVCV/IOC/Fiocruz) and members of the Local Health Commission from Aglomerado Cabana do Pai Tomás, in Belo Horizonte, Minas Gerais, Brazil. The project takes the happening as a methodologic proposal, which was developed by Allan Kaprow as an improvised and spontaneous dramatic spectacle, or a performance, being a mosaic of happenings.

Results & Discussion: A pilot test was performed during august 2021, in a synchronous remote form due to the Covid-19 pandemic, with participants that had profiles similar to the groups approved by the ethics committees involved. The happening's pilot test has shown that the interaction among university/academia/public services alongside community agents plays a central role in the modern concept of health promotion, which defends the importance of the participation of individuals and communities in the contexts of daily life.

Conclusion & Recommendation: Moreover, it is up to highlight the need to defocus the debate of communication about prevention and vector control, in order to include into this discussion provocations about the challenges of the structural context in which the arbovirus proliferates. **When the final results will be available**: November 2022.

ABS-649

Evaluation of the effectiveness of preventive measures on malaria prevalence among the communities of the health district of Haho, Togo (West Africa)

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Introduction : In Togo, the major strategies implemented to fight malaria aim to reduce its burden and even eliminate it. It is essential to evaluate and monitor the effectiveness of the tools used. This study aims to evaluate the effectiveness of the means of prevention on malaria prevalence among pregnant women in the Health District of Haho.

Materials and methods : A cross-sectional, descriptive and analytical study was conducted through an epidemiological survey. Pregnant women (PW) aged 15 to 49 years were eligible for the study. Twenty pregnant women were selected per health facility using the Lot Quality Assurance Sampling (LQAS) method). A total of 400 pregnant women were recruited. They were tested for malaria diagnostic: thin and tick blood smear (BS)) and the Rapid Diagnostic Test (RDT). The survey form included

the following modules: socio-demographic information (age, sex, education level, marital status, occupation) and knowledge, attitudes and practices of malaria (cause, prevention, treatment, suggestions).

Results : Long-lasting insecticide-treated nets (LLINs) were most commonly used by PW (76.25%) to prevent malaria and 90.5% of women reported having received at least one dose of Intermittent Preventive Treatment (IPT). Malaria prevalence was 33.75% by RDT and 33.25% by BS. *Plasmodium falciparum* was the only plasmodial species identified during the study. Parasite density (PD) varied from 0 to 94.285 parasites/µL. In addition, LLINs did not, reduce malaria prevalence. However, both LLINs and (IPT) were likely to reduce the PD in PW. Additionaly, PW aged 25-35 years and more had less probability of having malaria as well as those who received IPT and used LLINs in good condition.

Conclusion: Despite the efforts made, this study showed that malaria still persists among communities in Togo.

Keywords: Malaria, prevalence, pregnant women, LLINs, IPT, the Health district of Haho

ABS-628

Prevalence and associated factors of malaria, among Internally Displaced Children in Ntouessong health area, Central Region of Cameroon.

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Background: Malaria is a global health challenge with significant morbidity and mortality, with higher rates among children particularly in Africa. It is the most widespread endemic disease in Cameroon Recently there has been displacement of over a million people due to different crisis in Cameroon. However, there is limited study on the public health issues facing these vulnerable populations. This study evaluated the prevalence and associated factors for malaria infection, among children of internally displaced persons (IDP) in Ntouessong health area, Central Region of Cameroon.

Method: A total of 320 children up to 10 years old were included in the study in the year 2021. A mixed study was used for the study (Quantitative and qualitative). Malaria infection was confirmed by rapid diagnostic tests. The demographic characteristics were obtained by the use of questionnaire. The logistic regression analysis was used to determine associations between predictor variables and primary outcomes. Indept interviews were carried out to the children's parents on the use of mosquito net.

Result: Malaria infection was recorded for 67.2% of the children. Age was a significant risk factor for malaria with higher odds of having malaria infection in children 6–10 years of age [odds ratio (OR) = 2.032, P = 0.021] than in younger children. Specific attention needs to be paid to IDP children. Many homes don't have treated bed nets.

Conclusion: malaria control should include children above five years of age and the sharing of treated bed nets to households should be most frequent.

Parallel Scientific Session 5 :
Larval source management and integrated vector management

ABS-518

High efficacy of microbial larvicides for malaria vectors control in the city of Yaounde Cameroon: a cluster randomised study

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The rapid expansion of insecticide resistance and outdoor malaria transmission are affecting the efficacy of current malaria control measures. In urban settings, where malaria transmission is focal and breeding habitats are few, fix and findable, the addition of anti-larval control measures could be efficient for malaria vector control. But field evidences for this approach remains scarce. Here we provide findings of a randomized-control larviciding trial conducted in the city of Yaoundé that support the efficacy of this approach.

A two arms random control trial design including 26 clusters of 2 to 4 km^2 each (13 clusters in the intervention area and 13 in the non-intervention area) was used to assess larviciding efficacy. The microbial larvicide VectoMax®G combining *Bacillus thuringiensis* var *israelensis* (Bti) and *Bacillus sphaericus* in a single granule was applied twice per month in all standing water collection points. The biting anopheline density collected using CDC light traps was used as the primary outcome, secondary outcomes included the entomological inoculation rate, breeding habitats with anopheline larvae, and larval density. Baseline entomological data collection was conducted for 17 months from March 2017 to July 2018 and the intervention lasted 26 months from September 2018 to November 2020.

The intervention was associated with a reduction of over 85% of habitats with anopheline larvae. The application of the larvicide also resulted in a reduction of 68% of adult anopheline biting density and of 79% of the entomological inoculation rate (OR 0.21; 95% CI 0.14 – 0.30, P<0.0001). A reduction of 68.27% was recorded for indoor biting anophelines and 57.74% for outdoor biting anophelines. No impact on the composition of anopheline species was recorded. A reduction of over 35% of adult *Culex* biting densities was recorded. The study also assessed the impact of the microbial larvicide on non-target organisms and registered no significant impact of the larvicide VectoMax on the aquatic microfauna diversity.

The study indicated high efficacy of larviciding for reducing malaria transmission intensity in the city of Yaoundé. Larviciding could be part of an integrated control approach for controlling malaria vectors and other mosquito species in the urban environment.

Keywords: Larviciding, *Bacillus thuringiensis, Bacillus sphaericus, Anopheles*, malaria transmission, Yaoundé, Cameroon

ABS-367

Community Based Larval Source Management in Kenya

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Malaria prevalence in Kenya is at 6% with the Lake endemic zone at 19% and Coast Endemic zone at 4%. The main malaria species in Kenya is *Plasmodium falciparum* (76%) and minor species being *Plasmodium malariae* (4%) with missed infections (*P. falciparum and malariae*) at 19%. The main malaria vectors in Kenya are *Anopheles arabiensis* (evenly distributed), *Anopheles gambiae* and *Anopheles funestus*. Malaria prevention in Kenya involve implementation of Long Lasting Insecticide Treated nets (LLINs) in 27 counties through mass net distribution after 3 years and Indoor Residual Spraying (IRS) in 2 high malaria burden counties of Migori and Homabay. Larval Source Management (LSM) is considered as a supplementary intervention and is targeted for eight counties in Lake endemic zone. Implementation of the two interventions (LLIN and IRS) are currently under threat of widespread insecticides resistance especially to pyrethroids. One of the strategies for management of insecticide resistance in Kenya is LSM among others.

Kenya signed a bilateral agreement with Cuban government to conduct community based LSM in 8 malaria endemic counties for 2-years period. Under the agreement the Cuban government will provide ten (10) vector control experts and biolarvicides

– Bactivec (*Bacillus thuringiensis israelensis*) and Griselesf (*Bacillus sphaericus*). The biolarvicides have being sourced from Labiofam company in Kibaha Tanzania and are currently been stored in KEMSA Kisumu.. Application of biolarvicides will be after every 3 months at the beginning of the dry season or the end of the rainy season. The Cuban experts will provide technical expertise to Community based workers (CBWs) in Villages and public health officers at ward level. Currently county engagement meetings with Governors, County Health Ministers and County Directors of health of the 8 targeted counties have been conducted. Social mobilization have also been conducted in the villages by chiefs, village elders and community health volunteers through chief barazas and churches. Selection of a brigade per village consisting of five Community based workers and 1 – supervisor has been conducted. The Role of the Brigade/community-based workers will be; mobilization of households, mapping of breeding sites, application of biolarvicides and monitoring –adult and larvae sampling. Prior to application of larvicides, training will be conducted in 2 levels; 5 – days training of trainers and 5-days training of CBWs. Participants will be trained on – mapping of breeding habitats, application and reapplication of larvicides, environmental modification and manipulation, adult and larval monitoring, storage and handling of biolarvicides and equipment. After trainings, baseline mapping of larval habitats will be done. At the same time adult sampling of mosquitos in selected sentinel houses will be conducted as well as generation of malaria incidence data in the catchment health facilities within the Ward. During application of the biolarvicides, a hand-held Hudson pump will be used in small water bodies while motorized pumps will be used in large water bodies (high pressure). Reapplication will be dependent on monitoring data but based on the biolarvicides label its after 2-3 months. Quality of biolarvicides will be assured by monthly monitoring by Kenya Medical Research Institute (KEMRI-Kisumu). After application, monitoring and evaluation will be conducted on monthly basis where by selected sentinel breeding habitats will be surveyed for determination of larvae density. Adult collection of mosquitos to determine indoor density and infectivity rates will be conducted in selected sentinel houses. Malaria incidence data will be generated from catchment health facilities as well as through cross sectional surveys after every quarter.

ABS-491

Implementation of Community-based Larval Source Management for Enhancing Malaria Control in mainland Tanzania. A process narration

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In mainland Tanzania, implementation of insecticide treated nets and indoor residual spraying has helped in reducing malaria prevalence from 18.1% (2008) to 7.5% (2017). In enhancing malaria control, the country is planning to deploy Larval Source Management (LSM). LSM is the management of water bodies that are potentially mosquito breeding sites. WHO recommends LSM as a supplemental vector control intervention, suitable mostly in urban settings and where breeding habitats are few, fixed and findable. Little evidence is available on LSM implementation in rural settings. Tanzania is piloting routine LSM implementation in three councils: Handeni DC, Lushoto DC and Tanga CC, selected to represent both rural and urban settings, as well as different malaria risk strata: low (1-≤5 *Pf*$PR_{5\text{-}10yrs}$), moderate (5-≤30 *Pf*$PR_{5\text{-}10yrs}$) and high (>30% *Pf*$PR_{5\text{-}10yrs}$). Implementation follows a community-based approach set up following extensive consultations between Ministry of Health, implementing partners and research institutions. Two community owned resource persons implement LSM at the ground level, supervised by officers at village, ward and council levels using existing local government structures. The country uses two biolarvicide products that are produced locally by Tanzania Biotech Products Limited; *Bacillus thuringiensis var. israelensis* (Bti) and *Bacillus sphaericus* (*Bs*). LSM is conducted in all selected areas following a temporal approach based on rainfall patterns. Implementation is guided by standard operating procedures through the following phases: advocacy, training, logistical set-up, mapping, baseline data

collection, application, monitoring and evaluation. All councils have conducted baseline data collection and biolarviciding is expected to start in May 2022. This implementation experience using exclusively governmental mechanisms as well as locally produced biolarvicides is expected to contribute important real-world experience on the potential of this form of vector control across a range of ecologies and transmission situations. We will be reporting on this experience after six months of implementation.

ABS-594

Fitness cost of the bio-larvicide VectoMax G on pyrethroid-resistant populations of Anopheles coluzzii; contribution to resistance management

Nkahe Diane

Introduction: Combining larviciding with LLINs and IRS could impede the spread of pyrethroid resistance in malaria vector population. However, there is still not enough information on the impact of larviciding on insecticide resistance management. Here we checked if the biolarvicide VectoMax G can impact insecticide resistance prevalence within anopheline populations.

Methodology: Resistant *An. coluzzii* larvae were collected in the city of Yaoundé, pooled and selected to deltamethrin 1 X during 17 generations. Larvae from this resistant strain were splited into four groups and exposed to different selection pressures as follow; 1: deltamethrin 0.05%, 2: VectoMax/deltamethrin, 3: VectoMax, 4: VectoMax/deltamethrin+susceptible. Selections occurred once every two generations following the WHO criteria. After many generations of selection 100 females from each strain were blood fed and allowed for individual eggs laying. Life traits parameters were measured on the progeny and compered between colonies. The control was the susceptible laboratory strain "Ngousso". A multiplex detoxification assays and a qPCR for kdr genes detection were performed on selected samples. Gene's expression was compared between F1 and the last generations in each colony.

Results: The life traits parameters were clearly changing from one trains to the other depending on the selection pressure. The larval time were longer in the strain selected only to deltamethrin (10.61±0.33 days), as compared to the other selected groups (7.59±0.82 days) and to that of the susceptible mosquitoes (7.57±0.35). All the strains showed a higher death rate during emergence as compared to the deltamethrin selected strain. The average life span of VectoMax selected colony were below 16 days versus 20 days for susceptible mosquitoes. The expression level of the six detoxification genes assessed have not decrease from the first and the last generation as expected. However, the kdr gene expression has significantly decreased in the strain mixed with susceptible (P=0.012).

Conclusion: VectoMax impact mosquito's life traits parameters with some results similar to that of susceptible colony. Therefore a reversing effect of VectoMax on the resistance status remains possible with much more selections. This study also show that the resistant reversal phenomenon could be accelerated by the implementation of innovative control measures such as Genetically Modified mosquitoes.

Keywords: VectoMax G, larviciding, resistance reversal, Anopheles coluzzii.

ABS-327

Assessing malaria transmission and vector dynamic in a context of larviciding trial in the city of Yaoundé, Cameroon

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Introduction: Malaria remains a public health problem in Cameroon. The prevention of this disease is slowling down by

insecticide resistance, mosquito changing behaviour and the fast demographic growth of urban population. To manage those challenges, larval control could be effective. In the frame of a larviciding trial in the city of Yaoundé, a study was conducted in 26 districts from March 2017 to November 2020 to assess its impact on adult anophelinae densities, malaria transmission dynamic and prevalence.

Methods: A baseline survey was performed during one year then the larviciding was applied in 13 districts while the 13 others served as control. Entomological surveys were carried out once every two months to collect adult mosquitoes using CDC light traps and Human Landing Catches. Mosquitoes were identified up to the species level via PCR then analysed for *plasmodium falciparum* infectivity via ELISA. Two parasitological surveys were also conducted through malaria testing using blood smears and RDTs while dried blood spots were collected on filter papers to identify *Plasmodium* species. Slides were stained with Giemsa and examined by microscopy for malaria parasites detection.

Results: Indoor and outdoor anophelinae densities recorded with CDC declined by 69.13% and 61.55 % respectively during the larvicide treatment. The same trend was observed with HLC densities regarding the reduction rate of 79.99% and 63.47% recorded. Results also show that the spatio-temporal distribution of anophelinae species in the city was affected by the treatment. In the same way, larviciding reduced indoor and outdoor transmission by 68.97% and 61.77% respectively. The intervention was also associated with a reduction in malaria prevalence.

Conclusion: The study highlights the efficacy of larviciding in reducing anophelinae density, malaria transmission and malaria prevalence in the city of Yaoundé Cameroon. This approach could be undertaken to sustain the efficacy of existing tools.

Keywords : Larviciding, VectoMax, malaria, Anopheles, transmission, Yaoundé, Cameroon.

ABS-519

Association between house characteristics and community practices on anophelines distribution and malaria prevalence before and during a larviciding program in the city of Yaoundé-Cameroon.

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Background: The most efficient malaria vectors bite and rest inside houses, hence house play a determinant role in malaria transmission. During the implementation of additional vector control tool such as larviciding, individual disease risk perception could be affected. We carried out this study to evaluate the influence of house structures, community knowledge and practices on anophelines diversity and malaria prevalence, before and during a larviciding program.

Methods: The study was conducted before and during larviciding intervention in 26 districts. Indoor CDC light traps were used to collect mosquitoes. Questionnaires were administered to collect data on house characteristics and to evaluate the impact of larviciding on population knowledge and behaviour. After morphological identification, anophelines were tested by ELISA to detect infection to *Plasmodium* parasites. RDT was used to test blood samples participants. Binary analyses were used to assess correlation between different variables.

Results: The majority of houses was made with cement walls. The most abundant anophelines was *An. coluzzii,* following by *An. gambiae s.s,* with highest densities in traditional houses before the treatment in control sites, whereas, they were most abundant in modern houses in treated sites. Opened eaves, absence of ceiling exposed people to anophelines bites. Possession of LLINs before the treatment in control sites exposed people to anophelines bites while they were protected in treated sites. Infection to *Plasmodium* and malaria prevalence were highest in modern houses found in control sites; while in treated sites, infection to *Plasmodium* was highest in modern houses, but malaria prevalence was the same in the both house types. People who lived in treated sites knew more about malaria prevalence and mosquito breeding sites, and the latter used less LLINs.

Conclusion: Well built houses protect people against anophelines species. The implementation of larvicide control improved knowledge of people and decrease their personal protection against mosquito bites.

Keywords: treated sites, larvicide, house type, house parameters, VectoMax G, socio-anthropological, Yaoundé.

ABS-550

Contribution of VectoMax®G, a larvicide for the control of mosquito densities and malaria transmission in some districts in the city of Yaoundé

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Introduction: Malaria remains a major public health problem in Cameroon. In the frame of a larviciding trial, a study was conducted to assess the efficacy of larviciding with VectoMax®G for the control of mosquito population, composition and malaria transmission dynamic in the city of Yaoundé, Cameroon.

Methods: Clusters were grouped into treated sites, which received larviciding with VectoMax®G (*Bacillus thuringiensis* and *Bacillus sphaericus*); and into control sites. Adult mosquitoes were collected indoors and outdoors in both control and treated sites using Centers for disease control and prevention (CDC) light traps and human landing catches during the months of July, September, and November 2019 in eight districts of Yaoundé**.** Mosquitoes were sorted by genus using the morphological characteristics and identified to the species level using polymerase chain reaction (PCR). The enzyme linked immunosorbent assay (ELISA) method was used to determine mosquito infection status to *Plasmodium*.

Results: Amongst the 915 mosquitoes collected, C*ulex* species were predominant (66.34%) followed by *An. gambiae* sensu lato (s.l.) (30.27%). The proportion of mosquito species collected in control sites was high compared to treated sites. The difference was significant in Anophelinae collected (χ^2= 98.69; P<0.0001) with a reduction rate of 85.52% noted in *An. gambiae* s.l. Out of 122 *An. gambiae* s.l. analyzed, 77.05% (n = 94) were *An. coluzzii* and 22.95% (n=28) *An. gambiae* sensu stricto (ss.). The infection rate of *An. gambiae* s.l. by *Plasmodium falciparum* was 1.9% in control sites (5/260) and none in treated sites. The entomological inoculation rate varied from 0 to 3.83 infective bites/man/month in control sites therefore, a risk of malaria transmission in control sites.

Conclusion: Our findings suggest that larviciding with VectoMax®G can be highly effective for reducing mosquito density and malaria transmission in the city of Yaoundé Cameroon.

Keywords: VectoMax®G, Larviciding, Malaria, Anopheles, transmission, Yaoundé, Cameroon.

ABS-617

Larvicidal efficacy of chlofenapyr and clothiandian for control of malaria vector

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Malaria vector control through the use of insecticides have so far being the main stay of malaria control. However, increased insecticide resistance has being reported accross many countries mostly to the pyrethroids. Therefore, there is an urgent need for alternative insecticides for effective management of this increasing insecticide resistance in malaria vectors. Clothianidin and chlorfenapyr are novel insecticides use in control of malarial vector due to their unique mode of action. Determination of their potency as larvacide will be a milestone in larval source management. The aim of this study was to determine the effect of different concentrations of clothianidin and chlorfenapyr and their efficacies against larval and pupal stages of Anopheles gambiae, major malaria vector species in Nigeria.

Immature stages of Anopheles mosquitoes were collected from wild and reared at 26±3oC and 74±6% relative humidity. Test solutions of Chlorfenapyr and Clothiadian were prepared at concentrations of 6.25µg, 12.5µg, 25µg, 50µg, 100µg, 200µg, and 13µg respectively. Batches of twenty-five late 3rd to early 4th instar larvae and pupae of mosquito species were introduced separately in each of the test concentrations in 250ml deionized water for Chlorfenapyr. While test concentration of Clothiadian consisted of 1ml and 0.5ml of 13.2µg in 250ml of de-ionised water. Four replicates for each concentration and the positive control (1ml of acetone in 250ml deionised water only) and 250ml deionized water as the negative control, were tested for larval bio-efficacy. Mortalities were recorded at an interval of 24hrs for 5days.

The results showed that mortality of larval exposed to Chlofenapyr at all test concentration except 6.5µg was 100% within 24hrs. But in 6.5µg, 100% mortality was recorded in 72hrs. However, no mortality was recorded in pupae exposed to the toxicant at all concentrations.

For Clothiandian at 0.5 ml of 13.2 a.i concentration , 98% of exposed larvae died within 24hrs. But with 1ml of 13.2a.i, 100% larval mortality was recorded within 24hrs. Pupal mortality was 85% with 0.5ml of 13.2ug concentration within 48hrs, but with 1ml of 13.2a.i, 90% mortality was recorded within same time interval. Hence, Chlofenapyr has shown to be effective for larval source management within 72hrs of exospure but however not effective for control of pupal stage of anopheles mosquitos. While in Clothiandian, increase in volume of active ingredient increases mortality in larval stage while at adult emergence was higher at 0.5ml of 13.2ug compared to in 1ml of 13.2a.i.

ABS-796

The masked contribution of Larval Source Management in malaria control in the context of high insecticide-treated bed net use

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Background: Current standard interventions are not universally sufficient for malaria elimination. The effects of community-based house improvement (HI) and larval source management (LSM) as supplementary interventions to the Malawi National Malaria Control Programme (NMCP) interventions were assessed in the context of an intensive community engagement programme.

Methods: The study was a two-by-two factorial, cluster-randomized controlled trial in Malawi. Village clusters were randomly assigned to four arms: a control arm; HI; LSM; and HI+LSM. Malawi NMCP interventions and community engagement were used in all arms. Household-level, cross-sectional surveys were conducted on a rolling, 2-monthly basis to measure parasitological

and entomological outcomes over 3 years, beginning with one baseline year. The primary outcome was the entomological inoculation rate (EIR). Secondary outcomes included mosquito density, Plasmodium falciparum prevalence, and haemoglobin levels. All outcomes were assessed based on intention to treat, and comparisons between trial arms were conducted at both cluster and household level.

Results: Eighteen clusters derived from 53 villages with 4558 households and 20,013 people were randomly assigned to the four trial arms. The mean nightly EIR fell from 0.010 infectious bites per person (95% CI 0.006–0.015) in the baseline year to 0.001 (0.000, 0.003) in the last year of the trial. Over the full trial period, the EIR did not differ between the four trial arms (p=0.33). Similar results were observed for the other outcomes: mosquito density and P. falciparum prevalence decreased over 3 years of sampling, while haemoglobin levels increased; and there were minimal differences between the trial arms during the trial period.

Conclusions: In the context of high insecticide-treated bed net use, neither community-based HI, LSM, nor HI+LSM contributed to further reductions in malaria transmission or prevalence beyond the reductions observed over two years across all four trial arms. This was the first trial, as far as the authors are aware, to test the potential complementary impact of LSM and/or HI beyond levels achieved by standard interventions. The unexpectedly low EIR values following intervention implementation indicated a promising reduction in malaria transmission for the area, but also limited the usefulness of this outcome for measuring differences in malaria transmission among the trial arms

ABS-797

Evaluating the impact of community-based winter larviciding on malaria transmission in countries aiming for malaria elimination in southern Africa countries: The case of Namibia and Botswana.

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Background. Malaria prevention in Africa is mainly through the use of long-lasting insecticide treated nets (LLINs). The success of these interventions has led to more countries moving towards zero indigenous malaria cases. Further supplementary interventions are needed to further lower malaria cases and achieve elimination. The objective of the project was to assess the effect of supplementing IRS with community based larviciding with Bacillus thuringiensis israelensis (Bti).

Methods. The study involved a cluster-randomized, controlled trial conducted in Botswana and Namibia, to assess the impact of the following intervention options on mosquitoes and malaria prevalence: IRS only; IRS and Bti. Between 2019 and 2022, adult mosquitoes and larvae were collected fortnightly in each 12 villages of each of the project countries using community-based field workers. CDC light traps were used to sample adult mosquitoes and larvae were sampled from potential mosquito-breeding habitats using standard plastic dippers and sweep nets. Larviciding with Bti was implemented during winter (dry) season followed by IRS prior to the rainy season. Active and passive malaria cases detection were conducted, whereby, in Namibia, malaria cases were retrieved from health facilities and cross-sectional malaria parasite prevalence surveys were conducted in three hundred and sixty randomly selected households to all individuals with temperature above 37.5C or with clinical symptoms were tested with mRDT. In Botswana, malaria cases were retrieved from the DHIS monthly.

Results. In Botswana larviciding with bti resulted in an overall 76.6% reduction of Anopheles larvae. Malaria cases were reduced by 16.7% between baseline and intervention year while the risk of getting malaria in the areas that did larviciding with bti decreased from 1.34 (95% CI 0.638-3.00) to 0.41 (95%CI 0.77-2.97). In Namibia larviciding with bti resulted with a 76.1% reduction of Anopheles larvae. Larviciding with bti resulted a reduction of 87.3% of malaria cases between baseline and intervention year. The risk of getting malaria in the larviciding areas decrease from 1.48 (95% CI 1.382-1.582) to 1.25 (95%CI 1.153- 1.353).

Conclusion. The project demonstrated that combining IRS with larviciding with Bti further reduced malaria cases in a low prevalence setting in Botswana and Namibia beyond what is achieved with IRS alone.

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Parallel Scientific Session 6:
LLINS, IRS and Insecticide Resistance Management

ABS-578

Allelic variation of *GSTe3*, *GSTe4* and *GSTe6* contributes to insecticide resistance in *Anopheles funestus"*

Mersimine F. M. Kouamo, Sulaiman S. Ibrahim, Michael O. Kusimo , Abdullahi Muhammad, Jacob M. Riveron, Murielle J. Wondji, Helen Irving and Charles S. Wondj.

Background: Elucidating the resistance mechanisms of malaria vectors to insecticide is crucial for the development of new tools to fight against this pandemic. In this study, we assessed the role of allelic variation of glutathione s-transferase epsilon (GSTes) involved in insecticide resistance in the major malaria vector *Anopheles funestus*

Methods: The *GSTe3, GSTe4 and GSTe6* genes were amplified, sequenced and analyzed to detected mutations under selection. The role of identified alleles in insecticide resistance was further studied using *in silico* modelling and docking of candidate allele. Further functional validation with metabolic assay and transgenic expression of GSTes in *Drosophila melanogaster* was performed.

Result: Polymorphism analysis revealed the G26D-*GSTe3*, H181Y-*GSTe4* and E189A-*GSTe4* alleles in Benin and Cameroon, and T201S-*GSTe6* and G201E-*GSTe6* alleles in Benin and Malawi. Furthermore, *in silico* structural characterization of GSTes candidate's alleles revealed that the presence of allelic variations increases the binding cavity of the active site of the GSTes G26-*GSTe3* (37.88); Y/A-*GSTe4* (29.18) and E/S-*GSTe6* (19.45) and allows strong affinity with DDT and permethrin. The evaluation of the metabolic activities of the insecticides of the synthesized proteins confirms that GSTes are capable of eliminating DDT [depletion rate: D26-GSTe3 (51,06 ± 2,3 %), Y/A-GSTe4 (62,48 ± 3.0 %), E/S-GSTe6 (57,24 ± 3,1 %)]and permethrin [D26-GSTe3 (23,89 ± 1,44 %), Y/A-GSTe4 (13,48 ± 2,43 %), and E/S-GSTe6 (25,93 ± 0,16 %)]. Only GSTe4 proteins [Y/A-GSTe4 (28,75 ± 4,42 %), and H/E-GSTe4 (15,99 ± 0,76 %)] showed metabolic activity towards deltamethrin. However, the mutated proteins showed a greater ability to eliminate insecticides. Transgenic expression of GSTes in *Drosophila* showed that the expression of *GSTe3*, *GSTe4* and *GSTe6* and the presence of allelic variations confer greater resistance to DDTs and pyrethroids.

Conclusion: This study supports the role of GST epsilon genes in conferring resistance to pyrethroids/DDT which could impact the efficacy of LLINs in area where these genes are over-expressed.

Keywords: malaria; *Anopheles funestus*; metabolic resistance; glutathione s-transferase; allelic variation, structural characterization, transgenic expression, metabolic assay.

ABS-600

Long-lasting performance of pyrethroid-PBO LLINs against pyrethroid resistant mosquitoes: a post market evaluation of PermaNet® 3.0

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With widespread pyrethroid resistance reported throughout Africa, pyrethroid-PBO LLINs are fast becoming the new standard tool for malaria prevention. The updated WHO recommendation indicates mass distribution of pyrethroid-PBO LLINs in areas where pyrethroid resistance has been detected in local malaria vectors. Of the currently WHO prequalified pyrethroid-PBO LLIN products, there are information gaps on their long-term performance, in particular on the biological efficacy of used pyrethroid-PBO LLINs against pyrethroid resistant *Anopheles* strains throughout the three year expected lifetime of a net. Vestergaard has explored testing PermaNet® 3.0, a deltamethrin-PBO LLIN, after 2-3+ years of use in several countries under its post market monitoring program. In 2021, used PermaNet® 3.0 were collected and evaluated in Tanzania against well

characterized pyrethroid resistant *Anopheles* strains. The goal of the work is to assess the persistence of the PBO and Pyrethroid component and decline in net integrity and functionality after three years of field use (the WHO end of use lifetime for an LLIN). The efficacy of PermaNet® 3.0 roof was assessed against two comparators: a new, unused PermaNet® 3.0 roof and a new, unused deltamethrin-only net, PermaNet® 2.0. Post market monitoring on PermaNet® 3.0 in Tanzania after three years of use is ongoing and includes evaluation against the pyrethroid resistant *An. gambiae s.l*, Zeneti strain. Findings from this evaluation in Tanzania will be ready and reported during the conference .

ABS-622

Residual efficacy testing of Actellic 300CS for Indoor Residual Spraying and vector susceptibility to insecticides in Mangochi, Malawi

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Introduction. In November 2020, Indoor residual spraying(IRS) of Actellic 300CS was conducted in Mangochi district. The study was conducted to assess the residual efficacy of Actellic 300CS sprayed and to assess the susceptibility of local malaria vectors towards various insecticides.

Methods. The residual activity of Actellic 300CS was determined over a period of 5 months through wall cone bioassay tests that measured mortality after 24 hours using laboratory reared *An. gambiae* Kisumu strain. Quality spray assessments were conducted one day after spray. The bioassays were conducted on all wall types found in the district, mud, brick and cement. Insecticide susceptibility testing was done on local vectors using pirimiphos-methyl, pyrethroids, clothianidin and chlorfenapyr. All tests were done using WHO protocols.

Results. Spray quality was satisfactory with 100% mortality observed on wall surfaces. The residual efficacy of Actellic 300CS lasted a period of 2 months with <80% mortality observed on all wall surfaces. Results of susceptibility tests showed that malaria vectors in Mangochi were fully (100 %) susceptible to Actellic 300CS, Clothianidin and Chlorfenapyr. Resistance was observed towards pyrethroids (permethrin 0.75%, deltamethrin 0.05%, and alpha-cypermethrin 0.25%). Partial or full restoration of susceptibility was observed in *An. gambiae s.l* populations when pre-exposed to PBO, indicating the presence of the oxidase resistance mechanism

Conclusion. Residual lifespan of Actellic 300CS lasted for 2 months on all wall types. PBO nets be distributed in areas with moderate and high pyrethroid resistance in future mass distribution campaigns of nets in Malawi.Net usage in areas sprayed with Actellic should be encouraged as lifespan is shown to be short.

ABS-626

Insecticides resistance across the Sahelian, Humid savanna, Highland, Coastal and Forest eco-epidemiological settings in Cameroon.

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Background: Rapid emergence and spread of insecticide resistance in *Anopheles gambiae* populations is the main factor affecting malaria vector control program in Cameroon but little is known on the underlying mechanisms across epidemiological settings. The study aimed to assess the insecticide resistance status and underlying molecular mechanisms conferring resistance in the Sahelian, Humid savanna, Highland, and forest eco-epidemiological settings in Cameroon.

Methods: Susceptibility bioassays tests were performed with F0 females *An. gambiae* aged three to five days from Sahelian

zone(Maga),Humid savanna(Tibati), Highland (Santchou), Forest(Bertoua) using pyrethroids (permethrin 0.75% and deltamethrin 0.05%), carbamates (bendiocarb 0.1%) and organophosphate (Malathion). Species of *An. gambiae* s.l. complex were identified using molecular diagnostic tools. Target site mutations were detected using Taqman assays. Quantitative Reverse Transcription-real-time PCR (qRT-PCR) 3-plex TaqMan® assays were used for the quantification of 7 detoxification genes expression implicated in Pyrethroid resistance.

Results: *An. gambiae* and *An. coluzzii and An. arabiensis* were identified in the different settings. *An. gambiae* was dominant in Santchou and Bertoua and *An. coluzzii* was revalent in Tibati and Maga. High frequencies of L1014F allele were recorded in all sites excepted Maga ranging from 43.40% to 100 %. The L1014S kdr allele was detected only in the populations from Tibati with low frequencies (10%). The N1575Y was recorded in Maga, Santchou, Tibati and Bertoua with a frequency varying from 2.10% to 11.70%. The G119S mutation was detected in *An. gambiae* populations from Tibati, Bertoua and Santchou ranging from 71-87.3% with bendiocarb and from 77.1- 86.93% with malathion. Seven detoxification genes (CYP6P3, *CYP6M2*, *CYP9K1*, *CYP6P4*, *CYP6Z1*, *CYP4G16* and *GSTe 2*) were overexpressed in at least one population.

Conclusion: The dynamic of the resistance mechanisms is a threat for the vector control intervention and may inform the development of insecticide resistance management strategies across the settings.

Key words: Insecticide resistance ; detoxification genes, ecoepidemiological settings ; anopheles, Cameroon.

ABS-772

Complexity and challenges in managing insecticide resistance in the main malaria vectors in Mozambique

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Introduction: Vector control activities in Mozambique rely mainly on insecticide treated nets (ITNs) and indoor residual spraying (IRS). Wide spread of insecticide resistance in malaria vector population poses a huge threat to malaria control/elimination in Mozambique. As part of the country's routine entomology surveillance, this work explored insecticide resistance status in the main malaria vectors across the country.

Methodology: Insecticide resistance was monitored in 79 sentinel sites (41 in 2019 and 38 in 2020) between February-May. *Anopheles* larvae were collected and reared into adults. Emergent 3-5 days old unfed females were tested via WHO susceptibility procedures to four classes of insecticides (pyrethroids, organochlorines, organophosphates, and carbamates), standard CDC bottle assays to pyrrole (chlorfenapyr) and Abt associates testing procedures for neonicotinoid (clothianidin). A further intensity bioassays was performed to pyrethroids (5X and 10X) followed by PBO synergist assays.

Results: A total of 26,872 *Anopheles* were tested of which 25,287 (94.1%) were morphologically identified as *Anopheles gambiae* s. l and 1,585 as *An. funestus* s.l. In 2019, insecticide resistance was reported in: northern region; deltamethrin (6-85%), lambdacyhalothrin (32%), alphacypermethrin (5-15%) and DDT (79 -87%), central; deltamethrin (46-83%), and permethrin (20-89%), and southern; deltamethrin (39%), permethrin (24%), bendiocarb (60%). In 2020, in northern region; resistance was documented in all the same insecticides tested in 2019 including permethrin (10%) while in central, resistance was reported in deltamethrin;68-88%, lambdacyhalothrin;77-84%, and permethrin;12-43%. In southern region, this was reported in deltamethrin; 21%, bendiocarb;20%, and lambdacyhalothrin;56% respectively. Pre-exposure of PBO followed by deltamethrin or permethrin restored mortality in *An. gambiae s.l* populations in deltamethrin but not permethrin.

Conclusions: Resistance is documented in all classes of insecticides in Mozambique except Pyrrole. Restoration of susceptibility to deltamethrin with PBO confirms involvement of metabolic resistance mechanism mainly mediated by P450s but further evaluation is needed to understand other underlying mechanisms present in the vector populations.

ABS-325

Digitalized mass distribution campaign of insecticide-treated nets (ITNs) in the particular context of COVID-19 pandemic in Benin: challenges and lessons learned

Rock Aïkpon*, Cyriaque Affoukou, Benjamin Hounpkatin, Yves cyaka, Elijah Egwu, Filémon Tokponnon, Aurore Ogouyemi-Hounto

Background: In 2020, Benin has implemented a digitalized mass distribution campaign of insecticide-treated nets (ITNs) in the particular context of COVID-19 pandemic. This paper describes the implementation process as well as the challenges and lessons learned from this campaign.

Methods: A descriptive design was used for reporting the planning and implementation process of ITNs campaign. Moreover, the changes and adaptations related to COVID-19 pandemic are described.

Results: A total of 3,175,773 households were registered corresponding to a total of 14,423,998 persons (13.55% more from projection). Moreover, 94.16 % (13,581,637 people) of enumerated population were protected. A total of 7,652,166 ITNs were distributed countrywide through door to door distribution approach. High political commitment, engagement and support add to the financial and technical supports from partners were the essential factors that make 2020 ITNs mass campaign success in Benin despite the particular context of COVID-19 pandemic.

Conclusion: It is essential to maintain the prevention activities for malaria and this could substantially reduce the overall impact of the COVID-19 pandemic for the populations at malaria risk.

Keywords: Digital, ITNs campaign, Covid-19, lessons, Benin.

ABS-687

Evaluation of the effectiveness of malaria control tools prior to the distribution campaign of new long-lasting insecticide-treated nets in Southern Cameroon

Metitsi Danale

Introduction: In the context where malaria elimination is back to the agenda, and for long-term sustainable intervention, supplemental vector control approaches to complement existing ones (LLINS, IRS) are dire needed. It is in this context that we evaluated malaria control tools in a site that underwent numerous ecological modifications during the construction of a hydroelectric dam.

Methods: In the study site, all pools of water representing potential breeding grounds for *Anopheles* were surveyed for larvae. The larvae present in the roosts were removed by the "dipping" technique (Service, 1993; Silver et al., 2008). All the larvae were transported to the laboratory where they were reared into adulthood. Farmed adults were used for insecticide sensitivity testing and LLIN bioeffectiveness testing according to WHO protocol (WHO, 2018). Insecticide susceptibility tests of anopheles were carried out at 25 ° C (± 2 ° C) and relative humidity of 70 to 80% using the WHO protocol (WHO, 2018). The insecticides tested were permethrin 0.75% deltamethrin 0.05%, PBO + permethrin 0.75% and PBO + deltamethrin 0.05%. The bio efficacy of LLINs was done according to WHO protocol (WHO, 2013). Indeed, five susceptible, non-blood-fed, 2–5-day-old female Anopheles mosquitoes was exposed to each piece of netting (25 cm x 25 cm) for 3 min under standard WHO cones, after which they was held for 24 h with access to sugar solution. One piece each from four different nets (Duranet, Olyset, Permanet 2.0, Olyset plus) was tested.

Results: A total of 320 field mosquitoes were used for insecticide susceptibility and 200 for mosquito net efficacy. The same number of mosquitoes was used for the sensitive reference strain, *A. gambiae* (Kisumu strain). It appears that the mosquitoes were resistant to the different classes of insecticides used with a mortality rate of 1.25% and 43.75% for permethrin 0.75% and deltamethrin 0.05% respectively. Mosquito sensitivity was only restored with PBO + 0.05% deltamethrin with a mortality rate of 98.75%. After the tests on the mosquito nets, the same scenario was observed. Indeed, unlike mosquito laboratory susceptible strain, the *A. gambiae* field mosquitoes were resistant to all the mosquito nets tested. However, they were less resistant to Olyset plus (with a mortality rate of 80%) which is a mosquito net impregnated with PBO + permethrin.

Conclusion: Our results have shown that for the LLIN to be effective in this locality it would have to be impregnated with deltamethrin and a synergist such as PBO.

Keywords: Malaria, LLINs,insecticide resistance,, hydroelectric dam of menve'ele, South Cameroun

ABS-697

Countrywide entomological surveillance and insecticide resistance of *Anopheles funestus* mosquitoes in Tanzania

Joel Odero

With a limited vector control toolbox and increasing insecticide resistance across all malaria vectors, it is critical to understand local vector bionomics to ensure targeted interventions. In Tanzania, *Anopheles funestus* is increasingly becoming established as the most important malaria vector mediating most of the transmission. Here we present preliminary results from an ongoing countrywide survey designed to understand *Anopheles funestus* species composition, host blood feeding behaviour, *Plasmodium* infection, fitness traits (body size, parity status, insemination rates) and insecticide resistance profiling of this species. Mosquitoes were sampled from September 2021 ongoing for 1 year using a combination of Ifakara double-net trap placed both indoor and outdoor 10m away from household, CDC miniature light trap hung inside households at the rear end of a human occupied bed, and prokopack aspiration of resting vectors both inside households and outdoors in animal sheds. This was complemented with larval surveys to collect *Anopheles funestus* larvae from aquatic habitat. *Plasmodium* infection was analysed using CSP-ELISA assay, parity and insemination using microscopic ovarian and spermatheca dissections, resistance levels determined using standard WHO susceptibility bioassays and *An. funestus* s.l. species by PCR. A total of 23,465 mosquitoes were collected during the study period. *Anopheles* species out of this were 53% (12,372) were *An. funestus* s.l., 18% (4276) *An. gambiae* s.l., 11% (2503) *An. coustani*, 0.6% (132) *An. pharaoensis*, and 0.1% (18) *An. maculipalpis*. Other mosquito species caught included 6% (1428) *Culex* sp., 11% (2642) *Mansoni* sp. and 0.3% (67) *Coquillettidia* sp. Further molecular identification of the *An. funestus* s.l group in two districts, Kilombero and Ulanga, (N=2261) detected 95.7% (2163) *An. funestus* s.s., 0.12% (4) *An. leesoni*, and 4.2% (94) non-amplifications. *Plasmodium falciparum* infection rates amongst *An. funestus* s.l were 3% in Kilombero and 10.2% in Ulanga district. Mosquito sizes were similar in and outdoors in both location with an average size of 2.5mm. There was a susceptibility to pirimiphos-methyl and DDT with a confirmed resistance to bendiocarb, deltamethrin, and permethrin. Increasing the concentration of the two pyrethroids to 5x conferred susceptibility, likewise, combining the pyrethroids with a PBO synergist completely reversed the resistance. These preliminary findings confirm multiple insecticide resistance in *An. funestus* in Tanzania. The ongoing countrywide entomological surveillance will provide essential information that will guide selection of control strategy and understanding of malaria transmission dynamics across Tanzania.

ABS-754

The video cone test *plus* system: assessing the utility of using *Anopheles gambiae* behavioural responses to evaluate insecticide-treated bed net efficacy.

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Background: To combat increasing insecticide resistance in malaria vectors, insecticide-treated nets (ITNs) treated with co-formulations of pyrethroids and non-pyrethroid insecticides have been developed. The Video Cone Test (VCT) *PLUS,* an extension of the standard WHO cone test, is designed to characterise the effects of these co-formulations. This project aimed

at assessing the reliability of the test for use in evaluating the bio-efficacy of co-formulated ITNs considering the inherent variability observed in bioassays.

Methods: The study involves Bioassay testing data from three laboratories (one for internal validation and two for external validation), where pyrethroid susceptible and resistant *Anopheles gambiae* mosquitoes were exposed to untreated net or ITNs: Interceptor® G2 (IG2), Olyset (OS), PermaNet® 2.0 (P2), or PermaNet® 3.0 (P3). 21-42 replicates were tested per treatment. The proportion of mosquitoes contacting the net and total movement (quantified) within the cone were the outcomes considered. Test performance was evaluated using precision. Five distinct relative dispersion (RD) metrics were considered to determine the suitable descriptive measure for variability in behavioural bioassays. Mixed-effects models were employed for the variance component analysis (to assess the different levels of precision, e.g., intra-day, inter-day, reproducibility, etc.) and ITNs bio-efficacy assessment.

Results: Internal validation results showed that precision varied with net treatment and mosquito strain. The untreated net results met the acceptance criteria (RDs below 30-40%) except for the VK7 strain, revealing that the testing system is reliable. The ITN RDs met the acceptable criteria except for IG2, OS, and P2 (VK7 strain), showing consistency of the test when an ITN is added. The external validation experiments have been conducted and data analysis will be finalised by 31st July 2022.

Conclusions: Preliminary results show prospects of the VCT *PLUS* as a tool for characterising different ITN effects and can play a role in speeding up the evaluation and deployment of new co-formulated ITNs.

ABS-377

Two-year entomological surveillance results from a cluster-randomized controlled trial assessing the effectiveness of dual active ingredients Long-Lasting Insecticidal Nets (LLINs) compared to pyrethroid-only LLINs in north-western Tanzania

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Background: The effectiveness of current malaria vector control tools mainly pyrethroids-based long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) is threatened by the widespread pyrethroid resistance in malaria vectors. Next generation LLINs with two novel active ingredients of different mode of actions were evaluated against malaria transmitted by pyrethroid-resistant vector mosquitoes in Missungwi district, north-western Tanzania.

Methods: A 2-year single-blind, four arm cluster-randomized controlled trial was conducted to evaluate the effectiveness of dual-active LLINs compared to the standard pyrethroid-LLIN on density, and entomological inoculation rates of malaria vectors across 84 study clusters. Indoor light trap collections were carried out quarterly in eight houses in each cluster which received study interventions, between February 2019 and December 2020. Dual-active LLINs deployed included Royal Guard®, a mixture LLIN combining pyriproxyfen and the pyrethroid alpha-cypermethrin; Olyset® Plus, a mixture LLIN combining the synergist piperonyl butoxide and the pyrethroid permethrin; Interceptor® G2, a mixture LLIN contains chlorfenapyr and alpha-cypermethrin in comparison with a standard LLIN that contains alpha-cypermethrin alone. All Anopheles mosquitoes sampled were morphologically identified to species or species group, and a subset of malaria vectors were further tested for *Plasmodium falciparum* circumsporozoite protein and identified to sibling species using polymerase chain reaction.

Results: Malaria vector density was reduced by 57% (IRR=0.43, 95% CI 0.29-0.64; p <0.0001) in the chlorfenapyr-pyrethroid arm compared to the arm that received pyrethroid-only LLIN. Similarly, vector density was 46% significantly lower in the piperonyl butoxide LLIN arm (incidence rate ratio (IRR)=0.54, 95% CI 0.37-0.80; p = 0.002), relative to standard pyrethroid-only LLIN after two years of use. However, there was no statistically significant reduction in malaria vector population density in the pyriproxyfen-pyrethroid LLIN arm (IRR= 0.77, 95% CI 0.52-1.14; p = 0.195) compared to the standard LLIN arm. The entomological inoculation rates (EIR) was significantly reduced by 85% in chlorfenapyr-pyrethroid arm (IRR= 0.15, 95% CI 0.07-0.31; p <0.0001), and non-

significantly reduced by 60% in the piperonyl butoxide arm (IRR= 0.56, 95% CI 0.32-0.98; p = 0.043) compared to the pyrethroid alone LLIN arm, respectively. However, the EIR was non-significantly lower in the pyriproxyfen-pyrethroid LLIN arm, IRR= 0.73, 95% CI 0.40-1.34; p = 0.311) relative to standard LLIN arm. We observed a shift in the relative abundance of Anopheles species. Before intervention, *An. funestus* s.s. contributed to over 90% of *Anopheles* malaria vectors sampled across all intervention arms. Following the interventions, *An. funestus* ss was less abundant, less than 60% of the *An. funestus* s.l collected. The proportion of *An. arabiensis* increased in the arms with dual LLINs compared to baseline collection.

Conclusion: Over the two-years of use in the community, the dual active ingredient LLINs were more effective against vector density and entomological inoculation rate compared to the standard pyrethroid LLINs. The chlorfenapyr net, was the most effective net and substantially reduced human exposure to the main malaria vectors in an area with pyrethroid resistance.

ABS-534

Laboratory and field experiences with SumiShield™ 50WG, 5 years on

Barnabas Zogo

SUMITOMO CHEMICAL COMPANY, LIMITED.

Background. SumiShield™ 50WG is the first World Health Organization (WHO) prequalified indoor residual spray (IRS) product with a new mode of action insecticide in four decades. SumiShield does not contain a pyrethroid and is based on a single active ingredient, clothianidin, and has been listed as prequalified by WHO since 2017. Since then, it has been extensively used across malaria endemic countries including Africa and tested under various conditions that included laboratory, semi-field and field settings.

Methods. We collated various laboratory, semi-field, and field study data to evaluate SumiShield alongside other IRS products that had been generated both by cooperators and independent researchers.

Results. Results across multiple studies and countries confirmed that SumiShield has long residual efficacy against susceptible and pyrethroid resistant vector populations. SumiShield, which does not contain a pyrethroid, did not show irritancy.

Conclusions. SumiShield has demonstrated excellent residual efficacy against vectors across multiple studies conducted in malaria endemic countries. The use of an IRS product that does not contain a pyrethroid but is based on a single active ingredient such as SumiShield is expected to reduce the risk of development of resistance to new insecticides. It is also consistent with the WHO Global Plan for Insecticide Resistance Management.

Parallel Scientific Session 7 :
New and re-emerging arthropod-borne viruses, climate change, NTDs and One Health

ABS-332

Epidemiology of rift valley fever in Mali: Cases of Yelimane, Nioro, Kenieba and the hydro-agricultural areas of the Markala, Selingue and Manantali dams

Catd Colonel

This retrospective epidemiological survey was conducted during the period August - December 2021 and covered the circles of Yelimane, Nioro, Kenieba and hydro-agricultural areas of the Markala, Selingue and Manantali dams. ELISA was used to collect and test 825 samples of sera collected during bimonthly missions in sentinel herds of ruminants from these localities. In addition, 40 mosquito samples captured in the study sites were tested at PCR. Following the various analyzes, an overall serological prevalence rate of 2.06% immunoglobulin type M (IgM) (17 positive / 825 tested) was obtained. This is evidence of a recent infection of Rift Valley fever virus. All mosquito samples (40 mosquitoes) submitted for real-time PCR analysis were all negative and belonged to the genera Aedes and Culex.

The serological prevalence rate varied according to regions and ruminant species. Thus, the highest prevalence rate was observed in the region of Sikasso with 4.04%, followed by that of Segou (2.53%). In contrast, the lowest rate was found in the

Kayes region (1.51%). In addition, the statistical analyzes did not show any significant difference in prevalence rates by region (p = 0.231> 0.050).

The study also showed that the highest serological prevalence rate was obtained in the bovine species (4.40%), followed by sheep (2.15%). The lowest rate was recorded in goats with 0.40%. Thus, statistical analyzes made it possible to establish a significant difference in prevalence rates according to the ruminant species (p = 0.021 <0.050).

This study thus confirmed the recent circulation of RVF virus among ruminant populations in the localities visited.

Keywords: Rift Valley fever, epidemiology; Mali.

ABS-509

Climate Change Impact On Malaria Transmission In High-Resolution Climate Simulations (C2mt-Highres)

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Background: Understanding how climate change affects malaria transmission in Africa is essential for building resilient health services. Previous studies have discussed the impacts of climate change on malaria transmission in Africa but using low-resolution climate simulations. The present study investigates the influence of model resolution on the future projection of malaria transmission in Africa.

Methods: The study uses two sets of pan-African climate simulations (convection-permitting simulations at a horizontal resolution of 4.4 km (CP4) and parameterised-convection simulations with a grid spacing of 25 km (R25)) performed by the UK Met Office as part of the UK Government's Future Climate for Africa programme. These simulations were used to drive two dynamical malaria models, VECTRI (the *vec*tor-borne disease community model of the International Centre for Theoretical Physics, *Tri*este) and LMM (*L*iverpool *m*alaria *m*odel), during the present-day climate (1998-2006) and future climate (2086-2104).

Results: The analysis indicates that high-resolution simulation improves the climate over Africa. Malaria infection is projected to increase in the future, with the highest infection rate over the Central African Republic, Congo, and Sudan in particular.

Conclusion: The study indicates that explicitly representing deep convection improves the simulation of malaria transmission over Africa.

ABS-373

Alteration of plant species could control arboviral disease vectors: Evidence from Kenya

Tasneem Osman

Invasive alien plant species have threatened the integrity of ecosystems throughout the world. They affect not only the species diversity of native ecosystems, but also threaten their biological integrity. Due to the increase in the movement of people and goods around the world. The number of species being introduced into new areas is rising. The spread of invasive plant species is currently a major problem in Kenya, where indigenous flora is replaced by dwellings. These species reduce agricultural yields, irrigated croplands, grazing areas, water availabilities, and also contribute to the spread of vector-borne diseases. Invasive plant like *Parthenium* can affect the spread of insect-borne diseases by limiting or amplifying the spatiotemporal distribution

of vectors, pathogens, and hosts, which can, in turn, lead to the creation of infection. The aim of this study is to compare the diversity (richness and abundance) of mosquitoes in different sites in Baringo region in Kenya with refence of *Parthenium* plant, Parthenium is considered one of the world's most serious invasive plants (that is able to thrive and spread aggressively outside their original geographical areas. Mosquitoes Samples were collected using a combination of different trapping techniques from six sites: Longwan, Lororo, Ilgarua, Perkrra, Sandi, and Salabani. Three sites with *Parthenium* and three without *Parthenium*, traps were set on different farms, and captures were made between (06:00 - 18:00). A total of 50.000 mosquitoes were captured and 48 species were identified. The survey was to assess mosquito abundance and diversity in selected areas, knowledge which could be helpful for targeted control.

By the end of this project, I expect to have an inventory of the mosquito population composition and of the abundance and richness of arboviruses. I will further gain insight into how changes in community ecology interact with the main types of land-use change and influence the dynamics of relevant arboviruses in Kenya.

ABS-529

Schistosoma mansoni co-infection decelerates murine *Plasmodium berghei* ANKA induced inflammatory response and organ damage

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Malaria is a severe infection caused by the *Plasmodium* parasite. It causes high mortality and morbidity, especially in the malaria endemic region. Schistosomiasis is caused by blood flukes and is the second leading parasitic infection after malaria in morbidity and mortality rate. These two infections are co-endemic in many areas. Both parasites have definitive and intermediate hosts and each utilizes the host protein differently. Each utilizes the host protein differently. The objective of this study was to determine the outcome of chronic *S. mansoni* infection in the regulation of *Plasmodium berghei* ANKA (*Pb*A) associated disease severity and pathological events in a mouse model.

Mice were infected with 200 *Schistosoma mansoni* cercaria and later with 50000 *Pb*A infected red blood cells. Parasitemia was monitored on a two-day interval, to track the infection progression. Furthermore, relative organ weight, and inflammatory markers were quantified at the end of the study and analyzed at $p = 0.05$.

Chronic *S. mansoni* infection suppressed *Pb*A parasitemia. Meanwhile, co-infection with *S. mansoni* and *Pb*A protected against schistosomiasis induced hepatosplenomegaly. Moreover, induction of both schistosomiasis and malaria abrogated *Pb*A induced elevated levels of TNF-α and IFN-γ cytokines, associated with inflammation. Co-infection with *S. mansoni* and *Pb*A enhanced *Pb*A induced suppression of anti-inflammatory cytokine IL-10. Standard histopathological analysis revealed that when mice were infected with *S. mansoni* or *Pb*A alone they had pronounced organ damage, which was assuaged by co-infection with both parasites.

Findings from this study clearly reveals that co-infection with *S. mansoni* and *Pb*A, significantly protects mice against either *S. mansoni* or *Pb*A -driven inflammatory response and organ damage.

ABS-598

The Asian Tiger Mosquito invasion story in forest of Central Africa and potential consequences in a One Health perspective.

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The hypothesis of an invasion of forest environments of *Ae. albopictus* implies it has the ability to colonize forest ecosystems, including access to potential breeding sites, or feeding on wild reservoirs of arboviruses. The aim of our study was to demonstrate the potential of *Ae. albopictus* of invading wild forest habitats, and determine its degree of penetration in forest compartments from anthropo-sylvatic edges. To do this, in the Lopé national park, Gabon, we deployed during 5 days three networks of 30 to 40 ovitraps in three forest sites close to human habitations, over distances varying from 0 to 175m from edges towards deepest parts of the forest blocks. We also carried out larval surveys in natural and artificial water collections in the village and within the sylvan part of the park.

Our results showed that there is a continuum of colonization of the forest area, showing that *Ae. albopictus* has the ability to colonize the interior of forests. However, a modeling of the colonization dynamics showed that its level of colonization decreases progressively with the distance from the anthropo-sylvatic forest edges. Larval prospections revealed that in the sylvan areas of the park, *Ae. albopictus* is more likely to colonize forest groves and galleries, known as circulation hub of animal reservoirs, and where it may act as bridge vector of zoonotic viruses between those forest areas and anthropogenic compartments.

ABS-602

Longitudinal surveillance of arboviruses in Benin: Detection of Dengue virus 3 in *Ae. aegypti*

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Background: The resurgence of arboviruses in recent decades is a major public health issue facing the international community due to the domestication of insect vectors. *Aedes aegypti* is the most important vector of arboviruses. In West Africa, it is known to transmit dengue virus (DENV), yellow fever virus (YFV), chikungunya virus (CHIKV), and Zika virus (ZIKV). To determine the abundance of arboviruses a longitudinal surveillance study was conducted in three consecutive years in Benin, West Africa.

Methods: Adult mosquitoes were captured on human bait, Biogents Gravid Trap and BG-Sentinel traps at five ecological different locations in Benin from June 2019 to September 2021. A total of 3789 mosquitoes were collected and tested by RT-PCR for arboviruses. Blood fed mosquitoes were analysed for its host by sequencing the vertebrate COI gene.

Results: One pool of *Ae. aegypti* captured on 7 July 2021 in Porto Novo tested positive for dengue virus. PCR results were confirmed by sequencing and showed the occurrence of dengue virus serotype 3. Blood meal analysis confirmed the anthropophilic feed behaviour of *Ae. aegypti* as the majority of mosquitoes tested had taken their blood meal from humans.

Conclusion: Surveillance of the *Ae. aegypti* mosquitoes is important in the fight against arboviruses and will help to guide vector control efforts.

Key words: *Aedes aegypti*, dengue virus, blood meal analysis, Benin

ABS-603

First detection of the invasive mosquito vector *Aedes albopictus* (Skuse, 1894) in Benin, West Africa, 2021

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Key words: *Aedes albopictus*, West Africa, Bénin

Background. *Aedes albopictus* originated in Southeast Asia and has colonized tropical and temperate regions worldwide over the past three to four decades. In Africa, data on its distribution are incomplete, as most studies that have examined the abundance, competition with other species, and phylogenetics of this vector have been conducted in the central African region. We report here the first detection of *Ae. albopictus* in Benin, West Africa.

Material and methods. During a longitudinal study on *Ae. aegypti*, regular trapping of mosquitoes was carried out in the botanical garden of the University of Abomey-Calavi, in southern Benin. Morphological determination of the species was confirmed by DNA sequence analysis. Total DNA was extracted from a mosquito leg using the QiaAMP viral RNA MiniKit. A fragment of the cytochrome oxidase c subunit I (COI) region was amplified using primers LCO1490 and HCO2198. The polymerase chain reaction products were subjected to Sanger sequencing.

Results and discussion. We record for the first time the presence of *Ae. albopictus* in Benin. Several specimens were found in a botanical garden in southern Benin. The species is known to prefer suburban or natural habitats, especially when *Ae. aegypti* is present as the main species. In neighbouring Nigeria, the species was detected in 1991 and since then, published data show that *Ae. albopictus* has become well established in the region. In Benin, regular sampling is needed to estimate the distribution and abundance of *Ae. albopictus* in urban, suburban, rural and forest biotopes.

Key words: *Aedes albopictus*, West Africa, Bénin

ABS-650

Prospects for developing efficient targets for the xenomonitoring and control of *Simulium damnosum s.l.*, the major vectors of onchocerciasis in Africa.

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Background: The absence of standard collection tools for *S. damnosum,* the major vector of onchocerciasis in Africa, maintains the use of human landing collection (HLC) despite the ethical issues of this method. In the context of xenomonitoring or vector control, understanding the host-seeking behaviour of simulids is crucial in the development of collection tools to supply or replace. In this study, we studied the behaviour of *Simulium damnosum* towards stimuli and/or olfactory stimuli.

Method: We used electrocuting grids and sticky targets to assess blackfly responses to targets of different sizes (i.e., from 0.0625m^2 to 1m2), shapes (i.e., vertical and horizontal oblongs and square), and colour (i.e., black vs. blue). Experiments to assess responses to olfactory cues have been carried out comparing targets baited with carbon dioxide, BG-Lure©, and an artificial blend named POCA. The number of *S. damnosum*/trap/day and the number of *S. damnosum*/target area were recorded daily for the analyses and compared compared in Latin square design tests.

Findings & conclusion: Globally, HLCs captured more blackflies than the targets. Of the different targets tested, small targets (0.0625 and 0.5m^2) were the most efficient visual lure in terms of the number of S. damnosum captured per unit area 1.7-5x more than larger targets. Our results suggested, overall, that sticky black targets of horizontal rectangular shape (0.125-0.5m^2) and baited with a POCA and/or CO_2 mixture could provide a cheap practical field alternative to HLC for onchocerciasis xenomonitoring. However, further experiments are ongoing on sites, to ensure that the prototype design has no inherent bias

for certain members of the *S. damnosum* species complex.

ABS-660

Detection of emerging and re-emerging arbovirus infections in Kenya: The KEMRI Viral Hemorrhagic Fever Laboratory Perspective

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Background: In the recent past, there has been a significant increase in the occurrence and detection of arbovirus-related diseases in Kenya and the East African region. Infections have been associated with outbreaks with considerable social and economic consequences. The Kenya Medical Research institute through the Center for Virus Research is in the forefront in the prompt detection and response to arbovirus infections nationally and regionally.

Methods: Samples from suspect human cases are collected and sent to the laboratory in cold chain with accompanying clinical information. The immunoglobulin M enzyme linked immunosorbent assay (IgM ELISA), RT- PCR, cell culture and sequencing are utilized to detect presence of IgM antibodies against of a panel of arbovirus/VHF agents and for pathogen identification and characterization. Results are relayed to the respective health facilities and appropriate agencies for clinical management and response activities and to comply with the International Health Regulations.

Results: The laboratory has detected and responded to multiple arbovirus outbreaks both locally and regionally (**Locally** - Dengue 1982,2011- date, Yellow Fever 1992/93,2016, 2022, Rift Valley Fever 1979/2006/07,2014,2019-date, Crimean Congo hemorrhagic Fever 2000, Chikungunya 2004,2006,2016-date. **Regionally** – Yellow Fever South Sudan 2003, Chikungunya in Comoros, Re Union 2004, Dengue Eritrea 2010, and Somalia 2010. In addition, entomological surveillance has detected multiple viruses including West Nile, Bunyamwera, Pongola, Usutu, Ngari, dengue, Chikungunya, Ndumu, Usutu and Sindbis.

Conclusion: Surveillance and early detection is a critical tool in providing timely diagnosis and collection of early warning data for multiple public health threats associated with arboviruses. Disease circulation information is useful in keeping the country prepared and responsive to the various health threats posed by arbovirus diseases. There is however a constant for homegrown solutions and partnerships to invest in capacity building, technology and encourage laboratory networks in making the country and region a safer place.

ABS-700

The Use of Household Suitability Score On Prediction Of Aedes Mosquitoes Abundance as A Preventive Measure To Dengue Outbreak.

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Background: The frequency and magnitude of dengue epidemics has increased dramatically throughout the tropics in the past 40 years due to unplanned urbanization, climate change, globalization, and lack of effective mosquito control. Regions that were dengue free now experience regular outbreaks. All four dengue serotypes are now circulating in Africa, which increases the chances of Dengue related mortality. Without adequate vector monitoring and control further outbreaks will certainly occur. The aim of this research was to improvise a tool; Habitat Suitability Score to be used to predict the productivity of *Aedes aegypti* breeding habitats even when there are no rains or water collection and destroy them as part of proactive larval source management.

Method: A case series study followed 97 individuals with confirmed dengue fever (NS1 and/or IgM on rapid diagnostic test and/or PCR positive) to their households in Kinondoni, Dar es Salaam during the 2014 Dengue outbreak. Individuals answered questionnaire on dengue prevention and practices. Their houses were inspected for mosquito breeding sites and validated a Habitat Suitability Score that predicted their productivity before rains begin. The tool gives scores to breeding habitats found

based on their productivity potentials.

Discussion: There were 12 /312 positive *Aedes aegypti* breeding habitats. The HSS correctly identified 9/12 (75%) of Aedes breeding habitats. Countries with established vector surveillance programmes may incorporate Household Suitability Score for proactive dengue control as part of larval source management. The Habitat Suitability Score should be made available to households and local government to inform the population on how to prevent *Aedes aegypti* breeding before the rains begin.

Parallel Scientific Session 8 : Vector biology, ecology, taxonomy and population genetics

ABS-531

Phenotypic stability of natural pigmentation trait in *Anopheles gambiae* indicates readiness of the Uganda Virus Research Institute ACL-2 facility to handle transgenic mosquitoes.

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Background: Demonstration of containment and readiness for handling genetically modified mosquitoes requires laboratory-based studies with no perceived risk to the environment. This study used a natural mutation 'colour variant trait' within the *Anopheles gambiae* species, to evaluate functionality of an Arthropod Containment Level 2 (ACL-2) insectary at UVRI. One phenotype exhibits a white pigment beneath the transparent cuticle at the dorsum of their thorax and abdomen, while the other phenotype completely lacks that pigmentation. Similar to markers used with genetic modifications, the pigmentation is expressed as a simple dominant /recessive character.

Methods: Based on pigmentation, a pigmented and non-pigmented phenotype were isolated from a mosquito colony. A total of 500 larvae of each phenotype were reared in separate cages and allowed to produce the next generation. The pigmented phenotype was maintained in heterozygous state by backcrossing its progeny with pure-bred non-pigmented males at each of 9 generations Phenotype and sex ratios were analyzed using Chi-Square test. Free flyers within and around the insectary were monitored to validate containment measures.

Results: A total of 26,063 larvae were screened of which 49.93% (SEM = 0.36, n = 16) were pigmented, making a larval ratio of 1:1 of pigmented to non-pigmented progeny. Overall mean percentage of females for all pupae screened was 48.5% (SEM = 2. 5, n = 16), and the 50% proportion of females remained consistent regardless of backcross number or phenotype, Chi Square (3df, *P*-value >0.05). No escapee mosquitoes were detected within or outside the facility throughout the study period.

Conclusion: The data collected in this study suggests that the Target Malaria Uganda ACL-2 insectary is functionally ready to handle genetically modified mosquitoes for evaluation studies towards future genetic control strategies.

ABS-560

Genetic diversity of genes involved into *Anopheles gambiae s.l* fertility and vector competency in Sub-Saharan Africa

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Malaria remains a major public health burden, primarily in Sub-Saharan Africa. Dual resistance of *Anopheles* to insecticides and *Plasmodium* to antimalaria challenge and call for the development of new control strategies toward malaria elimination. Thus, the interest of targeting a specific gene function with small molecule inhibitors to control malaria is increasing. However, such approach might not be feasible if the target gene is highly diverse.

Here, we analyzed the genetic diversity of HPX15 (AGAP013327) a mating-induced heme peroxidase protein also called Immunomodulatory peroxidase which have been shown to be involved in *Anopheles* fertility and vector competency, using the sequencing data of the phase3 Ag1000G project. VCF SNPs data of the HPX15 gene (3L : 10786057-10788017) have been extracted from whole genomic data of Sub-Saharan Africa *Anopheles gambiae s.l* populations to perform a principal component analysis (PCA), calculate the fixation index of population structural differentiation (F_{st}) and the nucleotide diversity (Pi), and to perform Tajima's D neutrality tests and phylogenetic analysis ; between countries and species.

The PCA, Phylogenetic trees and fixation index calculation showed that *An. arabiensis* populations were slightly diverged from *An. gambiae s.s.* and *An. coluzzii* populations and their intermediates (SM) closer to *An. coluzzii* populations (F_{st}=0.091) than *An. gambiae* populations (F_{st}=0.115). Similarly, the nucleotide diversity was low in all populations with the highest Pi (less than 0.02) observed in *An. arabiensis* populations specifically collected in the eastern countries (Kenya, Tanzania, Malawi and Uganda). Within *An. gambiae* populations the highest Pi was observed in Tanzania', Uganda' and Cameroon', in The Gambia' and Burkina' for *An. coluzzii* populations, and Kenya' for the SM populations. The Tajima's D values were in overall suggesting a balancing selection.

Globally, this population genetic analysis suggested that HPX15 is likely conserved within species of the *An. gambiae* complex across sub-Saharan Africa and could be targeted with small molecule inhibitors to reduce malaria transmission. However, further analysis of the SNP effect on the proteins model structure and catalytic site might be necessary to improve the compounds designing.

Keywords: Genetic diversity, HPX15, *Anopheles gambiae s.l*, Sub-Saharan Africa

ABS-720

Predicting urban adaptation of *Anopheles gambiae* and *Anopheles coluzzii*, major malaria vectors, in Central Africa

Diego Ayala

In Central Africa, the recent *Anopheles* proliferation in urban settings is threatening the efforts of malaria control. *Anopheles coluzzii* and *Anopheles gambiae* have overcome anthropogenic pressures (e.g. presence of pollutants) through physiological and genetic changes. Here, we studied the ecological and environmental factors that have driven their urban expansion in order to predict convergent adaptative processes. We performed an exhaustive and systematic sampling of 380 *Anopheles* breeding sites in four major cities of Central Africa. We analyzed a large series of physicochemical and environmental parameters. We also performed statistical analyses to investigate their distribution and predict common urban adaptation patterns. The four cities offered a common and large mosaic of breeding sites that were colonized by both species, exhibiting an extraordinary ecological plasticity. Nonetheless, *An. coluzzii* was predominant in urban coastal habitats, while *An. gambiae* in inland settings. This difference was driven by few environmental factors, such as pH or dissolved oxygen. Our predictive approach found

common patterns of urban adaptation across cites, but fit a model of frequency-dependent selection between habitats. Overall, our results provide the basis to understand the urban adaptation process in two major malaria vectors, with important consequences for present and future malaria control strategies.

ABS-359

High-throughput sperm tracking technique for *Anopheles* male mating competitiveness studies

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Background. Mosquito release programmes involving sterile, genetically-modified or Wolbachia-carrying mosquitoes are increasingly used to control vector-borne diseases. Their efficacy often crucially depends on the mating competitiveness of released males. Therefore, high-throughput technique designed to track seminal fluid and assess male mating competitiveness, would be a valuable tool for mark release recapture studies.

Methods. In this study, *Anopheles coluzzii* male mosquitoes were labelled with 0.1% rhodamine B and 1% uranine in 10% sugar solution. After 5 days, labelled males from each dye were allowed to mate overnight at 3:1 ratio with virgin females. Mating competitiveness was assessed by combining either rhodamine B or uranine-labelled males with unlabelled males and females. All females were then collected, and the last two segments were chopped and placed into 384-well plate containing 10ul of PBS. The plate was read at Ex535/Em580 and Ex485/Em520 for the rhodamine B and uranine dyes, respectively.

Results. Both the rhodamine and uranine labels were visually detected in the accessory glands of male mosquitoes and in the female reproductive tract (spermatheca). Plate reader results showed a positive signal in females inseminated with labelled males compared to control females. In mating competitiveness experiments, both rhodamine and uranine labelled males outcompeted unlabelled males. For rhodamine 80% and for uranine (60-90%) of females were mated with marked males, respectively. False positive and false negative rates, associated with the presence of a mating plug and signal detection levels, were ~5% for the experiment.

Conclusion. These results report a 10-fold, higher-throughput method for tracking sperm in mated female *Anopheles* mosquitoes and therefore open up the possibility of addressing in-depth mating competitiveness studies. Interestingly, rhodamine B and uranine marked males were more competitive than unlabelled males. Further studies combining males labelled with both dyes and females will be necessary to validate dual-colour male mating competitiveness studies.

ABS-369

Improvement of water quality for mass anopheline rearing: dynamics of larval tray bacterial communities under different water treatments revealed by 16s ribosomal rna ultra-sequencing

Akpodiete

Background. Immature anophelines develop in aquatic environments with vast arrays of microorganisms and varying physicochemical properties. Under insectary conditions, where mosquitoes are reared in standing water, larval trays can accumulate high ammonia levels and anaerobic bacteria resulting in larval mortality. Other bacteria are known to regulate ammonia levels via processes of nitrification. Although several studies have shown that some bacteria are essential to nutrition, digestion, reproduction, and immune responses in *Anopheles gambiae* s.l., none has characterised the microbial communities in anopheline larval trays.

Methods. Following an earlier study testing the impact of ammonia-capturing zeolite and water changes on the rearing of *Anopheles coluzzii* larvae in the insectary, we characterised the bacteria communities in larval trays using 16S rRNA gene sequencing to highlight bacteria potentially associated with mosquito survival and phenotypic quality. Multi-dimensional functional filters were applied to sequence data to identify candidate bacteria species toxic to larvae or playing a beneficial role through ammonia nitrification. The 10 most important bacteria identified were further quantified by qPCR.

Results. Our results show that water change resulted in significantly lower bacteria diversity and abundance in *An. coluzzii*

rearing trays, positively impacting adult mosquitoes' developmental success and phenotypic quality. Alternately, treatments without water changes resulted in a higher abundance and diversity of potentially toxic bacteria species, negatively impacting mosquito development. Where zeolite was applied, there was a higher presence of nitrifying bacteria with a positive impact on mosquito development and a low abundance of potentially toxic bacteria.

Conclusions. The first in-depth analysis of bacterial communities in mosquito larval rearing water identified 1031 bacteria species associated with the ammonia nitrifying cycle and mosquito rearing success. In future, this identification of such beneficial bacteria could contribute to the development of 'water primers' designed to improve larval rearing conditions, whilst toxic bacteria may provide novel candidates for vector control.

ABS-547

IgG Antibody responses to *Anopheles gambiae* gSG6-P1 salivary peptide are induced in human populations exposed to secondary malaria vectors in forest areas in Cameroon

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Background: Human IgG antibody response to *Anopheles gambiae* gSG6-P1 salivary peptide was reported to be a pertinent indicator for assessing exposure to mosquito bites and evaluating the risk of malaria transmission as well as the effectiveness of vector control strategies. However, the applicability of this marker to measure malaria transmission risk where human populations are mostly bitten by secondary vectors has not yet been evaluated. In this study, we aimed to investigate whether anti-gSG6-P1 antibodies response could be induced in humans living in forest areas in Cameroon where *An. gambiae s.l* is not predominant.

Methods: ELISA assays were performed to detect IgG antibodies response to the gSG6-P1 salivary peptide in dried blood spots collected from the human population. Anti-gSG6-P1 antibody levels were assessed according to age, gender, the malaria infection status and the use of mosquito bed nets. Mosquito collections using human landing catches were performed to confirm the predominance of other vectors than An. gambiae s.l or An. funestus s.l in Nyabessang village on the banks of the Ntem River in the forest area, south region of Cameroon.

Results: Anti-gSG6-P1 IgG antibody response was detected in inhabitants of Nyabessang with high inter-individual heterogeneity. No significant variation in the level of this immune response was observed according to age and gender. The concentration of gSG6-P1 antibodies was significantly correlated with the malaria infection status and, Plasmodium falciparum-infected individuals presented a significantly higher level of IgG response than uninfected individuals (p=0.0087). No significant difference was observed according to the use of insecticide treated nets. Out of the 1,442 Anopheles mosquitoes species collected, 849 (58.9%) were identified as *An. paludis*, 489 (33.91%) as *An. moucheti*, 28 (4.44%) as *An. nili*, 22 (2.08%) as *An. gambiae s.l* and 12 (0.8%) as *An. marshallii*.

Conclusion: Our findings show that IgG response to *An. gambiae* gSG6-P1 peptide could be detected in humans exposed predominantly to *An. moucheti* and *An. paludis* bites. Taken together, the data revealed the potential of the Anti-gSG6-P1 IgG antibody response to serve as a universal marker to assess human exposure to any Anopheles species.

ABS-755

Polymorphic inversion 2La frequencies associate with ecotypes in populations of *An. gambiae* across Nigeria

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Background: Chromosomal inversion 2La play a vital role in local adaptation of the malaria vector Anopheles. This polymorphic inversion, linked with ecological and behavioral plasticity, ensures adaptation of these species to their ever-changing micro environment. The genetic adaptation of *An. gambiae* to their natural environment has not been presented in Nigeria. We therefore present the first report on the adaptive radiation of *An. gambiae* in Nigeria.

Method: Larval samples of anopheline mosquitoes were collected from 12 locations across the 6 ecological zones in Nigeria, using standard methods. Adult emergence was euthanized and identified using standard morphological identification guide. All samples belonging to the *An. gambiae s.l.* were further separated and identified using PCR. Inversion 2La PCR karyotyping was conducted on the resulting *An. gambiae* identified. Statistical analysis was conducted at P=0.05.

Result: Morphological identification results revealed that members of the *An. gambiae s.l.* constituted 98% of all the anopheline mosquitoes examined. Other mosquito species identified but restricted to certain areas include *An. funestus s.l.*, *An. maculipalpis* and *An. pretoriensis*. PCR identification further revealed that the population contained 397 (40%) *An. gambiae* and 600 (60%) *An. coluzzii*. These two species were found in all the populations examined across the six ecological zones. An adaptive Inversion on 2La was detected which can be associated with climate. Heterozygous frequencies vary significantly ($p<0.05$) across the geopolitical zones indicating an heterozygous advantage. However, the frequencies of 2La+/2La+ inversions were high in the mangrove/forest region but gradually tapers as we proceed towards the savannah (0.82, $p<0.001$) and replaced by the standard 2La/2La ($R = 0.84$, $p<0.001$) which indicate an adaptive radiation on inversion.

Conclusion: Inversion 2La is associated with the adaptation *An. gambiae* to climate in Nigeria with an advantage on heterozygous.

ABS-758

Spatial distribution and ecological niche modeling of geographical spread of *Anopheles gambiae*, *Anopheles coluzzii* and *Anopheles arabiensis* (Diptera: Culicidae) in Nigeria using real time data

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Background: The need for evidence-based data, to inform policy decisions on malaria vector control interventions in Nigeria, necessitated the establishment of mosquito surveillance sites 12 out of 36 states in Nigeria. In order to make evidence-based-decisions, predictive studies using available data becomes imperative. We therefore predict the distribution of the major members of the *An. gambiae* s.l. in Nigeria.

Methods: Larvae and adults mosquitoes collected and raised to adults from 72 study sites in 2020 resulted in the identification of over 60,000 *Anopheline* mosquitoes. Of these, seven-hundred-and-sixteen positive field-occurrence points (where the dominant vectors were recorded and used for modelling the potential geographical distribution of these important malaria vectors. Maximum Entropy distribution modeling was used for predicting their potential suitable habitats, using a portion of the occurrence records. A total of 23 environmental variables (19 bioclimatic and four topographic) were used to model the potential geographical distribution under current climatic conditions.

Results: Members of the *An. gambiae* s.l dominated the collections (98%) with *An coustani, An. funestus, An. moucheti, An. nilli* and *An. rhodensi* also present in the collections. An almost equal distribution of the two efficient vectors of malaria, *An. gambiae* and *An. coluzzii*, were observed across the 12 States before the model. *An. gambiae and An. coluzzii* had almost equal well distributed habitat suitability pattern with the latter having a slight range expansion. However, the central part of Nigeria (Abuja) and some highly elevated areas (Jos) in the savannah appears not *suitable* for the proliferation of these species. The

most suitable habitat for *An. arabiensis* was mainly in the South-west and North-east.

Conclusions: The results of this study will help decision makers to monitor the distribution of these species and establish a management plan for future national mosquito surveillance and control programs in Nigeria.

ABS-769

Bioecology of the different species of *Anopheles* from Djibouti involved in the vectorial transmission of malaria

Nadifo Ismail

Historically, malaria has had an epidemic in Djibouti, with the majority of cases imported by the migrant population from neighboring countries. Its transmission has always been highly seasonal, with a variable peak from North to South between October and March. The anopheline fauna of Djibouti identified to date includes *Anopheles gambiae* and *An.stephensi*. Generally, *An.stephensi* which is currently the major vector of malaria occurs in various containers inside houses and at construction sites providing breeding habitats. However, it mainly rests and bites indoors. An. gambiae is also endophilic and is more prevalent in humid areas. Its potential sites are variable: basins, wells, reservoirs, streams, furrows, earth borrowing holes. Djibouti is committed to eliminating malaria by 2030. In this logic, it is essential to update the research and vector control database by conducting entomological surveillance and evaluation.

Keywords: Malaria, Djibouti, *An.stephensi*, *Anopheles gambiae*, Bio-ecology

ABS-370

Application of a spatially explicit sampling design to identify heterogeneities in the distribution of mosquitoes

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Background: The quality of data collected during any research study depends on the sampling design that is employed to generate it. Unfortunately, in many entomological studies, the choice of sampling sites is governed by simple random sampling, which may or may not provide a representative sample of the area, or it may be influenced by the ease of access to the trapping site (accessibility) or due to the requirements of large numbers needed for Insecticide resistance monitoring, they prefer sites where large numbers have been found previously (legacy). but as outlined in the WHO vector surveillance strategy. The need to account for eco-epidemiological zones in the design of sampling programmes reflects the outsized influence environmental factors can have on vector borne diseases. This study reports on the practical application and outcome of a community-based field evaluation of a recently proposed vector surveillance model, which uses existing entomological and environmental data to generate sampling locations across the geographic area.

Methods: Study was conducted in Kilifi county to look at different sampling stages. Here,30 sampling points were selected and a maximum of 4 houses sampled within a 5km radius of each point. A volunteer, preferably a member of one of the households was selected and trained to assemble and operate a CDC light trap according to the SOPs. Each household was sampled once every 2 weeks for two months.

Results: Total of 3621 samples were collected out of which 28%(N=1011) were Anopheles. They include *An. funestus* (68.11%), *An. gambiae* (13.52%), *An. coustani* (9.58%), and An. *protoriensis, An. squamosus*, *An. moucheti* , *An. maculipalpis* ,all were less than 5% of collected samples.

Conclusion: The environmental stratification coupled with the lattice and close pair design established a clear relationship with the two primary vector species and the proximity to water. While this is not an unexpected finding the ability to isolate this relationship with freshwater bodies, the ability to quantify this relationship does clarify the picture and we believe provide clear actionable data that could be utilised by a vector control programme going forward.

ABS-795

The Vector Atlas: An open access platform for African malaria vector data, maps and evidence-based spatial models specifically targeting mosquito control.

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Background: Maps are powerful tools to illustrate the distribution of mosquito vector species that transmit some of the world's most debilitating diseases and highlight species' susceptibility to the insecticides used in their control.

Evidence-based maps rely on field data collected for a wide variety of purposes. In isolation, these data provide answers to specific questions, but when combined, their value multiplies. The **Vector Atlas** is a data-hub that links vector occurrence, bionomics, abundance and insecticide resistance data to provide a 'one stop shop' of relatable open-access cross-referenced data.

Methods: Using standardised collation protocols to abstract data from the published and grey literature (maintaining all data ownership), our core vector data is being fully updated and expanded to cover the prominent secondary vector species as well as dominant vector species driving malaria transmission. We are adding locally relevant human community behaviour, local flora (nectar sources) and fauna (livestock). Combined, these data will inform novel spatial models and maps that improve our understanding of the drivers of malaria transmission.

The three year development phase will culminate in a platform for data up- and download, alongside access to spatial models and maps. Close collaboration with vector control programmes will enable sub-national, bespoke spatial analyses directly addressing their specific challenges in vector control.

Conclusions: The unique worth of the **Vector Atlas** is found in the combined value of i) the comprehensive updated occurrence, bionomic, abundance and IR datasets spatially linked to the MAP's parasite rate surfaces; ii) advanced expertise in spatial analyses, modelling and mapping; iii) enhanced understanding of the intricacies, value and limitations of vector data; and iv) improve knowledge of vector behaviour and the underlying mechanisms of insecticide resistance. Consequently, the **Vector Atlas** will generate actionable products that feed into vector control programmes providing demonstrable results on the ground.

Parallel Scientific Session 9 :
Vector surveillance, epidemiology, disease control programs and global health

ABS-603

Aedes mosquito surveillance in Yaoundé, Cameroon using ovitraps, sweep nets and Biogent traps

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Introduction: Arboviruses diseases represent significant public health problem in Cameroon and vector surveillance is a key component of the prevention strategy. However there is still not enough evidences on the efficacy of different sampling methods used to monitor *Aedes* mosquito population dynamic. The present study provide data of the evaluation of different sampling methods in the city of Yaoundé and it neighbourhood.

Methods: Entomological surveys were carried out from February 2020 to March 2021 in urban to rural settings in Yaoundé (02 urban (Obili, Mvan), 02 peri-urban (Simbock, Ahala) and 02 rural sites (Lendom, Elig-essomballa). Three sampling methods including ovitraps, Biogent Sentinel trap and sweep-nets were evaluated. Differents ovitrap indices were estimated determined technic across study sites; a general linear model (GLM) was used to determine if there is statistical differences between positives ovitrap across ecologicals zone.

Results: A total of 16264 *Aedes* mosquito were collected during this entomological survey. Ovitraps provided the highest mosquito abundance (15323; 91.14%) registered. And five *Aedes* species have been identified: *Aedes albopictus* (59.74%), *Ae. simpsoni* (12.57%), *Ae. aegypti* (12.51%), *Ae. contigus* (6.43%) and *Aedes* (*neomelaniconion) palpalis* (0.0061%). Also, high ovitraps positivity (≥50%) have been observed in peri-urban and rural settings. And *Ae. albopictus* was the most abundant biting species collected around human habitats.

Conclusion: The present study shown that *Aedes* mosquitoes are largely distributed in Yaoundé, displaying high populations densities with 05 *Aedes* species identified. Ovitraps provided high efficacy in collecting *Aedes* species. And *Aedes albopictus* was the most prevalent and aggressive specie around human dwellings. These informations are very useful for planning effective vectors control measure against aboviruses vector in Yaoundé to prevent sudden emergence or outbreaks.

Keywords: Arboviruses diseases, *Aedes*, Sampling methods, rural, Peri-urban, urban, Yaoundé, Cameroon

ABS-643

Structures preferred for resting by *Anopheles arabiensis* in Ethiopia

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Anopheles arabiensis is a primary malaria vector in Ethiopia. In 2018, PMI VectorLink conducted indoor residual spraying (IRS) using Actellic 300CS in 44 districts in Benishangul-Gumuz, Gambela and Oromia regions. To understand the preferred indoor and outdoor resting sites of *An. arabiensis* after spraying, 116 structures including unsprayed and sprayed houses, animal shelters, kitchens, and latrines were surveyed in Pawi (Benishangul-Gumuz) and Lare (Gambela). In Pawi, a total of 881 *An. arabiensis* were collected ; 463 (52.6%) were from sprayed structures and 418 (47.4%) from unsprayed structures. The largest

mean number of *An. arabiensis* found were in sprayed (56.3) and unsprayed (42.4) animal shelters (p>0.05). The next highest densities were 12.2 in sprayed latrines and 8.1 in unsprayed latrines (p>0.05). The mean was 0.8 in sprayed houses and 0.7 in unsprayed houses (p>0.05). Of 394 *An. arabiensis* collected from sprayed animal shelters, 91.6% (n=361) were fed. Similarly, of the 339 collected from unsprayed animal shelters, 82.9% (n=281) were fed. The proportion of gravid plus half gravid was 8.1% in sprayed animal shelters and 13.9% in unsprayed animal shelters. In Lare, a total of 183 *An. arabiensis* were collected, 89.6% (n=164) from sprayed animal shelters. The mean number of *An. arabiensis* per structure was 10.9, 0.8, 0.3 and 0.2 in sprayed animal shelters, houses, latrines, and kitchens, respectively. Of the 164 *An. arabiensis* caught in sprayed animal shelters, 59.1% were gravid plus half gravid, while 40.2% were fed. The proportion of gravid *An. arabiensis* from sprayed animal shelters in Lare was significantly higher than in Pawi (p< 0.0001). In conclusion, in Pawi, the small number of gravid plus half gravid compared with fed mosquitoes implies that *An. arabiensis* completes egg development in other locations. On the other hand, in Lare, the greater percentage of gravid plus half gravid compared with fed mosquitoes implies that *An. arabiensis* rests in animal shelters for a longer time. This resting behavior difference may warrant the use of different vector control interventions such as spraying animal shelters in areas where the vector predominantly rests outdoors in animal shelters.

ABS-654

Anopheles mosquito observatory in Uganda

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Introduction: In Uganda, malaria has remained a leading cause of ill health and death. In 2019, malaria accounted for 30-50% of outpatient visits, 15-20% of hospital admissions and up to 20% inpatient deaths.[1]However, in the last 10 years, there has been a significant reduction in malaria prevalence from 42% in 2009 to 9% in 2019 *(UMIS 2009, 2018).* The most vulnerable groups include children under 5 years and pregnant women. *P. falciparum* is responsible for 90-98% of infections[2].The most common malaria vectors are *Anopheles gambiae* s.s., *A. arabiensis,* and *A. funestus. A. gambiae* s.s.

Methods: Twenty-four districts were selected to participate in the study depending on both Entomological and epidemiological profiles for the period of 5 years. CDC light trap collections was conducted in up to 20 randomly selected houses. Miniature CDC light traps (Model 512; John W. Hock Company, Gainesville, Florida, USA) was positioned 1 m above the floor at the foot end of a bed in all rooms where household members sleep. Traps was set at 7pm and collected at 7am the following morning. The presence and use of LLINs was recorded where the light traps was set.

Results: As expected An arabiensis is dominant in drier parts of Ugandan cattle corridor (Buyende). Relatedly, the proportion of drought tolerant Anopheles funestus is higher in relatively drier parts of the country (Hoima, Buliisa etc). Despite targeting indoor resting mosquitoes during collections, presence of outdoor (and/or exophilic) An arabiensis and An funestus may call for re-strategizing vector control current approaches in some districts. Generally, Anopheles gambiae sl is more widespread than Anopheles funestus ss. However, the proportion of An funestus s.s. is surprisingly higher than any other species in locations where it was not expected.

Conclusion: Behavior change of An. funestus from being exophagic to endophagic have been identified by the observatory. Species succession of An. funestus have been identified in urban areas of Wakiso and other areas where An. gambiae was a dominant species with in the 24 districts

Recommendation: Vector control strategies should be re-strategized to match the vector behavior change of *An. Funestus*. More studies to be conducted in the observatory districts to establish the resistance profiles and population structures of both An. gambiae and An. funestus vectors

ABS-694

Rapid age-grading and species identification of natural mosquitoes for malaria surveillance

Damon Roger

Anopheles mosquito species require a relatively long time to develop and transmit malaria parasites to humans. In vector surveillance, accurate and high-resolution estimation of both the mosquito abundance of morphological identical species and their age are essential for the assessment of the impact of vector control measures, as only specific species at relatively old age can transmit the disease. By applying a convolutional neural network (CNN) to mid-infrared spectra (MIRS) collected from three ecological settings, genetic (GV), laboratory (LV) and environmental (EV) variation datasets were analysed, and we were able to predict and classify the age and species using information from the infrared light absorbed by the mosquito cuticle, with varying accuracy depending on the type of variation. Furthermore, using simulations, we demonstrated that the model would be able to detect shifts in the age structure of mosquito population as those expected by vector control interventions. Finally, we validated our model on wild mosquitoes collected in Burkina Faso and Tanzania, and we compared MIRS-CNN predictions to the Polovodova age grading technique, which is based on dissection and morphological characterization of ovaries to determine the status, the number of gonotrophic cycles, and showing very similar estimates of population age structure between the two approaches.

This new approach based on deep learning of MIRS of mosquito cuticle, is easy-to-use, cost-effective, robust and high-throughput and presents several advantages by predicting simultaneously the age and species of mosquito which could help vector surveillance programmes.

Keywords: vectors, infrared spectroscopy, machine learning, classification, age, species, malaria, mosquito, surveillance

ABS-729

Mechanisms affecting sporozoite prevalence in wild mosquito populations

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Background. Understanding the mechanisms through which environmental variables affect malaria transmission remains challenging. The relationship between malaria transmission and disease is non-linear due to complex interactions with human immunity. Entomological metrics of malaria risk, such as the entomological inoculation rate (EIR), however, provide a direct measure of environmental malaria risk. Multiple mechanisms affect the EIR such as: the extrinsic incubation period (EIP) and mosquito emergence rate. The EIR is the product of the human biting rate (HBR) and sporozoite prevalence, which are determined by different processes meaning correlations can occur between them. Theoretically, increases in mosquito emergence, for example, increase the HBR but decrease the mean mosquito age. Because mosquitoes must survive the EIP to become infectious, decreases in mosquito age decrease sporozoite prevalence. Identifying the effects of different mechanisms on the different components of the EIR may, therefore, be more informative.

Methods. We incorporated seasonality in *Anopheles gambiae* and *Anopheles funestus* emergence and temperature-derived seasonality in the EIP into an established malaria transmission model. The accuracy of the predicted sporozoite prevalence values were assessed with and without these mechanisms using previously published longitudinal sporozoite prevalence data.

Results. For *A. gambiae*, but not *A. funestus*, there was a significant negative correlation between the intrinsic growth rate and sporozoite prevalence, indicating sporozoite prevalence declines when the *A. gambiae* population is growing. Incorporating seasonality in mosquito emergence increased the variance explained compared to the null model by approximately 22.8% for *A. gambiae* and 14.8% for *A. funestus*. Temperature-dependent seasonality in the EIP increased the variance explained by 0.8% for *A. gambiae* and 0.9% for *A. funestus*.

Conclusions. In the short-term, mosquito emergence has a large effect on sporozoite prevalence. When measuring entomological malaria risk longitudinal studies are, therefore, required to account for seasonality in mosquito emergence.

ABS-730

Feeding behavior of malaria vectors and its implications in malaria control, Mozambique

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Introduction: Malaria is still one of the main causes of morbidity and mortality in Mozambique. The main vectors are *Anopheles gambiae s.s*, *An. arabiensis* and *An. funestus s.s.* Control of malaria in the country is done mainly through insecticide treated nets (ITNs) and indoor residual spraying (IRS). Knowledge about feeding behavior of vectors is crucial for planning and evaluating the impact of control measures. The study examined the feeding behaviour of malaria vectors in the provinces of Zambézia and Nampula, Mozambique.

Methodology: The study was carried out in the provinces of Zambézia (districts: Milange, Maganja da Costa, Lugela and Mopeia) and Nampula (Nampula-city, Erati and Monapo) from January-2018 to December-2019. Mosquitoes were collected monthly, during 3 consecutive days, between 6 pm and 6 am using human land collections (HLCs) inside and outside the houses. Collected mosquitos were identified morphologically.

Results: A total of 7052 *Anopheles* mosquitoes were collected, of which 3807 were *Anopheles gambiae s.l*. (53.99%) and 245 were *An. funestus s.l*. *An. funestus s.l* showed a greater tendency to feed inside the houses in all locations except Milange, while *An. gambiae s.l*., had a greater tendency to feed outside in most places. These results suggest a possibility of malaria transmission occurring both inside and outside the houses. The peak biting varied by species, location and position. Most mosquitoes were found biting between 10pm-3am when most people were reportedly sleeping, although in some locations, peak biting occurred between 18:00-21:00 hours before people go to bed. There were significant differences between the bites by position and location ($P<0.05$, df=6).

Conclusions: Malaria vectors biting early inside/outside houses and outdoor vectors can reduce the impact of indoor residual spraying and mosquito net and consequently the goal to control and eventually eliminate malaria. Vector control tools that target early and outdoor vectors are urgently needed.

ABS-363

Natural sugar feeding rates of *Anopheles* mosquitoes collected by different methods in western Kenya

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Background: Attractive targeted sugar baits (ATSBs) are potential vector control tools that exploit the sugar-feeding behaviour of mosquitoes. This study evaluated the sugar feeding behaviour of *Anopheles* mosquitoes in western Kenya as part of baseline studies in advance of a cluster-randomized trial to evaluate the impact of ATSBs on malaria transmission.

Methods: *Anopheles* mosquitoes were collected from two villages in Siaya County in western Kenya. Three trapping methods

were compared, UV light traps placed indoors, outdoors within 10 meters from the structure, and outdoors 10 meters from the compound, prokopack aspirations (conducted indoors and outdoors), and malaise traps (set outside the compound). Individual mosquitoes were subjected to cold anthrone test to assess the presence of sugar.

Results: Overall, 15.7% of collected mosquitoes had fed on natural sugar sources. *Anopheles funestus* had the highest rate of sugar feeding with 38.2% of males and 27.3% of females, respectively, followed by *An. arabiensis* with 26.4% of males and 12.7% of females. For *An. coustani*, 9.7% of males and 8.2% of females had fed on sugar**.** Male mosquitoes collected by aspiration had the highest levels of sugar feeding compared to the other collection methods. Sugar feeding among the unfed female and male mosquitoes was significantly higher compared to blood-fed and gravid mosquitoes across all the species. The highest sugar feeding rates were observed in mosquitoes collected between 03:00 and 07:00 hours for *An. coustani* (14%), between 17:00 and 21:00 hours for *An. gambiae* s.l. (16%), and between 00:00 and 03:00 for *An. funestus* (52%).

Conclusion: Indoor resting *An. funestus* had the highest sugar feeding rate suggesting the potential for ATSBs to impact on the principal malaria vector in this region. Both indoor and outdoor resting mosquitoes are shown to sugar feed suggesting the potential of outdoor placed ATSBs to control both indoor and outdoor resting mosquitoes.

ABS-536

Optimisation of Tunnel Tests: An Important Bioassay for Vector Control Product Evaluation

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Background. Tunnel tests are an important WHO (World Health Organisation) method for evaluating wash resistance of insecticide treated netting. They may be preferable to some other bioassay methods as they allow and encourage the natural feeding behaviours of mosquitoes. However, this method has come under some scrutiny from animal welfare and ethics review boards as guinea pigs are required to be restrained overnight for tunnel tests to be carried out. This investigation aimed to evaluate new methods for these tests which improved welfare standards for the guinea pigs involved, without compromising the results of the test.

Methods. New methods evaluated included ones in which the guinea pigs were allowed to roam free in the bait chamber, and others which used an acrylic tunnel of a novel design as opposed to the current tunnels which are made of glass. The most successful new iteration of the tunnel test design used a yeast and sugar water mixture alongside wet socks as an odour source, and a Hemotek membrane feeder as a blood source along side treated and untreated nets, completely replacing the guinea pig against the gold standard tunnel set up.

Results. This iteration demonstrated a mean bloodfeeding rate of 74.4%, compared to the control mean of 77.3% (p=0.6006), and also showed a non-significant difference from the control in passage (p=0.0692), recovery (p=0.0639) and mortality (p=0.6598).

ABS-553

House improving as a supplemental intervention tools for reducing indoor vector densities and malaria prevalence in Emana, center Cameroon.

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Background: Modifications of typically rural house design can effectively reduce indoor mosquito vector densities and consequently decrease malaria transmission. We assessed the supplemental effects of this method of vector control on the density of indoor malaria vectors in a MILDA low coverage area of center Cameroon.

Methods: 16 houses were randomly selected for the study base on their indoor density of resting malaria vectors. Half were eaves screened (experimental) with fibreglass coated wire mesh and half left unscreened (control). Entomological baseline were collected both in experimental and control groups. Outdoors and indoors adults mosquitoes were sampling for entomological data collection in each houses using HLC. Malaria prevalence surveys were conducted after mosquitoes sampling in both groups.

Results: A total of 300 mosquitoes (*Anopheles funestus* (n=255; 85%) *Anopheles gambiae* sl (n=45; 15%) were collected over this period using HLC in 16 houses over the village (mean mosquitoes / house=18.75). Among *An. funestus*, 63.9% were unfed, 32.9% blood fed, 0.39% gravid and 1.56% gravid females. 17.7% of *An. gambiae* were unfed and 82.2% blood fed. More indoor adult mosquitoes were collected in the control (n=74) than experimental houses (n=56). Parasitological surveys results to relatively low malaria parasite prevalence rates in screened houses compared to the control houses. Overall, malaria prevalence was 57.8% (95% CI: 0.32-0.74) n=90, with baseline prevalence rate of 58.5% (95% CI: 0.67-1.13), n=65 and 2nd follow-up survey prevalence of 42.0% (95% CI: 0.52-0.76) n=66. At all the two parasitological follow-up survey points, house screening significantly reduced the malaria prevalence by 43% ($p< 0.001$).

Conclusions: The study demonstrated that house Housing improvement has potential to reduce indoor vector indoor human-vector contact and malaria prevalence. This highlight to promotes aspects of house design as complementary control tool against malaria transmission in epidemiological settings.

Keywords : Housing improvement, Anopheles density, Eaves, Screening, Malaria prevalence, Cameroon.

ABS-556

Development, piloting, and evaluation of an Entomological Adaptive Sampling Framework (EASF)

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Routine entomological surveillance is important for monitoring and evaluating interventions, however it is mostly carried out preferentially since no operational guidance for establishing optimal entomological sampling is available in programmatic settings. Entomological Adaptive Sampling Framework (EASF) adjusts the entomological sampling strategy across time and space and enables the capture of spatially heterogeneous changes in disease transmission dynamics to produce accurate and representative data that can guide programmatic and strategic decisions. The EASF will be piloted in Mozambique and Nigeria.

The EASF will be implemented in three stages. Stage 1, to develop spatiotemporal EASF model (Beta version) that will inform adaptive entomological sampling designs across space and time for detecting changes in the three priority indicators: 1) vector species compositions, 2) vector behavior, and 3) IR. Stage 2, pilot, optimise and validate Beta-EASF and compare with program routine surveillance framework over 2 years. Stage 3, based on the EASF pilot outcomes, recommend entomological sampling strategies for Mozambique and Nigeria, develop EASF operational guidance, and cost-effectiveness assessment for piloting EASF versus program routine surveillance framework.

The EASF will help programs establish cost-effective adaptive entomological surveillance strategy that is responsive to changing transmission dynamics, and optimize the use of available resources by obtaining more robust and informative data.

ABS-793

Progress in malaria vector surveillance in combatting insecticide resistance in nigeria: lesson learnt from the past to reach a future free of malaria

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Background: Despite the importance of vector surveillance in malaria control, systematic coordination of insecticide resistance monitoring at the national level was lacking owing majorly to the limited number of vector surveillance sentinel sites in Nigeria. This paper presents the lessons learnt from the past and provides future recommendations.

Description: In 2013, the National Malaria Elimination Programme (NMEP) domiciled in the Division of Malaria and Vector Control Department included it in its monitoring and evaluation plan for the year 2014 – 2022 to set up three sentinel sites for vector surveillance in each geopolitical zone in Nigeria before the end of 2020.

Lesson learnt: Today, the NMEP through collaborations with various partners can boast of over 169 active vector surveillance locations spread across 29 States of the country supported by two major partners; the Global Fund and US-President's Malaria Initiative. We stressed the importance of proper coordination, capacity building, timely collaborations with partners, prompt evaluation of programmatic activities, and involvement of academia as major drivers of this paradigm shift.

Conclusions/Next Steps: Vector control activities has greatly improved across the country. We now have meaningful information on resistance status and species distribution of major malaria vector(s) across the country. However, there is need to establish new sentinel sites across the remaining states in the country. Also, new methodologies are being used to better understand the species distribution and transmission dynamics of major malaria vectors, one of such methodology are mathematical modelling and spatio-temporal modelling of vectors using our generated data as basis. This will involve a multidisciplinary approach involving mathematicians, geographers and infectious diseases modeler. Also, now is the time for operationalization of existing database to capture real time entomological data that are interactive for decision making. Specifically, by ensuring the linkage of such database to the National Malaria Data Repository (NMDR).

ABS-522

Dissecting the impacts of interventions on mosquito fitness and population dynamics using standard entomological surveillance data

Mafalda Viana

Vector populations behave differently to different interventions, but malaria control is at a critical point where solely estimating the impacts in terms of reductions in population size is no longer sufficient. Unless we understand how the underling vector demographic processes are impacted and contribute to that observed response, in particular with combined tools and different modes of action, long-term control will remain elusive. Entomological surveillance is continually generating extensive, longitudinal datasets that can enable identification of the factors that underpin population persistence and regulation. Here, we develop a modelling framework to dissect the impacts of interventions on mosquito fitness from standard entomological

surveillance. Specifically, we combine a stage-structured population model implemented under a Bayesian state-space framework with monthly vector surveillance from a 2-year, large-scale randomised clinical trial of a combination bednet (i.e. Olyset-DUO) implemented in Burkina Faso. It is hypothesized that these nets reduce mosquito populations through two different routes: by reducing adult mosquito survival (through pyrethroids), and fecundity (through pyriproxyfen). We found that this intervention initially reduced vector population density by an additional ~20%, compared to standard Olyset bednets, and importantly we were able to determine if the expected demographic impacts were translated under operational conditions within natural populations. In addition, as our modelling approach captured the vector population dynamics, we were able to determine that key ecological processes such as larval density-dependence play a critical role in balancing adult survival and fecundity trade-offs in perturbed wild populations, with a non-linear effects on mosquito population sizes. Together these results open opportunities to identify different intervention combinations that are most likely to control or eliminate wild mosquito populations. More broadly, bridging contemporary ecological modelling with public health data on vector-borne diseases can provide game-changing insights into the factors that underpin the persistence of vector populations, allowing more effective targeting of interventions. This is particularly important as we move from control to elimination.

Parallel Scientific Session 10 : Vector biology, ecology, taxonomy and population genetics

ABS-346

The evolution of the genetic structure of populations of two species of the *Anopheles gambiae* s.l. complex using the *Kdr* gene before and after indoor residual spraying in some agroecological zones of Benin (West Africa)

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Introduction: In Benin, the resistance of *An. gambiae s.l.* mosquitoes to pyrethroids remains a major concern. The development and use of alternative insecticides seems to be the solution. Organophosphates (Actelic@300 CS) are currently the best candidates to meet this challenge. The present study aims to compare the genetic structure of vector populations of two species of the *An. gambiae s.l.* complex through the *L1014F* resistance allele of the *Kdr* gene during two periods marked by characteristic environments to better understand its impact on the dynamics and biology of these organisms.

Methods: Eight locations in three agro-ecological zones, one of which is a control, were studied. Larval surveys were carried out during the rainy seasons of May to July 2016 for the pre-IRS period and May to November 2018 for the post-IRS period. Larvae were reared at the insectarium of the Centre de Recherche Entomologique de Cotonou. The adult females obtained were identified morphologically and by molecular approaches. Thanks to the *L1014F* and *L1014L* alleles of *Kdr*, the genetic structure of the populations at various hierarchical levels could be determined.

Results: Molecular analysis revealed three vector species of the *An. gambiae* complex both before and after IRS, two of which are in the majority. These were 171 *An. coluzzii*, 297 *An. gambiae* s.s., 11 *An. arabiensis* and 211 *An. coluzzii*, 256 An. gambiae s.s., 8 *An. arabiensis* respectively out of 479 sampled before treatment and 475 sampled after IRS. In both *An. gambiae* s.s. and *An. coluzzii*, the gene frequency of *L1014F* was found to increase significantly following treatment, approaching the limit of fixation in some populations. A deficit of heterozygosity is widespread with values of the indices, F_{ST}, F_{SC} and F_{CT}, expressing little or no differentiation within and between the defined populations.

Conclusions: IRS has more favoured the selection and spread of the *L1014F* resistance allele of the *Kdr* gene. The apparent adaptation of *An. coluzzii* to polluted areas would be a factor in its proliferation to the detriment of its twin sister *An. gambiae s.s.* in IRS areas. The genetic structuring of the populations, whatever the species, remains almost the same despite the treatment.

ABS-476

Evaluation of different trapping methods for the collection of anopheles mosquitoes in Western Kenya

Jackline Kosgei

Background and Objective: Entomological surveillance is essential for monitoring the impact of control tools and is mostly conducted using human landing catches (HLCS) or CDC-light traps (CDC-LT). HLCs may expose collectors to infectious mosquitoes. To assess the optimal approach for mosquito surveillance for a large-scale trial of attractive targeted sugar baits, we compared five trapping in western Kenya.

Materials and Methods: Five mosquito sampling methods—CDC-LT), UV light traps (UV-LT), aspiration, HLC, and malaise trapping were evaluated in villages of Asembo, in Siaya County, western Kenya between July and September 2020. CDC-LTs, UV-LTs, and HLCs were conducted in three locations of the same compound (inside houses; outside 10 meters from the house; and outside 10 meters from the compound boundary). Collections were rotated through houses following a five-by-five Latin-square design. Mosquito densities, species abundance, and sporozoite infectivity rates were compared across all sampling methods. Data analysis was performed using R statistics software version 4.1.2.

Results and discussion: 5483 *Anopheles* mosquitoes were sampled from 868 trapping efforts. *Anopheles funestus* constituted 3824, (69.74%) of the sampled *Anopheles* mosquitoes. Compared to HLC, indoor aspiration captured highest number of *An. funestus,* mean=8.82 (RR =12.74, 95% CI 6.02-24.58, *P* <0.001) followed by indoor UV-LT, mean=4.26, (RR= 5.13, 95% CI 2.80-9.39, *P* <0.001) and indoor CDC-LT mean=2.30 (RR= 3.00, 95% CI 1.63-5.53, *P* <0.001). Similarly, outdoor UV-LT and CDC-LT collected higher number of *Anopheles* mosquitoes across all species when compared to outdoor HLC. Hourly biting in UV-LT and CDC-LT indicated different peaks compared to HLC.

Conclusion and recommendation: *Anopheles funestus* were primarily caught indoors. *An. arabiensis* and *An. coustani* were mostly collected outdoors with UV-LTs. The UV-LT and CDC-LT were superior to HLC both indoors and outdoors. Differences in hourly biting by different collection methods indicate the need to further investigate the behaviour of *An. funestus*.

ABS-569

Life history parameters of two *Anopheles gambiae* phenotypes in target malaria ACL 2 insectaries, a proxy for rearing performance.

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Background: In insectary management practice, routine recording of life history traits is key for monitoring performance, assessing changes over time and allowing appropriate remedial action if required. This study has evaluated the mosquito rearing performance in the Target Malaria Arthropod Containment Level 2 (ACL 2) insectary at UVRI. Two colour variant phenotypes that occur naturally within the *Anopheles gambiae* species were used. The first phenotype exhibits a white pigment beneath the transparent cuticle at the dorsum of the thorax and abdomen, while the other lacks that pigmentation. Maintaining the phenotypes requires careful crossing and sorting.

Methods: A colony of non-pigmented mosquitoes was reared for 9 generations in parallel with a heterozygous pigmented colony maintained through backcrossing. Mosquito progeny were screened for pigmentation and sexed at each generation which served to validate our rearing methodologies and processes. For each generation, the egg count, egg hatch rate, larval development time and emergence rate of the two colonies were recorded. Data was analyzed using General Linear Modelling.

Results: Mean number of eggs per female per generation was 23.93 (SEM = 4.5, n = 18), no significant difference between pigmented and non-pigmented colony, egg hatch rate, larval development time and emergence rates $t(15) = 0.119$, $p = 0.907$. General Linear Model indicated sex ($p>0.05$) and pigmentation phenotype ($p>0.05$) had no significant effect on development time and emergence rate ($p > 0.05$). As expected, 100% of progeny from non-pigmented colony were non-pigmented, but those of pigmented colony were in 1:1 ratio (pigmented: non-pigmented) for all generations.

Conclusion: Consistent maintenance of the two colonies was with the expected Mendelian ratios despite no difference in the life history parameters confirming that the rearing, screening and sex sorting methodologies implemented in the ACL 2 facility all performed flawlessly resulting in no strain contaminations and successful maintenance of the two contrasted phenotypes/ strains.

ABS-573

Monitoring species diversity, abundance, composition and parasite infections of *Anopheles* mosquitoes in a malaria-endemic area of Luampa District, Western Province, Zambia.

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Background

Long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) are the main malaria vector control methods in Zambia. Despite scaling-up LLINs and IRS in Luampa district of western Zambia, malaria transmission persists, posing a serious public health challenge. The Zambia National Malaria Elimination Programme is carrying out operational research studies to evaluate next-generation vector control tools to aid in achieving malaria elimination. One of the potential additional tools being evaluated is the use of attractive sugar baits (ASBs). Additionally, enhanced entomological surveillance is required to provide data that will guide selection of effective and sustainable vector control strategies in western Zambia. This study monitored species diversity, relative abundance, species composition and parasite infection of *Anopheles* mosquitoes in Luampa District, Western Province of Zambia.

Methods: Entomological cross-sectional surveys were conducted from March to May 2020 in Katongo village of Luampa district (lies between latitude 15.0633°S and longitude 24.4077°E) in western province of Zambia. Four cross-sectional entomological surveys were carried out; one pre-collection period where mosquitoes were sampled for 15 nights and three post-collections periods which lasted for 45 nights (i.e. each round with 15 nights). Different collection methods were used to sample the mosquitoes includes indoor and outdoor CDC light traps, indoor prokopack aspiration and outdoor clay pots. Sub-samples of *An. gambiae* s.l and *An. funestus* s. l. were randomly selected for *Plasmodium falciparum* sporozoite detection using Enzyme-Linked Immunosorbent Assay (ELISA) while polymerase chain reaction (PCR) was used for sibling-species identification.

Results: A total of 60 nights of mosquito trapping was conducted with a total of 4,018 adult anopheline mosquitoes belonging to thirteen species were collected during pre- and post-collection period. The most abundant species was *An. squamosus* accounting for 53.7 %(n=2,156) followed by *An. gambaies.l* 18% (n=725),*An. tchekedii* 13.6% (n= 545), *An. coustani* 5.2% (n=207), *An. funestuss.l* 3.8% (n=152), *An. pretoriensis* 2.8% (n=114), *An. gibbinsi* 1% (n=40), *An. longipalpis* 0.4% (n=16), *An. maculipalpis* 0.2% (n=10), *An. tenebrosus* 0.1% (n=5), *An. implexus* 0.05% (n=2) and *An.rufipes* 0.02% (n=1). Out of 4,018 anopheline mosquitoes, 783 belonging to *An. gambiae s.l* and *An. funestus s.l* complexes were further analyzed by PCR technique. Three species of the *An. gambiaes.l* complex were identified; *An. gambiae s. s*(29%, n=185), *An. arabiensis* (18.8%,n=118) and *An. quadriannulatus* (0.8%, n=5), and only two species belonging to *An. funestus s.l* complex were identified; *An. funestus* s.s (40.3%,n=62)and *An. leesoni*(1.9%,n=3) in the study area. Of the 2039 anopheline mosquitoes that were screened for *Plasmodium falciparum* (*Pf*),14 positives were detected in *An.gambiae s.s*(7/2039) and *An.arabiensis* (3/2039) giving a mean *P.f* sporozoite infection rate of 0.7% (n=14/2039).None of the secondary vectors tested positive for *P. falciparum* sporozoites in the study area.

Conclusion: The identification of thirteen species of anopheline mosquitoes in the study area of Luampa district highlights high species diversity which might compromise the malaria control and elimination efforts in western Zambia. *Anopheles gambiae* s.s and *An. arabiensis* are the main vectors of malaria in the study area. Longitudinal studies focusing on the seasonality, ecology, and biology of potential secondary vectors of malariawill be critical in the selection, designing and implementation of sustainable vector strategies in Western Zambia.

ABS-577

Assessing the effectiveness of powdered beans, maize, and dried herrings as alternative feed on the larval development of *Anopheles gambiae s.l* mosquito

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Background and objective: Laboratory maintained mosquito colonies are important in studying vector biology and testing vector control tools. Standard operating procedures often require feeding larvae with commercial fish meal. However, procuring this in labs in many developing countries is often challenging as they are imported products. The inconsistencies in adaptation of larvae to different brands of fish meals implies that one must maintain buying the same brand each time. These challenges can affect the production of mosquitoes for research purposes. This study explored the effect of locally acquired feeds including maize, beans and dried herrings, on the development of mosquito larvae reared under laboratory conditions.

Materials and method: 100 *Anopheles gambiae* larvae were introduced into 500mL of dechlorinated tap water for 4 single feed treatments with 4 replicates per treatment. They were kept under standard insectary conditions of 30±2°C temperature and 65±10% humidity. 40g of powdered beans, maize, and herrings was introduced into each replicate for each treatment with Tetra Goldfish as control. Pupae and larvae were counted in each bowl and mortality was recorded daily. Adults from each treatment were blood fed and allowed to lay eggs and the number of eggs counted to assess fertility. Other fitness measures included mosquito weight and wing length.

Results: Pupation rates were similar ($p>0.05$) between the feeds, ranging between 92.4% to 99.1%. Pupation started after 4 days with Tetra goldfish bowls, 5 days with beans and dried herring, and 6 days with Maize. 10 blood fed females were sampled from each treatment and allowed to lay eggs. 155 eggs were counted for tetra goldfish, 46 for dried herrings, 40 beans and 16 for maize.

Conclusion: Testing and analysis is ongoing and additional results comparing fitness parameters for bioassay testing will be included. This study shown the potential of these local feed for laboratory maintenance of larvae.

ABS-597

Bacterial products from mosquito midgut microbiota negatively impact parasite burden of *P. falciparum* in *Anopheles gambiae.*

Esinam Arkoli

Background: Novel mosquito-borne disease control ideas include the use of bacterial symbionts to reduce transmission. Bacteria belonging to the family Enterobacteriaceae have shown promise in limiting *Plasmodium* intensity in the *Anopheles* vector. However, it remains unclear whether the interaction between bacteria and parasite is a direct cell-to-cell or indirect through secreted products. This study aimed at determining if naturally- occurring bacteria release substances that can disrupt mosquito stages of *P. falciparum* development.

Method: *Enterobacter cloacae* and *Serratia marcescens* bacterial species were isolated from field-caught *Anopheles gambiae* mosquitoes in Ghana. Media from liquid cultures of these bacteria were filtered, lyophilized and dissolved in sterile phosphate buffered saline (PBS). Their impact on the prevalence and intensity of infection with *Plasmodium falciparum* in the mosquito was assessed by introducing these bacterial products in a blood meal containing gametocytes grown *in vitro*, and feeding via membrane feeders to *An. gambiae* mosquitoes. Mosquitoes were dissected 10-11 days post-infection and oocysts were counted.

Results: Mosquitoes fed an infectious blood meal containing *S. marcescens* product had a significantly reduced prevalence of *P. falciparum* infection (P=0.00119) and infection intensity (P=7.85 x10^{-12}) compared to the control with lyophilized LB medium added. The addition of products from *E. cloacae* cultures however had no significant effect on prevalence of infection (P=0.306) or infection intensity (P=0.152).

Conclusion: These products released by symbiotic bacteria can be used as potential transmission blocking agents to reduce the burden of Malaria.

Keywords: mosquito midgut microbiota, *Enterobacter cloacae*, *Serratia marcescens*, *Anopheles gambiae*, *P. falciparum*

ABS-611

Impact of a "lethal house lure" intervention on malaria transmission intensity and *Anopheles* mosquito vector diversity during a cluster randomized controlled trial in central Côte d'Ivoire

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Background: Assessing local vectors contribution to malaria transmission is essential, when evaluating the impact of a lethal house lure (In2Care EaveTubes) targeting mosquitoes.

Methods: A cluster-randomized controlled trial with 40 villages (20 control and 20 intervention) was conducted in central Côte d'Ivoire from May 2017 to April 2019, to evaluate the effectiveness of In2Care EaveTubes. Mosquitoes were collected using indoor and outdoor human landing catch, from 06.00 p.m.-08.00 a.m. For each identified malaria vector species, mosquitoes were processed for entomological indicators of transmission (human biting rate, parity, sporozoite infection and the entomological inoculation rates). These indicators identified were compared between control and intervention groups, and then between species.

Results: Overall, 260,747 mosquitoes were captured. *Anopheles gambiae* s.l., *An. funestus* and *An. nili* were the three malaria vectors found over the study period. *An. gambiae* s.l. (71.21 %) was predominant compared to *An. funestus* (7.84%) and *An. nili* (1.74%). The overall mean human biting rate (HBR) was higher in the control group (20.21 bites per human per night (b/h/n)) than in the intervention group (10.79 b/h/n) (P=0.0005). The mean party rate was higher in the control group (83.26 %) than in the intervention group (76.39%) (P= 0.001). For the sporozoite index, the value was higher in the control group (4.27%) than in the intervention group (2.15%) (P= 0.003). For entomological inoculation rate, the value was higher in the control group (0.91 infected bites per human per night (ib/h/n)) than in the intervention group (0.25 ib/h/n) (P= 0.002); i.e. a reduction rate of 66% indoors and 53% outdoors. The outcomes for these indicators were also evident in outdoor (P<0.01). In term of each species contribution to malaria transmission, the HBR was higher for *An.gambiae* s.l (17.22-19.89 b/h/n), while *An. funestus* had the highest sporozoite infection rate (5.38-6.08%) and *An.nili*; highest parity rate (83.62-97.12%) (P<0.01).

Conclusion: The In2Care EaveTubes intervention provided an evidence of effectiveness in reducing malaria transmission in addition to the effects of standard insecticide-treated nets.

Keywords: Species diversity, Species contribution, Malaria transmission indicators, Côte d'Ivoire

ABS-635

Molecular basis of immune response of combining Wolbachia and entomopathogenic fungi for Dengue Control in Burkina Faso

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Background. In recent decades, dengue fever has been the most rapidly spreading arbovirosis requiring the implementation of effective control strategies. Although many control strategies have traditionally been deployed against infectious diseases, nowadays only vector control lends itself to fight against dengue fever. The involvement of *Wolbachia* and entomopathogenic fungi in mosquito population control strategies is a real advantage for biological vector control. However, little is known about the molecular immunity of mosquitoes artificially infected with *Wolbachia* after a fungal infection. This work therefore aimed at investigating the immune basis of the protection conferred to *Aedes aegypti* by *Wolbachia* strains (wAu, wAlbB) against *Metarhizium pingshaense* infection.

Methods. Following experimental infection with *Metarhizium pingshaense* in our three mosquito populations (wAu, wAlbB and wild mosquitoes), the sensitivity of the mosquitoes to the fungal infection was determined. Then, the impact of the fungal infection on the density of Wolbachia in the mosquitoes was evaluated by real-time RT-PCR. Finally, the impact of fungal infection and Wolbachia infection status on the expression of some genes of the Toll and IMD immune pathways was studied by real-time RT-PCR.

Results. While a strong protection against infection was observed in mosquitoes transinfected with Wolbachia wAu (wAu+), an increased susceptibility to infection was observed in mosquitoes devoid of any Wolbachia infection (W-) and a moderate susceptibility in mosquitoes transinfected with Wolbachia wAlbB (wAlbB+). Furthermore, they suggest that fungal infection and Wolbachia strain increases Wolbachia density in mosquitoes. Finally, they indicate that the Toll and IMD pathways are involved in the antifungal response in mosquitoes and that wAu conferred a better immune response during fungal infection.

Conclusion. This study provides evidence-based answers at the molecular level that the combination of Wolbachia and *M. pingshaense* could be an effective vector control strategy.

Keywords: *Aedes aegypti*, *Wolbachia*, Entomopathogenic fungi, Immune pathways, Gene expression.

ABS-668

Longitudinal survey *on Aedes aegypti* larval ecology in urban and peri-urban sites of Burkina Faso: implication for dengue control

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Dengue is a viral emerging disease transmitted by a mosquitoes from *Aedes* genus breeding preferentially in man-made water holding containers closely associated to human dwellings. Larvae source management which is an effective strategy for dengue vector control require a good understanding of larvae ecology and habitat characteristics. A longitudinal investigation over year

was undertaken to assess *Aedes* mosquito breeding ecology and determine key productive containers.

Around forty (40) selected households from urban and semi urban areas of the cities of Ouagadougou and Banfora were visited once per month from July 2019 to December 2020 covering dry and rainy seasons for the presence of water holding containers. All the water holding containers were characterized and inspected for *Aedes* sp larvae and pupae. The key immature stage productive water holding containers were determined and compared between periods, sites area and localities.

Aedes aegypti was the predominant *Aedes* genus mosquito and found breeding in various type of water holding containers. A total of 801 containers was inspected and 327 were positive with *Aedes aegypti* immature stages (11 868 larvae and 1 346 pupae). All the classic stegomya indices (Breteau, House and container Indices) were over the WHO arboviruses risk of transmission threshold values during the rainy season (June-October) both 2019 and 2020 years and significantly higher in urban (1200 logements and Banfora) compared to peri-urban (Tabtenga and Bounouna) sites ($p< 0.01$). Overall the top three significant key *Aedes aegypti* immature (both larvae and pupae) productive containers were respectively car tyres, small and medium containers and this productivity was significant higher during rainy season regardless areas and cities.

Our results provide relevant information on the high entomological risk of arboviruses disease transmission in urban sites during the rainy season and the key productive water containers that could be targeted during control intervention based on water holding containers cleaning strategy to reduce dengue transmission in outbreak context.

Keywords: *Aedes aegypti*, containers productivity, dengue control, Burkina Faso

ABS-688

Study of the polymorphism of the fruitless gene in *Anopheles coluzzii* in 9 African countries

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Malaria is an endemic disease in the world. Conventional control tools are struggling to achieve the goal of malaria elimination. To reinforce these control strategies, innovative control tools are being developed, among which genetic control is promising. Our work consisted in studying the polymorphism of the fruitless gene in *Anopheles coluzzii*, one of the major vectors of malaria, in a perspective of genetic control of malaria vectors. Our study was carried out at the Institut de Recherche en Sciences de la Santé (IRSS). The sample consists of 675 *Anopheles coluzzii* specimens collected in 9 African countries. The sequencing data used in this study are from the third phase of the 1000 genomes of *Anopheles gambiae* project in which IRSS is a partner. Mosquito samples were sequenced using Illumina HiSeq technology at the Wellcome Sanger Institute. Data analysis was performed with JupyterLab. In *Anopheles coluzzii*, 26593 mutations including 363 non-synonymous mutations in the fruitless gene were identified. The nucleotide diversity varied between 0.3% and 0.5% in countries. Of the 363 non-synonymous fruitless gene mutations, 25 had allelic frequencies exceeding 5% in at least one population. The allelic frequencies of these mutations were low except for mutation 1309218 with a frequency greater than or equal to 0.8 in all populations. Nucleotide diversity in specific regions of the fruitless gene was low at the coding regions compared to the non-coding regions. The present study shows low variability of the fruitless gene in *Anopheles coluzzii* populations. The gene can be targeted for genome editing to disrupt mosquito sexual and feeding behavior.

Keywords: fruitless, *An. coluzzii*, polymorphism, IRSS

Parallel Scientific Session 11 :
Precision public health and innovations for VBD elimination: AI, entomological databases, modelling and genomic surveillance

ABS-568

Validating the modelled impact of vector control interventions using randomised controlled trials

Lemant Jeane

Background & Objective. Malaria models are increasingly used to support National Malaria Control Programs by simulating possible impacts of various interventions, especially since the launch of the High Burden to High Impact initiative by the World Health Organisation in 2018. However, the effect sizes of vector control interventions are often calibrated using entomological data from experimental hut studies. As clinical trials evaluating these interventions are conducted, it becomes essential to understand whether models can reproduce the observed epidemiological outcomes. The objective of this study was therefore to validate the epidemiological effect sizes predicted by the agent-based model OpenMalaria using randomised controlled trials.

Materials & Method. Following the methodology from a recent validation of another model, we reproduced for each trial arm the history of interventions before the start of the trial, case management level, relative abundance of *Anopheles* mosquito species, seasonality of transmission as well as timing and coverage of the evaluated interventions, Insecticide-Residual Spraying (IRS) and Insecticide-Treated Nets. Intensity of transmission was calibrated to the observed prevalence at baseline.

We then compared the predicted prevalence or incidence to the trial outcomes.

Results & Discussion. Trials conducted over the last decade in Uganda and Tanzania and evaluating two IRS ingredients and four types of ITNs have been reproduced by the model. Despite disparities between trials, the model predicts the right variations of prevalence over time. Understanding the baseline burden of infection, duration of insecticide and coverage levels are critical to reproduce the effect sizes. Next, it would be essential to refine how the model captures levels of insecticide resistance, and to validate using more trials, especially in the West African region.

Conclusion & Recommendation. Such validation of effect sizes of vector control interventions is key to demonstrate the reliability of models. This process should be prioritised as it helps increase transparency and confidence in models, and accelerates their uptake by policy-makers.

ABS-604

Expanding vector surveillance capabilities with a system for rapid training and deployment of deep learning techniques for automated identification, counting, and digitization of mosquito vector species

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Background: Vector surveillance, the monitoring of abundance, distribution, and diversity of mosquito species, is a critical step in assessing vector-borne disease risk. Morphological inspection of specimens remains a challenging task of the surveillance process. In many vector control programs, technicians of varying taxonomic expertise are responsible for species identification to guide important downstream invention strategies. However, accurate data gathering can pose a challenge given mosquitos' fine morphological differences and evolving mosquito populations.

Methods: Several technical modalities have been explored for their potential to improve data accuracy and quality throughout the vector surveillance workflow. Applied deep learning convolutional neural networks (CNNs) for image recognition have been among the most promising, demonstrating the capability to visually differentiate between mosquito species in controlled optical scenarios and with limited mosquito species datasets. Our team has developed IDX, an standardized imaging device integrated with CNN software trained on a large dataset of mosquito images. The system allows for rapid training and deployment of CNN algorithms for operational use by vector management programs.

Results: Early testing has demonstrated 97% species identification accuracy for 16 mosquito species tested in a dataset gathered using six IDX devices. An unknown species detection algorithm was applied to this dataset and achieved a 92.7% F1-score in detecting whether a specimen was of a species known to the species identification CNN or outside the distribution of known species.

Conclusions: These advancements represent a step towards a practical system for rapid training, expansion, and deployment of automated species identification capabilities in operational vector surveillance programs.

ABS-613

Genetically modified mosquito technologies in malaria control. Where are we in Mali?

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Background: In 2021, Target Malaria Mali concluded its studies on the non-gene drive genetically modified sterile male mosquitoes that were housed in the Arthropod Containment Level 2 insectary based at the Malaria Research and Training Center at the University of Sciences, Techniques and Technologies of Bamako. This was the first genetically modified mosquito in Mali.

Methods: *Anopheles gambiae* eggs containing the transgene known as Ag(DSM)2 were imported late 2019 following rigorous preparation and regulatory approval from competent national authority (Ministry of the Environment, Sanitation and Sustainable Development). The imported transgene was subsequently introgressed into local *Anopheles coluzzii* colony before detailed studies of life history parameters were conducted and compared between transgenic and non-transgenic mosquitoes. This included longevity, mating competitiveness, female blood feeding avidity, egg production and insecticide resistance.

Results: Following successful introgression into local Mali mosquito colony the transgene stability was confirmed over multiple generations conferring sterility phenotype to males carrying transgene and expressing a visible marker allowing identification of larvae with transgene. Furthermore, life history results were as expected based on previous studies and did not have any unexpected effects, thus confirming the anticipated results from risk assessments and the system safety.

Conclusion: Successful accomplishment of these studies demonstrated that the team acquired the skills to work on genetically modified mosquitoes. The regulatory and technical knowledge obtain from import and evaluation represented a significant capacity building advancement for Mali in the use of genetically modified mosquitoes for malaria control. Moving forward Mali is ready to work on advanced genetic technologies for vector control of malaria and other vector-borne diseases.

Keywords: genetically modified mosquitoes, capacity building

ABS-639

A mixed methods evaluation of factors associated with discarding of long-lasting insecticidal nets in Bagamoyo, Tanzania

Edith Madumla

Background: Between 2000 and 2019, more than 1.8 billion long-lasting insecticidal nets (LLINs) were distributed in Africa. While the insecticidal durability of LLINs is around 3 years, nets are commonly discarded 2 years post distribution. This study investigated the factors associated with the decision of users to discard LLINs.

Methods. A mixed-method sequential explanatory approach using a structured questionnaire followed by focus group discussions (FGDs) to collect information on experiences, views, reasons, how and when LLINs are discarded was conducted in four villages in Bagamoyo Tanzania. A total of sixteen FGDs with 155 participants each comprising of 8-10 adults were conducted; older women (40–60 years), older men (40-60 years), younger women (18-39 years), younger men (18-39 years). During the FGDs, participants visually inspected seven samples of damaged LLINs and participants had to determine if such LLINs were to be kept or discarded.

Results. In FGDs, integrity of LLIN influenced the decision to discard or keep a net. Those of older age, women, and householders with lower income were more likely to classify a WHO "too-torn" net as "good". Similar findings were also seen in the quantitative analysis. For every additional hole, the odds of discarding a WHO "too-torn" LLIN increased [OR=1.05 (95%CI (1.04 – 1.07)), p<0.001]. Younger age group [OR=4.97 (95%CI (3.25 – 7.32)), p<0.001], male-headed households [OR=6.85 (95%CI (4.44 –10.59)), p<0.001], and wealthy households [OR=3.88 (95%CI (2.33 – 6.46)), p<0.001] were more likely to discard LLINs.

Conclusion. Integrity of LLIN was the main determinant for discarding or keeping LLINs and the decision to discard the net is associated with socioeconomic status of the household, and the age and gender of respondents. Behaviour change communication is needed to encourage younger people to continue to use damaged LLINs that are still insecticidal, until replacement with a new campaign net.

ABS-658

Efficacy of a 'lethal house lure' against *Culex quinquefasciatus* from Bouaké, central Côte d'Ivoire.

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Background: Eave tubes technology is a novel method of insecticide application that uses electrostatic coating system to boost insecticide efficacy against resistant mosquitoes. A series of previous experiments have shown encouraging insecticidal impact against malaria vectors. This study was undertaken to assess the effects of the eave tube approach on other Culicidea, in particular *Culex quinquefasciatus* under laboratory and semi field conditions.

Methods: Larvae of local *Cx. quinquefasciatus* from Bouaké were collected and reared to adult stage in the laboratory and cylinder tests performed to determine resistance status. WHO standard 3 min cone bioassays were conducted on pyrethroid treated netting versus various exposure period using cone on eave tubes treated inserts. Eave tubes bioassay method utilizing smelly socks as attractant was then performed at increasing exposure periods (1 min up to 60 min) on 10% beta-cyfluthrin and residual activity monitored over several months. Release recapture experiment within enclosure around experimental huts fitted with windows, eave tubes untreated or treated with insecticide (10% beta-cyfluthrin) was conducted to determine house entry preference of *Cx. quinquefasciatus* and impact of tubes on survival of this species.

Results: Bouaké *Cx. quinquefasciatus* displayed high intensity of resistance to three out of four classes of insecticides currently used in public health. With 3 min exposure in cone tests, 10% beta-cyfluthrin treated insert induced 100% mortality of *Cx. quinquefasciatus* whereas LLINs only killed 5%. With reduced exposure to the eave tube inserts, mortality was still 100% after 2 min, 88.7% after 1 min and 44% for a transient exposure of 30 s. Mortality with 10% beta-cyfluthrin treated inserts was > 80% up to 7 months post-treatment. Data suggest that *Cx. quinquefasciatus* have strong preference to enter house through the eaves than windows. Beta-cyfluthrin treated inserts were able to kill 52% of resistant *Cx. quinquefasciatus* released in within the enclosure.

Conclusion: Eave tubes technology is a novel delivery method of insecticide to the house. It attracts nuisance host seeking *Cx. quinquefasciatus* mosquitoes and control them effectively despite high level of resistance they have developped.

ABS-496

The development of target spraying technology: bioassay test shows potential impact of the swarm-killing in *Anopheles gambiae* s.l.

Abdoulaye Niang

Vector control tools based on the use of insecticide treated-bet nets and Indoor Residual Spraying shows highly effective in reducing the malaria incidence over the two past decades in Africa. However, residual malaria transmission might be maintained by bites occurring when people are not protected by the conventional tools such as insecticide treated-bet nets and Indoor Residual Spraying which are known to affect adult mosquito populations indoors and their vectorial capacities. Designing additional effective outdoor vector control interventions could be a key solution in residual malaria transmission. *An. gambiae s.l.* mosquito species mate in flight at sunset over visual markers characterizing specific swarm sites where thousands of males may gather to attract conspicuous females. Swarm-killing is a dramatic approach involving an attempt to suppress mosquito populations, by directly targeting mosquitoes in mating swarms with highly effective insecticides. In this study we tested the potential effect of this new vector control approach in three villages of the southwest Burkina Faso including Santidougou as a control, Zeyama with broadcast space spraying and Nastenga with target swarm spraying. A 25 g/l treatment dose of Actellic 50 EC (primiphos-methyl) was used in bioassay tests against caged mosquitoes of two strains of *An. gambiae s.l.*, one from a susceptible laboratory population and the other from resistant field population. The amounts of effective and residual insecticide and the effect of acute toxicity on the post-exposure time to mortality of mosquitoes were quantified and compared between the two spraying methods. The quantity of insecticide used in target spraying appears to be density dependent, increasing with swarm abundance while that used in broadcast spraying was not significantly correlated to the number of swarms. The mortality was significantly higher in both treated villages compared to the control indicating that target swarm spraying and broadcast space spraying are both significantly impactful, even though lower insecticide quantities were used when targeting swarms. Thus, this strategy could be used to fight against all major malaria vectors in Africa, as they all are characterized by swarming behaviour and mate in swarms.

Keywords: Bioassay test, Target spraying technology, Potential impact, Swarm-killing, *Anopheles gambiae* s.l.

ABS-546

Irradiation dose optimisation of a colonised *Anopheles funestus strain*

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Background & Objective. The threat of insecticide resistance in the main African malaria vector Anopheles funestus, necessitate the development of research into additional vector control interventions such the sterile insect technique (SIT). One of the key components to successful implementation of this technology is the induction of sterility in the targeted population through ionising radiation. However, sterilization can compromise physiological fitness and it is therefore important to determine an optimal irradiation dose without affecting the mating competitiveness of released males. The irradiation dose cannot be extrapolated between species, since this is species-specific

Materials & Method. The effects of six irradiation doses ranging from 30 Gy – 120 Gy, as well as an un-irradiated control group, were evaluated on An. funestus survival and reproductive. Male pupae were irradiated using a Gammacell 220. Subsequently, pupal emergence and adult longevity of resultant adult males were monitored. Furthermore, irradiated males were allowed to mate with virgin fertile females, bloodfeed and induced to lay eggs. Fecundity and fertility of females were determined.

Results & Discussion. There were no statistical significant difference in the pupal emergence and fecundity regardless of the irradiation dose used when compared to the un-irradiated control group. However, irradiation had a effect on longevity. An increase in the irradiation dose resulted in a statistically significant decrease in longevity and fertility. Irradiation at doses greater than 100 Gy resulted in a significant difference in both fecundity and fertility.

Conclusion & Recommendation. Irradiation at doses higher than 100 Gy impacted on physiological and reproductive

parameters. A sterilising irradiation dose of 100 Gy is recommended to induce sterility for future SIT approaches against *Anopheles funestus*.

ABS-585

The Global Vector Hub - building entomological capacity worldwide and improving epidemic preparedness

Fredrick Seelig

The Global Vector Hub (GVH) is an exciting new online platform currently under development at the London School of Hygiene & Tropical Medicine (LSHTM), focusing on control of arthropod disease vectors globally. An early beta version was launched in summer 2020 in the context of the COVID-19 pandemic to address the urgent need for accurate and up-to-date information and resources on vector-borne diseases and vector control interventions. Following on from this success, a full version will be released in April 2022.

The aims of the GVH are to assist in **capacity building** for vector control globally, establish a **community of practice** for vector control interventions, and enable stakeholders to make **evidence-based decisions**. The main audiences of the GVH are **public health officials, vector control agents** and **vector researchers**. The GVH consists of a community-led, online, **open-access** resource to provide comprehensive information on vector control and vector biology. This includes geo-tagged entomological **data** (including abundance data, surveillance for insecticide resistance, and pathogens vectored) and epidemiological data, a searchable registry and worldwide **network** of vector researchers and vector controllers, and a comprehensive **resource** database of training and educational materials, vector control guidelines and research tools.

In addition, the Special Programme for Research and Training in Tropical Diseases (TDR) and the Global Vector Hub have developed a web-based **global directory of medical entomology courses** as a new resource for strengthening the capacity of scientists combating neglected tropical diseases and other vector-borne diseases. The directory currently lists a total of 126 medical entomology courses offered both on-campus and through distance learning in 32 countries across all WHO regions, covering seven languages. The freely available directory was developed in collaboration with the GVH and Arctech Innovations, following the mapping of courses available globally. WHO's Department of Control of Neglected Tropical Diseases and the WHO Global Malaria Programme have also reviewed the directory and provided recommendations. For each course, session dates, course outline, fees, language of instruction and responsible managers are listed.

We are also planning to include versions in Spanish, French and Portuguese as soon as possible.
You can learn more about the GVH (and register) here: **https://globalvectorhub.lshtm.ac.uk/**

ABS-646

Genomic surveillance of Pfcsp, the RTS,S/AS01 malaria vaccine target antigens in Senegalese parasites

Mamadou Diallo

The RTS,S/AS01 malaria vaccine confers only moderate protection against malaria. Evidence suggests that the effectiveness of the RTS,S/AS01 vaccine depends upon the parasite population genetics, specifically with regard to the circumsporozoite protein (CSP) haplotypes in the population. CSP is the major protein found on the sporozoite stage, which is the form transmitted from the mosquito to human. We investigated *Plasmodium falciparum* circumsporozoite protein (PfCSP) gene sequences from two endemic sites in 2018 in Senegal. PfCSP sequences were compared to those retrieved from the Pf3k genome database. In the central repeat region of PfCSP, the distribution of haplotypes differed significantly between the two study sites (Fisher's exact test, $p < 0.001$). No 3D7 vaccine strain haplotype was observed in this locus. In the C-terminal region, there was no significant difference in haplotypes distribution between Kedougou and Diourbel (Fischer's exact test, $p = 0.122$). The 3D7 haplotype frequency was 8.4% in early samples (2001-2011); but then it contracted in the subsequent years. The extensive plasticity of the *P. falciparum* genes coding the RTS,S/AS01 vaccine target antigens may influence the immune responses to circulating alleles. Monitoring the genetic diversity baseline and its dynamics over time and space would be instrumental in rationally improving the malaria RTS,S/AS01 vaccine and/or its implementation schedule.

ABS-702

Spatial distribution and modeling of the ecological niche of the lymphatic filariasis pathogen (Wuchereria bancrofti (Cobbold, 1877)) in the context of climate and global changes (Benin, West Africa)

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Lymphatic filariasis is a disfiguring parasitic disease transmitted to humans by mosquitoes and constitutes a public health problem in countries of tropical Africa including Benin. In 2000, the prevalence of infection covered 50 communes in Benin, plus the high prevalence was observed in the departments of the South and the Center. The general objective of this study is to identify areas at risk for Lymphatic filariasis in order to contribute to the protection of populations at risk in public health. To achieve this objective, the presence and abundance of potential vectors of Lymphatic filariasis was prospected as well as the socio-economic weight of the disease on the population. Likewise, the potential distribution of Wuchereria bancrofti was estimated under current and future climatic conditions. Three vectors were identified after capture: Anopheles gambiae, Anopheles funestus and culex quinquefasciatus. This study revealed that Lymphatic filariasis contributes to lower productivity and partial abandonment of economic activities of patients. Five different algorithms were used for the modeling: Maxent, GLM, GAM, BRT and RF. The best prediction performance was obtained by Maxent and BRT. This led to the combination of the two methods to obtain better results. In Benin, the current potential distribution of Wuchereria bancrofti is concentrated in the south, reflecting the current distribution of the species. Projections of Maxent and BRT towards future conditions showed a potential distribution less than that of current conditions, with the emergence of new risk areas in northern Benin. The predictions of Maxent and BRT make it possible to anticipate the evolution of areas at risk for Lymphatic filariasis in the decades to come.

Keywords: Lymphatic filariasis, Maxent, BRT, Wuchereria bancrofti, Benin, Africa

Parallel Scientific Session 12 :
LLINS, IRS and Insecticide Resistance Management

ABS-498

Assessing the entomological performance of next-generation chlorfenapyr-treated nets in the presence of pyrethroid-piperonyl butoxide (PBO) insecticide-treated nets

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Background Pyrethroid-piperonyl butoxide (PBO) and pyrethroid-chlorfenapyr insecticide-treated nets (ITNs) are being scaled up in endemic countries. Some control programmes have deployed both ITN types in the same communities through multiple distribution channels. PBO inhibits enzymes associated with pyrethroid resistance, notably cytochrome P450 monooxygenases (P450s) while, chlorfenapyr is a pro-insecticide requiring activation by P450s. The inhibitory action of PBO against P450s may therefore, reduce the impact of chlorfenapyr when pyrethroid-PBO and pyrethroid-chlorfenapyr nets are used in the same household.

Methods We performed a series of experimental hut trials to evaluate the entomological impact of combining pyrethroid-chlorfenapyr and pyrethroid-PBO ITNs against a pyrethroid-resistant malaria vector population in Benin. Comparison was made to combinations with pyrethroid-only ITNs. All net types were also tested as single and double treatments. Susceptibility tests were performed to assess the resistance profile of the vector population during the trials.

Results Susceptibility bioassays revealed high intensity pyrethroid resistance that was overcome with PBO pre-exposure but susceptibility to chlorfenapyr. Applied singly, pyrethroid-chlorfenapyr nets induced significantly higher vector mortality (82%) than pyrethroid-PBO ITNs (37%, $p<0.001$) and pyrethroid-only ITNs (22%, $p<0.001$). Except for pyrethroid-PBO ITNs, mortality in huts with two nets of the same type was similar to single nets. Applying two pyrethroid-chlorfenapyr ITNs in the same hut induced significantly higher mortality (85%) than combinations of pyrethroid-chlorfenapyr ITNs with pyrethroid-only ITNs (61%, $p<0.001$) and pyrethroid-PBO ITNs (74%, $p<0.001$).

Conclusions Pyrethroid-chlorfenapyr ITNs induced highest levels of vector mortality. Combining these nets with pyrethroid-PBO or pyrethroid-only nets in the same households may reduce control of pyrethroid-resistant vectors compared to when deployed alone. Programmes should prioritise distribution of pyrethroid-chlorfenapyr ITNs to maximise control impact.

ABS-499

Bio-efficacy and durability (insecticidal and physical) of next generation insecticide-treated bed nets against pyrethroid resistant malaria vectors in Tanzania.

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Introduction: Long-lasting insecticidal nets (LLINs) have been the main contributor to the reduction of malaria in the past two decades in Sub-Saharan Africa. Development of pyrethroid insecticide resistance threatens the effectiveness of these LLINs, especially when nets become holed and the insecticide decays.

Method: Three classes of dual Active Ingredient (AI) LLINs, have been assessed for their bio-efficacy, using cone and tunnel tests, and physical durability as follows: 1) Royal Guard®, combining pyriproxyfen, which is known to disrupt female reproduction and fertility of eggs, and a pyrethroid alpha-cypermethrin; 2) Interceptor®G2, two adulticides with differing modes of action;

chlorfenapyr and alpha-cypermethrin; 3) Olyset™ Plus incorporates permethrin (pyrethroid) and a synergist, piperonyl butoxide, to enhance the potency of pyrethroid insecticides compared to standard pyrethroid only net. About 40,000 nets of each type were distributed in February 2019 to different villages in Misungwi and two net cohorts enrolled shortly after. The first cohort was followed every 12 months to assess survivorship and fabric integrity for up to 3 years of use. Every 6 months a subsample of nets selected from cohort 2 were collected to assess AI bio-efficacy against resistant and susceptible *Anopheles* mosquitoes.

Results: At six months, no differences observed in attrition rate (net loss) between net types. After 24 months, 60% of Olyset Plus nets were lost due to wear and tears compared to 31% for standard LLIN, 43% for Royal Guard and 29% for Interceptor G2. The proportion of nets observed in relatively good condition (hole area <790 cm^2) after two years of use were 29% for Olyset Plus, 51% for both Royal Guard and Interceptor G2 and 56% for standard Interceptor net. High sterility was observed in resistant *Anopheles gambiae* after exposure to new Royal Guard nets (86%) but the sterility was reduced to half after six months of net use and was lower than 20% at 12 and 24 months.

Conclusion: All dual AI LLINS have a poor textile durability with Olyset Plus being the worst of the three. Efficacy of dual AI LLNS were better than standard LLINs but this superior effect did not last for Royal guard.

ABS-510

Textile durability and protective efficacy against malaria of a PBO-pyrethroid synergist-treated nets Olyset® Plus, over 3-year in Tanzania

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Long-lasting insecticidal nets (LLINs) have been a core malaria intervention for decades in Sub-Saharan Africa. Current malaria control strategies rely on an assumed effective 3-year lifespan for LLINs. There is limited information on durability and long-term protective efficacy of PBO synergist LLINs under field use. This study investigates the net loss, physical integrity, chemical content, and the association between holed and aged LLINs and malaria infection in children under 15 years, over three years of use in field conditions.

A cohort of 390 PBO LLINs (Olyset Plus) and 367 standard pyrethroid LLIN (Olyset net) were followed for 36 months post net distribution to estimate the median survival time of the LLIN. Cross-sectional surveys were conducted at 6 months intervals for 3 years to assess the association between the condition of the LLIN and malaria infection. After 3 years less than 17% of nets distributed were available for sleeping. The fabric condition was not associated with malaria infection in either type of net, however older PBO nets were more protective than standard LLIN (33% for PBO LLIN vs 50% for standard LLIN) but this advantage waned after two years (57% for PBO LLIN vs 64% for standard LLIN), and was also less marked compared to when both types of nets were new as the standard LLIN still provide good protection. The estimated median functional survival time for net products was less than 2 years. These results highlight that LLIN lifespan is less than the recommended 3 years for both net types. These findings have major implications and will inform manufacturers and malaria prevention policy making bodies on the functional survival of Olyset Plus and also on what should to be done to lengthen their protective efficacy to 3 years as recommended by WHO.

ABS-565

Comparative effectiveness of single and dual-treated bednets on malaria prevalence at antenatal clinics in Sud Ubangi, Democratic Republic of Congo

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Mosquito insecticide resistance is one of the factors limiting the effectiveness of standard pyrethroid-treated bednets. To improve effectiveness, dual-treated nets add either a second insecticide or the synergist PBO, with encouraging results from trials to date. Wider evidence of comparative effectiveness from different transmission settings is required, preferably using relatively inexpensive methodologies, implementable at large scale. The present study is a cluster randomised control trial linked to a 2020 programmatic distribution of almost two million standard and PBO co-treated bednets across Sud Ubangi province, Democratic Republic of Congo. Performance of PBO+pyrethroid and pyrethroid-only nets are compared by assessing

malaria prevalence in pregnant women attending their first routine ante-natal clinic appointment (ANC1). Health zones in Sud Ubangi were randomly allocated to receive either net type in a two armed-trial with 8 clusters per arm. Seven health centres holding regular ante-natal clinics were randomly selected in each health zone for monthly monitoring with consenting ANC1 visitors tested for malaria using RDTs.

During the first 18 months of the study, over 44,000 ANC1 visitors were enrolled in the study. The overall median prevalence of malaria in ANC1 visitors was 0.33 with a range of 0.17-0.43 across the 16 health zones in the province. Malaria was generally reduced in the PBO co-treated net arm compared to the standard net arm (overall odds ratio = 0.72 ; peak monthly odds ratio = 0.61), with benefit throughout the study period, though variations over time and among clusters were évident. The study provides evidence for the benefit of dual treated nets in a different geographical and transmission setting to previous trials. More generally, the study confirms the utility of monitoring malaria prevalence at antenatal clinics as an epidemiological trial outcome permitting gathering of continuous data over a wide study area.

ABS-586

Susceptibility profiles of *Aedes aegypty* to different families of insecticide in three ecological zones in Benin

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In order to implement effective and sustainable arbovirus vector control measures in Benin, the susceptibility of *Aedes aegypti* adults from three different ecological zones (urban, peri urban and forest) to the organo-chlorine DDT (4%), the pyrethroids permethrin (0.75%), deltamethrin (0.05%) and the carbamate bendiocarb (0.1) was determined using WHO standard procedures. Results from the bioassays showed that all screened populations of *Aedes* were fully susceptible to bendiocarb. In contrast, these same populations of *Ae. Aegypti* had developed strong resistance profiles to DDT with average mortality rates of 16%, 20% and 26% respectively in urban, peri-urban and forest area. Moderate resistance was found with permethrin from all the 3 study sites with average mortalities of 48%, 54% and 62% respectively. For deltamethrin, only *Ae. aegypti* populations from forest area were fully susceptible to this insecticide. Moreover, the values of the Knockdown time (KDT50 and KDT95) of *Ae. aegypti* populations from the 3 study sites during the 1hour exposure to pyrethroids and organochlorines of the resistant populations were considerably higher compared to the reference laboratory strain from Benin (SBE) ($P<0.05$). However, there was no significant difference in the KdT50 and KdT95 values of the wild population of *Ae. aegypti* from the forest area with deltamethrin compared to the reference laboratory strain ($P>0.05$).

Data generated on the susceptibility profiles of the 3 wild populations of *Ae. Aegypti* to bendiocarb could serve as baseline information for controlling these mosquito species in cases of arbovirus outbreaks in these regions.

Keywords: *Aedes aegypti*, insecticides, resistance, peri urban, urban, forest, Benin

ABS-588

Impacts of a 4.3kb structural variant on Gene Expression and insecticide resistance phenotype in the malaria vector *An. funestus* s.s.

Leon Mugenzi

Insecticides are essential in controlling the vector populations which transmit malaria. To better manage insecticide resistance and prolong the effectiveness of insecticides, an understanding of the genetic drivers of insecticide resistance is needed. Most of the genetic variants identified and characterized are single-nucleotide polymorphism and small indels with little known about the contribution of structural variants (SVs) in the evolution of insecticide resistance. Here we identified and

characterized a 4.3kb SV inserted in the promoter region of an insecticide resistance gene *CYP6P9b*. This SV was found in *An. funestus* populations of Central (Cameroon) and East Africa (Uganda) at very high frequencies approaching fixation and absent elsewhere. Genetic crosses revealed that this SV impacted the expression of nearby genes and was associated with resistance to type II pyrethroid. Our findings highlight the underexplored role of SVs in the evolution of insecticide resistance and provide additional tools for molecular surveillance of insecticide resistance.

ABS-621

Residual efficacy and entomological impact of new generation insecticides, Actellic® 300CS (Pirimiphos-methyl) and Fludora® Fusion WP-SB 56.25 in two Districts of Rwanda

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Background. Pyrethroid resistance has necessitated the development of new generation insecticides for indoor residual spraying (IRS). The two districts of Ngoma and Kayonza of Eastern Province of Rwanda benefited from IRS intervention for the first time in 2019 with Actellic® 300 CS and Fludora® Fusion respectively. This study aimed to assess the residual efficacy and the entomological impact of the two novel insecticides.

Methods. The entomological surveys were performed in two sentinel sites of Remera in Ngoma and Rukara in Kayonza. The surveys were conducted for 11 months before and after IRS, June 2018 to April 2019 and May 2019 to March 2020. A paired indoor-outdoor Human Landing Catching (HLC) and indoor pyrethrum spraying catching (PSC) were respectively conducted in 9 and 15 houses for two consecutive nights per month and per site. The residual efficacy was tested using WHO cone tests with susceptible Anopheles gambiae s.s. colony.

Results. With the HLC, mosquito populations declined by 56.2% (533-232) for An. gambiae s.l., and 36.6% (1570-996) for Culicines in Kayonza. In Ngoma district, An. gambiae s.l. was reduced by 79.6% (402-82) and by 22.5% (2942 to 2282) for Culicines. With PSC method in Kayonza, An. gambiae s.l. declined by 77.8% (8-1) while in Ngoma it was reduced by 94% (358-11). With the threshold of 80% of mosquito mortality, the residual efficacy was found to be 10 months at 24 hours of holding time for mosquito mortality observations for Actellic® 300 CS and 6, 8 and 10 months at 24, 48 and 72 hours of exposed mosquito holding time for Fludora® Fusion.

Conclusion. The two insecticides reduced the population of Anopheles gambiae s.l., the primary malaria vector, more than that of Culicines species. The residual efficacy was found to be 10 months for both insecticides, noting that the residual efficacy test of Fludora® Fusion was optimized at 72 hours. These results imply that application of one IRS round per year is sufficient.

ABS-662

Timing of infective anopheline biting and human behaviour under high indoor residual spraying (IRS) and insecticide treated net (ITN) use in Ulanga, Tanzania

In areas where insecticide treated nets (ITNs) or indoor residual spraying (IRS) of insecticides coverage is high, exposure to *Anopheles* bites outdoors and indoors but out of bed has been thought to play an important role in residual malaria transmission. However, there has been no clear link between exposure to *Anopheles* biting in such contexts and the risk of malaria parasite transmission. We investigated hourly human exposure to infective anopheline bites in an endemic area in rural Tanzania where high ITN use was reported and a community-wide IRS program had been implemented. Mosquito surveys by hourly indoor and outdoor human landing catch (HLC) were conducted in the frame of an indoor residual spraying (IRS) trial in Ulanga District, southeast Tanzania. In the same area and over corresponding seasonal periods, trained members of selected households recorded the hourly whereabouts and activities of their householders (outdoors, indoors and awake or asleep).

Nightly human and mosquito behavioural data were summarized by hour for the period 6 PM to 6 AM to assess outdoor and indoor exposure to infective mosquito bites. In our findings, individuals spent most of the time preceding 10 PM outdoors, but nearly everyone (96%) was indoors each hour between 11 PM and 6 AM. The vector population consisted of *An. funestus* and *An. arabiensis*. The prevalence of malaria sporozoite infection was 4% and 1% indoors, and 1% and 0% outdoors, in *An. funestus* and *An. arabiensis*, respectively. A pooled estimate for *An. funestus* and *An. arabiensis* showed that 87% of the exposure to infective bites was indoors between 10 PM and 6 AM. The high ITN use of 98.4% was estimated to avert nine out of ten (90%) of all infective bites received indoors and outdoors. In conclusion, the bulk of infective mosquito bites occurred indoors and at a time when individuals are usually asleep. Therefore, ensuring high ITN use is essential to contain malaria transmission in this area, while innovative approaches targeting outdoor biting may have a complementary effect.

ABS-759

Impact of exposure to insecticide-treated nets on host-seeking behaviour and life-history traits in *Anopheles. gambiae s.l* using a baited box bioassay

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Background. The efficacy of malaria control tools such as insecticide-treated nets is decreasing area where pyrethroid-resistant is predominant. A better understanding of the interaction between malaria vector behaviours and control tools such as insecticide-treated nets would be a key to managing existing insecticide resistance and designing more suitable insecticide-based malaria vector control interventions and other alternative integrated tools. Here, we investigate the impact of exposure to new generation nets on host-seeking behaviours and life-history traits in *An. gambiae* population using a baited box bioassay.

Methodology. Adult females of the first generation of *Anopheles gambiae s.l.* from Zakpota and aged 3 to 5 days were starved for 5 h and exposed for 10 min to impregnated nets PermaNet 2.0 (P2), PermaNet 3.0 (P3), Interceptor G1 (IG1) Interceptor G2 (IG2), Olyset plus (Oly+), Royal Guard (RG) and Untreated net, using the baited box bioassay protocol. Critical parameters of blood-feeding rate, blood-feeding volume, longevity and oviposition rate were also monitored.

Results. Mosquitoes exposed to Oly+ and RG were lesser able to blood-feed ($p< 0.05$) than those exposed to the remaining nets. Blood feeding time was significantly reduced ($p=8.151 \times 10^{-6}$) when exposed to P2, IG2, P3, and RG than in the untreated net. Furthermore, the blood-feeding volume was significantly reduced with all treated nets ($p=2.384 \times 10^{-12}$), which was more pronounced with P3. There was also a significant positive correlation between blood intake volume and blood-feeding time (Pearson r = 0.64, $p=9.856 \times 10^{-08}$). The time of first net contact increased significantly ($p=0.001$) with IG1 and P2. Mosquito exposed to P3, Oly+ and RG displayed lower survivorship ($p< 0.05$). In addition, Oly+ and RG significantly inhibited oviposition rate ($p< 0.05$).

Conclusion: The results demonstrate that P3, Oly+ and RG displayed the potential to improve malaria vector control and provide better community protection against malaria transmission in pyrethroid-resistant areas.

Key words: *Anopheles gambiae s.l.*, Behaviour, Insecticide-treated nets, Life history traits, Baited box bioassay.

ABS-339

Title Experimental hut trials reveal that CYP6P9a/b P450 alleles are reducing the efficacy of pyrethroid-only Olyset net against the malaria vector Anopheles funestus but PBO-based Olyset Plus net remains effective

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Malaria remains a major public health concern in Africa. Metabolic resistance in major malaria vectors such as *An. funestus* is jeopardizing the effectiveness of Long-lasting insecticidal nets (LLINs) to control malaria. Here, we used experimental hut trials (EHT) to investigate the impact of cytochrome P450-based resistance on the efficacy of permethrin-only net (Olyset) compared to a PBO-based net (Olyset Plus) revealing a greater loss of efficacy for the latter. EHT performed with progenies of F5 crossing between *An. funestus* pyrethroid-resistant strain FUMOZ and pyrethroid susceptible strain FANG revealed that PBO-based nets (Olyset Plus) induced a significantly higher mortality rate (99.1%) than pyrethroid-only nets (Olyset) (56.7%)(P<0.0001). The blood-feeding rate was higher in Olyset compared to Olyset Plus (11.6% v 5.6%; P=0.013). Genotyping the *CYP6P9a/b* and the intergenic *6.5kb* structural variant (SV) resistance alleles showed that, for both nets, homozygote resistant mosquitoes have a greater ability to blood feed than susceptible. Homozygote-resistant genotypes significantly survived more with Olyset after cone assays (e.g. *CYP6P9a* OR=34.6; P<0.0001) than homozygote susceptible. A similar, but lower correlation was seen with Olyset Plus (OR= 6.4; P<0.001). Genotyping of experimental hut trial samples confirmed that *CYP6P9a/b* and *6.5kb_SV* homozygote resistant mosquitoes survive and blood-fed significantly more than homozygote susceptible when exposed to Olyset. Our findings highlight the negative impact of `p450-based resistance on pyrethroid-only nets further supporting that PBO nets such as Olyset Plus are a better solution in areas of P450-mediated resistance to pyrethroids.

Keywords: Malaria; Long Lasting Insecticidal Nets; Insecticide resistance; metabolic resistance; Cytochrome P450; *Anopheles funestus*

ABS-320

Potential impacts of climate change on malaria vector control in Africa

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There has been extensive consideration of how climate change may impact the distribution and intensity of vector-borne disease transmission; with a particular focus on malaria risk in Africa. However such analyses primarily focus on how the "malaria map" will shift in response to changes in the environmental determinants of transmission, but rarely consider the equally if not more important question of whether climate change will impact the effectiveness of vector control measures. We hypothesize that the efficacy and ability to implement malaria vector control will be significantly impacted by climate change due to direct and indirect impacts of mosquito vectors and interventions. We will highlight mechanisms through which the type of climate change expected in different regions of sub-Saharan Africa may modify, and potentially impede, the efficacy and feasibility of the major core and supplementary interventions of Insecticide Treated Nets, Indoor Residual Spraying and Larviciding. Consideration is focussed on how climate change may impact four key determinants of vector control impact: 1) mosquito vector ecology, 2) environmental determinants of product efficacy, 3) mosquito resistance strategies and 4) human behaviour and intervention use. Finally we review potential indirect impacts of climate change on the ability to finance, implement and sustain vector control through changes in land use, urbanization, socioeconomic conditions and health systems.

To better prepare and mitigate against the most negative impacts, we advocate for consideration of climate change impacts to be built into future vector control and public health planning.

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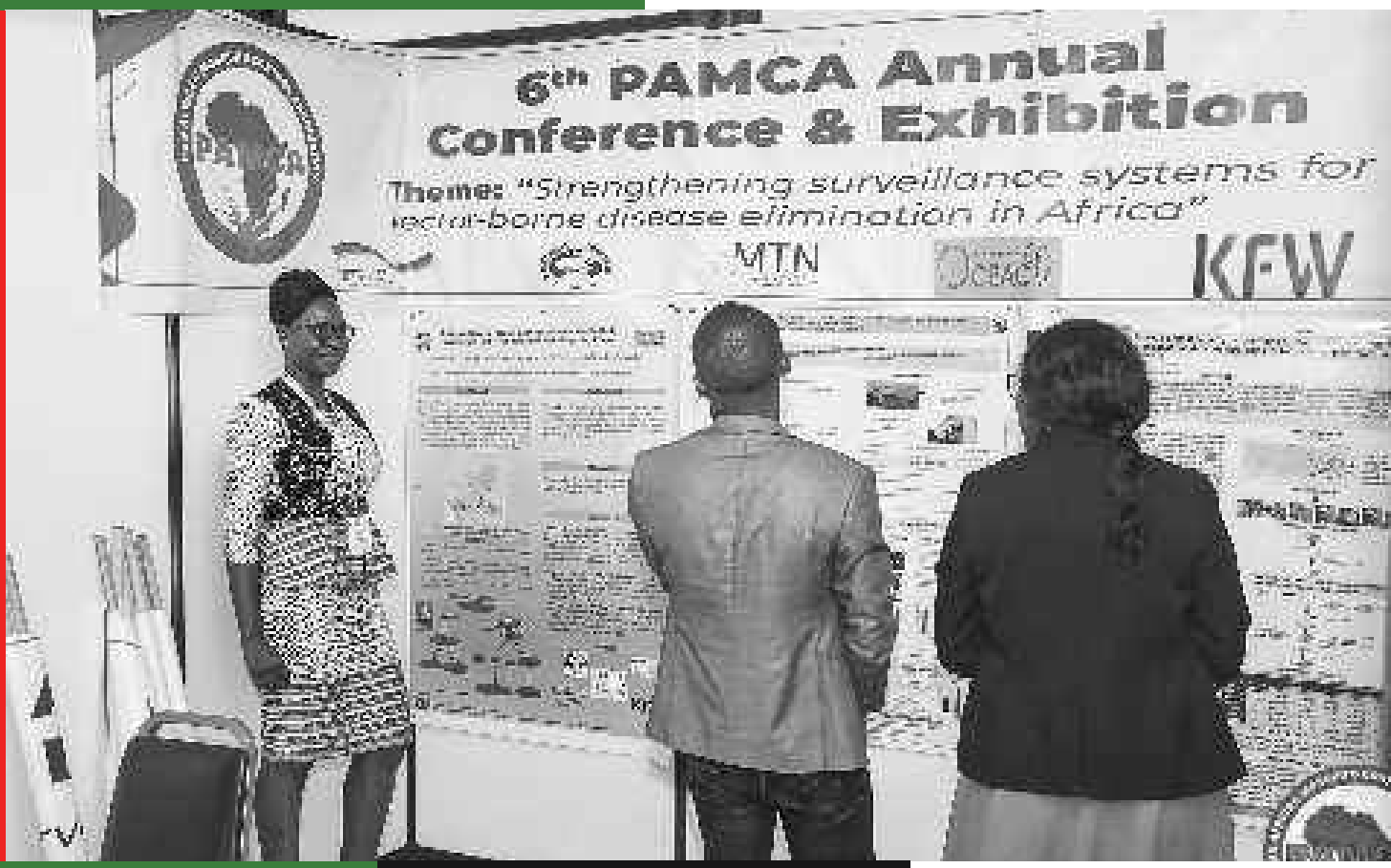

POSTER ABSTRACTS

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

POSTER ABSTRACTS

DAY 1: Poster Session 1 (Posters #1-50): During Coffee and Lunch Breaks

ABS-549

Bioassay-guided Isolation and Purification of Mosquitocidal Toxins from Bacillus cereus

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Background: Challenges to current mosquito control approaches have warranted research into more effective yet environmentally safer alternatives. Biological control of mosquitoes, as one such alternative, has largely focused on the use of entomopathogenic bacteria B. thuringiensis subspecies isrealensis (Bti), and to a smaller extent B. sphaericus. Here, however, we report on the isolation of larvicidal toxins from the much less known entomopathogen, Bacillus cereus.

Methods: The bacteria were cultured in nutrient broth at varying temperatures for 1-5 days in order to optimize conditions for maximum larvicidal activity. These cultures were centrifuged to separate the cell-spore suspension from the cell-free supernatant. Larvicidal toxins were then isolated from the cell-free supernatant by precipitation using ammonium sulphate and purified via a single passage through desalting columns, while a detergent free-protein extraction kit was used for the cell-spore suspension. Bioassays were conducted using Aedes egypti and Anopheles gambiae 3rd instar larvae to assess the larvicidal activity of these toxins at every stage in the isolation and purification process. We finally assessed potency of these toxins using a standard preparation of the Bti larvicide.

Results: Five-day old cultures grown at 35°C exhibited the highest larvicidal activity against both An. gambiae and Ae. egypti larvae, albeit with a higher efficacy against the latter. Larvicidal toxins in the cell-free supernatant were precipitated at 75% salt concentration. In contrast, proteins isolated from the cell-spore suspensions showed no larvicidal activity. Two-dimensional gel imaging of the toxins yielded 3-distinct bands at 17kDa, 35kDa and 45kDa. This finding is similar to the 3-domain structure of the cry and cyt larvicidal toxins of Bti that have been previously reported. However, unlike Bti, the B. cereus toxins isolated here appear to be exotoxins and not endotoxins. This is the supported by the finding that the correlation between spore counts and larvicidal activity was not significant (p=0.09), which should not be expected for parasporal endotoxins. Nonetheless, the potency of the toxins at ED50 was established at 320 ITU/ml, 8-times inferior to that of the standard Bti preparation, but still high enough to achieve the required efficacy in less than 6-hours.

Conclusion: This study shows the potential of B. cereus as a possible source for development of indigenous larvicides for mosquito vector control in Uganda. We recommend using more robust purification techniques to improve on the potency reported here. We envisage that future research will likely focus on safety, specificity and selectivity studies, and possibly synthetic design to enable bulk production of these toxins.

ABS-405

Larval habitat stability and productivity in two sites in Southern Ghana

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Mosquito Larval Source Management (LSM) is a valuable additional tool for malaria vector control. Understanding the characteristics of mosquito larval breeding habitats and its ecology in different land use types can give valuable insight for an effective larval control strategy. This study determined the stability and productivity of Anopheline breeding habitats in two different ecological sites; Anyakpor and Dodowa in Southern Ghana. Fifty nine aquatic habitats positive for Anopheline larvae were identified and sampled every two weeks for 28 weeks period. Larvae were collected using standard dippers and raised in the insectary for identification. Sibling species of the An. gambiae s. l. were further identified by rDNA PCR. The abundance of

aquatic larval habitats, their stability and larvae positive habitats were compared between the two sites using Mann-Whitney U and the Kruskal-Wallis test. Factors affecting the presence of Anopheles gambiae larvae and physico-chemical properties at the sites were determined using multiple logistic regression analysis and spearman's correlation.

Out of a total of 13,681 mosquito immatures collected, 22.62% (3,095) were Anophelines and 77.38% (10,586) were Culicines. Out of the 3,095 Anophelines collected, Anopheles gambiae s. l. was predominant (99.48%, n = 3,079), followed by An. rufipes (0.45%, n=14), and An. pharoensis (0.064%, n = 2). Sibling species of the Anopheles gambiae revealed An. coluzzii (71%), followed by An. gambiae s. s (23 %), and An. melas (6%). Anopheles mean larval density was highest in wells (2.35) and lowest in man-made ponds (0.58), puddles (0.41), swamps (0.36) and furrows (1.97). Elevated levels of pH (rho = 0.119), electrical conductivity (rho = 0.246) and TDS (rho = 0.227) had a significantly association ($p < 0.01$) with increasing Anopheles larval densities. Further, larval species abundance was influenced by vegetation cover ($p = 0.001$), and distance to nearest settlement ($p = 0.02$). Generally, weekly rainfall intensity led to an increase or decrease in mosquito larval abundance and habitats depending on the site.

Differences in larval abundance were dependent on rainfall intensity, proximity to human settlements and vegetation cover. This study suggests that breeding habitats are highly localized and provides a good opportunity for targeted larval control since the habitats are well-defined and easily traceable.

ABS-731

Determination of the biological larvicide VectoMax G effect on micro and macroinvertebrates in natural environment

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Background: There has been a renewed interest for larviciding during the recent decade. Although biological larvicides are considered not to be harmful to non-target organisms, there is still not sufficient data on the effect of new larvicide formulations lasting longer in the environment such as Vectomax G combining Bacillus thuringiensis israelensis and B. sphaericus on non-target organisms. The present study aims to assess the possible influence of VectoMax G on the diversity and abundance of the aquatic fauna cohabiting with mosquito larvae in breeding habitats during a larviciding trial in the city of Yaoundé.

Methodology: Twelve districts of the city of Yaoundé divided into 6 intervention and 6 control sites were chosen for the study. In each district 4 semi-permanent or permanent aquatic habitats were followed. VectoMax G application was done once every two weeks during 6 months and the aquatic organisms collected 48h after each treatment. All collected organisms were brought to the laboratory for identification. Physico-chemical parameters were recorded as well.

Results: A high diversity of the zooplankton was recorded in the intervention areas with 28 species collected against 14 species in the control areas. Cladocerans were the most represented group in both sites while Oestracods were found only in control sites. A total of 19 macro-invertebrates species were recorded in the control areas vs 16 species in intervention areas. Gasteropods were the most represented groups of macro-invertebrates.

Conclusion: The study indicated no significant influence of larviciding with Vectomax on the diversity and abundance of the non-target aquatic fauna in the city of Yaoundé.

Key words: Larviciding, VectoMax G, Diverty, Aquatic fauna, Yaoundé.

ABS-520

Water physicochemical parameters and microbial composition distinguish Anopheles and Culex mosquito breeding sites: potential as ecological markers for larval source surveillance.

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Background. Identification of breeding habitats for effective vector surveillance and larval source management is key in disease control programmes. Biotic and abiotic factors that enrich nutrients for mosquito larval development could be useful ecological markers for identifying potential breeding sites.

Method. We investigated water physicochemical parameters and microbial diversity of selected mosquito breeding sites in Accra, Ghana and associated these with the distribution of Anopheles and Culex larvae.

Results. Physicochemical parameters and microbial composition explained up to 72% variance observed among the breeding sites and significantly separated Anopheles and Culex habitats ($p< 0.05$). Anopheles and Culex abundances were commonly influenced by water temperature, pH, nitrate, and total hardness with contrasting impacts on the two mosquito species. Total dissolved solids, biochemical oxygen demand, and alkalinity uniquely influenced Anopheles abundance while total suspended solids, phosphate, sulphate, ammonium, and salinity were significantly associated with Culex ($R2= 0.99$, $p<0.001$). The most abundant bacterial phyla Patescibacteria, Cyanobacteria and Proteobacteria constituted >70% of the total bacterial richness. The oligotrophic Patescibacteria was strongly associated with Anopheles suggestive of the mosquito's adaptation to environments with less nutrients, while predominance of Cyanobacteria, indicative of rich nutritional source was associated with Culex larval ponds.

Conclusion. We propose further evaluation of these significant abiotic and biotic parameters in field identification of larval sources and how knowledge of these can be harnessed effectively to reduce conducive breeding sites for mosquitoes.

Keywords: Anopheles, Culex, water physicochemical properties, larval density, bacterial composition.

ABS-347

The effectiveness and efficaciousness of Bactivec and Griselesf biolarvicides as an integrated intervention in eliminating malaria at Kibaha Town Council in Tanzania.

Samwel Paul Mziray, Alejandro Gonzalez Torres, Ahmed Shaa.

Background: The use of chemolarvicides and other chemical insecticides has become a great problem in the community due to their adverse effects to health, environment and ecosystem in general, Never theless a community can be protected from malaria by controlling larvae stages of mosquitoes.

Objective: To make a monitoring and evaluation on the effectiveness and efficaciousness of biolarvicides (Bactivec and Griselesf) against mosquito larvae at Kibaha District.

Method: Three sentinel sites were selected, one being in the town and the other two in the outskirt of the council.

Biolarvicides were applied in all areas weekly and malaria incidence were monitored in health facilities.

Result: We successfully demonstrated the applicability, effectiveness and efficaciousness of biolarvicides (Bactivec and Griselesf) for malaria control and elimination to council level.

Malaria prevalence was reduced in Kibaha Town Council from 7.3% in 2017 to 0 in 2021, whilst in the outskirt of Kibaha Town Council malaria prevalence was reduced from 7.3% in 2017 to 4.0% in 2021

Conclusion: The results shows that biolarvicides is effective tool in the elimination of malaria when integrated with other interventions.

ABS-545

Does larviciding intervention targeting malaria vectors also affect *Culex* mosquito species in the city of Yaoundé, Cameroon?

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Abstract: Introduction: Although *Culex* species are considered to be equally affected by control measures targeting malaria vectors, there is still not enough evidences of the impact of interventions such as larviciding on these mosquitoes species distribution. The present study assessed the impact of a larviciding trial targeting malaria vectors on *Culex* mosquito species in the city of Yaoundé. Methods: A cluster randomized trial comparing thirteen treated clusters and thirteen untreated clusters was implemented. Data were collected at baseline and during larviciding intervention, from March 2017 to November 2020. The microbial larvicide VectoMax G was applied once every 2 weeks in intervention areas. Adult mosquitoes were collected using CDC light traps in both intervention and non-intervention areas and compare between arms. Results: Globally, larviciding intervention was associated with 69% reduction of aquatic habitats with *Culex* larvae and 36.65% reduction of adult *Culex* biting densities in houses. No change in the composition of *Culex* species and their susceptibility to insecticides was recorded. Conclusion: The study suggested a high impact of larviciding on *Culex* mosquito species distribution. The impact of the intervention could be improved if typical *Culex* breeding habitats including pit latrine are targeted.

Keywords: larviciding, *Culex*, *Bacillus thuringiensis*, *Bacillus sphaericus*, Yaoundé.

ABS-691

Phenotypic, Genotypic and Biochemical Changes during Pyrethroid Resistance Selection in *Anopheles gambiae* Mosquitoes

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The directional selection for insecticide resistance due to indiscriminate use of insecticides in public health and agricultural system favors an increase in the frequency of insecticide-resistant alleles in the natural populations. Similarly, removal of selection pressure generally leads to decay in resistance. Past investigations on the emergence of insecticide resistance in mosquitoes mostly relied on field survey of resistance in vector populations that typically had a complex history of exposure to various public health and agricultural pest control insecticides in nature, and thus the effect of specific insecticides on rate of resistance emergence or resistance decay rate is not known. This study examined the phenotypic, genotypic, and biochemical changes that had occurred during the process of selection for pyrethroid resistance in *Anopheles gambiae*, the most important malaria vector in Africa. In parallel, we also examined these changes in resistant populations when there is no selection pressure applied. Through repeated deltamethrin selection in adult mosquitoes from a field population collected in western Kenya for 12 generations, we obtained three independent and highly pyrethroid-resistant *An. gambiae* populations. Three susceptible populations from the same parental population were generated by removing selection pressure. These two lines of mosquito populations differed significantly in monooxygenase and beta-esterase activities, but not in *Vgsc* gene mutation frequency, suggesting metabolic detoxification mechanism plays a major role in generating moderate-intensity resistance or high-intensity resistance. Pre-exposure to the synergist piperonyl butoxide restored the susceptibility to insecticide among the highly resistant mosquitoes, confirming the role of monooxygenases in pyrethroid resistance. The rate of resistance decay to become fully susceptible from moderate-intensity resistance took 15 generations, supporting at least 2-years interval is needed when the

rotational use of insecticides with different modes of action is considered for resistance management.

Keywords: Deltamethrin, selection pressure, insecticide resistance, *Anopheles gambiae*

ABS-511

Implementing GLP principles for the evaluation of novel vector control tools: A case study with two novel LLINs, SafeNet® and SafeNet NF®

Salum Azizi*, Janneke Snetselaar, Robert Kaaya, Johnson Matowo, Franklin Mosha and Matt Kirby

To sustain high universal Long-Lasting Insecticidal Nets (LLINs) coverage, affordable nets that provide better protection are required. While it is essential to follow the World Health Organization Pesticide Evaluation Scheme (WHOPES) guidelines for the evaluation of LLINs, adherence to Good Laboratory Practice (GLP) principles guarantees generation of reliable and reproducible data which ensures substandard LLINs are not reaching the market. This case study evaluated the efficacy of SafeNet NF® and SafeNet® LLIN in accordance with both the WHOPES and the GLP standards. Both candidate LLINs were manufactured with fewer fabrics to cut down manufacturing costs to facilitate increased production, motivated by LLIN supply shortage.

Methods: Efficacy in terms of mosquito blood-feeding inhibition and mortality was compared with Interceptor® LLIN and an untreated net in experimental huts against wild, pyrethroid-resistant *An. arabiensis* mosquitoes. Methodology was based on the 2013 WHOPES guidelines for LLIN evaluation with adherence to the GLP standards during net washings, cone assays, rotation of treatments, collection of mosquitoes, scoring of primary outcome measures and experimental determination of alpha-cypermethrin.

Results: GLP compliance: Internal audits for critical phases confirmed the 10th and all previous washings, the conduct of cone assays, the rotation of treatments, the collection of mosquitoes, scoring of primary outcome measures and experimental determination of alpha-cypermethrin complied with SOPs and study plan. External audit by SANAS confirmed that the study complied with the GLP standards.

Hut trial: 1047 free-flying *An. arabiensis* were collected during the 49 collection nights. Mosquito entry rates in the huts were reduced in the 0W Interceptor® LLIN, 20W washed Interceptor® 20W LLIN, SafeNet NF and 20W Safenet LLIN compared to negative control hut at 46.4%, 32.1%, 12.9% and 3.5% respectively. There was significant blood-feeding inhibition only in the unwashed and washed Interceptor® LLIN treatment arms at 17.6% and 19.6% respectively. Mortalities induced by SafeNet NF® unwashed and washed were 28.8% and 16.2% respectively. Mortalities induced by Safenet LLIN unwashed and washed were 17.3% and 15.9% respectively. The 0W and 20W Interceptor® LLIN induced 26.4% and 24.1% mortalities respectively.

Conclusions: Step-wise procedures to conduct LLIN evaluation in compliance with both WHOPES and GLP standards are elaborated in this study. SafeNet NF® and SafeNet® LLIN offer equivalent protection to Interceptor® LLIN. However, further research is needed to investigate the durability, acceptability, and residual efficacy of these nets in the community.

Keywords: Good Laboratory Practice, SafeNet NF®, SafeNet® LLIN, Interceptor® LLIN, experimental hut, *Anopheles arabiensis*

ABS-632

Redistribution of *kdr* l1014f and *ace-1* mutations involved in the resistance of vectors to insecticides in Benin

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Background: Unfortunately, the development of resistance to insecticides in natural populations of *An. gambiae* is a major challenge for sustainable vector control for malaria in Africa. Therefore, appropriate follow-up on the sensitivity of *An. gambiae* s.l to different insecticides and the mechanisms involved in this resistance have been studied on the transect North South of Benin in order to allow the National Control Program against malaria (NCPM) .

Methods: The larvae and pupae of *An. gambiae s.l.* have been collected in 27 communities from different ecological zones distributed on the North South transect. Specimens of *An. gambiae s.l.* living and dead from these tests were analyzed for the detection of the kdr mutation West Africa (L1014F) and the *Ace - 1* mutation using PCR techniques.

Results: The resistance to DDT, permethrin and deltamethrin was observed in all localities. As for the bendiocarb, vectors were susceptible in most localities with the exception to the cotton growing areas and areas of cotton crops and indoor residual spray of Insecticide (IRS). The high frequency of alleles L1014F registered in all localities suggests the role of this gene in the resistance of vectors to insecticides. In addition, the *Ace-1* mutation was found in the cotton growing areas associated or not to the IRS with low allele frequency ranging from 1.08 to 2.02%.

Conclusions: On the other hand, susceptibility is good with pirimiphos-methyl in ecological zones. The *kdr* L1410F mutation remains the main mechanism of resistance in *An. gambiae s.l.*

Keywords: Resistance, *An. gambiae*, Pyrethroids, DDT, Bendiocarb, Fenitrothion, Pyrimiphos-methyl.

ABS-575

Native entomopathogenic fungi *Metarhizium spp.* infection influences the susceptibility of insecticide resistant *An. coluzzii* to deltamethrin

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Vector control contributes to nearly 80% of the malaria control effort. However, insecticide resistance in malaria vectors threatens malaria control. Entomopathogenic fungi have been proposed in this context as an alternative tool to chemical insecticides. In the present study, we have proposed an integrated pest management approach combining local strains of *Metarhizium spp*. with deltamethrin, a chemical insecticide commonly used in bed net.

Three isolates of *Metarhizium spp.* were isolated and their virulence was tested on *An. coluzzii*; first alone and then in combination with deltamethrin. A concentration of

107107 conidia/mL was used. Three combination methods were carried out with deltamethrin.

The virulence of the fungi alone was respectively 69.00%; 68.70%; 68.5% for strains S10, S26 and S31. When combined with

chemical insecticide, the mortality varied from 93.18% to 100% for the combination fungus followed by insecticide; 69.23% to 78.04% for the combination insecticide followed by fungus and 26.53% to 27.08% for fungus plus insecticide simultaneously. Native strains of the entomopathogenic fungus *Metarhizium spp.* could be used in combination with chemical insecticides to derive a synergistic effect far greater than the effect of each taken individually.

We also found that native *Metarhizium spp* have a good crossing capacity of the mosquito cuticle (3 days). This opens up different possibilities of using *Metarhizium spp.* as a vector for different technologies. It can be used as a microRNA delivery tool in the RNAi approach to block genes that confer insecticide resistance in malaria vectors.

Key words: *Malaria, insecticide resistance, entomopathogenic fungus, integrated vector control*

ABS-374

Cone bioassays provide reproducible bioefficacy estimates with different anopheline mosquitoes and can be used for quality assurance of pyrethroid insecticide treated nets

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Background: Quality assurance (QA) of insecticide-treated nets (ITNs) delivered to malaria-endemic countries is conducted by measuring physiochemical parameters, but not bioefficacy against malaria mosquitoes. This study explored utility of cone bioassays for pre-delivery QA of pyrethroid ITNs in two test facilities using different anopheline mosquitoes to test the assumption that cone bioassays are consistent and reproducible across locations, mosquito strains, and laboratories.

Methods: Double-blinded bioassays were conducted on twenty unused pyrethroid ITNs of 4 brands (100 subsamples, 5 subsamples per net) that had been delivered for mass distribution having passed physiochemical testing of chemical content. Cone bioassays were performed using pyrethroid susceptible strains on the same net pieces at PNG Institute of Medical Research (PNGIMR) with Anopheles farauti s.s. and at Ifakara Health Institute (IHI), Tanzania with Anopheles gambiae s.s. Results from IHI and PNGIMR were compared using Spearman's Rank, Bland Altman and Cohen's kappa.

Results: Overall, 13/20 nets (65%) met WHO bioefficacy criteria at IHI and 8/20 (40%) at PNGIMR. Results from IHI and PNGIMR correlated on 60-minute knockdown (r_s=0.6, p=0.002, n=20) and 24-hour mortality (r_s=0.9, p<0.0001, n=20) but there was systematic bias between the results measured by Bland Altman. Of the 5 nets with discrepant results between IHI and PNGIMR, three had confidence intervals overlapping the 80% mortality threshold, with averages within 1-3% of the threshold. The agreement between the results to predict ITN failure was good with kappa=0.79 (0.53-1.00) and 90% accuracy.

Conclusions: WHO cone is a reproducible provided statistical considerations are added to measure pyrethroid ITN bioefficacy using a combination of knockdown and mortality. However, mortality is a more reliable endpoint for ITN quality monitoring. Cone tests could be used to assess the availability of active ingredients at the surface of ITN (where mosquitoes encounter it) as part of pre-delivery QA.

Keywords: Bioefficacy, bioassay, cone bioassay, tunnel test, insecticide treated nets, ITN, long lasting insecticidal nets, LLIN, pyrethroid, mosquito, Anopheles, malaria, quality assurance

ABS-379

Insecticide resistance status of *Aedes aegypti* in urban and sub-urban areas of Ghana

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Introduction

Aedes mosquitoes are vectors of dengue and yellow fever which are global major public health concerns. Increasing outbreaks of yellow fever and dengue fever have been reported in African countries such as Nigeria, Senegal, Cote d'Ivoire and Ethiopia. In Ghana, there has been an outbreak of yellow fever in the northern part of the country and cases of dengue fever virus were recently detected in suspected malaria patients. However, there is no organized control program for arboviral diseases in Ghana. Widespread insecticide resistance in the vectors further complicates control especially during an arboviral disease outbreak. Thus, prior knowledge of the resistance status of *Aedes* mosquito populations in Ghana will be useful in improving pre-existing arboviral vector control measures.

Methods & Results

This study was carried out in urban (Accra and Tema) and suburban (Navrongo and Ada) sites. *Aedes* larvae were collected from the study sites and raised to become adults in the insectary. Phenotypic resistance was determined using WHO susceptibility tests and resistant genes were detected using allele-specific PCR. Synergist assays were performed with piperonyl butoxide (PBO) to detect the involvement of oxidase enzymes in resistance. The results showed high phenotypic resistance to DDT (11.3% to 75.8%) and pyrethroids (62.5% to 88.8%) in all sites. *Aedes* mosquitoes in Tema were resistant to all classes of insecticides tested. Suspected resistance to carbamate and organophosphates was detected also detected in some sites. High frequencies of the F1534C kdr allele and V1016I kdr allele (0.98 to 1) were detected in resistant and susceptible *Aedes* mosquitoes from all sites suggesting that these mutations may be fixed in *Aedes* populations. Low frequencies of the V410L kdr allele (0.03 to 0.31) were observed. This is the first report of the presence of the V410L kdr allele in Ghana. Pre-exposure to PBO significantly enhanced the susceptibility of *Aedes* to some of the insecticides tested in all the sites. This may be an indicator that metabolic enzymes (oxidases) may be involved in the development of resistance in some *Aedes* populations.

Conclusion

These findings show that insecticide resistance among *Aedes* populations in Ghana is high and is mediated by a combination of genetic and metabolic resistance mechanisms. Therefore, regular monitoring of the resistance profile of *Aedes* mosquitoes is needed to inform vector control policies for arboviral diseases in Ghana.

Keywords: insecticide resistance, *Aedes aegypti*, Synergist, Ghana

ABS-385

Comparative study of the effect of solvents on the efficacy of neonicotinoid insecticides against malaria vector populations across Africa

Bouopda Tuedom

Background: New insecticides with novel modes of action such as neonicotinoids have recently been recommended for public health use by WHO. Resistance monitoring of such novel insecticides requires a robust protocol to monitor the development of resistance in natural populations. In this study, we comparatively used three different solvents to assess the susceptibility of malaria vectors to neonicotinoids across Africa.

Methods: Mosquitoes were collected from May to July 2021 from three agricultural settings in Cameroon (Njombe-Penja, Nkolondom, and Mangoum), the Democratic

Republic of Congo (Ndjili-Brasserie), Ghana (Atatam), and Uganda (Mayuge). Using the CDC bottle test, we compared the effect of three different solvents (ethanol,
acetone, acetone+MERO) on the efficacy of neonicotinoids against *Anopheles gambiae* s.l. In addition, TaqMan assays were used to genotype key pyrethroid-resistant
markers in *An. gambiae* and to evaluate potential cross-resistance between pyrethroids and clothianidin.

Results: Lower mortalities were observed for all populations when using absolute ethanol or acetone alone as solvent (11.4-51.9% mortality for Nkolondom, 31.7-
48.2% for Mangoum, 34.6- 56.1% for Mayuge, 39.4- 45.6% for Atatam, 83.7- 89.3% for Congo and 71.05- 95.9% for Njombe pendja) compared to acetone + MERO for which
100% mortality was observed for all the populations. Synergist assays (PBO, DEM and DEF) revealed a significant increase of mortality suggesting that metabolic
resistance mechanisms are contributing to the reduced susceptibility. A negative association was observed between the L1014F-*kdr* mutation and clothianidin
resistance with a greater frequency of homozygote resistant mosquitoes among the dead than among survivors (OR=0.5; P=0.02). However, the I114T-GSTe2 was in
contrast significantly associated with a greater ability to survive clothianidin with a higher frequency of homozygote resistant among survivors than other genotypes
(OR=2.10; P=0.013).

Conclusions: This study revealed a contrasted susceptibility pattern depending on the solvents with ethanol/acetone resulting in lower mortality, thus possibly
overestimating resistance, whereas the addition of MERO consistently increased the efficacy of neonicotinoids in terms of percentage mortalities and time to final
mortality. The addition of MERO could however prevent the early detection of resistance development. We therefore recommend monitoring susceptibility using
both acetone alone and acetone+MERO (8-10µg/ml for clothianidin) to capture the accurate resistance profile of the mosquito populations.

ABS-388

Monitoring insecticide resistance and related resistance mechanisms in malaria vectors from different agricultural practices in Côte d'Ivoire

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Background: While growing resistance to insecticides in mosquitoes is increasingly drowning out malaria control strategies, agricultural areas are known to induce strong selection pressure in larval habitats. Thus, the current study aimed to assess the insecticide resistance level and underlying mechanisms in *Anopheles gambiae s.l* from different agricultural areas in Côte d'Ivoire.

Methods: *An. gambiae s.l* larvae were collected in two areas of each of three different types of agricultural practices: rice, vegetable and cocoa. Emerged adult females were exposed to discriminating concentrations of deltamethrin, DDT, bendicarb and malathion using WHO susceptibility bioassays. Then, target site mutations and metabolic genes expression were

characterized and quantified based on Multiplex TaqMan-probe assays.

Results: Apart from malathion (84-100% mortality rates), high resistance levels were observed with the other insecticides in all three agricultural areas. The mutant *Vgsc*-L995F allele was found at high frequencies (55-87%), followed by the *Vgsc*-N1570Y allele in cocoa-growing area where the highest kdr-L995F frequencies were detected. Three P450s genes associated to pyrethroid and carbamate resistance were the most overexpressed. CYP6P3, CYP6M2 and CYP9K1 were overexpressed on average of 1.92, 2.17 and 2.38 respectively higher in rice- compared to cocoa-growing areas. CYP4G16 gene linked to cuticular resistance was up-regulated at a level of 1.15 higher in vegetable- than cocoa- areas. In additional, GSTe2 was significantly overexpressed on average 1.18 in vegetable as well higher than cocoa-growing area.

Conclusion: The current study showed that in Côte d'Ivoire, rice, vegetable and cocoa agricultural practices induce very strong resistance to insecticides used in public health with a great diversity of resistance genes in *Anopheles gambiae*. This strong relationship between agriculture and vector resistance suggested that the development of appropriate control strategies is required for an effective control of malaria in agricultural areas in Africa.

Keywords: Malaria, *Anopheles gambiae*, resistance mechanism, insecticide, agriculture, vector control, Côte d'Ivoire.

ABS-396

Seasonal abundance and insecticide resistance status of *Aedes* mosquitoes in Ghana

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Despite the existence of a safe vaccine for yellow fever, this disease continues to cause morbidity and mortality in thousands of people in Africa. The re-emergence of this virus in areas where the incidence had been controlled or eliminated is largely due to increased insecticide resistance in the *Aedes* vector and human-vector migration. This study investigated the seasonal abundance and insecticide resistance status of *Aedes* mosquitoes in seven study sites (Ada Foah, Tema, Accra, Konongo, Larabanga, Navrongo and Paga) from three different ecological zones of Ghana. Indoor and outdoor adult sampling were done using BG traps, human landing catch, and prokopack aspirator during the dry and rainy seasons of 2017/2018. Distributions of immatures and adult *Aedes* mosquitoes were determined seasonally for both indoors and outdoors at all sites. Phenotypic resistance status of *Aedes* mosquitoes to insecticides was determined using WHO bioassays. A total of 16,711 *Aedes* immatures were sampled from car tires (73.9%), discarded containers (18.8%), air-condition saucers (4.4%), buckets (1.4%), tanks (1.3%) and drums (0.3%). There were more positive habitats during the rainy season 50 (61.73%) compared to the dry season 31 (38.27 %) (df = 5; $\chi 2$ = 19.4435; p = 0.001). A total of 1,895 adult *Aedes* mosquitos were collected consisting of *Ae. aegypti* (97.8%), *Ae. africanus* (2.1%) and *Ae. luteocephalus* (0.1%). Adult *Aedes* mosquitoes were more abundant during the rainy season 1,257(66.3%) compared to the dry season 638 (33.7%) (z = -1.433; p = 0.1519). *Aedes aegypti* populations were resistant to DDT at all study sites (0-88%). Vectors showed suspected resistance to bendiocarb (96-97%), permethrin (90-96%) and deltamethrin (91-96%) and were susceptible to the organophosphate malathion at all study sites. About 90% of vectors had taken a blood meal from humans. *Aedes* mosquitoes were found at high densities in all ecological zones of Ghana. Resistance to pyrethroids and carbamates may limit the efficacy of current vector control tools and requires constant monitoring.

ABS-411

Spatial distribution and insecticide resistance profile of *Aedes aegypti* and *Aedes albopictus* in Douala, the most important city of Cameroon

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Background: Prevention and control of *Aedes*-borne viral diseases such as dengue rely on vector control, including the use of insecticides and reduction of larval sources. However, this is threatened by the emergence of insecticide resistance. This study aimed to update the spatial distribution, the insecticide resistance profile of *A. aegypti and A. albopictus* and the potential resistant mechanisms implicated in the city of Douala.

Material and methods: Immature stages of *Aedes* were collected in August 2020 in eight neighbourhoods in Douala and reared to adult stages. Adult bioassays, and piperonyl butoxide (PBO) synergist assays were carried out according to World Health Organization (WHO) recommendations. Expression of some candidate metabolic genes were assessed using qPCR. *A. aegypti* adults G0 were screened using real time melting curve qPCR analyses to genotype the F1534C, V1016I and V410L *Aedes kdr* mutations.

Results: Overall, *A. aegypti* is the predominant *Aedes* species, but analyses revealed that both *A. albopictus* and *A. aegypti* coexist in all the prospected neighbourhoods of Douala. High level of resistance was observed to three pyrethroids tested in both *Aedes* species. In *A. aegypti* low mortality rate was reported to permethrin (5.83%) and high mortality rate to deltamethrin (63.74%). Meanwhile, for *A. albopictus*, low (6.72%) and high (84.11%) mortality rates were reported to deltamethrin. Similar analysis with bendiocarb, revealed for *A. aegypti* a moderate level of resistance. However, in *A. albopictus* samples, analyses revealed a susceptibility in Logbessou, and high resistance in Kotto (59.78%). A partial recovery of mortality was found to insecticides after pre-exposure to PBO. *Cyp6P12* was found significantly overexpressed in *A. albopictus* permethrin resistant and *Cyp9M6F88/87* for *A. aegypti* deltamethrin resistant. F1534C, V1016I and V410L mutations were detected in *A. aegypti* from different neighbourhoods.

Conclusion: These findings provide relevant information which should be capitalised in the implementation of arbovirus vector control strategies and insecticide resistance management.

Keywords: *Aedes aegypti*, *Aedes albopictus*, spatial distribution, insecticide resistance, knock down resistance, metabolic resistance, Douala, Cameroon

ABS-420

Temporal variation of high-level pyrethroid resistance in the major malaria vector *Anopheles gambiae* s.l in Yaoundé, Cameroon, is mediated by target-site and metabolic resistance.

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Constant assessment of insecticide resistance levels is mandatory to implement adequate malaria control tools, but little information is available on the annual dynamics of resistance. We therefore monitored variations in resistance in *Anopheles gambiae* s.l. over four seasons during two years in two localities of Yaoundé: urban Etoa-Meki and peri-urban Nkolondom. Mosquitoes were collected seasonally at larval stage and reared to adults for insecticide susceptibility tests and molecular analysis of resistance mechanisms. *Anopheles coluzzii* was found in Etoa-Meki and *An. gambiae* in Nkolondom. Low mortalities to pyrethroids were observed (permethrin <10%, deltamethrin <21%), resistance extended to 5x and 10x diagnostic doses, revealing a marked increase compared to previous studies. A seasonal variation in resistance was observed with the highest levels within dry seasons in Etoa-Meki and rainy seasons in Nkolondom. The 1014F *kdr* allele shows a high frequency (0.9), associated with overexpression of metabolic genes (Cyp6M2, Cyp6P4, Cyp9K1, Cyp6Z1, and Cyp6Z2) varying significantly seasonally. This study reveals an escalation in resistance to pyrethroids in Yaoundé's malaria vectors with seasonal variations. An adequate choice of the implementation period of punctual vector control actions according to the resistance profile will help to potentiate the desired effect and thus improve its efficiency.

Keywords: insecticide resistance, seasons, *Anopheles coluzzii*; *Anopheles gambiae*; resistance intensity; resistance dynamic; vector control.

ABS-533

Impact of next-generation dual-active ingredient long-lasting insecticidal net deployment in Tanzania on insecticide resistance in *Anopheles funestus* s.l. and *Anopheles gambiae* s.l.

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Insecticide resistance among mosquito species is now a pervasive phenomenon, which threatens to jeopardize global malaria control efforts. Novel vector control tools, including long-lasting insecticidal nets (LLINs) incorporating new active ingredients with different modes of action are urgently needed to delay the evolution and spread of resistance. During a four-arm cluster-randomised trial in Misungwi district, Tanzania, evaluating the effectiveness of (1) Royal Guard, a LLIN combining pyriproxyfen and alpha-cypermethrin; (2) Interceptor G2, a LLIN combining chlorfenapyr and alpha-cypermethrin; (3) Olyset Plus, a LLIN combining piperonyl butoxide (PBO) and the pyrethroid permethrin; compared to (4) Interceptor, a standard alpha-cypermethrin LLIN, we measured longitudinal trends in insecticide resistance among >46,000 wild mosquitoes collected over 36 months. Prior to LLIN distribution, pyrethroid resistance was high, with 30-min knock-down ranging from 43.7-59.4% for *Anopheles funestus* s.l. and *An. gambiae* s.l. following exposure to alpha-cypermethrin and mean 24-hr mortality of 38.3-56.5% in permethrin bioassays. Following LLIN distribution, we detected a significant increase in permethrin resistance intensity in *An. funestus* s.l. across all trial arms. Levels of alpha-cypermethrin resistance also increased but only in clusters which received Interceptor® or Royal Guard. PBO pre-exposure restored permethrin susceptibility among vector populations and high levels of chlorfenapyr susceptibility were also observed. We assessed oviposition inhibition to pyriproxyfen using dissection 3-days after exposure with variable results between trial years. *An. gambiae* s.s. populations were characterised by high frequencies of L1014FS-*kdr* (98%) and overexpression of *CYP6M2, CYP6P3, CYP6P4* and *CYP9K1*. Study findings highlight increasing pyrethroid resistance intensity in *An. funestus* s.l. associated with the deployment of next-generation LLINs, with additional work required to thoroughly understand the operational implications and potential mechanisms driving cross-resistance.

ABS-592

High survivorship of *anopheles gambiae* to sublethal doses of neonicotinoids suggesting resistance selection at larval stages

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Background: despite a significant reduction in malaria incidence over the last decades, this mosquito-borne disease remains a major public health concern, especially in sub-saharan africa. The use of insecticides is a cornerstone in malaria vector control, but widespread insecticide resistance is threatening the sustainability of this strategy. Lethal effects of insecticides have been the focus of much attention over the past years. However, exposure of wild populations to sub-lethal concentrations of diverse xenobiotics is a major route of insecticide resistance selection.

Methods: to gain insight into the effects of exposure to sublethal concentrations of agricultural pesticides on mosquito survivorship, we subjected larvae from agricultural and urban cities of cameroon to field-realistic concentrations of four insecticides: deltamethrin (pyrethroid), imidacloprid, acetamiprid and clothianidin (neonicotinoids) in laboratory conditions. All data were analysed using r software.

Results: like for adult populations tested, we found a gradient of susceptibility to different insecticides among field-collected larvae. Larval populations from agricultural sites where a wide range of pesticides are intensively used for crop protection displayed remarkably high survivorship in sublethal doses of insecticides. While third instar larvae of the laboratory strain

anopheles gambiae kisumu died after 24h in 0.035ppm clothianidin, 0.15ppm acetamiprid and 0.075ppm imidacloprid, *an. Gambiae* larvae from the agricultural site show high pupation rates of 26%, 78%, 52% respectively, emergence rates of 10%, 63%, 52% respectively and survival probabilities of 7%, 64%, 45% respectively in those neonicotinoids. An. Coluzzii field larvae did not emerge in any of the neonicotinoid tested confirming the higher susceptibility of this species to neonicotinoids. Both *an. Gambiae* and *an. Coluzzii* populations grew faster and survived in water containing sublethal concentrations of deltamethrin.

Conclusion: our results show that exposure to sublethal concentrations of insecticides via contamination of soil-water system might contribute to insecticide resistance selection at larval stages in mosquito populations.

ABS-723

Expression of pyrethroid metabolizing P450 enzymes characterizes highly resistant Anopheles vector species targeted by successful deployment of PBO-treated bednets in Tanzania

Johnson Matowo

Long lasting insecticidal nets (LLINs) are a proven tool to reduce malaria transmission, but in Africa efficacy is being reduced by pyrethroid resistance in the major vectors. A previous study that was conducted in Muleba district, Tanzania indicated possible involvement of cytochrome P450 monooxygenases in a pyrethroid resistance in *An. gambiae* population where pre-exposure to piperonyl butoxide (PBO) followed by permethrin exposure in CDC bottle bioassays led to partial restoration of susceptibility. PBO is a synergist that can block pyrethroid-metabolizing enzymes in a mosquito. Insecticide resistance profiles and underlying mechanisms were investigated in *Anopheles gambiae* and *An. funestus* from Muleba during a cluster randomized trial. Diagnostic dose bioassays using permethrin, together with intensity assays, suggest pyrethroid resistance that is both strong and very common, but not extreme. Transcriptomic analysis found multiple P450 genes over expressed including CYP6M2, CYP6Z3, CYP6P3, CYP6P4, CYP6AA1 and CYP9K1 in *An. gambiae* and CYP6N1, CYP6M7, CYP6M1 and CYP6Z1 in *An. funestus*. Indeed, very similar suites of P450 enzymes commonly associated with resistant populations elsewhere in Africa were detected as over expressed suggesting a convergence of mechanisms across Sub-Saharan African malaria vectors. The findings give insight into factors that may correlate with pyrethroid PBO LLIN success, broadly supporting model predictions, but revision to guidelines previously issued by the World Health Organization is warranted.

ABS-364

Influence of testing modality on bioefficacy for the evaluation of Interceptor® G2 mosquito nets to combat malaria mosquitoes in Tanzania

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Background: Insecticide treated nets (ITNs) durability are evaluated through longitudinal bioefficacy and fabric integrity sampling post-distribution. Interceptor® G2 was developed for resistance management and contains two adulticides: alpha-cypermethrin and chlorfenapyr, a pro-insecticide that is metabolized into its active form by mosquito detoxifying enzymes and may be enhanced when the mosquito is physiologically active. To assess the impact of bioassay modality, mosquito exposures

to the alphacypermethrin ITN InterceptorÒ and the InterceptorÒ G2 were compared.

Methods: Efficacy of ITNs were measured by four bioassay types: 1) World Health Organisation (WHO) Cone Test (cone), 2) WHO Tunnel test (tunnel) 3) Ifakara Ambient Chamber Test (I-ACT) and 4) the WHO gold standard Experimental Hut test (hut). Hut tests were conducted against free flying wild pyrethroid metabolically resistant *Anopheles arabiensis* and *Culex quinquefasciatus.* Cone, tunnel, and I-ACT bioassays used laboratory reared metabolic resistant *An. arabiensis* and *Cx. quinquefasciatus*; and pyrethroid susceptible *Anopheles gambiae* s.s. and *Aedes aegypti*. Mosquito mortality and blood feeding inhibition endpoints were investigated.

Results: Mortality of unwashed InterceptorÒ G2 among *An. arabiensis* was lowest in hut tests 42.9% (95% CI:37.3-48.5), although this increased to 66.7% (95% CI:47.1-86.3) by blocking hut exit traps so mosquitoes presumably increased frequencies of contact with ITNs. Higher odds of mortality were consistently observed in InterceptorÒ G2 as compared to InterceptorÒ in "free-flying" bioassays using *An. arabiensis*: tunnel (OR=1.42 [95%CI:1.19-1.70], p<0.001), I-ACT (OR=1.61 [95%CI: 1.05-2.49], p=0.031) and hut (OR=2.53 [95%CI:1.96-3.26], p<0.001). In cone tests (which restricts mosquito flight) (OR=0.05 [95%CI:0.20-0.09], p<0.001) was recorded. InterceptorÒ and InterceptorÒ G2 showed high blood-feeding inhibition against all strains .

Conclusion: WHO Tunnel and I-ACT consistently measured similarly and both predicted the results of the experimental hut test. For bioefficacy monitoring and upstream product evaluation of ITNs *in situ*, the I-ACT may provide an alternative bioassay modality with improved statistical power.

Key words: I-ACT, Ifakara Ambient Chamber Test, ITNs, chlorfenapyr, bioefficacy, bioassays

ABS-371

The influence of time of exposure and intensity of resistance on the bioefficacy of insecticides against metabolic resistant mosquitoes.

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Background: Increasing insecticidal resistance among malaria vector mosquitoes limits the effectiveness of vector control interventions for public health use. Bioassays that accurately measure the efficacy of new insecticides designed to combat insecticide resistance are needed. One of the main mechanisms of insecticide resistance is metabolic resistance where mosquitoes detoxify insecticides. It is likely that there is a circadian component to the upregulation of enzymes. Thus, this study assessed 1) the influence of time of mosquito exposure, 2) the time post exposure and 3) the resistance level of the mosquito strain on the bioefficacy (mortality at 24- and 72- hours) of insecticides: Deltamethrin (DM), and chlorpyriphos methyl (CM) alone and in combination with synergists: piperonyl butoxide (PBO) and Amitraz (AM) against mosquito vectors in Vietnam and Tanzania, using the World Health Organisation (WHO) cone assays.

Methods: WHO cone assays were conducted following WHO guidelines on netting treated with 120 mg/m^2 of DM, or 500 mg /m^2 CM alone, or combined with synergists 95 mg/m^2 PBO, or 100 mg/m^2 AM. A positive control: permethrin and PBO incorporated insecticide treated net (ITN) - Olyset Plus and negative untreated net were also conducted. Net was tested during the day time (9:00 – 16:00 hours) and repeated in the evening (18:00 – 21:00 hours), mosquitoes were held to assess delayed mortality at 24, 48 and 72 hours and nets were tested against *Culex (Cx.) quinquefasciatus* mosquitoes of moderate and high resistance.

Results: Cone assays measured higher mortality at day time, and at 72 hours (P-value <0.05) for pyrethroid resistant *An. arabiensis*, and *cx. quinquefasciatus*. Bland-Altman analysis used to explore the agreement between the mortality recorded for moderately resistant Cx. quinquefasciatus (Hanoi strain) mosquitoes and the highly resistant Cx. quinquefasciatus (Bagamoyo

strain) showed that there was no agreement on any of the insecticides tested.

Conclusion: Time of day and hours of assessment of delayed mortality, as well as resistance profile are important considerations in WHO cone assays of insecticides designed to combat metabolic insecticide resistance.

Keywords: Deltamethrin, Amitraz, Chloripyrifos methyl, piperonyl butoxide (PBO), Cone assay, Insecticide Treated nets, Malaria, vector-borne diseases, Tanzania, Hanoi.

ABS-548

Malaria burden and associated risk factors in an area of pyrethroid-resistant vectors in southern Benin

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Malaria remains the main cause of morbidity and mortality in Benin despite the scale-up of long-lasting insecticidal nets (LLINs), indoor residual spraying, and malaria case management. This study aimed to determine the malaria burden and its associated risk factors in a rural area of Benin characterized by high net coverage and pyrethroid-resistant mosquito vectors. A community-based cross-sectional survey was conducted in three districts in southern Benin. Approximately 4,320 randomly selected participants of all ages were tested for malaria using rapid diagnostic tests within 60 clusters. Risk factors for malaria infection were evaluated using mixed-effect logistic regression models. Despite high population net use (96%), malaria infection prevalence was 43.5% (cluster range: 15.1-72.7%). Children (58.7%) were more likely to be infected than adults (31.2%), with a higher malaria prevalence among older children (5-10 years: 69.1%; 10-15 years: 67.9%) compared to young children (<5 years: 42.1%); however, young children were more likely to be symptomatic. High household density, low socioeconomic status, young age (<15years), poor net conditions, and low net usage during the previous week were significantly associated with malaria infection. Malaria prevalence remains high in this area of intense pyrethroid resistance despite high net use. New classes of LLINs effective against resistant vectors are therefore crucial to further reduce malaria in this area.

ABS-582

Detection of GSTE2-I114T gene Mutation in a pyrethroid susceptible *Anopheles gambiae s.s.* Kisumu *strain in Accra, Ghana.*

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Introduction: Laboratory maintained insecticide susceptible mosquitoes are a requirement for bioefficacy testing of insecticidal vector control tools under the current WHO guidelines. The susceptible *Anopheles gambiae s.s.* Kisumu strain is a common laboratory strain used for these tests. Routine confirmation of susceptibility to various insecticides is key. While the Kisumu strain maintained at the Vestergaard-NMIMR Vector Labs (VNVL) remains susceptible to pyrethroids, resistance to DDT was observed beginning in 2018. Glutathione S-Transferases epsilon 2 mutations (*GSTe2*) are one of the target site gene mutations associated with DDT resistance either, alone or alongside other resistance mechanisms, in *An. gambiae s.l.* This study

explores the possible DDT resistance mechanisms in the VNVL Kisumu strain.

Materials and methods: 200 to 300 female *An. gambiae s.s.* Kisumu strain reared at VNVL were subjected to WHO susceptibility tests using DDT. Mosquitoes that survived the exposure to DDT were screened for *VGSC L1014F/S*, Ace-1 *G119S*, and *GSte2-I114T* genes.

Results: Among metabolic mechanisms, over expression of mixed function monooxygenases, esterases, and glutathione S-transferases (GSTs) were routinely tested relative to resistant *Anopheles gambiae* strain. Preliminary data indicates GSTs were significantly over expressed (P<0.05). The *VGSC L1014F/S*, Ace-1 *G119S* mutations were not detected in the Kisumu strain. Preliminary qPCR tests with a small subsample in the process of setting up and testing probes for *GSte2-I114T* mutation indicated its presence.

Conclusion: Testing and analysis of all samples from *An. gambiae s.s.* Kisumu strain is underway and will be reported. Further steps will involve the investigation of the effects of over expression of GSTs activity and *GSte2-I114T* mutation, including behavioural assays. This study highlights the essence for regular phenotypic and genotypic monitoring of susceptible strains.

ABS-601

New, dual-active ingredient insecticide-treated nets (itns) in Rwanda: access, use and barriers

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Background: Global progress against malaria has stalled due in part to increased resistance to pyrethroid insecticides in key vector populations. New, dual-active ingredient insecticide-treated nets (itns) that are effective at killing insecticide-resistant mosquitos have been developed. The new nets project is conducting observational analyses accompanying the pilot distribution of these new itns in four african countries, including rwanda, to generate evidence on their effectiveness and cost-effectiveness.

Methods: Qualitative findings from a mixed method evaluation are presented. Key informant interviews and focus group discussions were conducted with community members across three districts of implementation.

Results: Participants described getting itns primarily through government distribution campaigns, and there was variability in whether households reported receiving enough itns and at the desired frequency. The majority of participants preferred the conical type of itns that were distributed in previous campaigns compared to the square itns distributed in 2020. Awareness of the importance of itns in reducing malaria transmission, high mosquito and insect nuisance, and malaria history at the family level were cited as motivating factors for consistent use. Barriers to use included an inability to replace old or torn itns, laziness or negligence, discomfort and increased heat, lack of understanding of malaria severity,

perceived lack of susceptibility to malaria particularly among youth (teenagers), allergic reactions or irritation in response to the insecticides used, the small size of itns, difficulties hanging itns, having too few itns compared to available sleeping spaces, attending community events, as well as working night jobs/shifts.

Conclusions: Heterogeneity in access, use, and barriers to use could have substantial impact on net effectiveness. Final results will be available in 2023.

ABS-610

Preliminary entomological findings of observational analyses to evaluate the impact of new nets following 2020 mass distribution in Rwanda

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Background: Universal coverage of insecticide-treated nets (itns) remains the optimal target for effective control of malaria in endemic countries. Unfortunately, the effectiveness of itns is threatened by widespread pyrethroid resistance. Through the new nets project, a comparison of dual-active ingredient itns (interceptor g2®) and standard itns (yahe® ln) is being conducted for three years in three districts of rwanda. The first-year entomological findings, from march 2020 to march 2021, after itn distribution are presented.

Methods: Two types of itns were distributed in 2020: standard itns in ruhango and nyamagabe in february and ig2 itns in karongi in june. Entomological surveys are carried out for two consecutive nights every two weeks in three villages per district. Indoor cdc light traps and paired indoor-outdoor human landing collections are performed in five and three sentinel houses per village, respectively. The insecticide resistance tests are performed using who tubes tests or cdc bottles for testing resistance mechanisms involving PBO.

Results: During year 1, *an. Gambiae* s.l. was dominant in karongi (89.5%) and ruhango (69.4%) while *an. Funestus* s.l. was dominant in nyamagabe (78.3%). The overall sporozoite infection rate in total anopheles was low, 0.42% (n=1,429). *Plasmodium* infections were found in 0.68% (n=730) of *an. Gambiae* s.l. and 0.41% (n=239) in *an. Funestus* s.l. the indoor-outdoor biting ratio of *an. Gambiae* s.l ranged from 0.48 to 1.1, and the peak of biting times also varied per district. The insecticide susceptibility patterns in *an. Gambiae* s.l. indicated an emerging resistance to pyrethroids (86-97% of mortality). The confirmed resistance was mitigated by pre-exposure to pbo.

Conclusion. The bionomic characteristics of malaria vectors vary per study district. Refining these preliminary entomological findings will inform the interpretation of final results on the impact of the itn distributions on malaria transmission in rwanda. Final results will be available in 2023.

ABS-686

Pyrethroid insecticide susceptibility status of anopheles mosquitoes population, availability and use of long-lasting insecticide treated nets(llins) in Binduri, Talensi and Builsa South Dist

Sydney Ageyomah

Background: The World Health Organization (WHO) estimates that there were 655,000 malaria deaths in 2010, with 86% occurring in children under 5yrs (WHO,2011). Malaria deaths are declining with the massive scaling up of control measures, of which insecticide treated bed nets (ITNs) are a major component. ITNs reduce deaths in children (Lengeler C. (2004) and provide personal protection to the user, and at scale they provide community-wide protection by reducing the number of infective mosquitoes in the vicinity where ITNs are used (Jones CM et al. (2012) and Okia M, Ndyomugyenyi R. et al. (2013).

Between 2008 and 2010, 254 million ITNs were supplied to countries in sub-Saharan Africa, and the proportion of African households in possession of a net rose from 3% in 2000 to 50% by 2010 (WHO, 2010). Nets, when in good condition and used correctly, are effective, simple to use, easy to deliver to rural communities, and cost-effective when used in highly endemic malarious areas (Okumu FO et al. (2012). On account of their low mammalian toxicity, speed of action, and high insecticidal activity, pyrethroids (Briet OJ et al. (2013) are the only insecticide class recommended by the WHO for use in ITNs (Hougard JM et al. (2003). The control of malaria vectors with insecticides remains an essential component in the fight to eliminate or eventually eradicate malaria. Malaria vector control is intended to protect individuals against infective mosquito bites and reduce the intensity of local malaria transmission (WHO, 2009). In Ghana the National Malaria Control Program (NMCP) has embarked on a rapid distribution of ITN's countrywide in a recent LLIN Point Mass Distribution campaign 2018, a total of 653,863 LLINs were distributed to households in the Upper East (Malaria Report UER 2018) as part of the strategies aimed at achieving the millennium development goals. Several sectors have also adapted to the vector control in reducing malaria burden and also to control mosquito nuisance.

However, the development of pyrethroid resistance in populations of *Anopheles gambiae* has become a serious threat to the effectiveness of these two vector control measures (Santolamazza, 2003). According to the recent World Malaria report for 2011, mosquito resistance to pyrethroid insecticides has been reported in 27 African countries and 41 countries worldwide.

Objective of the study: The main objective is to determine Pyrethroid insecticide susceptibility status of local malaria vector species, knowledge on LLIN benefits, availability and use of LLIN in three selected districts (Binduri, Talensi and Builsa South) with inconsistent OPD malaria cases from 2015-2018 using the Ghana Health Service DHIMs information in the Upper East of Ghana.

Methodology: Household Survey and Pyrethroid *Susceptibility Test*

A questionnaire was used to collect information on the knowledge, availability and use of LLIN in households within the study districts. Susceptibility of the local *Anopheles* species to the pyrethroid insecticides was tested by exposing the Anopheles Mosquitoes to a 0.05% Alphacypermethrin pyrethroid insecticide in communities within the selected districts.

Results: From the study results 83% of households surveyed had LLINs, 17% of the household did not have LLIN in the households and 99.1% of the individual surveyed had knowledge on the importance and use of LLIN. Mosquitoes sampled from all the three districts showed considered resistance to pyrethroid(Alphacypermethrin 0.05%).

Conclusion: The results of the study shows that the knowledge on LLIN benefits and availability/access was good but the results on the use of LLIN which will help prevent Malaria is very low thus the information from the study will help the Upper East Regional malaria control team restructure their malaria control efforts to meet the lapses on the usage of LLINs and liase with National Malaria Control Programme(NMCP) to relook at the efficacy of pyrethroid since the study shows local vector resistance to pyrethroid which can compromise the malaria vector control strategy of LLINs(reducing the vector density).

ABS-714

Efficacy of various types of impregnated mosquito nets (conventional and new generation) in a context of high intensity of resistance of *An. gambiae* s.l. to pyrethroids in the cotton production zone in Benin, West Africa.

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The use of impregnated mosquito nets as a method of malaria prevention has been adopted in most countries. Studies conducted since 1988 in many countries have demonstrated the effectiveness of this tool (Carnevale *et al.,* 1988; Akogbéto and Nahum, 1996 and Konan, 2003). Thus, since 2007, Benin has integrated in its vector control program, the use of conventional LLINs (LLINs impregnated only with pyrethroids). Unfortunately, the resistance of vectors to insecticides hinders the effectiveness of the latter. Alternatively, new generation LLINs incorporating both a pyrethroid insecticide and piperonyl butoxide (an oxidase inhibiting PBO synergist) is an alternative and feasible option. It is therefore important to evaluate the efficacy of these two types of LLINs (conventional and PBO) on wild populations of *An. gambiae* s.l. collected directly in the field. The study was conducted from November 2019 to December 2020 in the different districts of the cotton zone (Kandi, Bantè, Dassa and Savè)

of North Benin. All the districts of this zone are characterized by a high use of insecticides (carbamates, organophosphates and pyrethroids) against cotton pests. With the "Dipping" method, larvae of *An. gambiae* s.l. were collected. The efficacy of seven different types of LLINs incorporated with pyrethroids was evaluated on populations of susceptible Kisumu and wild mosquitoes. After exposure of the kisumu strain to different types of conventional nets (Olyset-Net, Permanet 2.0, Yorkool, Dawa Net and Aspirational), a knock-down effect greater than 95% is induced after just fifteen (15min) minutes of observation or with the different strains in the field, a decrease in the kd and mortality rate is observed in all districts. Unlike conventional nets, new generation nets significantly increase the kd effect and mortality rate on field strains. These results show that detoxification enzymes plus mainly mixed function oxidases are strongly involved in the resistance of *An. gambiae* s.l. to pyrethroids in these districts.

From these results, we can say that the new generation nets (Olyset-Net plus and Permanet 3.0) are a solution for the NMCP in its fight against *An. gambiae* s.l. in these districts.

Key words: Resistance, *knock-down*, pyrethroids, *Anopheles gambiae* and NMCP.

ABS-736

Efficacy of two Dual-active ingredients insecticide treated-nets against pyrethroid resistant *An. gambiae* s.l. and their effect on life traits history using experimental hut collections in Burkina Faso.

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Introduction: Malaria vector resistance to Pyrethroid is threatening efficacy of vector control tool such as Pyrethroid-only-nets. For the 2019–2022 bed-net distribution, two of 70 health districts in Burkina Faso were covered with dual-active ingredients insecticide treated-nets (AI-ITN) including Pyrethroid-pyrrole, pyrethroid-PBO while the rest where covered with Pyrethroid-only-nets. For the coming distribution campaign in 2022, it is likely that no more Pyrethroid-only-nets will be deployed. Thus, it is important to compare the efficacy of these AI-ITN compared to the Pyrethroid-only one. The aim of the current study was to compare the bio-efficacy of Pyrethroid-pyrrole and pyrethroid-PBO nets and their impacts on *An. gambiae* s.l. life history traits compared to the Pyrethroid-only one.

Methods: The efficacy of new-unwashed, new-washed and naturally-aged Pyrethroid-pyrrole, pyrethroid-PBO and Pyrethroid-only-nets were assessed using three-year experimental hut trial data. Data were collected in Tengrela and Tiefora, different in vector species composition and known for the high insecticide resistance levels. During collection, alive female vectors were divided into two groups. The first group (N=1,476) blood-fed female *An. gambiae* s.l. was used for assessing their life history. The second group consisting of 16,139 blood-fed and unfed females were used for survival analysis.

Results: Roughly, 32,146 mosquitoes were collected with ~62% being *An. gambiae* s.l. Entry rate varied between villages, being ~16 and ~6 *An. gambiae* s.l. per day and per hut respectively in Tengrela and Tiefora over the three years. In overall the blood-feeding rate was higher as 46% [95% CI: 40.6 – 51.7] but varied between treatments in localized manner. The overall mortality was 17% [95% CI: 15.4 – 18.7] at 24 hour and increase by 15% at 72 h post-collection. This mortality rate varied significantly at both village and treatment levels without reaching 80% recommended by WHO guidelines. The overall oviposition rate was 12.6% [95% CI: 9.45 – 16.7] however, no significant difference in *An. gambiae* s.l. fecundity and fertility between treatments ($p > 0.05$). The median survival rate was ~10 days and variedg regardless the site, the net washing and aged status. Both aged and unwashed pyrethroid-PBO significantly reduced *An. gambiae* s.l. survival in Tengrela ($p<0.0001$). While in Tiefora the unwashed Pyrethroid-pyrrole reduced the survival by 3-4 days compared to the Pyrethroid-only-nets and control net.

Conclusion: Results indicate that the efficacy of these dual AI-ITN may varied according to the sites and their status of wash or aged.

Keywords: Burkina Faso, Pyrethroid-pyrrole, pyrethroid-PBO, standard nets, *An. gambiae* s.l., Experimental hut trial.

ABS-771

Monitoring insecticide resistance in *anopheles coluzzii* from a high malaria burden district prior to the implementation of new compounds candidates for indoor residual spraying: case of sakassou, central Côte d'Ivoire

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Background and objective: The health district of Sakassou belongs to the stratum of high malaria prevalence in Côte d'Ivoire, (incidence >37 % according to NMCP) and knowing the current insecticide resistance status in local *Anopheles* mosquito vectors, is important to guide the deployment of a complementary tool for vector control such as indoor residual spraying (IRS).This study evaluated *Anopheles* vector resistance to the common classes of insecticides and new compound candidates for IRS and determined the associated resistance mechanisms in Sakassou, central Côte d'Ivoire.

Materials and Methods: *An. gambiae* s.l mosquito larvae were collected in the health district of Sakassou, from 2018 to 2020. Emerged adult females were tested against pyrethroids (permethrin 0.75%, deltamethrin 0.05%, alphacypermethrin 0.05%), organophosphates (pirimiphos-methyl 0.25%), carbamates (bendiocarb 1%) and new compounds including the pyrolle (chlorfenapyr 200 ug/bottle) and neonicotinoid (clothianidin 2%) over three years of survey using WHO standard protocol for bioassay. *An. gambiae* s.l. species and presence of mutation genes were analysed by polymerase chain reaction (PCR).

Results: *An. gambiae* s.l. populations were exclusively *An. coluzzii* (100%). Overall, they were resistant to the common insecticides. Especially, pyrethroid mortality rate ranged from 0% to 6% over the three years of observation. *An. gambiae* s.l. was susceptible to clothianidin, (mortality of 100% was observed at seven day post-exposure). The 200 µg/bottle dose of chlorfenapyr yielded less than 98% of mortality in year two, but 100% mortality in year three. High L1014F frequency ranging from 54 to 71% was recorded over the time. L1014S allele was also detected, but at lower frequency compared to L1014F. G119S allele frequency (37-50%) was recorded and was less than L1014F.

Conclusion: Wild *An. gambiae s.l* populations from Sakassou, Côte d'Ivoire, showed strong resistance to the common insecticide classes with presence target-site mutation involving pyrethroids, carbamates, organophosphates, organochlorine insecticides, but high susceptibility to the newer candidates chlorfenapyr and clothianidin. Therefore, chlorfenapyr and clothianidin-based tools and interventions could be promising strategy for vector control in Sakassou health district.

ABS-558

Residual effectiveness of Clothianidin and Pirimiphos-methyl for indoor residual spraying on malaria vectors control in North-western Tanzania

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Background: The aim of this study was to assess the residual efficacy of clothianidin and pirimiphos-methyl (p-methyl) used as indoor residual spray (IRS) on different wall surfaces inside houses and their effectiveness in controlling malaria vectors in Tanzania from October 2019 to September 2020.

Methods: WHO wall cone and fumigant bioassays were conducted monthly for 12 months with laboratory susceptible *An. gambiae* s.s. Kisumu strain on different wall surface types sprayed with either clothianidin or p-methyl. The walls were mud, oil or water painted, lime washed, unplastered cement and burnt bricks. Clay pots, CDC light traps, Prokopack aspirators and collection bottle rotators with CDC light traps were used during monthly entomological surveillance conducted in 10 districts (6 IRS and 4 without IRS as control). Collected mosquitoes were identified morphologically and sibling species identified by PCR.

Results: Mean mortality on all wall surface types was above the 80% WHO threshold for eleven months post-IRS with clothianidin. All p-methyl-sprayed wall surfaces had a mean mortality above 80% post-IRS for seven consecutive months. There was no significant variation among different wall surfaces ($p>0.05$). A total of 39,686 female *Anopheles* mosquitoes were collected and morphologically identified as *An. gambiae* s.l. (71.9%), *An. funestus* s.l. (21.7%), *An. coustani* (3.7%), *An. pharoensis* (1.8%) and *An. rufipes* (0.9%). Molecular identification conducted on 23,961 mosquitoes revealed the local malaria vector population was predominated by *An. funestus* s.s. (40.9%), *An. arabiensis* (37.6%), *An. gambiae* s.s. (15.7%) and *An. parensis* (1.1%). In sprayed sites, *An. funestus* were predominant before IRS and *An. arabiensis* after IRS. *An. funestus* s.s. was predominant in unsprayed control sites. The average pre-IRS sporozoite rate was 1.6 and reduced to 0.9 after spraying. The sporozoite rate remained higher (1.8%) in unsprayed sites ($p<0.01$).

Conclusion: Clothianidin and p-methyl remained efficacious on all types of sprayed wall surfaces post-IRS during peak transmission season. IRS with these insecticides has significantly reduced sporozoite rates in *Anopheles* vectors.

ABS-336

Correlations between biological age, distance from aquatic habitats and pyrethroid resistance phenotypes of *Anopheles funestus* mosquitoes in south-eastern Tanzania

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Background: Malaria transmission can be highly heterogeneous between and within villages, and is influenced by biological factors such as the age and biting frequencies of *Anopheles* mosquitoes. We investigated how the age of *Anopheles funestus* and their susceptibility to insecticides used for vector control vary by distance from their aquatic habitats, and how these correlations may inform vector control strategies in southern Tanzania.

Methods: Adult female *An. funestus* were collected in houses located at 50-100m, 150-200m or over 200m from nearest known aquatic habitats. The mosquitoes were exposed to 1×, 5× and 10× the diagnostic doses of either deltamethrin or permethrin, or the synergist, piperonyl butoxide (PBO) followed by the pyrethroids, then monitored for 24hr-mortality. Ovaries of exposed and non-exposed mosquitoes were dissected to assess parity status as a proxy for age. Emergent adults from larval collections in the same villages were exposed to the same insecticides at either 3-5 days, 8-11 days or 17-20 days old. Generalized linear mixed-effects models were used to compare the 24hr-mortality for candidate insecticides by age and distance.

Findings: Mosquitoes collected nearest to the aquatic habitats (50-100m) had the lowest mortality compared to those from other distances; with a maximum of 51% mortality at 10× permethrin. For the age-synchronized emergent mosquitoes collected as larvae, the highest mortalities were observed at the oldest age (17-20 days) when exposed at 1x doses. At 10× permethrin and deltamethrin doses, 99% and 76% mortality was observed among the 8-11 day-olds compared to 56% and 58% among 3-5 day old mosquitoes respectively. Pre-exposure to PBO restored the insecticides potency on mosquitoes. The percentage of parous mosquitoes increased with distance from aquatic habitats.

Conclusion: Older *An. funestus* and those collected farthest from the aquatic habitats (near the centre of the village) were more likely to die from exposure to pyrethroids than younger ones and those caught nearest to the habitats. Additional studies should investigate whether insecticide-based interventions would remain sufficiently effective in areas of widespread pyrethroid-resistance by killing the older, less-resistant and potentially-infective females; and whether fine-scale targeting of insecticide-based interventions such as IRS (e.g. by prioritizing households farthest from habitats) would be optimal.

Keywords: Insecticide resistance, mosquito age, parity, age grading, *Anopheles funestus*, piperonyl butoxide, malaria, aquatic habitats.

ABS-526

The efficacy of Actellic 300CS as an insecticide for Indoor Residual Spraying on common building material

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Background: Insecticide resistance impacts on malaria elimination through diminishing effects on vector control. Resistance to all groups of insecticides have been reported in African. In southern Africa the elimination agenda is in jeopardy. Actellic 300CS, with its AI pirimiphos-methyl, was tested on 4 different surfaces and DDT was used as positive control.

Methodology: Field studies to assess the effectiveness of Actellic 300CS were conducted in northern KwaZulu-Natal, South Africa on various surfaces, that included mud, cement, paint and galvanized steel. The standard WHO cone bioassay was used to test the effectiveness of the insecticide and its residual life under field conditions. The vectors used for the bioassay were fully susceptible insectary reared *Anopheles arabiensis*. Ten unfed, 3-5-day old female mosquitoes were transferred to the cone affixed to the wall to expose them to the insecticide for 30 minutes, then removed and placed into paper cups, with access to sugar solution. The knock-down was recorded at 30 minutes and 60 minutes post exposure. Mortality was recorded every 24 hours until 100% mortality was achieved.

Results:. Actellic took a maximum of 5 days to achieve 100% mortality on mud and the positive control took a maximum of 4 days. On cement surfaces, Actellic and DDT both achieved a 100% mortality within 6 days. On painted surfaces, both Actellic and DDT achieved 100% mortality within 4 days. On painted surfaces, Actellic and the DDT achieved a 100% mortality within 6 days across the 12 months. On galvanized steel surfaces, Actellic achieved 100% mortality within 4 days for the first 6 months and 100% over 5 days. After 12 months DDT achieved 100% after day 4 .

Conclusion: Actellic is as effective in controlling malaria vector mosquitoes and can be a replacement insecticide for IRS

ABS-540

Does the efficacy of new classes of insecticide-treated nets against malaria last for 3 years?

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Background: Several randomised controlled trials evaluating new classes of insecticide-treated nets combining either the synergist piperonyl butoxide or Chlorfenapyr (CFP) insecticide with a pyrethroid showed better efficacy on malaria prevalence and incidence compared to standard pyrethroid LLIN in area of insecticide resistance for up to 2 years.

Methods: Two, RCTs were conducted in Tanzania in Muleba and Misungwi districts with third-year data collected in 2017 and 2021/2022 respectively. Malaria infection prevalence cross-sectional surveys in children under 15 years old were conducted at 28-30 months and 33-36 months post-intervention in each of these trials. Here we report a secondary analysis of those surveys reporting only the interventions arms that demonstrated efficacy up to 2 years; PBO LLIN in Muleba trial and CFP LLIN in Misungwi trial compared to the standard LLIN.

Findings: In Muleba study net usage was 59% and 33% at 28 months and 33 months respectively. Malaria prevalence was significantly lower in children residing in PBO LLIN arm (68%) compared to standard LLIN arm (83%; OR: 0.45, 95%CI 0.21-0.95, p: 0.036) at t28 while reduction was borderline significant at t33 (49% vs 65%, OR: 0.52, 95%CI 0.25-1.07, p=0.0747). Results for the Misungwi trial are being analysed and will be available for presentation.

Conclusion: Superior effect of PBO LLINs seems to be maintained during the third year and could be a carryover from previous years considering low net use and concentration of PBO in the net depleted after 2 years. However with prevalence over 49%, it should hardly be considered a success and further development or deployment strategies will be necessary to maintain appropriate malaria control. Answering the questions regarding performance of these new classes of LLIN over 3 years is essential as it will have direct implications on cost-effectiveness and roles to play alongside current vector control tools.

ABS-593

Cross-resistance to neonicotinoids in anopheles gambiae associated with agricultural use of pesticides

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Background: Progress made in the fight against malaria is rapidly fading due in part to the fast emergence and spread of resistance to insecticides used in vector control. To uphold this progress, new molecules such as neonicotinoids have drawn huge attention due to their unique mode of action. However, the use of some neonicotinoids in agriculture can induce selection, which might reduce susceptibility of wild populations to the newly approved insecticide clothianidin for malaria vector control. In this study, we infer cross-resistance, comparing the susceptibility of urban, agricultural and rural populations of *anopheles gambiae* and *an. Coluzzii* from the forest region of cameroon to diagnostic doses of four neonicotinoids (acetamiprid, imidacloprid, clothianidin and thiamethoxam) and three pyrethroids (bifenthrin, deltamethrin and permethrin) using standard bioassays.

Method: field-collected larvae were reared alongside two laboratory colonies: *an. Gambiae* kisumu and *an. Coluzzii* ngousso to adult. For neonicotinoids, using cdc bottle bioassay, we exposed laboratory colonies to increasing concentrations and determined the diagnostic dose of each insecticide using regression model. For pyrethroids, we used recommended diagnostic doses. The mortality post 60 min exposure was recorded for each insecticide every 24 h for 7 days.

Results: the diagnostic dose were 69.33±1.16, 166.22±1.43 and 196.2±1.27 µg/ML FOR ACETAMIPRID, IMIDACLOPRID AND THIAMETHOXAM RESPECTIVELY AFTER A 24 H HOLDING PERIOD. *An. Gambiae* populations from agricultural site were resistant to the four neonicotinoids tested (mortality: 44%, 32%, 85% and 86% respectively for acetamiprid, clothianidin, imidacloprid, thiamethoxam) while urban *an. Coluzzii* adults were fully susceptible to acetamiprid, clothianidin and thiamethoxam. In rural areas, *an. Gambiae* populations were also resistant to acetamiprid and clothianidin. All populations tested were resistant to pyrethroids, with mortality ranging from 25% to 92%.

Conclusion: our results show that *an. Gambiae* populations have reduced susceptibility to several neonicotinoids suggesting cross-resistance between active ingredients of this family.

ABS-606

Evolutionary profile of knockdown resistance (*kdr*) mutation in *Anopheles gambiae* and *Anopheles coluzzii* malaria vectors across mountainous plains of Cameroon

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Malaria control programmes across Africa and beyond are threatened by increasing insecticide resistance in the major anopheline vectors. In the *Anopheles gambiae* complex, two point-mutations (*L1014F* and *L1014S*) in the voltage-dependent sodium channel gene that confer target-site knockdown resistance (*kdr*) to DDT and pyrethroid insecticides, have been described across the northern sudano-sahelian and the southern forested zones of Cameroon, contrarily to an unclear *kdr* status in anophelines of mountainous agro-ecosystems across the Cameroon Great West domain. In order to determine the evolutionary profile of *kdr* alleles in *An. gambiae* and *An. coluzzii* sibling species both found in the Cameroon Great West domain, genotyping of the *kdr* locus on a total of 1172 individual specimen across 5 mountainous massifs, and sequencing of a 510 base pairs fragment of the downstream exon-20, were performed. Knockdown resistance *1014F* allele was found to be widespread with *An. gambiae* having high frequencies compared to *An. coluzzii*. Meanwhile *1014S-kdr* allele was confined in *An. gambiae* populations. The results suggest that *kdr* alleles may have arisen through introgression. Estimates of genetic

variability provided evidence of selection acting on these alleles, particularly the *1014F* which was driven to fixation. Spatial occurrence of *1014F* was heterogenous, being seemingly influence by land elevation and gene flow. This study delineates the holistic distribution of *kdr* mutations in *An. gambiae* and *An. coluzzii* across mountainous ecosystems of Cameroon. Taking action to limit the spread of *kdr* alleles into mountainous landscapes would be helpful for the management and sustainability of malaria vector control.

ABS-743

Multiple insecticide resistance mechanisms in urban population of Anopheles coluzzii (Diptera: Culicidae) from Lagos, South-West Nigeria.

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Background: Malaria is a major public health challenge in Africa with Nigeria accounting for the highest burden of the disease in the world. Vector control has proved to be a highly effective component of malaria control, however, the development and spread of insecticide resistance in major vectors of malaria have been a major challenge.

Methods: This study assessed resistance mechanisms in Anopheles coluzzii populations from Kosofe, Lagos mainland and Ojo Local Government Areas in Lagos, Nigeria where An. gambiae s.l is resistant to DDT and Permethrin. WHO susceptibility bioassay test was used in determining resistance status of An. coluzzii to discriminating doses of DDT and Permethrin while synergist assay was used to assess the involvement of monooxygenases in resistance development. Sub-species of An. gambiae s.l (An. gambiae and An. coluzzii) were identified using polymerase chain reaction (PCR) and Restriction Fragment Length Polymorphism (PCR-RFLP) while Allele-Specific Polymerase Chain Reaction (AS-PCR) assay was used to detect knockdown mutation (kdr-West; L1014F). Biochemical assays were used in determining the activities of metabolic enzymes.

Results: High DDT resistance was recorded in An. coluzzii populations from the three sites. Mortality rate of mosquitoes exposed confirmed Permethrin resistance in Kosofe (50%) and Lagos mainland (48%) but resistance was suspected in Ojo (96%). All specimens tested were

confirmed as An. coluzzii with low kdr frequency; 11.6%, 16.4% and 6.7% in Kosofe, Lagos mainland and Ojo respectively. Pre-exposure to synergist; PBO before exposure to Permethrin led to increased mortality in all populations. Esterase activity was insignificantly overexpressed in Kosofe ($p = 0.849$) and Lagos mainland ($p = 0.229$) populations. In contrast, GST activity was significantly lower in populations from Lagos mainland ($63.650 + 9.861$; $p = 0.007$) and Ojo ($91.765 + 4.959$; $p = 0.042$) than Kisumu susceptible strains ($120.250 + 13.972$). Monooxygenase activity was higher in Lagos mainland ($2.371 + 0.261$) and Ojo ($1.361 + 0.067$) populations, albeit significantly in Lagos mainland ($p = 0.007$) only.

Conclusion: Presence of target-site mutation in all populations, increased mortality with pre-exposure to PBO and elevated monooxygenase in Lagos mainland were confirmed. Multiple resistance mechanisms in some urban populations of An. coluzzii from Lagos, Nigeria calls for appropriate resistance management strategies.

ABS-710

Divergence and similarities on insecticides resistance profiles recorded with populations of An. gambiae s.l. breeding in vegetable farms in Yaoundé, Cameroon

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Background: Pesticide management by vegetable farmers might play a key role in the selection of insecticide resistance in wild of mosquito vectors. Here, we investigated the distribution of insecticides resistance profiles recorded with populations of An. gambiae s.l. breeding in vegetable farms in the city of Yaoundé in Cameroon.

Methodology: Four sites were selected; Nkolondom, Famassi and Ezazou as test sites and Mvan as control site. The knowledge, attitudes and practices of 50 vegetable farmers were collected in test sites through semi-structured questionnaire. Wild An. gambiae s.l. populations were collected and their susceptibility pattern to lambdacyhalothrin and permethrin assessed using WHO bioassay tests. Synergist bioassays with PBO were conducted and kdr target-site mutations were investigated using the TaqMan genotyping assay. The genetic diversity of An. gambiae s.l. was assessed by sequencing of the exon-20 element of the voltage-gated sodium channel.

Results: Overall, Lambdacyhalothrin constituted the main insecticide used by vegetable farmers in test sites. Mortalities to lambdacyhalohrin were 8.71%, 20.38%, 41.02% and 49% respectively at Nkolondom, Famassi Ezazou and Mvan. Susceptibilities to permethrin at Nkolondom, Famassi Ezazou and Mvan were respectively 6.14%, 13.19%, 17.11% and 9.62%. The PBO synergist assays showed partial recovery of the susceptibility to lambdacyhalothrin in Anopheles gambiae sl population as to permethrin. In all sites, the kdr 1014F was close to fixation and Ace1 mutations were low.

Conclusions: There was heterogeneity in An. gambiae sl population in resistance profile to pyrethroid, involvement of cytochrome P50 and in genetic diversity from one site to another. There was a similarity in Kdr mutation and Ace1-R distribution in all sites. This study suggests vector control strategies should also be implemented at a small scale for a better management of malaria transmission.

Keywords: Divergence, similarities, insecticides resistance, An. gambiae sl, vegetable fa

ABS-322

Insecticide Resistance Status of *Anopheles gambiae* s.l in Amechi Idodo, a Rural Community in Enugu State, Nigeria

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A study of the insecticide resistance status of *Anopheles gambiae* complex in Amechi Idodo, a rural community in Enugu State, was conducted from October, 2018 to November, 2020. The sampling of mosquitoes was done in all four villages (Eziobodo, Ohuani, Eziama and Obunagu) that make up Amechi Idodo community. *Anopheles* larvae were collected from diverse natural breeding sites including puddles; ditches, rice fields, hoof prints, among others, using ladles, dippers and pipettes. They were reared to adults in the laboratory. *Anopheles gambiae* susceptibility to insecticides (Deltamethrin 0.05%, DDT 4%, Pirimiphos-methyl 0.25% and Bendiocarb 0.1%) was assessed using the WHO susceptibility test protocol. Susceptibility test showed that Bendiocarb recorded the highest mortality rate 98.75%, while DDT recorded the least 5.0%. Deltamethrin and pirimiphos-methyl recorded 8.75% and 10.0%, respectively. *Anopheles gambiae* was susceptible to only Bendiocarb. On the contrary, they were highly resistant to DDT, deltamethrin and pirimiphos-methyl. There is need for adequate insecticide resistance management to curb the growing threat of insecticide resistance in Amechi Idodo.

Keywords: Vectors, *Anopheles gambiae* s.l larvae, Insecticide, Resistance, Bendiocarb, DDT, Deltamethrin

ABS-350

Genetic heterogeneity and resistance of malaria vectors (*Anopheles gambiae s.l*) to insecticides in the cotton area of Benin

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Background & Objective : The resistance of malaria vectors to insecticides used in vector control is one of the major obstacles to malaria control. The purpose of this study was to assess the seasonal diversity of *Anopheles gambiae* populations and the *L1014F* mutation of the *kdr* resistance gene.

Materials & Method : The study took place from March to August 2019 in three communes in the department of Atacora located in northwestern Benin, which is a cotton-growing area with high insecticide pressure including a dry season and a rainy season. Nightly captures of mosquitoes in homes on volunteers protected by chemoprophylaxis with sulfadoxine-pyrimethamine and the collection of residual fauna in the morning by spray constituted the sample. The species of the genus *Anopheles* were discriminated and genotyped using PCR. The Genepop 4.2 software was used to calculate the allelic frequencies, the fixation index and the genetic differentiation index while the binomial test of the R.3.3.3 software determines the significance of these frequencies

Results & Discussion : *Anopheles gambiae s.s.* and *Anopheles coluzzii,* two malaria vectors are identified. The study shows a seasonal variation in the frequency of the *kdr* resistance gene between the rainy and dry seasons with a high frequency f(*L1014F*) ⩾ 0.8 (P-value ⩽ 0.05) in the rainy season due to intense insecticide use allowing the elimination of the susceptible in favor of the resistant. There is also strong fixation of this allele in all populations F_{IS} ⩾ 0 showing strong selection and low genetic differentiation between the populations of the three communes indicating gene flow between these communes F_{ST} ⩽ 0.05.

Conclusion & Recommendation : This study shows a strong selection of resistance genes in mosquito populations against insecticides. It is necessary to change strategies and molecules in these areas

Key words : vectors, resistance, *kdr,* malaria

ABS-356

Fitness cost of target-site and metabolic resistance to pyrethroids drives restoration of susceptibility in a highly resistant *An gambiae* population from Uganda

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Background: Insecticide resistance threatens the effectiveness of malaria vector control, calling for an urgent need to design

suitable resistance management strategies. Here, we established the resistance profiling of a Ugandan *An. gambiae* population using WHO procedures and assessed potential restoration of susceptibility in the hybrid line Mayuge/Kisumu in an insecticide-free environment.

Results: This *An gambiae* population exhibited very high intensity of resistance to permethrin, deltamethrin and alphacypermethrin (mortality rate <5% with the diagnostic dose (DD), <50% with 5x DD and <75% with 10x DD) with consistent loss of efficacy of all long-lasting insecticidal nets (LLINs) tested including PBO-based and new generation nets Interceptor G2 (IG2) and Royal guard. Molecular analysis revealed a fixation of the L1014S-kdr mutation together with the overexpression of some P450 metabolic genes (*CYP6Z1*, *CYP9K1*, *CYP6P1*, 3 & 4) besides the cuticular resistance-related genes (*CYP4G16*) and sensorial appendage proteins (*SAP1*, *SAP2*, and *SAP3*) but no *GSTe2* overexpression. In the absence of selection pressure, a significant reduction in the frequency of KdrE was observed after 13 generations coupled to reduced expression of most metabolic resistance genes. Accordingly, the mortality rate after exposure to insecticides increased significantly over generations, and restoration of susceptibility was observed for most of the insecticides in less than 10 generations.

Conclusions: The results of this study show that the high intensity of pyrethroid resistance observed in *An gambiae* from Uganda associated with the loss of efficacy of LLINs could compromise vector control efforts. The study also highlights that an early rotation of insecticides could help manage resistance by restoring susceptibility thus, calls for the use of new tools to maximise the control of malaria vectors in the region.

ABS-737

Life-history attributes of *An. gambiae* s. l. and *An. funestus* exposed to new generation nets: An experimental hut study, Lake Zone, Tanzania

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Background: Anophelines are developing resistance to all classes of insecticides used for mosquito control. The emergence and rapid spread of pyrethroid resistance in malaria vectors populations is a threat for the sustainability of both IRS and LLINs programmes in many African countries. There is a need for new tools and better ways to assess the available and new tools. To evaluate the vector control tools, understanding the behaviour of malaria mosquito vector is important. Therefore, the present study aimed to determine the life-history attributes of *An. gambiae* s. l. and *An. funestus* exposed to new generation nets.

Methods: This was an experimental hut trial conducted as per World health Organization (WHO) guidelines for the duration of six weeks in Mwagagala, Misungwi. Nets tested in Experimental huts were unwashed interceptor G1 (IG1), unwashed interceptor G2 (IG2), washed 20 times Royal guard (RG), unwashed Royal guard, washed 20 times interceptor G2 and untreated net which was used as the control. Mosquitoes were collected inside the huts using hand-held aspirators. All malaria vectors collected from each hut and net source were assessed on their physiological status and recorded. Half (number) of fed, gravid and semi-gravid were monitored individually and allowed to lay eggs, which were followed-up until the F1emerged. The numbers of eggs, larvae, pupa and adult emerged were counted. All mosquitoes which were followed (F0) were also monitored until they die.

Results: A total of 255 malaria vectors were followed for life history traits, among them 198 were *An. gambiae* s. l. and 57 were *An. funestus.* The proportions of *An. gambiae* s. l. that laid eggs were 20.7% (n=41) in the IG2 washed 20 times while untreated control nets were 19.7% (n=39). The average number of eggs laid, pupae and adult emerged per female *An. gambiae* s. l. were 37.6, 11.4 and 11.3, respectively in IG2 washed 20 times. In the Royal guard unwashed nets, the average number of larvae hatched were 2.8 while for the pupae and adult emerged per female *An. gambiae* s. l. was 2.4 each. No *An. funestus* laid eggs in Royal guard unwashed and washed 20 times. The findings of the present study have shown a slight variations in longevity between malaria vectors post-exposure to different net types.

Conclusion: The present study has revealed the insecticidal effect on the life history attributes of *An. gambiae* s. l. and *An. funestus* exposed to new generation nets in experimental huts. Coupled with ongoing behavioural work nested in this study, it will provide important information to identify entomological correlates that can be used to predict epidemiological impact on new generation nets.

ABS-343

Performance and longevity of seven brands of long-lasting insecticidal nets (LLINs) under various field conditions in Africa, example of Benin after three years of monitoring.

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Abstract

Long-lasting insecticide-treated mosquito nets (LLINs) are important tool for malaria control. Durability, physical integrity, and bio-efficacy are key effectiveness variables of LLINs. The goal of this investigation was to determine the factors that impact the survival of seven brands of LLINs with different physical characteristics. A cohort consisting of 270 nets of each brand was studied semiannually from August 2017 to September 2020 in Zagnanado, Benin. Brands included PermaNet®2.0, PermaNet®3.0, OlysetNet®, Royal Sentry®, (with a reinforced border), and three nets with alternate specifications: DCT aspirational net (66g/m2 fabric weight, polyester, 150denier), DawaPlus®2.0 (40g/m2 fabric weight, polyester, 150denier), and Yorkool® (85 g/m2 fabric weight, polyester, 75denier). Globally, 330 LLINs of the 1,890 distributed were found at 36 months post-utilization. The total LLINs attrition rate was 82.5%. The main reasons of those that were loss were movement (52.9%), accidental tears (38.7%), and repurposing (8.4%) ($p<0.001$) with a significant difference between the different brands of LLINs ($p=0.04$). The median proportionate hole index (pHI) ranged from 25 to 221 with a significantly lower pHI for PermaNet®3.0 compared to the Yorkool® ($P<0.05$). After 36 months of use, 78.6% were in good condition ($0\leq pHI\leq 64$), 14.6% were damaged ($65\leq pHI\leq 642$) and 6.8% were too torn ($pHI\geq 643$). A significant decrease in the physical survivorship of LLINs (all brands) was observed at 36 months (25.7%, range 23.3-28.2%) compared to 6 months (91.8%, range 90.5-92.9%) ($p<0.001$). The bio-efficacy of LLINs after 2 years was greater than 70% in mosquito mortality. The decrease in LLINs survivorship during this study underlines the necessity of developing and implementing new strategies to manage this important vector control tool.

Keys words: Malaria, durability, LLINs, bio-efficacy

ABS-355

Evaluation at the level of health facilities, of the protective efficacy of LLINs in children under 5 years old from localities of low and high resistance of vectors to pyrethroid insecticides in Benin in West Africa.

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Context: The resistance to pyrethroids in malaria vectors continues to grow in Africa and could therefore compromise or reduce substantially the effectiveness of LLINs in preventing malaria. This study assess the effect of the use of LLINs on malaria morbidity in clusters of low and high resistance of vectors to pyrethroids.

Methods: This is a cross-sectional case-control study with one control for one case that was conducted in 4 communes in the Plateau department of southern Benin. The use of LLINs and malaria morbidity was measured and compared in children from clusters of low and high vector resistance to insecticides. In each commune, 30 cases and 30 controls were recruited for a total of 240 children under 5 years of age from villages with low and high insecticide resistance.

Results: 169 (70.4%) asserted the children slept under a LLIN the day before they arrived at the health center. This rate represents 70.8% (85 children) among the cases and 70.0% (84 children) among the controls without significant difference ($p = 0.8$). The use of LLINs the day before the survey, their availability at the household level, the use of other tools for protection against mosquito bites are the same in the two groups of children (cases and controls) ($p \geq 0.05$) as well in low and high resistance villages. On the other hand, the parasite prevalence, the splenomegaly and the geometric means of the parasite densities, are significantly higher in the cases than in the controls ($p < 0.05$).

Conclusion: The evaluation of epidemiological indicators in children under five years old at the level of health centers did not enable demonstrating the impact of resistance on the operational effectiveness of the LLINs.

Keywords: Case-controls, LLINs, malaria morbidity, pyrethroids resistance, Benin

ABS-614

Evaluation of Klypson 500 WG Indoor Residual Spray against laboratory pyrethroid susceptible *Anopheles gambiae* and resistant *Anopheles arabiensis* in Tanzania.

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Background: Indoor residual spray (IRS) has shown a significant impact on malaria reduction in sub-Saharan Africa. The neonicotinoid clothianidin has emerged as an alternative insecticide to pyrethroids for the management of insecticide resistance. This study evaluated the bio-efficacy and residual activity of Klypson 500WG (clothianidin) on wood, mud, and concrete substrates following World health Organisation (WHO) procedures to determine equivalence to the WHO Prequalification (PQ) listed SumiShield 50WG against pyrethroid susceptible *Anopheles gambiae* and metabolically resistant *An. arabiensis*.

Method: Wood, mud, and concrete substrates were sprayed with 300 mg a.i/m^2 active ingredient using Goizper sprayers. Substrates were stored out of direct light at 27°C ± 5°C and 40%-99% relative humidity. Each month, four treated substrates from each type were tested for bioefficacy using a standard WHO cone test. Sixteen replicates of 10 laboratory-bred *An. gambiae* and *An. arabiensis* were introduced into each cone and exposed for 30 minutes. The mosquitoes were kept in paper cups and provided with 10% glucose solution. Knockdown was recorded after 60 minutes and mortality every 24 hours up to 120 hours post exposure.

Results: Eight months post spray with 120 hours holding time, both Klypson 500WG and SumiShield induced >80% mortality among pyrethroid susceptible *An. gambiae* and pyrethroid resistant *An. arabiensis* on all three substrates. Against resistant *An. arabiensis* Klypson 500WG induced higher mortality than SumiShield 50WG after 24 hrs (OR=1.8, [95%CI: 1.7-2.0], p-value <0.001) and 72 hrs (OR = 2.0, [95%CI: 1.8-2.2], p-value <0.001) However, after 120 hours holding time, the mortality induced by Klypson and SumiShield against resistant *An. arabiensis* did not differ (OR=1.1, [95%CI:0.9-1.3], p=0.43).

Conclusion: Klypson 500WG provided 8 months of protection against resistant *An. arabiensis* as well as susceptible *An. gambiae*. It offers an alternative clothianidin based IRS product for insecticide resistance management and is now listed by WHO prequalification.

Key words: Indoor residual spray, Klypson 500WG, SumiShield 50WG, World Health Organisation, Wood, Mud, Concrete, *Anopheles gambiae, Anopheles arabiensis.*

ABS-751

Assessment of malaria entomological indicators and efficiency of double net mini trap in ulanga district, south-eastern Tanzania

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Efforts to control malaria are challenged by persistent transmission maintained by mosquitoes that are not responsive to primary malaria control intervention such as LLINs and Indoor Residual Spray (IRS). Development of effective interventions requires a fully understanding of entomological parameters including vector distribution, feeding behavior, abundance, host preference, human-biting, and infection rates, which determine the vectorial competence of natural mosquito population.

Using a miniaturized double net trap (DN-Mini trap), CDC light trap and Prokopack, we conducted a cross-sectional study to sample indoor and outdoor host seeking mosquitoes to assess entomological indicators such as species composition, densities, feeding and resting behaviour, testing the efficacies of DN-Mini trap in relation to CDC light trap for indoor host seeking, in inside the 37 houses that randomly selected in each of three villages south-eastern of Tanzania. A DN-Mini is a free exposure which enable for monitoring of indoor and outdoor host-seeking mosquitoes without interfering a natural behaviors of mosquitoes. Collection is done by a human volunteer who sits in the middle chamber and collects mosquitoes without direct mosquito contact.

Each village, we selected one house as a sentinel while other 36 houses as a random, Mosquito collected from 18:00hrs to 07:00hrs and collection is done in three days per week, each morning the volunteers collecting mosquitoes indoor and outdoor in the sentinel houses by using a Prokopack aspirator. All mosquitoes retrieved from the traps are stored in the labelled papers cups, then killed, sorted and properly packed into the storage box and sent to laboratory the Polymerase chain reaction (PCR) will be used to detect members of *An. funestus* and *Anopheles gambiae* complexes. Enzyme-linked immunosorbent assay (ELISA) will be used to detect Plasmodium sporozoites in mosquito salivary glands. Statistical analysis will be done and the results will be shared after completing data collection.

ABS-333

Permethrin Resistance Progression in Generations of Anopheles gambiae (Kisumu) Adults Exposed to Minimal Sub-lethal Concentrations

Adesoye Adegbola

Insecticide resistance development in the major malaria vector, *Anopheles gambiae* mosquito, is well documented but its rate of development and biological fitness costs remain obscure. This study was designed to investigate baseline Permethrin resistance response progression in susceptible *A. gambiae* (Kisumu) over generations by: (i) determining the lowest sub-lethal insecticide concentrations (LSLCs); (ii) comparing resistance statuses of LSLC exposed and unexposed adults; (iii) correlating metabolic enzymes levels with resistance responses over generations; (iv) determining biological fitness costs of resistance development; (v) monitoring resistance status progression over generations; and (vi) determining resistance development rate and inferring the full blown filial generation.

Established, insectary reared and fully susceptible strain of Kisumu populations were sourced, reared and exposed for mortality assay and LSLCs determination at the adult stage. Various exposure concentrations were achieved by slight modification of Centre for Disease Control (CDC) protocol. Adult Kisumu mosquitoes exposed to same LSLC over generations, using modified CDC protocol, were compared with unexposed Control populations by way of resistance statuses, life table analyses and correlating activities of esterase, monooxygenase and Glutathione S-transferases (GST) metabolic enzymes. Information obtained were calculated as means, percentages and expressed in tables and charts using SPSS 16.0. These were compared statistically using Analysis of Variance at P=0.05 with the aid of Graph-Pad prism 8. Resistance development rate and inference

on filial generation with full blown resistance were determined using R-Programme.

The study revealed that:

i. The Kisumu population was fully susceptible to Permethrin and demonstrated reduced susceptibility at very low concentrations. The LSLCs of Permethrin with mortality rates comparable to unexposed susceptible Kisumu strains were 0.2µg and 0.4µg per CDC bottle, i.e., LSLC 1 and LSLC 2, respectively;

ii. Kisumu adult population exposed persistently to LSLC 2 did not survive beyond f0 generation while the LSLC 1 exposed lasted five generations (f0 to f4) during which resistance statuses were consistently below 1.00±0.82 (4.0%) after 1hour;

iii. There were insignificant differences ($P>0.05$) in the levels of esterase across generations, while monooxygenase and GST levels were up-regulated significantly ($P<0.05$) in subsequent generations of LSLC 1 treated mosquitoes. GST activity, however, showed consistent and progressive increase with advancing generations;

iv. Permethrin resistance development in Kisumu prolonged longevity of the larval and pupal stages by 3 and 13 days, respectively with slight but significant ($P<0.05$) increase by f3 and f4 generations. Fecundity rates also dropped progressively from 638.67±1.53 to 100.00±2.00 per oviposition medium over the generations;

v. Resistance status of the Kisumu population progresses over generations with 5.0µg (18.25±0.50;73%) and 10.0µg (20.75±2.22;83%) significantly different ($P<0.05$) from 0.6µg test case (0.00±0.00;0%) at f4; and

vi. The Kisumu population had 2.51% resistance development rate with inferred full blown resistance at the 220th generational exposure to LSLC 1.

This study concluded that resistance development in *A. gambiae* rates 2.51% per generation until it fully blown at 220th generation with huge disadvantage on life cycle and fecundity of the vector. This information will help alley fear and change the narratives around the prowess of resistant vectors among mosquito managers.

ABS-742

High pyrethroid-resistance intensity in Culex quinquefasciatus (Say) (Diptera: Culicidae) populations from Jigawa, North-West, Nigeria

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Background: This study examined pyrethroid resistance intensity and mechanisms in Culex quinquefasciatus (Say) (Diptera: Culicidae) populations from Jigawa, North-West Nigeria. Methods: Resistance statuses to permethrin, lambda-cyhalothrin and alphacypermethrin were determined with both WHO and CDC resistance bioassays. Synergist assay was conducted by pre-exposing the populations to Piperonyl butoxide (PBO) using the WHO method. Resistance intensities to 2x, 5x and 10x of diagnostic concentrations were determined with the CDC bottle method. Species analysis and presence of knockdown mutation (Leu-Phe) were done using Polymerase Chain Reaction (PCR).

Results: Results showed that Cx. quinquefasciatus was the only Culex spp. present and "Kdr-west" mutation was not detected in all analyzed samples. Using WHO method, Cx. quinquefasciatus resistance to permethrin was detected in Dutse (12.2%) and Kafin-Hausa (77.78%). Lambda-cyhalothrin resistance was recorded only in Kafin-Hausa (83.95%) with resistance suspected in Ringim (90%). Resistance to alphacypermethrin was recorded in all locations. Pre-exposure to PBO led to 100% mortality to alphacypermethrin and lambda-cyhalothrin in Ringim while mortality to permethrin and alphacypermethrin in Dutse increased from 12.2% to 97.5% and 64.37% to 79.52% respectively. Using CDC bottle bioassay, resistance

was also recorded in all populations and the result shows a significant positive correlation ($R2 = 0.728$, $p = 0.026$) with the result from the WHO bioassay. Results of resistance intensity revealed a very high level of resistance in Kafin-Hausa with susceptibility to lambda-cyhalothrin and alphacypermethrin not achieved at 10x of diagnostic doses. Resistance intensity was also high in Dutse with susceptibility to all insecticides not achieved at 5x of diagnostic doses.

Conclusion: Widespread and high intensity of resistance in Cx. quinquefasciatus from North-West Nigeria is a major threat to the control of diseases transmitted by Culex and other mosquito species. It is a challenge that needs to be adequately addressed so as to prevent the failure of pyrethroid-based vector control tools.

ABS-323

What do we know about mosquito-borne arbovirus prevalence in Africa, and how can we improve our understanding?

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Mosquito-borne viruses such as dengue, chikungunya, Zika and Yellow fever (YF) viruses are originating from Africa. However, diseases caused by these viruses were formerly considered as scarce in the continent except for YFV for which outbreaks are frequently reported despite of the availability of an efficient vaccine. The scarcity of cases of dengue, Zika and chikungunya was probably due to the under-diagnosis/misdiagnosis and/or similar symptoms with malaria and other infectious diseases like typhoid prevalent in Africa. During the last two decades several *Aede*s-borne viral diseases outbreaks have been reported in several African countries. Nowadays, it possible the prevalence of these diseases in Africa could be higher than expected. Indeed, certain studies revealed that several acute febrile patients consulting hospitals for malaria suspicion were due to dengue. It was previously considered that domestic *Aedes aegypti* in Africa was not a good vector for dengue but we demonstrated that this mosquito species is rather very efficient to transmit several arboviruses including dengue and Zika viruses in Central Africa. Additionally, the invasive *Aedes albopictus* mosquito is now the most prevalent *Aedes* species in certain African countries. All

this could contribute to increase the prevalence of *Aedes*-borne viral diseases in the continent. To improve our understanding, it would be good to encourage research on arboviruses in Africa and each African country to put in place a programme to fight against arbovirus diseases with mission to ensure virological and entomological monitoring.

ABS-642

Entomologic surveillance of arboviruses and its significance in vector control and outbreak prevention: kenya

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Background: Prior to 2006, there was limited arbovirus surveillance in Kenya, probably because: fewer/ far-apart outbreaks were reported [dengue (1982), YF (1992-1993), RVF (1997-1998), chikungunya (2004)]; lack of knowledge on non-malaria febrile illnesses, surveillance system, diagnostic capacity, human resource. Currently, dengue, chikungunya cause repeated outbreaks in coastal, northeastern Kenya and are rapidly expanding to new geographic areas.

Methods: In 2008, countrywide entomologic arbovirus surveillance program was established to monitor vector presence, distribution, densities, arbovirus activity. Mosquitoes were collected using standard entomologic tools; viruses detected by cell culture, molecular methods.

Results: From 2008-2019, >900,000 mosquitoes were collected; mostly from pastoral arid/semi-arid Garissa (n=343,457;-37%), Baringo (n=196,185;-31%). Overall, *Ae. mcintoshi* was most abundant (n=116,670;-13%), *Culex pipiens* (n=81,292;-9%), *Ae. tricholabis* (n=132,667;-15%), *Mansonia africana* (78,047;-8.9%), *Mn. uniformis* (n=41,489-;4.7%), *Ae. ochraceus* (n=58,148;-7%), *Cx. univittatus* (n=14,790;-1.7%), *Cx. vansomereni* (n=8,935;-1%). *Ae. aegypti,* the principal vector of urban dengue, chikungunya, zika were comparatively fewer (n=2,692), as were sylvatic vectors *Ae. simpsoni* (n=365), *Ae. africanus* (n=101), *Ae. vittatus* (n=42). These species were mostly from coastal region except *Ae. vittatus* from Kisumu. 90 of >180 virus isolates (50% from arid/semi-arid areas) were fully characterized: Bunyamwera (n=47), Ndumu (n=12), West Nile virus (n=7), Semliki Forest virus (n=6), Babanki (n=4), Sindbis (n=3), Pongola (n=1), Usutu (n=1), Ngari (n=1), chikungunya (n=1); all associated with human disease. Several outbreaks were also investigated: dengue (2011-2022), and chikungunya (2016-2018), during which two interesting observations were made: i) unprecedented collection of *Ae. vittatus*, sylvatic vector of YF, dengue, chikungunya, zika, in Mombasa city (n=1,137), ii) isolation of chikungunya from *Cx. quinquefasciatus*.

Conclusions: These findings highlight: nationwide distribution of arbovirus vectors, active transmission of arboviruses of public health significance mostly in arid/semi-arid zones; potential for emergence/re-emergence of arboviral diseases in other areas; implications on epidemiology, significance of continuous surveillance for early detection, and monitoring virus evolutionary trends all to inform future control programs.

ABS-761

Vectors of cutaneous leishmaniasis diversity and blood feeding preference in mt. Elgon region, western Kenya

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Leishmaniasis, a neglected tropical disease, is caused by *Leishmania* parasite and transmitted through the bite of an infected female phlebotomine sand fly. Cutaneous Leishmaniasis (CL) is endemic and of public health in Kenya. Although the latest reported CL morbidity data in Mt. Elgon, Bungoma County, was in 1993, recent studies indicate presence of CL cases thus transmission. To improve CL control measures, we investigated sand fly vector abundance, diversity and blood feeding preference in Mt. Elgon region, Western Kenya in February 2020. Sand flies were trapped using CDC light traps. The flies were dissected for

morphological species identification using the taxonomic keys and PCR analysis of the cytochrome c oxidase subunit 1 (*Cox1*) gene. Midguts of engorged females were separated for blood meal analysis to determine sand fly feeding preference. Sand fly blood meal sources were identified by PCR analysis of the vertebrate cytochrome b (*Cyt b*) gene followed by high-resolution melt (HRM) analysis. 271 sand flies were sampled where 93.3% (n=253) were *Phlebotomus pedifer, Sergentomyia africana* 4% (n=10), *S antenatus* 1.5% (n=4), *S. adlerai* 0.4% (n=1), *S. bedfordi* 0.8% (n=2) and *S schwetzi* 0.4% (n=1). Out of the 271 sand flies, 15% (n=41) were engorged. Host preference analysis revealed exclusive and multiple feeding behaviour, with the majority of the sandflies feeding exclusively on humans. Mixed feeding was mainly between humans and rats, humans and hyraxes and between livestock (cow) and humans. Our findings suggest that *Ph. Pedifer*, a vector for *Leishmania aethiopica* in south-western Ethiopia, is the predominant sand fly species in the Mt Elgon region. Analysis of sand fly blood meal sources revealed that *Ph. pedifer* does not feed exclusively on humans but also other vertebrate hosts, suggesting the possibility of zoonotic transmission of CL in the area. Further studies are needed to determine the reservoir hosts and vector breeding habitats for effective CL control in the region.

ABS-595

Entomologic surveillance of yellow fever and dengue in Northern Kenya

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Major outbreaks of arboviral diseases such as dengue and yellow fever continue to be witnessed in East Africa with threats of cross border transmission. There is poor understanding of the transmission ecology of these diseases which limits our ability to accurately assess risk and spread of these diseases. Also, inaccurate diagnosis affects estimates of exposure levels in humans. As part of surveillance efforts, we have examined the entomologic associated risk factors for these infections in two ecologies Turkana and West Pokot counties in northern Kenya. These areas border Uganda and Ethiopia which continue to experience increased outbreaks of these diseases, raising the possibility of spillover. Specifically, we describe the bionomic traits of potential vectors including abundance, blood feeding trends, and vector competence in transmitting the causative viruses of these diseases and association with mosquito genetics. Adult mosquitoes were sampled using CO_2-baited BG sentinel traps at three time points during the rainy seasons from the two counties. Blood fed specimens were processed targeting 12S rRNA fragment, to identify host blood meal sources. Cytochrome c Oxidase subunit 1 (*COI*) gene was used to determine the genetic variability of *Ae. aegypti* populations collected from the two counties, and their susceptibility for DENV-2 was determined. The study confirmed the presence of *Ae. aegypti* (77.3%), *Ae. vittatus* (11.4%), *Ae. metallicus* (10.2%) and *Ae. unilineatus* (1.1%) in the region. Shannon diversity index showed significant differences across sampling periods ($p < 0.0001$). The *Stegomyia* species exhibited zoophagic tendency with the mosquitoes mainly feeding on rock hyraxes (79%), goats (9%), cattle and humans (each 4%). The study also confirms the presence of both subspecies of *Ae. aegypti* (domestic and forest) in the northern region and the difference in their susceptibility to dengue-2 virus varied significantly. This study provides useful baseline on the *Aedes* mosquito fauna inhabiting this ecology. The findings suggest a low risk of YF and dengue in West Pokot and Turkana counties, nonetheless, underscoring the need for continued monitoring of the border region to enable appropriate and timely intervention by public health authorities.

ABS-562

Entomological investigation of confirmed cases of yellow fever in Pointe-Noire, Congo

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Introduction: In November 2021, two positive cases of yellow fever were reported in the city of Pointe-Noire, Republic of Congo. In order to assess the extent of viral circulation, the risk to the local population and to prepare a response to yellow fever, an entomological investigation was conducted in this city.

Methods: The entomological investigation conducted in March 2022 in Pointe-Noire was carried out through larval surveys and calculation of entomological indices, collection of residual morning fauna, capture of aggressive fauna and installation of nesting traps.

Results: The entomological investigation showed that the larval breeding sites were mainly made up of drums (25.32%), cut drums (10.4%), buckets (22.7%), tires (19.5%), flower pots (7.1%), barrels (6.5%) and the others less than 2% each.

The calculated stegomyian indices were 61% container index, 87% house index and 216% Breteau index.

Larvae collected from these lodges were reared to adulthood. After the emergence of adults, three species were identified with a strong representation of *Aedes albopictus* (65.80%) followed by *Culex quinquefasciatus* (27.08%) and finally *Aedes aegypti* (7.13%).

Concerning the collection of adult culicids, 338 adults were collected in and around the houses. Four species were identified: (76%) *Culex quinquefasciatus*, (22.5%) *Aedes aegypti*, (1.2%) *Aedes albopictus* and (0.3%) *Anopheles gambiae*.

The species identified after the emergence of eggs collected from the ovipositor traps consisted of (74.67%) *Aedes albopictus* and (25.33%) *Aedes aegypti*.

Discussion: These results show that the yellow fever vector in urban areas is present and that the stegomyian indices are high enough to promote the spread of the yellow fever epidemic. The deterioration of the living environment has as a corollary the creation of breeding grounds favourable to the development of *Aedes aegypti*.

Thus, urgent measures to clean this area of potential mosquito sites are strongly recommended.

Keywords: Yellow fever; urban vectors; stegomyces Congo

ABS-657

Mass production of a non-gene-drive genetically modified sterile male mosquito Ac(DSM)2 colony in the insectary in Mali

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Background: The Ac(DSM)2 strain was obtained by introgression; crossing transgenic *Anopheles gambiae* females (Ag(DSM)2) imported from the Target Malaria laboratory in Terni, Italy, with local *An coluzzii* males from Mali. Due to nature of transgene (sterility of males carrying transgene) backcrossing transgenic females with non-transgenic males must be sustained requiring labour intensive transgenic and sex sorting process every generation. Mass production was conducted to gain

experience in increasing the size of the Ag(DSM)2 colonies in order to simulate the productions required for potential field evaluation. Planning involved the development of a detailed augmentation plan specific to the insectary, taking into account the unique characteristics of maintaining the Ac(DSM)2 colony and resources available in terms of labour, space and equipment.

Methods: A target was set to increase the colony to a size capable of producing approximately 20,000 Ac(DSM)2 pupae in a single cohort of the Ac(DSM)2 colony. It was estimated that the colony would require between 3 and 4 consecutive generations of expansion to meet this target. The augmentation exercise was implemented as planned by establishing 2, 4, 6 and 10 cages in 4 consecutive generations. Detailed rearing metric data was collected including fecundity, egg hatch, larval and pupal survival. This enabled estimation of maximum colony expansion rate had all eggs been maintained through to adult each generation.

Results: The expansion rate of the colony was higher than expected and the target production was achieved after the third generation. Maximum colony expansion rate of 4.77 (SEM = 0.96, n = 3) was estimated, assuming a single gonotrophic cycle (blood feed).

Conclusion: This study provided valuable data and experience for Ac(DSM)2 colony expansion in terms of biological characteristics (fecundity, larval survival, etc.) and resources (labour, space, equipment, etc.) required.

Keywords: augmentation, genetically modified mosquito, capacity building

ABS-725

Self-Limiting Mosquitoes: A New Tool Against the Invasive Malaria Vector, *Anopheles stephensi*

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The self-limiting genetic platform is a target-specific, biological solution to control pest insects, including mosquito disease vectors. Self-limiting mosquitoes carry a gene that prevents survival of female offspring, enabling highly flexible modes of deployment – including just-add-water egg release devices – and offers targeted suppression of the treated vector population. This technology has now been applied to a key vector of malaria and has significant implications for eradication efforts in key regions globally. *Anopheles stephensi*, a long-standing and primary vector of malaria in South Asia and the Middle East, has - since 2012 - posed a new public health threat to the African continent. *An. stephensi* is well-adapted to urban environments and since its arrival in the horn of Africa, it has caused a significant increase in malaria cases in and around Djibouti City. In 2018, more than 10% of Djibouti's population was estimated to have been infected. *An. stephensi* has now reached Ethiopia, Sudan and Somalia, and as it spreads further it threatens to cause devastating outbreaks in major cities across the continent. This mosquito readily bites outdoors, and is difficult to control by conventional methods, partly because of widespread resistance to insecticides. Here we describe the development of new self-limiting strains of this invasive vector species and describe plans to conduct the first pilot releases globally to validate the approach for prevention of malaria. This marks a new chapter in the application of the self-limiting platform, with the potential to provide an effective and sustainable means of reducing malaria-transmitting mosquitoes in the communities most under threat.

ABS-747

Leveraging on bioinformatics on mitochondrial gene sequences of domestic and slyvatic *aedes aegypti* for information on dengue

David Mburu

Background: Genotyping has shed more light into mosquito genetics and improved our understanding of vector-borne disease transmission cycles. For instance, outside of Africa, *Aedes aegypti,* the main vector of arboviruses prefers humans for a blood meal, resting and breeding in close association with human settlements. However, in the African ecology, domestic, *Ae.*

aegypti aegypti and sylvatic (forest), *Ae. aegypti formosus* lineages occur. The African, *Ae. aegypti* populations have been found to exhibit divergence in typically conserved mitochondrial cytochrome *c* oxidase subunit I (*COI*) genes. Further divergence has been reported for traits such as developmental time, foraging, oviposition, and resting behaviour. The study tested the hypothesis that mitochondrial variation in *Ae. aegypti (*both in the domestic and sylvatic) populations correlates with dengue outbreak occurrence patterns. Specifically, we compared the mitochondrial gene sequences of sylvatic and domestic strains of *Ae. aegypti* in East Africa to strictly anthropophilic strains in continents outside of Africa.

Materials and Methods: Both vectors were sampled from selected sites in Kenya *viz:* Kilifi and Kwale counties in coastal Kenya (endemic for dengue), Maasai Mara National Reserve in Narok County (sylvatic), and Kakamega, Bungoma, and Busia counties in western Kenya (non-dengue endemic region). The mitochondrial cytochrome *c* oxidase subunits I and II (*COI, COII*), and cytochrome *b* (*cyt b*) among gene sequences of domestic and sylvatic, *Ae. aegypti* populations generated by Sanger sequencing together with those that were available in GenBank and the Barcode of Life Data (BOLD) portal we utilized. The fragment sizes of the generated *Ae. aegypti* sequences were ~1100 bp, 700 bp, and ~350 bp for *COI, COII*, and *cyt b,* respectively. These sequences were analysed by maximum likelihood phylogenetic reconstruction. The *COI* gene sequences from sylvatic and domestic settings resolved *Ae. aegypti* into three lineages using bioinformatic tools for cluster and phylogenetic analyses.

Results and Discussion: The majority of the *COI* sequences of samples from Bungoma, Busia, and Kakamega counties clustered with referenced sylvatic rather than domestic strains, suggesting the occurrence of the forest form in the domestic sites in these counties in Kenya. Most *COI* sequences of samples from Kilifi, Narok, and Kwale counties clustered with referenced domestic than sylvatic strains.

Conclusion: Since the domestic form is a better vector of dengue virus than the forest form, these findings, coupled with factors such as variation in temperature, humidity and rainfall, may explain recurrence of dengue outbreaks at the coast of Kenya.

Key words: *Ae. aegypti aegypti*, *Ae. aegypti formosus*, Mitochondrial cytochrome *c* and *b* genes, dengue, *Bioinformatics*

ABS-719

Participatory development of practical, affordable, insecticide-treated mosquito proofing for a range of housing designs in rural southern Tanzania

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Background: Insecticidal mosquito-proof netting screens could combine the best features of insecticide treated nets (ITNs) and indoor residual spraying (IRS), and also overcome the most important limitations of these two methods. This study engaged with members of a rural Tanzanian community in developing and evaluating simple, affordable and scalable procedures for installing readily available screening materials on eave gaps and windows of their own houses and then treating those screens with a widely used IRS formulation of the organophosphate insecticide pirimiphos-methyl (PM).

Methods: A cohort of 54 households were consented, following which the structural features and occupant demographics of their houses were surveyed. Indoor mosquito densities were surveyed longitudinally for nine months, counting both before and after a participatory house modification, and screening was done using locally available materials. Each house was randomly assigned to one of three study arms: (1) No screens installed (negative control), (2) untreated screens installed, and (3) screened installed and then those screens treated with PM. The longevity of activity of the insecticide applied to these screens was assessed using standard WHO cone assays.

Results: When compared to unscreened houses, screened houses, regardless of their treatment status, almost entirely excluded *Anopheles arabiensis* (Relative reduction (RR) ≥ 96%, P << 0.0001), but were far less effective against *Culex quinquefasciatus*, a non-malaria vector with significant biting nuisance (RR ≤ 46%, P <<0.0001). While the PM treatment of these netting screens reduced indoor densities of *Cx. quinquefasciatus* by only 24%, *An. arabiensis* was reduced by 63% compared to house fitted with untreated screen. Treated screens retained residual efficacy (89% mortality of susceptible insectary mosquitoes following a 30-minute exposure) eight months after treatment.

Conclusions: Participatory approaches to mosquito proofing houses may well be acceptable and effective, and installed screens may be suitable targets for treatment with residual insecticides.

Key Words: *Anopheles*, malaria, vector control, housing, participatory, ventilation, eaves and windows proofing, treated house screens.

ABS-721

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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Background & Objective: 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, and can accurately predict the age, species, blood-meal sources, and pathogen infections in *Anopheles* and *Aedes* mosquitoes. Since the techniques are still in early-stage development, there are no standardized procedures for handling mosquito samples. We, therefore, assessed the effects of different preservation methods and storage duration on the performance of mid-infrared spectroscopy for age-grading malaria-transmitting mosquitoes.

Materials & Method: Laboratory-reared *Anopheles arabiensis* (N=3,681) were collected as 5 or 17-day olds and killed with ethanol then preserved using either silica desiccant at 5**°C**, freezing at -20°C, or absolute ethanol at room temperatures. 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 on the mid-infrared wavelengths. Supervised machine learning classifiers were trained with the infrared spectra, and used to predict the mosquito ages.

Results & Discussion: The best performing classifier for age-grading mosquitoes were 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 samples being tested (test samples) were preserved the same way or stored for equal durations. However, when the test and training samples were handled differently, the classification accuracies declined significantly.

Conclusions & Recommendation: 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 the same way and stored for the same durations. Protocols for infrared-based entomological studies should therefore emphasize standardized sample-handling procedures; and possibly, additional statistical procedures such as transfer learning for greater accuracy.

ABS-525

Scalable camera traps for measuring attractive targeted sugar baits efficacy to malaria and dengue mosquitoes

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Background: Attractive targeted sugar baits (ATSB) is one of the new promising intervention that can work synergistically with existing vector control tools. However, there is a need for evaluating the best ATSB attractant to provide reproducible and quantitative information on the level of attractiveness of ATSBs. To do so, we customized camera traps for close-up imaging and integrated them in to rugged ATSB monitoring station for day and night time recording of mosquito landing on baits.

Methods: The camera monitoring stations, were evaluated, in a semi-field system and next in a small-scale field trial in Tanzania. In the semi-field system, 2m x 5m x 2m net chambers were set either with ATSB with attractant, a blank ATSB or 20% sucrose and the camera monitoring stations set-up to record landing numbers. Next, 200 mosquitoes (100 males and 100 females of *An. arabiensis*, *An. funestus* and *Aedes*) were released into each chamber and allowed to seek a sugar-meal for 72h, with the camera recorded images of mosquitoes landing on the ATSB at 1min interval.

Results: Under, the local environmental conditions of the study, the mean number of mosquitoes landing on ATSB over 72h were higher in the ATSB with attractant compared to ATSB blank (Mean 8, SD2.7 and Mean 0.25, SD0.04 respectively). When ATSB were compared with the 20% sucrose, the landing success of mosquitoes were higher in the sucrose (Mean 39, SD8 and Mean 12, SD3 respectively). Mosquitoes also stayed longer on sucrose than on ATSB station. The field trials generated comparable data.

Conclusions: The use camera trap recording still images of mosquitoes landing on ATSBs provides a robust reproducible and quantitative information on the attractiveness and efficacy of different ATSB and similar devices under different environmental conditions. Therefore, camera traps are powerful tools for improving the ATSB technology.

ABS-766

The impact of Larviciding as a supplementary tool for malaria vector control in Rufiji, Tanzania

Gerald Kiwelu

Background: LLIN's and IRS have contributed significantly to the reduction of malaria over the past decades, however they may not be sufficient for malaria elimination due behavioral change of mosquitoes. This brought forth an argument that these tools have lost their effectiveness and will not be able to eliminate malaria unless other interventions are added to supplement them. Larviciding is one of them. WHO recommends larviciding with a reservation that it should be conducted in an area where LLIN's and IRS have attained optimal coverage, but Malaria transmission still exists. National Malaria Control Program (NMCP) in Tanzania in line with WHO has indorsed the use of larviciding in many areas in the country through a programme called TOWARD. The plan is to implement larviciding for four years in five regions in Tanzania and the program has already started.

Methods and Results: The pilot project was implemented in Rufiji, southern-eastern of Tanzania from November 2020 to October 2021, the study took place in two wards and included 19 villages. Coverage of LLIN's and IRS was 80%-85%. Malaria vectors were collected indoors using CDC-light traps, clay ports were used for both indoor and outdoor collection. Biolarvicides,

Bacillus thuringiensis israelensis (Bti) and Bacillus sphaericus (Bs), were applied to waterbodies surrounding human habitats. We fitted liner model to determine the effectiveness of larviciding and the result shows there is significant decline in average number of mosquitos with time (p-value < 0.001, CI= 0.67, 0.89) which is 88.2% reduction in average mosquito due to larviciding management. Through treatment of the larvicides the mortality impact observed for over nine months for immature anopheles was 87% and 92% for larvae and pupae respectively, where this indicates the approximation of 100% impact in the usage over a long period of time. The mortality impact of larviciding to the adult mosquito is said to be 98% to the Anopheles Gambiae which is the most dangerous species in the Rufiji area.

Conclusion: Biolarviciding received high acceptance from both the government and community members in southern eastern Tanzania due to its ability to target immature mosquitoes and reduce the rate of fecundity, which makes it an efficient tool to be adopted as a supplementary measure for malaria vector control.

ABS-474

Enhanced procedures for mosquito identification by MALDI-TOF MS

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Background. The increasing interest in arthropod identification by MALDI-TOF MS, conducted to the emergence of heterogenic procedures, including sample preparation and selection of body part to use. The absence of consensual strategy hampers direct inter-studies comparisons and brings confusion for new users. Establishing optimized procedures and standardized protocols for mosquito identification by MALDI-TOF MS becomes compulsory, allowing notably, the sharing of reference MS database. **Objective:** Then, here, we propose to assess the optimal conditions for mosquito identification using MALDI-TOF MS profiling. **Methods:** Three homogenization methods, two manuals and one automatic, applied on three distinct body parts, legs, thorax and head, were evaluated on two mosquito laboratory strains, *Anopheles coluzzii* and *Aedes aegypti*. MS profiles reproducibility, identification rate with relevant scores and the suitable procedures for high-throughput analyses were the main criteria for establishing optimized guidelines. Additionally, the consequences of blood feeding and geographical origin were evaluated using both laboratory strain and field collected mosquitoes. **Results:** The three body parts exhibited relevant score values for mosquito identification using MALDI-TOF MS profiling, however, thorax and legs appeared the most suitable, independently of homogenization methods or species. Although manual grindings displayed high identification performance for the three body parts, this homogenization mode is not adapted to process large number of samples. Then, the automatic procedure was selected as reference homogenization method. Blood feeding status did not hamper the identification of mosquito species, despite the presence of MS peaks from blood origin in MS profiles from three body parts tested on both species. Finally, a significant improvement of identification scores was obtained for specimens from field origins, when MS spectra of counter species from the same geographical area were added to the database.

Conclusion: The present work established guidelines concerning the selection of mosquito anatomic part and modality of sample preparation (*eg*, homogenization) for future specimen identification by MALDI-TOF MS profiling. These standardized operational protocols could be used as references for the creation of an international MS database.

Keys words: Mosquitoes identification, MALDI-TOF MS, optimization, standardization

ABS-636

Development of optimal handling, packaging and transport conditions of radiation-sterilised *Anopheles arabiensis* (Diptera: Culicidae) adult male mosquitoes earmarked for pilot sterile insect technique release in South Africa

Thambo Rine

With malaria still a major global disease burden, South Africa has been investigating the sterile insect technique (SIT) as a potential complementary malaria vector control strategy, particularly against one of the major vectors, *Anopheles arabiensis* (Diptera: Culicidae). The SIT necessitates the laboratory production and field release of a large number of high-quality, sterile males that can mate with the wild population and cause infertility, thereby reducing population size. Several technical aspects of the technology have already been optimized in preparation for a small-scale pilot trial. One of the most critical elements that has yet to be addressed is the development of optimal handling, packaging, and transport conditions for sex-separated, radiation-sterilised male mosquitoes to the release site with minimal impact on survival and quality. To date, most pilot projects around the world have used low temperatures to immobilize sterile males and package them in low density (compacted) containers until their manual ground release in the field. The current study aims to investigate the effects of different low temperatures, exposure durations, and compaction on the resulting quality of male adults in terms of physiological and reproductive fitness. Preliminary results show that male mosquitoes can maintain a high level of quality under optimal chilling and compacted conditions, implying that SIT operational strategies for mosquito control could be simplified under these conditions. These studies, however, are ongoing and will necessitate additional research into the effect of both simulated and actual transport conditions on male reproductive fitness.

ABS-652

Genetic structuration of Aedes aegypti populations of Burkina Faso is driven by climatic factors

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Arboviruses case numbers and outbreaks are on the rise in West Africa, with Burkina Faso recent dengue outbreaks as example. The lack of information on *Aedes aegypti* populations has impaired an efficient response to these dengue outbreaks. Historically, *Aedes aegypti* is recognized to exist in two morphological forms based on white scales patterns of the first tergite, but that still lacks genetic support. *Aedes aegypti* eggs were collected in 12 localities of Burkina Faso encompassing the three ecoclimatic zones of the country and adults from these eggs were characterized morphologically, and genetically based on 12 microsatellites.

Morphological identification showed continuous white scales pattern inconsistent with the aegypti/formosus dichotomic subdivision. The global analysis of genetic variations in *Aedes aegypti* populations using 12 microsatellites diversity did not reveal structure in the populations of *Aedes aegypti*, which is much more consistent with a single species of *Aedes aegypti*. However DAPC and PCA analysis showed clear population structuration based on rainfall isohyets, and locality longitude. The structuration of the populations based on morphotype is not as clearer. It is relevant to hypothesize that global warming may accelerate the genetic differentiation of *Aedes aegypti* populations, but the consequences on arboviruses epidemiology in West Africa remain to be investigated.

ABS-713

Knowledge and use of alternative electric vector control tools

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To date, no single vector control tool can ensure effective protection. A combination of methods is needed. Electric" tools have recently been introduced into vector control in sub-Saharan Africa. These include electric snowshoes, UV lamps, electric insecticide diffusers and acoustic night lights. The objective of this study is to assess the level of knowledge and use of alternative electric mosquito control tools in two main cities of Burkina Faso: Ouagadougou and Bobo Dioulasso.

A questionnaire was implemented in Googleform. Data was collected using a mixed-method approach. Part of the data was collected through WhatsApp sharing and the other part was collected by fieldworkers interviewing the population. A questionnaire was sent to the health worker via a WhatsApp group of PNLP Burkina Faso. Continuous monitoring during data collection ensured the quality of the data and the results generated by Googleform.

The survey interviewed 287 people. 62% of respondents were in Ouagadougou and 38% in Bobo-Dioulasso. 47.7% were women. The results showed that 63% of the surveyed population knew at least one of the above-mentioned tools. 82% know the acoustic nightlight, 67% the UV lamps and the electric diffusers and 37% the racket. In general, 24% of the surveyed population uses one of the tools. The diffuser is the most used tool (43%), followed by the query (35%), then the lamps (16%) and finally the acoustic nightlight (5%). The main obstacles to their use are their ignorance, their high cost and their unavailability on the market.

Better dissemination and awareness-raising campaigns will help to improve the rate of use and thus improve vector control.

ABS-656

Need, magnitude and opportunities for housing improvement for malaria control in southern Tanzania

Background: Malaria disproportionately affects poor and rural communities, where poor housing is a common factor. Poor housing is associated with the increased burden and severity of malaria. Despite this knowledge, it is rarely included in the malaria control toolbox due to limited evidence if the magnitude of its needs and available opportunities. To fill this knowledge gap, this study assessed the need, magnitude and opportunities for housing improvement for malaria control in malaria endemic settings southern Tanzania.

Methods: A cross sectional study design was conducted in 19 villages in four councils in the Kilombero Valley in southern Tanzania. A structured survey was conducted with representatives of 802 households about equally distributed within the four councils, to assess community members' perceptions of housing improvement as malaria control tool.

Results: Of the 802 households recruited, 79.8% (n=640),19.1% (n=153) and 1.1%(n=9) have metal, thatched and other roofs respectively, 83.5% (n=670) have brick walls, 13.6% (n=109) mud walls and 2.9%(n=23) other materials. 92.3% of the household representatives surveyed reported that their houses needed modifications to provide protection against mosquitoes. The major needs for housing modifications expressed included window screening (91.1%, n= 450), add wood cover door screening (41.6%, n=112), closing eaves (16.2%, n=99), plaster or repair holes on the walls (79.6%, n=249) and new roofs (18.9%, n=44).

Conclusion: A majority of the households surveyed need modest modifications, including screening windows, doors and eaves. This knowledge is critical in informing the amount of investment needed to protect communities in malaria endemic settings against malaria-transmitting mosquitoes.

ABS-609

Operational challenges to measuring the entomological impact of new nets in Mozambique

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Background: in order to estimate the impact on malaria transmission of dual active ingredient insecticide treated nets (itns), compared to standard pyrethroid-only itns, the new nets project is supporting pilot evaluations of different net types in two settings in mozambique.

Description: Expanded mosquito surveillance was implemented in order to assess the impact of different itn types on key entomological indicators, including vector densities and biting patterns, while also characterizing the corresponding insecticide resistance profiles. The primary collection method for monitoring vector densities and biting behaviors was the human landing collection (hlc). Supplementary collection methods to support the resistance testing included larval collections and adult resting collections using prokopack aspiration. The primary hlc collections were conducted across 6 study districts. In each district, paired indoor and outdoor collections were performed on consecutive nights at three sentinel houses from three sentinel villages, every other month for 24 months. In many of these districts, no mosquito surveillance activities had been performed prior to the new nets project study.

Lessons learned: two key challenges that have been identified include (1) the diversity of *anopheles* species encountered – at least 9 total species groups based on morphological identification, with molecular species identification and sporozoite analyses pending, and (2) sampling method limitations – given the available resources and the number of rural, hard to reach sentinel sites required, the number of collection nights was limited and often sampled few anopheline mosquitoes, likely limiting the power needed to draw definitive statistical conclusions about differences across districts.

Conclusions/next steps: Mozambique has diverse ecologies and a rich *anopheles* mosquito diversity. While current mosquito sampling approaches may not be robust enough to provide compelling evidence of intervention impact, data generated here will help to identify the primary vectors, and their insecticide susceptibility profiles, across a range of malaria endemic settings in Mozambique.

ABS-680

Conducting the first release of sterilised males of an african malaria vector

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Background: The sterile insect technique (sit) is a form of birth control in which wild populations are bombarded with laboratory-reared, sterilised males. These then compete with their wild counterparts to induce production of sterile progeny within the population. In the instance of disease vectors, such as *anopheles* mosquitoes, this can decrease disease transmission and incidence.

Description: In 2021, mass production of *anopheles arabiensis* mosquitoes began with the intention of a pilot sit release in mamfene, kwazulu natal – a malaria-endemic study site. This coincided with preparations including community engagement in the target area as well as monthly surveillance efforts and collection of preliminary data such as population fertility and fecundity. The releases, scheduled for november 2021, would include 4 consecutive weeks of releasing 25,000 marked male mosquitoes per week. This would be followed by daily collection of passive traps placed according to a geographic model. Mosquitoes collected from these traps as well as evening swarms would be observed for species and marking, and their fertility

and fecundity would be assessed. The study site was adjacent to a control site with similar trap placement where which no mosquitoes were released to allow for comparison of induced sterility.

Lessons learned: The mass production of *an. Arabiensis* for such an exercise was a novel endeavour and as such many lessons were learned. Establishing quality control in the production pipeline was vital and some oversights led to inability to conduct sustainable releases. Furthermore, the logistics of the release protocol required modification as it proved to be more difficult to coordinate than was anticipated.

Conclusions: While a single release of sterile mosquitoes was achieved, we were unable to sustain production for the consecutive weekly releases. However, based on the experience, we determined that with some time to make the necessary adjustments, the releases would be feasible in may 2022.

ABS-690

Research Capacity Monitoring and Evaluation System: A robust dynamic web-based application for measuring the impact of research capacity strengthening initiatives

Janice Maige

Developing national research capacity is considered an essential tool in increasing socio-economic development and population health. To support this, global development partners invest large amounts of funding yearly to support capacity building initiatives in Low- and Middle-income countries (LMIC's). However, the lack of generalizable monitoring and evaluation system poses a drawback to assess and/or initiate timely and impactful capacity building initiatives. Hence, there is a need to establish a dynamic tool to monitor and evaluate the impact of such initiatives based on well-established indicators. Here, we have developed a research capacity monitoring and evaluation web-based application (ReCAMES) that can be used across several research capacity strengthening initiatives. The evaluation metrics used by ReCAMES are given by points and grouped across the three indicator groups, i.e., Outcome, Output, and Impact. The indicators being skills attained and their application, their collaboration with other initiatives and/or stakeholders, knowledge translation done and recognition received from other institutions/parties. A graphical presentation of the progress achieved for each indicator is displayed on the dashboard for all participating individuals. An assessment of the impact of the program is also calculated and displayed on the system based on the same identified indicators. In addition, the system allows the principal investigator to provide access to all required stakeholders on different access levels to ensure data security. ReCAMES provides a dynamic framework with the ability to measure impact for research capacity strengthening initiatives performed in different settings. It can be used by diverse research capacity strengthening initiatives to assess their impact in the short and long term. ReCAMES can be used by a wide range of stakeholders such as research institutions, universities, funders, program evaluators and implementing partners.

ABS-746

Assessment of the efficacy of eave-ribbons treated with a residual insecticide, pirimiphos-methyl for controlling malaria and dengue fever vectors.

Ruth Shirima

Mosquito resistance to pyrethroids limits the effectiveness of insecticide treated nets and indoor residual spraying (IRS). Although other classes of insecticides are still effective for IRS, this technology remains costly in terms of logistics and operations. Therefore, there is a need to simplify residual spraying without minimizing its effectiveness to control malaria and dengue vectors and complement the existing tools. This study investigates the use of eave ribbons treated with a residual insecticide, pirimiphos-methyl, as an alternative to IRS for malaria and dengue vector control. Eave ribbons treated with residual insecticides could potentially be used as an alternative to IRS. This technology might be cost-effective and easy to operate compared to IRS.

ABS-504

Collaborating with communities in resolving complaints regarding research on novel genetic approach for Malaria Vector. The case for Uganda

Emmanuel Magala, Jude Bigirwenkya, Richard R. Linga, Jonathan Kayondo

Research in novel approaches to reduce malaria involving genetic modification has gained significant attention within country and globally. World Health Organisation (WHO) has given a green light that genetically modified mosquitoes should be evaluated as a potential tool to fight malaria. A co-development approach, which recognizes the importance of knowledge engagement with scientists and publics in countries where the tool will be tested or implemented, is fundamental to all facets of research on Genetically Modified Mosquitoes (GMMs). Communities must be given the opportunity to interact with the research team and to shape the process of engagement and authorization of field research[1].

Target Malaria aims to develop and share a novel accessible, sustainable, and cost-effective gene drive technology for malaria control espouses the values of co-development, accountability and openness. The project is built on three pillars of scientific excellence, stakeholder engagement together with regulatory compliance for the successful development of the research. The project has dedicated stakeholder engagement teams working in communities to share information, consult, obtain agreement, get feedback, and gather concerns on the research. A stepwise approach for both the research and engagements takes into consideration the need to provide evidence based information of one phase before proceeding to the next. Uganda a collaborating partner of the project is in the early phases of the research and is engaging communities to build the knowledge of the research activities being undertaken. To this end, the project working together with communities, has put in place a mechanism to receive and process grievances or complaints that members of the public may have against the project's work.

Project activities in the specialised laboratory -Arthropod Containment Level 2 (ACL2) could impact the community hence the project has collaborated with stakeholders living around the insectary to establish a grievance management mechanism. The grievance committee aims to understand and address any complaints or grievances that arise due to project's activities. The grievance mechanism also enables complaints get resolved in an efficient and timely manner. Complaints raised from the community living around the specialised laboratory are addressed with the community leadership participation through the grievance committees.

The exploration of how this has worked in Uganda could provide insights on its possible replication elsewhere and foster collaboration between research projects and communities.

ABS-665

Effects of agricultural pesticides on the susceptibility and fitness of malaria vectors in rural south-eastern Tanzania

Naomi Urio

Background: Agricultural pesticides may exert strong selection pressures on malaria vectors during the aquatic life stages and may contribute to resistance in adult mosquitoes. This could reduce the performance of key vector control interventions such as indoor-residual spraying and insecticide-treated nets. The aim of this study was to investigate effects of agrochemicals on susceptibility and fitness of the malaria vectors, across farming areas in Tanzania.

Methods: An exploratory mixed-methods study was conducted to assess pesticide use in four villages (V1-V4) in south-eastern Tanzania. *An. gambiae s.l* larvae were collected from agricultural fields in the same villages and their emergent adults examined for insecticide susceptibility, egg-laying, and wing lengths (as proxy for body size). These tests were repeated using two groups of laboratory-reared *An. arabiensis*, one of which was pre-exposed for 48hrs to sub-lethal aquatic doses of agricultural pesticides found in the villages.

Results: Farmers lacked awareness on the linkages between public health and agriculture sectors but were interested in being more informed. Agrochemicals usage was reported as extensive in V1, V2 & V3 but minimal in V4. Similarly, mosquitoes

from V1-V3 but not V4 were resistant to pyrethroids, and either pirimiphos-methyl, bendiocarb or both. Adding the synergist, piperonyl butoxide, restored potency of the pyrethroids. Pre-exposure of laboratory-reared mosquitoes to pesticides during aquatic stages did not affect insecticide susceptibility in emergent adults of the same filial generation. There was also no effect on fecundity, except after pre-exposure to organophosphates, which were associated with fewer eggs and smaller mosquitoes. Wild mosquitoes were smaller than laboratory-reared ones, but fecundity was similar.

Conclusions: Safeguarding the potential of insecticide-based interventions requires improved understanding of how agricultural pesticides influence important life-cycle processes and transmission potential of mosquito vectors. In this study, susceptibility of mosquitoes to public health insecticides was lower in villages reporting frequent use of pesticides compared to villages with little or no pesticide use. Variations in the fitness parameters, fecundity and wing length, marginally reflected the differences in exposure to agrochemicals, and should be investigated further. Pesticide use may exert additional life-cycle constraints on mosquito vectors, but this likely occurs after multi-generational exposures.

Keywords: *Anopheles arabiensis*, insecticide susceptibility/resistance, agricultural pesticides, fecundity, malaria, focus group discussion and Ifakara Health Institute.

ABS-503

Native fungi *Metarhizium* and their virulence against malaria mosquitoes in Burkina Faso

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Background: Malaria control efforts are under threat today due to widespread insecticide resistance in mosquitoes populations. It is therefore necessary to develop and implement new complementary vector control strategies. The use of wild entomopathogenic fungi is a promising alternative way. Indeed, entomopathogenic fungi are effective in controlling *Anopheles* populations and eco-friendly. We hypothesize that the virulence of the fungus might be positively correlated with the adhesion of the fungus to the mosquito cuticle, although this has not yet been confirmed. This study aimed to isolate strains of wild fungi in Burkina Faso to test their killing efficiency and assess the link between adhesion and virulence of these fungi.

Materials and method: Plant and insect root collections were carried out over a period of two months (October and December 2019) in the village of Soumousso (11 ° 04'N, 4 ° 03'W). We collected around 1600 species distributed in 201 insects (dead and alive) and 1399 plants (roots and barks). Then we isolated fungi on Petri dishes, prepared the fungal suspensions of 4 strains of *Metarhizium* and infected 3-day old female *Anopheles coluzzi* mosquitoes with two different concentrations (10^6 and 10^8 spores / mL). Survival of mosquitoes was measured for 14 days for to quantify fungal killing efficiency. Additionally, to assess adhesion of the different fungal strains on mosquito cuticle, we quantified fungal growth on mosquito after 1 and 24 hours.

Results and Discussion: All four strains significant increased mortality of the mosquitoes compared to the control at both concentrations (Cox proportional hazards model, $p < 2.2^{-16}$). Additionally, at both concentrations all strains were observed to adhered to the mosquito cuticle after 24 hours, although while at 10^8 spores / mL all mosquito were infected, at 10^6 spores / mL fungal adherence was present only in a proportion of females (10-30% of mosquitoes). One strain, which was also the most virulent strain, was the only strain observed to adhere to the mosquito cuticle already after 1 hour upon infection (at 10^8 spores / mL), suggesting that killing efficiency and adhesion rate might be associated.

Conclusion: These results show that native *Metarhizium spp.* fungi are a promising tool for controlling malaria vectors. Some strains were effective enough to adhere to the mosquito cuticle at low concentration and showed high virulence. Further studies

should screen additional native strains to establish the link between adhesion and virulence to ultimately select fungi with high virulence that can be implemented in the field.

ABS-517

Could the African malaria mosquito *Anopheles gambiae* be a pollinator?

Gyimah

Understanding species interaction network structure provides insight into the role and function individual species play in the stability and function of the ecosystem. The loss of key species from communities can lead to extinction cascades, thus threatening the entire ecosystem.

Apart from transmitting disease parasites, *Anopheles gambiae* visit plants for sugar meals and may therefore contribute to pollination. Since many malaria control efforts focus on suppressing *An. gambiae* population, it is vital to investigate its role, if any, in pollination. These public health efforts are contrasted against the global challenge of pollinator decline and decreasing food security. Here we employ a community ecology plant-pollinator network approach to investigate the role of An. *gambiae* in pollination, and whether its suppression may affect the reproductive success of any plant in the study sites. Insects visiting flowers were collected along defined transects within four vegetation land-use types (grassland, farm, built-up, and fallow/forest) at two rural communities (Abutia Amegame and Mafi Agorve). Samples were collected between 5:00 am and 9:00 pm. Data collection began in July 2021 and will continue until December 2022. We assume all insect flower visitors to be pollinators and have thus far collected over 4,000 insects belonging to ~100 insect species, from 30 plant species. We used flower-insect interactions to construct a plant-pollinator network. The role and function of *An. gambiae* were then calculated from the network using centrality metrics (e.g. degree, closeness, and betweenness). Results thus far indicate that *An. gambiae* is a peripheral species in its network, hence, its suppression will likely have no or minimal impact on the reproductive success of plants in the study areas. This study will be the first comprehensive plant-pollinator network study in Tropical West Africa, the second within the Subregion, and the only plant-pollinator network study in Ghana.

ABS-666

Using ecological observations to improve malaria control in areas where *Anopheles funestus* is the dominant vector

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The major malaria vector in sub-Saharan Africa are *Anopheles gambiae s.s., Anopheles arabiensis, Anopheles funestus s.s.,* and *Anopheles coluzzii*. Of these, *An. funestus s.s.* presently dominates in many settings in east and southern Africa. Research on this vector species has been impeded due to difficulties of creating laboratory colonies, and there is limited understanding of its biology in the wild. However, it possesses certain unique attributes and ecological vulnerabilities that could be strategically exploited to greatly reduce malaria transmission in areas where it dominates. This paper examines the major life-history traits of *An. funestus s.s.*, its aquatic and adult ecologies, and its responsiveness to key interventions. It then outlines a plausible strategy for reducing malaria transmission by the vector and sustaining the gains over the medium to long term. To illustrate the

propositions, the article uses data from south-eastern Tanzania where *An. funestus* mediates over 85% of malaria transmission events and is highly resistant to most public health insecticides. Both male and female *An. funestus* rest indoors, and the females frequently feed on humans indoors, although moderate to high degrees of zoophagy can occur in areas with large livestock populations. There are also reports of outdoor-biting by the species, highlighting a broader range of behavioral phenotypes that can be considered when designing new interventions to improve vector control. In comparison to other African malaria vectors, *An. funestus* is distinctive in that it prefers perennial aquatic habitats, such as streams, ponds, swamps, and spring-fed pools. The species is, therefore, well-adapted to sustain its populations even during dry months and can support year-round malaria transmission. Controlling *An. funestus* could therefore be optimized through combinations of species-targeted larval source management and effective insecticide-based strategies targeting adult mosquitoes in human and animal shelters. Such an integrated strategy could potentially result in local elimination of the vector populations, and significantly reduce malaria transmission in areas where the species dominate. For best results, such ecologically targeted programs should be complemented with gradual environmental improvements such as house modification to maintain biting exposure at a bare minimum, and strong community engagements to ensure sustainability.

ABS-679

Distribution and water quality in *Anopheles gambiae* s.l. habitats in the Volta Region of Ghana

Andreas Adwutum

Background: Malaria remains a public health problem in Ghana. Although current vector control interventions have reduced the malaria burden, the disease persists. New interventions are needed to eradicate the disease. However, an effective implementation may require a good understanding of the habitat ecology of *Anopheles* mosquitoes. Physicochemical parameters (e.g. temperature, salinity, conductivity, e.t.c) have a significant influence on the occurrence and larval abundance among mosquito species. This study was conducted to assess the effect of physicochemical parameters on the occurrence of *Anopheles larvae* in potential mosquito habitats.

Methods: The study was conducted in Mamfi Agorve and Abutia Amegame, two rural communities in the Volta region of Ghana. A larval survey was carried out in each community for 12 months. Every month, seven physicochemical parameters were measured in potential mosquito breeding habitats found within a 1 km radius of each of the communities with a water quality meter (YSL multi-parameter). The water bodies were screened for *Anopheles, Culex* and any other aquatic invertebrate.

Results: Out of the 413 measurements conducted within the 12 months, 11.6% were done in *Anopheles* habitats and 17.9% *Culex* habitats. In Abutia Amegame, the mean (+/-SE) temperature was higher in *Anopheles* (27.8° C +/- 0.5) habitats than in habitats that contain other invertebrates. Also, at Mamfi Agorve, conductivity, salinity and total dissolved solids were higher in *Anopheles* habitats than in other invertebrate habitats. However, dissolved oxygen, ammonia and pH were similar in all the three habitat categories.

Conclusion: High salinity and conductivity were significantly associated with the increased occurrence of *Anopheles* larvae. The possible reasons for tolerance to a higher level of physicochemical parameters among *Anopheles* mosquitoes and its ecological implication need to be ascertained.

ABS-708

Mapping of the main mosquito breeding sites in the city of Cotonou in southern Benin

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Background:The city of Cotonou, due to its climate and its position in the coastal plain as a flood zone, generates a wide variety of culicidial breeding grounds. The wide distribution and high abundance of Culicidae fauna is responsible for nuisances and

the transmission of vector-borne diseases such as malaria. A good knowledge of the geographical distribution of the breeding sites of these vectors in time and space is a prerequisite for successful control.

Methods: Field data collection was carried out in 2020 during the alternating period between the long dry season and the short rainy season (February to September). We identified breeding sites, took geographical coordinates of these sites by GPS (Global Positioning System), determined larval densities by the Bruce-Chwatt (1985) squint method. Larvae were collected by depositing ovipositors containing well water in the different neighbourhoods and by larval surveys in gutters, abandoned tyres and cesspools. The larvae and pupae collected were transported alive to the insectarium for further work.

Results:392 mosquito breeding sites were identified. Aedes mosquito). The differences observed between mosquito breeding sites were significant ($P < 0.0001$) 0.05. 218 sites (56%) are temporary, 29% are semi-permanent and 15% are permanent. The differences between the frequency of temporary, semi-permanent and permanent breeding sites are significant ($P < 0.0001$) 0.05.

Conclusion: this study aims to contribute to the development of targeted disease vector control strategies to better control diseases by investigating one of the links in the transmission chain of these species.

Key words : Culicidae fauna, lymphatic filariasis, dengue fever, temporary, semi-permanent, permanent

ABS-567

Effects of salinity on development of a laboratory reared colony of *Anopheles gambiae s.s* mosquitoes from Coastal Kenya

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Background: Saltwater tolerance is important in the epidemiology of mosquito borne diseases. This is especially important in coastal areas where abundance of saline-tolerant mosquitoes is expected to increase as saline water bodies increase due to rising sea levels caused by global warming. Besides *Anopheles merus*, salt tolerance in other malaria vector species present along the Kenyan coast is not well understood. This study was conducted to determine the effect of salinity on development of an insectary reared *An. gambiae s. s* strain from coastal Kenya.

Materials and methods: *An. gambiae s.s* larvae were reared under standard insectary rearing conditions in four types of breeding water: ground water alone, deionized water alone, and ground water and deionized water each mixed with 0.25% (w/v) sodium chloride. We assessed the time taken for larvae to develop into pupae and measured wing length of emerging adults as a proxy for body size.

Results and discussion: Addition sodium chloride into rearing water regardless of the type of water used, significantly reduced time to pupation and resulted in larger sized mosquitoes.

Conclusion: Salt is an important component in development of coastal strains of *An. gambiae s.s* mosquitoes. Within an insectary setting, salt could be incorporated into standard rearing practice to enhance production of these strains. Further studies using wild caught *An. gambiae. s.s* and other malaria vector species present in the region is needed.

ABS-648

The Influence of Subsistence Farming and Fishing on Mosquito Abundance and Malaria Transmission Intensity in Greater Kamuli District, Uganda

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Background and Objective: Malaria remains a leading cause of morbidity and mortality in Uganda. The study aimed at

assessing the influence of subsistence crop farming and fishing on mosquito abundance and malaria transmission intensity in greater Kamuli District.

Materials and Methods: Indoor human biting catches of female Anopheles mosquitoes were sampled from 70 houses selected from both crop farming and fishing communities using battery-operated CDC light traps. A sub sample of the Anopheles mosquitoes was tested for Plasmodium falciparum Circumsporozoite protein (P.f.CSP) using sporozoite ELISA methods. The proportions of P.f. CSP positive sample pools were compared between the two communities using Wilcoxon Signed Rank Test with continuity correction. The Annual Entomological Inoculation Rates (AEIRs) were compared by One-way Analysis of Variance (ANOVA) using Graph Pad Prism Soft Ware, Version 5.

Results and Discussion: A total of 1,527 female anopheline mosquitoes were caught biting humans in both communities, of which 936 (60.6%) were Anopheles gambiae sensu lato and 601 (39.4%) were An. funestus group. Out of 265 anophelines (in 53 five mosquito pools) tested for P.f .CSP, 50.9% (27) were CSP positive, with Minimum Infection Rates of 0.21 and 0.09 in the two communities, respectively. Annual Entomological Inoculation Rates of 292.23 and 6.75 in the respective communities were observed. Both livelihoods significantly played a big role in malaria transmission (p = 0.692), with many transmission risk factors identified in both communities.

Conclusion and Recommendations: Cultivation methods, fishing-related activities and human behaviour in the respective study areas played a big role in malaria transmission. Good agricultural practices, community sensitization on environmental hygiene, good housing, and human behavioural change communication strategies are recommended in the area to reduce human biting mosquito densities, transmission intensity, and hence curb the malaria burden. Collective efforts among the subsistence farming and fishing communities are also recommended for malaria control and prevention.

Key Words: Anopheles, Malaria, Transmission Intensity, Subsistence farming, Fishing

ABS-349

Evaluation of the specific diversity of *Plasmodium* infection by molecular biology in *Anopheles* vectors of malaria in Northern Benin

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Context: Malaria is a parasitic disease caused by a hematzoan of the genus *Plasmodium* transmitted by an infected female Anopheles. In Benin, diagnostic methods as well as therapeutic efforts are often focused on *P. falciparum* to the detriment of other species. The objective of this study was to evaluate the specific diversity of Plasmodium infection in *Anopheles* in northern Benin.

Methods: *Anopheles* mosquitoes were captured on human bait in four communes: Malanville, Cobly, Matéri and Boukoumbé. These mosquitoes were identified morphologically and characterized by PCR. *Plasmodium* species were detected by PCR. The sporozoite index was calculated to determine the prevalence of antigens identified by CSP-ELISA. The P-value test was used to compare infection rates. The kappa index (k) was determined to study the sensitivity and specificity between these two techniques.

Results: A total of 3739 anopheles were collected of which 97.67% were *Anopheles gambiae s.l* and 2.32% were Anopheles funestus. Two twin species of the gambiae complex and one hybrid were identified: *An. gambiae s.l* (74.38%), *An. coluzii* (24.79%) and *An. gambiae/An. coluzii* (0.82%). Indeed, *P. falciparum* and *P. vivax* were detected in the communes of Malanville and Cobly, but only *P. falciparum* was detected in Matéri and Boukoumbé by PCR.

Conclusion: This study allowed the identification of *P. falciparum* and *P. vivax* in the North of Benin. It will therefore allow to update the mapping of circulating plasmodial species, for a better evaluation of the epidemiology of the infection and a better appreciation of the transmission dynamics of malaria in Benin and in West Africa.

Key words: *P. falciparum, P. vivax*, ELISA-CSP, PCR, *Anopheles gambiae*, Northern Benin

ABS-352

Detection of antibody response to *An. gambiae* gSG6-P1 peptide in human population most exposed to malaria secondary vectors in forest area in Cameroon

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Background: Human IgG antibody response to *Anopheles gambiae* salivary peptide gSG6-P1 was reported to be a pertinent indicator for assessing exposure to mosquito bites and evaluating the risk of malaria transmission as well as the effectiveness of vector control strategies. However, the applicability of this marker to measure malaria transmission risk where human populations are mostly bitten by secondary vectors has not yet been evaluated. The present study aimed to investigate whether anti-gSG6-P1 antibodies response could be induced in humans living in forest areas in Cameroon where malaria secondary vectors are predominant.

Method: ELISA assays were performed to detect IgG antibodies response to *An. gambiae* gSG6-P1 salivary peptide in dried blood spot collected from human population in Nyabessang, a village located on the banks of the Ntem river in the forest area in the southern region in Cameroon. *An. moucheti* and *An. paludis* are reported to be the predominant *Anopheles* mosquito species in this area. Anti-gSG6-P1 antibody concentrations were assessed according to age, gender, the malaria infection status of the human population and their use of mosquito bed nets. Mosquito collections using human landing catches were also performed to confirm the predominance of vectors other than *An. gambiae* s.l or *An. funestus* s.l in the village.

Results: Anti-gSG6-P1 IgG antibody response was detected in inhabitants of Nyabessang with high inter-individual heterogeneity. No significant variation in the level of this immune response was observed according to the age and gender of the individuals. The concentration of gSG6-P1 antibodies was significantly correlated with malaria infection status, with individuals infected by Plasmodium presenting a significantly higher level of IgG response than uninfected ones (p=0.0087). However, no significant difference was observed according to the use of insecticides treated nets (ITNs). In a total of 1, 442 *Anopheles* mosquitoes species collected during this study, 849 (58.87%) were identified as *An. paludis*, 489 (33.91%) as *An. moucheti*, 28 (4.44%) as *An. nili*, 22 (2.08%) were *An. gambiae s.l* and 12 (0.8%) as *An. marshallii*.

Conclusion: Our findings show that IgG response to *An. gambiae* gSG6-P1 peptide could be induced in humans exposed predominantly to *An. moucheti* and *An. paludis* bites. This observation confirms the potential of these antibodies responses to serve as a unique marker to assess human exposure to *Anopheles* species in all malaria epidemiological settings in Africa.

ABS-37

Molecular bases of native fungi *Metarhizium* and their virulence against malaria mosquitoes in Burkina Faso

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Background & Objective: Malaria control efforts are under threat today due to widespread insecticide resistance in mosquitoes populations. It is therefore necessary to develop and implement new complementary vector control strategies. This study aimed to isolate strains of wild fungi in Burkina Faso to test their killing efficiency and assess the link between adhesion and virulence of these fungi.

Materials & method: Plant and insect root collections were carried out over a period of two months in the village of Soumousso. Then we isolated fungi on Petri dishes, prepared the fungal suspensions of 4 strains of *Metarhizium* and infected 3-day old female *Anopheles coluzzi* mosquitoes with two different concentrations (10^6 and 10^8 spores / mL). Survival of mosquitoes was measured for 14 days for to quantify fungal killing efficiency. Additionally, to assess adhesion of the different fungal strains on mosquito cuticle, we quantified fungal growth on mosquito after 1 and 24 hours.

Results& Discussion: All four strains significant increased mortality of the mosquitoes compared to the control at both concentrations (Cox proportional hazards model, $p < 2.2^{-16}$). One strain, which was also the most virulent strain, was the only strain observed to adhere to the mosquito cuticle already after 1 hour upon infection (at 10^8 spores / mL), suggesting that killing efficiency and adhesion rate might be associated.

Conclusion & Recommendation: These results show that native *Metarhizium spp.* fungi are a promising tool for controlling malaria vectors. Some strains were effective enough to adhere to the mosquito cuticle at low concentration and showed high virulence. Further studies should screen additional native strains to establish the link between adhesion and virulence to ultimately select fungi with high virulence that can be implemented in the field.

Key words: fungi, metarhizium sp, malaria, Burkina Faso

ABS-404

Whole transcriptomic analysis of *Anopheles arabiensis* resistant to pyrethroids and organophosphates from western Kenya reveals overexpression of salivary gland and cuticular proteins

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Background and objective: Effective vector control is key to malaria prevention. However, this is now compromised by increased insecticide resistance in malaria vectors due to continued reliance on insecticide-based control interventions, thus posing a global challenge. In Kenya, resistance to pyrethroids and organophosphates has been shown to occur at varying levels in *Anopheles arabiensis* which is one of the major malaria vectors. We investigated the gene expression profiles of insecticide resistant *An. arabiensis* populations from Migori and Siaya counties in Western Kenya using RNA-Seq.

Materials and methods: CDC bottle assays were conducted using deltamethrin (DELTA), alphacypermethrin (ACYP) and pirimiphos-methyl (PMM) to determine the resistance status in both sites. RNA-sequencing was done on pools of mosquitoes which were 1) resistant, 2) non-exposed, and 3) the susceptible Dongola strain of *An. arabiensis*.

Results and discussion: Gene expression profiles of mosquitoes from Migori resistant to DELTA (average mortality of 91%), ACYP (92%), and PMM (58%); and mosquitoes from Siaya resistant to DELTA (85%), ACYP (86%), and PMM (30%), showed overexpression of mainly salivary gland proteins belonging to both the short and long form D7 genes, and cuticular proteins (including CPR9, CPR10, CPR15, CPR16). Additionally, the overexpression of detoxification genes including cytochrome P450s (CYP9M1, CYP325H1, CYP4C27, CYP9L1 and CYP307A1), 2 carboxylesterases and a glutathione-s-transferase (GSTE4) were also found to be shared between DELTA, ACYP, and PMM survivors, reflecting their association with both pyrethroid and organophosphate resistance.

Conclusion and recommendation: This study expands our understanding of the molecular basis of insecticide resistance in Western Kenyan *An. arabiensis*, further adding to the evidence base that suggests that salivary gland proteins and cuticular proteins may play an important role in conferring resistance across insecticide classes.

ABS-581

Genomic surveillance of malaria vectors in the Kassena-Nankana districts of Northern Ghana 2016-2018

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Background: Malaria remains hyper-endemic in the Upper East Region of Ghana despite ongoing vector control interventions. The prevalence of the disease is highly correlated with rainfall, but other ecological factors such as the presence of irrigated areas may also be playing a role in disease transmission. The major malaria vectors are *Anopheles gambiae* and *An. coluzzii*, with minor vectors *An. funestus* and *An. arabiensis* also present. Previous surveys have found resistance to pyrethroids, DDT and carbamates in *An. gambiae*, but the mechanisms of resistance have not been determined. In this study we aimed to perform a genomic survey of major malaria vectors at four villages in the Kassena-Nankana districts, to investigate the influence of local

variation and changes in ecology and insecticide resistance on rates of malaria transmission.

Methods: Entomological surveys were performed monthly from 2016-2018 in the villages of Naaga, Kayoro, Kandiga and Bonia, separated by at most 60 km, selected to represent variations in local ecology, human population density and proximity to irrigation. We assessed vector abundance, entomological inoculation rate and levels of mosquito infectivity via standard methods. From our mosquito collections we obtained high coverage Illumina whole-genome sequence data for a total of 945 specimens (810 *An. coluzzii*; 101 *An. gambiae*; 32 *An. arabiensis*; 2 hybrid). We performed variant calling following methods established by the *Anopheles gambiae* 1000 Genomes Project to obtain genome-wide data on single nucleotide polymorphisms (SNPs) and copy number variants (CNVs). We analysed these data to investigate population structure and the prevalence of insecticide resistance variants. We also compared our data with genomic data from the GAARD and GAARDIAN projects in Southern Ghana, to investigate geographical variations in vector genomics at the national level.

Results: Entomological surveys confirmed previous studies finding that *An. gambiae* s.l. biting rates and infectivity were higher in irrigated areas, and that *An. funestus* has a distinct biting pattern with peak activity later than *An. gambiae* s.l. We found no evidence for genetic population structure in the study area in either *An. gambiae* or *An. coluzzii*, indicating historically high rates of gene flow. At a national level, we observed population structure with *An. coluzzii*, with our northern specimens clustering separately from southern specimens collected by the GAARD and GAARDIAN projects in the Greater Accra and Ashanti regions, confirming previous evidence for distinct coastal and inland populations of *An. coluzzii* in West Africa. There was no such north/south differentiation in *An. gambiae*, however, highlighting important differences between the two species at the national level. Analysis of SNPs in the pyrethroid target-site resistance gene *Vgsc* showed that within *An. coluzzii* a new resistance variant V402L+I1527T is replacing the *kdr* variant L995F in our study area. In 2017 V402L+I1527T had reached at least 40% frequency, with a clear trend towards increasing frequency over time, in all four villages. Within *An. gambiae*, the L995F variant was at 100% frequency in all villages, with the triple mutant L995F+T791M+A1746S most common in Kandiga (31-42%), and the double mutant L995F+P1874L most common in Kayoro and Naaga (31-40%). Analysis of CNVs in cytochrome P450 (*Cyp*) genes, responsible for metabolic insecticide resistance, revealed a high frequency of *Cyp6aa1* amplifications in *An. coluzzii*, above 74% frequency in all villages and years. In contrast, *Cyp9k1* amplifications were at high frequency in *An. gambiae* (63-76%). Thus although *Cyp*-mediated metabolic resistance is at high frequency in both species, different genes appear to be responsible.

Conclusions: Both *An. gambiae* and *An. coluzzii* populations in our study area are at high frequency for both target-site and metabolic variants conferring resistance to pyrethroids, with a new variant V402L+I1527T clearly outcompeting the previously established *kdr* L995F variant in *An. coluzzii*. Since the study period, Ghana has begun a transition towards PBO and dual AI LLINs, and our data provide evidence that these should be more effective than standard LLINs. However, the emergence of new pyrethroid target-site resistance variants is cause for concern for the efficacy of PBO LLINs, and the high levels of pyrethroid resistance will accelerate the evolution of resistance to the secondary insecticide in dual AI LLINs. We did not observe any population structure between mosquito populations in the villages we sampled in Northern Ghana, indicating high levels of gene flow within the study area. However, at the national level we found evidence for north/south differentiation within *An. coluzzii*, and thus further genomic surveys at the national level are recommended to map sub-national variation in insecticide resistance profiles, as well as track the evolutionary response to changes in vector control policy.

ABS-724

Adult mosquito predation and potential impact on the sterile insect technique

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The sterile insect technique is a promising environmentally friendly method for mosquito control. This technique involves

releasing laboratory-produced sterile males into a target field site, and its effectiveness may be affected by the extent of adult mosquito predation. Sterile males undergo several treatments. Therefore, it is vital to understand which treatments are essential in minimizing risks to predation once released. The present study investigates the predation propensity of four mantis species (*Phyllocrania paradoxa, Hymenopus coronatus, Blepharopsis mendica, Deroplatys desiccata*) and two gecko species (*Phelsuma standingi, P. laticauda)* on adult *Aedes aegypti*, *Ae. albopictus* and *Anopheles arabiensis* mosquitoes in a laboratory setting. First, any inherent predation preferences regarding mosquito species and sex were evaluated. Subsequently, the effects of chilling, marking, and irradiation, on predation rates were assessed. The selected predators effectively preyed on all mosquito species regardless of the treatment. Predation propensity varied over days for the same individuals and between predator individuals. Overall, there was no impact of laboratory treatments of sterile males on the relative risk of predation by the test predators, unless purposely exposed to double the required sterilizing irradiation dose. Further investigations on standardized predation trials may lead to additional quality control tools for irradiated mosquitoes.

Keywords : Adult mosquito predation, *Aedes*, *Anopheles,* Mantis, Gecko, Sterile insect technique

ABS-357

Age-grading of *Anopheles gambiae sensu stricto* mosquitoes using maldi-tof ms protein profiling

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Background & Objective: Malaria is transmitted by the bite of an infected female *Anopheles* mosquito. Transmission can only occur if a mosquito survives the extrinsic incubation period of 10 to 14 days. Assessing the age structure of mosquito populations could help in evaluating the impact of control methods. Traditional techniques are cumbersome and subjective. Malaria vectors have been shown to undergo proteomic changes as they age. MALDI-TOF is a mass spectrometry technique that uses laser technology for protein profiling and identification. This study aimed to determine if MALDI-TOF MS is capable of distinguishing different age groups of *Anopheles gambiae s.s.* mosquitoes based on their protein profiles.

Materials & Method: *Anopheles gambiae sensu stricto* mosquitoes (Kilifi strain) were reared in a laboratory controlled environment at KEMRI-Wellcome Trust insectary. Mosquito were reared to different physiological and chronological ages. The individual life history of each mosquito was recorded including mating, blood-feeding and oviposition. Approximately 100 mosquitoes per group of distinct physiological and chronological age were processed using MALDI TOF MS.

Results & Discussion: Principal components analysis was used to explore differences in each group's spectrum profiles. Age-grading databases were created using ClinProTools and validated with spectra of unknown age. We expect to present the protein profiles of different ages of mosquitoes and database accuracy. We also aim discussing whether the method is worth exploring more widely in the field.

Conclusion & Recommendation: The information will be used to validate the importance of MALDI-TOF MS as a new tool for entomological surveillance

ABS-589

Characterization of the endosymbiont fungus, Microsporidia MB in *An. gambiae* s.l, a potential biopesticide for malaria control in western Burkina Faso

Abel Millogo

A characterization study of *Microsporidia MB* in natural populations of the *An. gambiae* complex was conducted in western Burkina Faso, more precisely in three sites, Soumousso, Banlho and the Kou valley. A survival study of MB-positive larvae was carried out to determine the duration of emergence of MB-infected larvae as well as their density compared to the control group. The correlation between MB and *Plasmodium falciparum* in *An. coluzii* was determined using molecular analyses. MB males were mated with uninfected females to determine sexual transmission of the symbiont fungus with sex ratios of 1:3 and 1:5 respectively. The overall prevalence of MB in *An. coluzzii* and *An. gambiae* Giles was 9.43% and 5%, respectively, in the three

sites. Soumousso and Banlho shared respective MB prevalences for *An. gambiae* Giles of 7.5% and 2.1%. A significant predominance of MB prevalence was found in An. coluzii compared to *An. gambiae* Giles. MB-positive *An. coluzii* larvae emerged more rapidly than uninfected ones. In addition, the density of infected larvae was significantly higher than the control group except for L3 larvae where there was no significant difference. Sexual transmission of MB resulted in a prevalence of 8.33%. In contrast, a significant correlation was found between MB positive field anopheles and the presence of *Plasmodium falciparum*. This study suggests that *Microsporidia MB* is a potential symbiotic biopesticide that could block Plasmodium transmission in malaria vectors in Burkina Faso.

Keywords: *Microsporidia MB*, *Anopheles gambiae* s.l, *Plasmodium facliparum*, symbiont, Burkina Faso.

ABS-703

Anopheles Merus distribution and *TEP1* genotype along the Kenyan Coast.

Ann Kelly

Background: Malaria remains one of the most important infectious diseases in Sub-Saharan Africa, responsible for approximately 228 million cases and 602,000 deaths in 2020. Malaria transmission is mainly driven by mosquitoes of the *Anopheles gambiae* and more recently *Anopheles funestus* complex. The gains made in malaria control are threatened by insecticide resistance and behavioural plasticity among these vectors. This, therefore, calls for the development of alternative approaches such as malaria transmission-blocking using gene drive systems that can lead to population replacement of infection-susceptible mosquitoes with mosquitoes that are refractory to *Plasmodium spp.* infection. One such gene that can be utilised is the *Thioester-containing protein 1 (TEP1)* gene which mediates the killing of *Plasmodium falciparum* in the mosquito midgut. Here we investigated the frequencies and distribution of *TEP1* alleles in wild-caught malaria vectors along the Kenyan coast.

Methods: Mosquitoes were collected using CDC light traps both indoors and outdoors from 20 houses in Garithe village, along the Kenyan coast. The mosquitoes were dissected, and the different parts were used to determine their species, blood-meal source, and sporozoite status. The data was analysed and visualised using the R (v 4.0.1) and STATA (v 17.0).

Results: A total of 18,802 mosquitoes were collected consisting of 77.8% (n = 14,631) *Culex spp*, 21.4% (n = 4,026) *An. gambiae s.l*, 0.4% (n = 67) *An. funestus* and 0.4% (n = 78) other *Anopheles* (*An. coustanii, An. pharoensis and An. pretoriensis*). A subset of randomly selected *An. gambiae s.l* (n=518) was identified by polymerase chain reaction (PCR), of these 77.2% were *An. merus*, 22% were *An. arabiensis* and the rest were not detected. Mosquitoes collected were predominantly exophilic with the outdoor catches being higher across all the species: *Culex spp* 93% (IRR = 11.6, 95% CI [5.9 – 22.9] p < 0.001), *An. gambiae s.l* 92% (IRR = 7.2, 95% CI [3.6 – 14.5]; p < 0.001), *An. funestus* 91% (IRR = 10.3, 95% CI [3.3 – 32.3]; p < 0.001). We identified the following genotypes among *An. merus*: **R2/R2, *R3/R3, *R3/S2, *S1/S1* and **S2/S2*. Among *An. arabiensis*, we identified **R2/R2, *S1/S1, *S2/S2*. Tests on haplotype diversity showed that the most diverse allele was *TEP1*S1* followed by *TEP1*R2*. Tajima's D values were positive for *TEP1*S1* indicating that there is a balancing selection, negative for *TEP1*R2* indicating there is a recent selective sweep and as for *TEP1*R3* there was no evidence of selection. Phylogenetic analysis showed two

distinct clades exist: Refractory and susceptible alleles.

Conclusion: We find that the malaria vectors *An. gambiae s.l* and *An. funestus* are predominantly exophilic. *TEP1* genotyping for *An. merus* revealed 5 allelic combinations: **R2/R2, *R3/R3, *R3/S2, *S1/S1 and *S2/S2* while in *An. arabiensis*, we only identified 3 allelic combinations: **R2/R2, *S1/S1, *S2/S2.* The *TEP1**R3 allele was restricted to only *An. merus* among these sympatric mosquito species and we find that there is no evidence of recombination or selection in this allele.

ABS-541

Anopheline Community Structure and Host Preference in a nearby Domestic and Sylvatic Area: implications on human malaria transmission risk

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Habitat settings can deeply affect bioecology of vectors and therefore influence transmission dynamics of vector-borne diseases. Anophelines colonized a wide variety of habitats, living under different environmental conditions and feeding on various hosts. However, some species including *An. gambiae, An. coluzzii* and *An. funestus* have specialized on humans from whom they draw all their survival resources. Recent observations of these extremely anthropophilic vector populations in a sylvatic area (inside Lopé National Park) suggest a local adaptation by shifting of feeding habits.

In order to understand impact of habitat on population structure and host preference, we carried out an experiment to collect mosquitoes in both domestic (village on the outskirts of the park) and sylvatic (unanthropized area inside the park) environments.

At each collection site, we simultaneously used two collection methods: human landing catches (HLC) and an animal-baited catches (ABC) device.

Our results showed that although both domestic and sylvatic habitats are contiguous without any natural physical barrier, there is a well-defined segregation of the two types of habitat according to abundance and species diversity. We highlighted a significantly different structuring of the anopheline communities even at a relatively thin geographical scale. Unlike to our assumptions, the anthropophilic species found inside the park still have a strong attraction to humans as a source of bloodmeal.

These results tend to demonstrate a potential use of sylvatic environment as a refuge when domestic environment is no longer suitable in terms of access to resources (feeding hosts, breeding sites).

ABS-340

The effect physiochemical parameters of water on the abundance of Anopheles mosquito larvae in various breeding sites of Kapiri Mposhi district of Zambia

Moses Muzo

Malaria is a global public health problem, caused by malaria parasites transmitted by a vector female *Anopheles* mosquitoes, belonging to the order Diptera. Their developmental cycle under goes a complete holometabolous with the larval stages associated with aquatic habitats. It is envisaged that the larval control measures are intended to reduce malaria transmission when vector development is prevented. This due to the fact that for some reasons, most drug treatments coupled with other bed net insecticide treatments of adult mosquitoes are increasingly failing. In this study, it was important to determine whether the abundance of *Anopheles* mosquito larvae in different water sites was associated with the following parameters: (i) particular pH level, (ii) particular temperature (iii) the Total Dissolved Solids (TDS) (iv) or a particular electrical conductivity of water (IV). It was also essential in this study to establish the species composition of adult *Anopheles* mosquitoes in Kapiri Mposhi district of Zambia. Both larvae and adult mosquitoes were identified using a morphological key. To achieve relevant results, a variety of qualitative and quantitative analytical methods were involved, inclusive of Polymerase Chain Reaction (PCR) and numerous multivariate statistical analyses involving SPSS statistical package version 21.0. Out of the total of 489 *Anopheles* larvae that were collected from breeding sites and reared in the insectary, only 45% emerged into adults. It was observed that the *Anopheles*

larvae was absent in Rivers and dam breeding sites. Further molecular results revealed that the most abundant mosquito species in Kapiri Mposhi were *An*. gambiae (60%) and breeds well in temporal water ponds, followed by *An. arabiensis* Paton (35%) and 5% were no amplified results. A positive significance was recorded on Pearson Correlation for physicochemical parameters of electrical conductivity (p = 0.003), Total Dissolved Solids (TDS) (p =0. 004), temperature (p =0.001) and pH (p = 0.000).Consequently, it was, concluded that electrical conductivity, pH, temperature and Total Dissolved Solids (TDS) of water in various mosquito breeding sites of Kapiri Mposhi has an effect on the abundance of *Anopheles* larvae. This study has also shown that *Anopheles* mosquitoes thrive better in fresh mineral domestic water.

Keywords: Malaria, *Anopheles* mosquito, Larvae, Physicochemical parameters, Kapiri Mposhi

ABS-430

Evaluation of the survival, age structure, and dispersal distance of *Anopheles funestus* and *Anopheles arabiensis* in Ulanga, Tanzania using the Mark-release-recapture technique

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Subject area; Vector biology, ecology, taxonomy and population genetics

Introduction: *Anopheles arabiensis* and *Anopheles funestus* are the two major malaria vectors largely contributing to malaria transmission in East Africa. Understanding the dispersal and population structure of such vectors is critical for the prevention, control and eradication of malaria.

Methods: A study was carried out to determine *An. arabiensis* and *An. funestus* flight range and dispersal patterns from 3 experimental phases of mark-release-recapture (MRR) experiments which were conducted over 51 nights, from early September to the end of October 2020 at Ikungua village, South-eastern Tanzania. Mosquitoes were collected indoors and outdoors by using human landing catches (HLC) and Centers for Disease Control and Prevention miniature light traps (CDC-LT). A total of 4,210 (*An. arabiensis* and *An. funestus*) were marked with fluorescent dye pigments and released to the wild population using a self-marking device located over breeding sites.

Results: Total marked and recaptured was 316 (7.5%) with 138(3.28%) *An. arabiensis* and 178(4.23%) *An. funestus*. Daily mean marked and recaptured was (6.75, SD ± 7.6) *An. arabiensis* and (8.9, SD ± 8.3) *An. funestus.* The probability of daily survival was 0.76 for *An. arabiensis* and 0.86 for *An. funestus*. The average dispersal distance of marked mosquitoes was 0.65 km for *An. arabiensis* and 0.50 km for *An. funestus*. Life expectancy estimated by using daily survival rate was 3.64 days for *An. arabiensis* and 6.51 for *An. funestus.*

Conclusion: The study concluded that *An. funestus* had almost twice the life expectancy of *An. arabiensis.* The higher survival rate observed may account for the higher sporozoite rate observed among *An. funestus* in this area. Data suggest that targeted malaria vector control measures should be applied up to 1 km from the nearest breeding site.

ABS-512

Spatial sensory detection of permethrin by the malaria main vector *Anopheles gambiae*

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Pyrethroids are one of the most frequently and widely used class of insecticides to control vectors transmitting diseases including malaria. However, several physiological resistance mechanisms to pyrethroids have been described, which threatens the efficacy of vector control strategies. Beyond these well-known mechanisms of resistance, behavioural resistance is now under scrutiny. Recent studies suggest a spatial sensory detection in *Anopheles* mosquitoes of pyrethroids used in vector control opening the way to behavioural adaptations. However, the spatial sensory detection of these molecules is controversial and needs to be demonstrated. The goals of this study are firstly, to determine the compounds emitted by permethrin-based insecticide treated nets (ITN's), secondly to behaviourally characterize the spatial sensory detection of permethrin, and finally, to elucidate

the sensory organs involved in the spatial detection. To reach our goals, we first performed dynamic headspace collections of indoor air in a room with permethrin treated net. GC-MS analyses confirmed the presence of cis- and trans-permethrin. Secondly, we recorded the behaviour of *Anopheles gambiae* pyrethroids-sensitive and resistant strains when exposed to a 30 s air-flow containing different amounts of permethrin at 25 and 35°C. We found that the proportion of mosquitoes flying away in the presence of permethrin increased with dose and temperature in both strains. Thirdly, we sequentially obliterated or covering with resin, the main mosquito's sensory organs (antennae, palpi, proboscis tarsi) to decipher which ones played a role in the spatial detection. These experiments showed that the individuals' behavioural response observed after permethrin exposition was almost completely interrupted when the tarsi were covered with resin. We noted that obliterating the palpi, antennae and proboscis together reduced also significantly the escape flight.

Based on these results, future work will aim to determine how pyrethroids' spatial detection can contribute to the evolution of behavioural resistance in *An. gambiae* in natural populations.

Key words: Sensory detection, permethrin, *Anopheles gambiae*

ABS-584

Comparison of adult male and female *Anopheles gambiae* s.l mosquito microbiota reveal *Elizabethkingia meningoseptica* is most abundant after feeding

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Background: The discovery of high prevalence of *Microsporidia MB* in both sexes of *Anopheles* has informed the need to also include male mosquitoes in the study of mosquito-associated microbiome which had mainly been female-focused. In this study, the microbiota of male and female *Anopheles gambiae* s.l were compared to identify similarity or otherwise of bacterial composition between the two sexes.

Materials and methods: Late larval instars of *Anopheles* mosquitoes were collected from the field and raised to the adults. 20 males and 20 females each of 1-day-old non-sugar-fed, 4-5 day old sugar-fed and 20 post blood-fed females were randomly selected. Genomic DNA was extracted from pools of mosquitoes for bacteria 16S rRNA amplicon sequencing. The bacterial diversity, taxa abundance and differential compositional analyses were performed using established pipelines in QIIME-2 and custom R-scripts.

Results: Results reveal that male and female mosquitoes generally share similar microbiota (p= 0.73). As expected, the feeding status increased dissimilarity in both males (ANOSIM: R= 0.41 p=0.007) and females (ANOSIM: R= 0.49 p=0.001). The amount of variation explained, however, was greater in females (48% p=0.002) than in males (29% p=0.02), likely driven by blood feeding which does not occur in males. *Asaia* and *Chryseobacterium* were differentially more abundant in sugar-fed and blood-fed females, respectively (LDA scores >3.5). *Elizabethkingia meningoseptica* was shown to be the only common differentially significant bacteria in both male and female sugar-fed mosquitoes (LDA score >5.0) with relative abundance even higher in blood fed females (LDA score >5.0).

Conclusion: Blood meals appear to drive the difference in microbiota composition between male and female *Anopheles* mosquitoes. The high abundance of *E. meningoseptica,* a bacterium known to have anti-Plasmodial effects in females, warrants further functional investigation also in males to better understand their association with mosquitoes and opportunities for developing novel transmission blocking strategies.

Keywords: mosquito microbiota, *Anopheles gambiae* s.l., *Elizabethkingia meningoseptica*

ABS-629

The variability of wing morphometry in *Aedes aegypti* (Diptera: Culicidae) from different environments in West Africa

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Background: *Aedes aegypti* is the most important vector for arboviruses worldwide. In West Africa, it is known to transmit dengue virus (DENV), yellow fever virus (YFV), chikungunya virus (CHIKV), and Zika virus (ZIKV). The vector is highly adapted to urbanized environments and can be found worldwide. The environment, therefore, plays a role in the microevolution of the wings. Data on disease and vector ranges are sparse and issues such as genetic, ecological, and morphological diversity are poorly understood. Geometric morphometrics is a promising alternative technique to identify insect species using anatomical landmarks on the wings. It is a cost-effective technique, which requires very little entomological experience compared to standard morphological identification and will help to develop a new and robust tool for vector identification without the use of genetic sequencing. In this study, we, therefore, sought to investigate if and how wing geometric morphometrics can characterize populations of *Aedes aegypti* from different ecological niches leading to their adaptation.

Method: Mosquito larvae were collected along a transect reaching from urban sites with high anthropogenic impact, over rural sites with medium anthropogenic impact to sylvatic sites with low anthropogenic impact. The larvae were reared to adults under controlled conditions and identified using established taxonomic keys. The wings were removed, mounted, and visualized using an advanced stereomicroscope fitted with a camera targeting marked indicators on the wings. The generated images were digitized and will be analyzed using Canonical variate analysis and Mahalanobis distance will be used to investigate the degree of wing-shape dissimilarity among populations. Regression analysis of Canonical Variation Analysis scores against wing-shape variation will be calculated using thin-plate splines. For each individual, a cross-validated reclassification will be performed. Finally, a neighbor-joining phylogenetic tree will then be built.

Expected outcome: This study expects that wing morphometrics can be used to differentiate populations of *Aedes aegypti* with different anthropogenic influences of their environment. Understanding the vector populations can give indications of their relative threat and can also guide control efforts. In the long term, wing morphometry could be an added tool for mosquito identification and characterization.

ABS-653

Malaria vector composition and phenotypic resistance to insecticides in different epidemiologic settings across Zambia

Background: Malaria is one of the leading causes of morbidity and mortality in Zambia. There has been close to two decades of control, utilizing effective methods including indoor residual spraying (IRS), distribution of bed nets and artemisinin-based combination therapies (ACTs). This has resulted in varied impact on disease transmission across different epidemiological settings in the country. We carried out vector surveillance to determine the impact of season and vector control efforts on species composition and insecticide resistance in malaria vectors in three different epidemiologic zones across the country.

Methodology: Larval collections were conducted in one site and adult collections were conducted in all the three sites during rainy and dry seasons. Both WHO and CDC bioassays were used to test for insecticide resistance.

Results: A total of 8239 female mosquitoes were collected from all the study sites between August 2020 and July 2021. Of these 5545 were anopheline and the rest were culines, including Culex, Aedes and Mansonia. Malaria vectors included 4212 Anopheles funestus, 1311 An. gambiae and 2 An. arabiensis. Others included 8 An. coustani, 2 An. gabbinsi and 12 An. rufipes. Nchelenge in northern Zambia had the largest number and variety of the anophelines and Choma in southern Zambia had the least.

Tests indicated high phenotypic resistance against pyrethroids, carbamates, and organochlorins. There was no resistance to

organophosphates and neonicotinoids. There were differences in resistance pattern against carbamates in the two primary malaria vectors.

Conclusion: The spatial differences in species composition and population densities of malaria vectors from the north to the south of the country was consistent with epidemiologic pattern of malaria. Susceptibility to clothianidin seen across the study sites indicated that IRS with this insecticide would be effective. Widespread resistance to pyrethroids would mean that treated bed nets would serve as barrier without insecticidal protection.

ABS-358

Standardised bioassays reveal that mosquitoes learn to avoid compounds used in chemical vector control after a single sub-lethal exposure

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Background: Vector-borne diseases are worldwide public health issues. Despite research focused on vectorial capacity determinants in pathogen transmitting mosquitoes, their behavioural plasticity remains poorly understood. Memory and associative learning have been linked to behavioural changes in several insect species, but their relevance in behavioural responses to pesticide vector control has been largely overlooked.

Methods: In this study, female *Aedes aegypti* and *Culex quinquefasciastus* were exposed to sub-lethal doses of 5 pesticide compounds using modified World Health Organization (WHO) tube bioassays. Conditioned females, subsequently exposed to the same pesticides in WHO tunnel assays, exhibited behavioural avoidance by forgoing blood-feeding to ensure survival.

Results: Standardized resting site choice tests showed that pre-exposed females avoided the pesticides smell and choose to rest in a pesticide-free compartment. These results showed that, following single exposure mosquitoes can associate the olfactory stimulus of pesticides with their detrimental effects and subsequently avoid pesticide contact.

Conclusions: These findings highlight the importance of mosquito cognition as determinants of pesticide resistance in mosquito populations targeted by chemical control.

ABS-538

Effect of Chlorfenapyr and Clothianidin on non-targeted organisms (Mayfly and Tadpole) while controlling malaria vector

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Continuing application of chemical insecticides to control mosquito to prevent vector borne diseases has led development of resistance in mosquito population, bioaccumulation of insecticide residues and depletion of non-target organism diversity and population. But all these are undermining the gains made thus far and may ultimately lead to operational failure of existing chemical control tools. Clothianidin and chlorfenapyr are promising insecticides with unique modes of action that could serve as panacea for the growing pyrethroid resistance. Prior to field use as larvicides, it is imperative to establish their toxicity against local mosquito populations and evaluate their safety to aquatic non-target organisms. The aim of this study was to determine the diagnostic doses of clothianidin and chlorfenapyr and to assess their baseline toxicity/safety to Tadpoles and *Mayfly nymphs*, the aquatic non-target organism. Tadpoles were differently subjected to 1ml of 6.25ug, 12.5ug, 25ug, 50ug, 100ug and 200ug of Chlorfenapyr concentrations in 500ml water (rainwater), same was also done using mayfly nymphs in 250ml water. This procedure was repeated for Clothianidian at 0.5ml of 13ug and 1ml of 13ug concentration and controls were setup using 1ml of acetone. Mortalities were recorded daily for 5days. Mayfly had 100% mortality at all concentration of Chlorfenapyr and Clothianidin after 24 hrs of exposure. Tadpole had zero mortality when exposed to different concentration of clothianidin, but the mortality of tadpoles due to chlorfenapyr increased with increase in concentration. Mayfly among other macro-inveterbrates are highly sensitive to their environment. Chlorfenapyr has a toxic mechanisms and fatality when

intoxicated, hence was fatal to tadpole and may not be safe for other macro-veterbrates. This shows that Clothianidin has low toxicity against tadpole and safe to non-target aquatic organism, therefore at recommended dosage it can be used as larvicides to control pyrethroid resistant mosquito vectors.

Keywords: Chlorfenapyr, Clothianidin, non-target aquatic oraganisms, safety, Insecticides

DAY 3: Poster Session 3 (Posters #101-150): During Coffee and Lunch Breaks

ABS-624

No evidence for long-range male sex pheromones in two malaria mosquitoes

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Background: Cues involved in mate seeking and recognition prevent hybridization and can be involved in speciation processes. In malaria mosquitoes, females of the two sibling species *Anopheles gambiae* and *An. coluzzii* are two sibling species, often found in sympatry, mate in spatially segregated species-specific male swarms and hybrids are rare. This suggests the existence of strong pre-mating reproductive barriers between these two sibling species. The involvement of long-range sex pheromones in mating behavior in *Anopheles* species have been debated in literature but to date, no study has provided strong evidence. Here, we attempted to bring to light the existence of male sex pheromones driving the assortative mating between these two sibling species.

Methods: To put all the odds in our favor, we used different chemical ecology methods. First, we investigated the long-range behavioral response of females exposed to headspace of male swarms in an olfactometer. Second, we collected and analyzed volatile organic compounds (VOCs) with different methods on both laboratory-induced swarms and natural swarms. And third, we tested for an electroantennographic response of females to male swarm VOCs. We used both recently colonized mosquitoes and large experimental set-ups to ensure males produced a free swarming behavior.

Results: Behavioral analyze did not show an attraction of females to male swarms. In the chemical analyses, no specific compound was found in the swarm extracts. And in the electrophysiological analyze, female antennae did not show a detection for any specific compound in the swarm extracts.

Conclusion: Despite all our efforts, our results support the absence of long-range sex pheromones involved in swarm detection and recognition by females in *An. gambiae* and *An. coluzzii*. This finding has an importance in ecology, evolution and control strategies of malaria vectors. Moreover, the question of how *Anopheles* females seek male swarms is still open.

Key words: *Anopheles*, male swarm, mating behavior, mate seeking, chemical cues.

ABS-659

Assessing the diversity and behavior of *Anopheles* species across different ecological settings in Cameroon: contribution to vector control decision-making

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Background: Understanding malaria vector behavior is important for planning effective vector control. Together with the NMCP (National Malaria Control Programme) and local partners, PMI VectorLink Cameroon assessed the species composition, biting rate, feeding and resting behavior, and host preference of *Anopheles* mosquitoes in different ecological zones.

Methods: Adult mosquitoes were collected monthly from October 2020–May 2021 and every other month from July–September 2021 in five sites (Simatou, Gounougou, Mangoum, Nyabessang, Bonabéri) using Human Landing Catches (HLCs), Pyrethrum Spray Catches (PSCs) and Prokopack aspirators. Mosquitoes were morphologically identified using taxonomic keys and preserved for laboratory analysis for species identification, sporozoite detection, and human blood source.

Results: Overall, 34,990 *Anopheles* mosquitoes were collected across five sites—24,055 using HLCs, 9,930 using PSCs, and 1,005 through Prokopack. Twelve species (*An. gambiae* s.l., *An. funestus* s.l., *An. pharoensis*, *An. paludis*, *An. moucheti*, *An. demeilloni*, *An. ziemanni*, *An. nili*, *An. marshallii*, *An. multicinctus*, *An. rufipes*, *An. squamosus*) were recorded across all collection methods and sites. *Anopheles gambiae* s.l. was found in all sites and by all methods. Across sites, hourly biting rates peaked after midnight for all *Anopheles* species found. *Anopheles gambiae* s.l., *An. moucheti*, and *An. nili* were found biting until at least 8 a.m. indoors and outdoors across sites where collected. The indoor resting density of *An. gambiae* s.l. varied from 0.06 females/room (f/r) in Nyabessang to 25.5 f/r in Simatou, and for *An. funestus* s.l. from 0.25 f/r in Simatou to 2.4 in Gounougou. Among 2,427 fed *Anopheles* tested, the human blood index was 40.3% for *An. gambiae* s.l., 67.1% for *An. funestus* s.l., and 11.1% for *An. rufipes*.

Conclusion: These results show Cameroon's high diversity of *Anopheles* mosquitoes, with behavior and density varying by site, and will help the NMCP select an appropriate vector control strategy targeting the behavior of key vector species.

Keywords: *Anopheles* species, density, behavior, vector control, Cameroon

ABS-744

Inversion 2la associate with the adaptive radiation of *an. Coluzzii* across the six ecological zones in Nigeria

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Background: *Anopheles coluzzii*, one of the major malaria vectors in Nigeria, is found in almost every part of the country. There adaptation to the local environment in the southwestern part of the country has recently been associated with assortment of inversion 2La. Here we examined the assortment of this inversion across the six geopolitical zones in Nigeria.

Method: Larval samples of anopheline mosquitoes were collected from 12 locations across the 6 ecological zones in Nigeria,

using standard methods. Adult emergence was euthanized and identified using standard morphological identification guide. All samples belonging to the *An. gambiae s.l.* were further separated and identified using PCR. Inversion 2La karyotyping was conducted on the resulting *An. coluzzii* identified. Statistical analysis was conducted at P<0.05.

Result: Morphological identification results revealed that members of the *An. gambiae s.l.* constituted 98% of all the anopheline mosquitoes examined. Other mosquito species identified but restricted to certain areas include *An. funestus s.l.*, *An. maculipalpis* and *An. pretoriensis*. PCR identification further revealed that the population contained 600 (60%) of *An. coluzzii* and 397 (40%) of the closest relative *An. gambiae*. These two species were found in all the populations examined across the six ecological zones. An adaptive Inversion on 2La was detected which can be associated with climate. Majority of the mosquitoes in the southern parts of Nigeria (around the mangrove and forest regions) carry the 2La+/2La+ inversions (R^2 = 0.78, p<0.001) which is gradually relaced by the 2La/2La inversions as we proceed northwards towards the savannah (R^2 = 0.82, p<0.001). A relatively high proportion of heterozygous form 2La/2La+ was detected in the southern parts, an indication of heterozygous advantage, which reduced in frequency (R = 0.67, p<0.05) as we proceed towards the savannah.

Conclusion: Inversion 2La is associated with the adaptation *An. coluzzii* to climate in Nigeria. This might be an important target for future control of this species in Nigeria.

ABS-348

Entomological investigation on breeding sites of *Aedes aegypti* using Stegomyia indices during dengue transmission season in Kassala city, Eastern Sudan

Khider Alsedig

Background: The *Aedes* mosquito is a vector for transmitting many arboviruses including dengue, Rift valley fever, chikungunya, and other emerging arboviruses. Knowledge of the breeding habitat and status of this vector is vital for implementing appropriate interventions. Thus, this study was conducted to investigate the breeding habitats and presence of *Aedes* mosquito species during dengue transmission season in Kassala city, eastern Sudan.

Methods: Entomological surveys of water-holding containers for immature stages of *Aedes* were carried out from September to December 2019 in Kassala city through a random sampling method. A total of 450 houses distributed in 6 districts were surveyed monthly for three months across the city.

Results: Overall, 1244 potential larval habitats were surveyed. *Aedes aegypti* was collected across the city with an overall high prevalence of *Ae. aegypti* (n = 2405, 96.8%). The study showed that *Ae. aegypti* was more abundant (n = 2405, 96.8%) in Kassala city. Breeding containers, especially clay pots and Water barrels were the most strongly preferred productive larval habitat for *Ae. aegypti* with the prevalence of 12.38% and 5.39% respectively. Globally, the house index (HI), Breteau index (BI), and container index (CI) were high for *Ae. aegypti* (26.6%, 38.4% and 22.6% respectively) and compared to the transmission risk threshold (5%, 20% and 5% respectively) established by the WHO/PAHO.

Conclusions: The findings of this study suggest a risk for transmission of arbovirus diseases in Kassala and call for an urgent need to implement vector control strategies against these vectors in Kassala, Eastern Sudan.

Keywords: *Aedes aegypti*, house index, Breteau index, container index, Kassala, Breeding container

ABS-528

Mapping of the main mosquito breeding sites in the city of Cotonou in Southern Benin

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Background: The city of Cotonou, due to its climate and its position in the coastal plain as a flood zone, generates a wide variety of culicidial breeding grounds. The wide distribution and high abundance of Culicidae fauna is responsible for nuisances and the transmission of vector-borne diseases such as malaria. A good knowledge of the geographical distribution of the breeding sites of these vectors in time and space is a prerequisite for successful control.

Methods: Field data collection was carried out in 2020 during the alternating period between the long dry season and the short rainy season (February to September). We identified breeding sites, took geographical coordinates of these sites by GPS (Global Positioning System), determined larval densities by the Bruce-Chwatt (1985) squint method. Larvae were collected by depositing ovipositors containing well water in the different neighbourhoods and by larval surveys in gutters, abandoned tyres and cesspools. The larvae and pupae collected were transported alive to the insectarium for further work.

Results: 392 mosquito breeding sites were identified. Aedes mosquito). The differences observed between mosquito breeding sites were significant ($P < 0.0001$) 0.05. 218 sites (56%) are temporary, 29% are semi-permanent and 15% are permanent. The differences between the frequency of temporary, semi-permanent and permanent breeding sites are significant ($P < 0.0001$) 0.05.

Conclusion: this study aims to contribute to the development of targeted disease vector control strategies to better control diseases by investigating one of the links in the transmission chain of these species.

Keywords: Culicidae fauna, lymphatic filariasis, dengue fever, temporary, semi-permanent, permanent

ABS-331

Mosquito diversity and behavioral activity of Anopheles species across different altitudes and seasons along the slopes of mount Cameroon

Kwi Pilate Nkineh

Malaria is endemic in Cameroon, with heterogeneous transmission accruing mainly to eco-climatic variations and entomological parameters such vector diversity and spatial distribution. The intensification of malaria prevention and control through the free distribution of insecticide treated nets (ITN) in recent years may have altered the composition, geographic distribution and natural infection rate of *Anopheles* species, with implications for malaria transmission dynamics.

This cross-sectional study involved the exploratory sampling of mosquitoes both indoors and outdoors in eleven eco-epidemiological settings by human landing catch (HLC), each collection period lasting for 12 hours uninterrupted, from 6:00 pm to 6:00 am. The mosquitoes were identified morphologically under a stereomicroscope using the keys of Gillies and De Meillon and the parity status of a proportion of unfed mosquitoes ascertained by dissecting their ovaries and examining the tracheoles. The prevalence of *Plasmodium* infection in the target communities was simultaneously assessed using rapid diagnostic tests.

A total of 7327 (18.0 mosquitoes/trap/night) mosquitoes were trapped during the entire survey period, mainly during the rainy season (5678, 77.5%) and at low altitude (3669, 50.1%). Five genera were recorded: *Anopheles spp* (5079, 69.3%), *Culex spp* (2024, 27.6%), *Aedes spp* (165, 2.3%), *Mansonia spp* (55, 0.8%) and *Toxorhynchetes spp* (4, 0.1%). In all, 81.4% (4136/5079) of

the *Anopheles spp* fauna were major malaria vectors; *An. gambiae complex* (2691, 36.7%), *An. funestus* (560, 7.6%), *An. nili* (438, 6.0%), *An. hancoki* (270, 3.7%) and *An. mousheti* (177, 2.4%) whose distribution varied significantly with altitude ($p<0.001$) and season ($p<0.001$). *An. cinctus* (155), *An. longipalpis* (117), *An. kingi* (106), *An. ziemani* (100) and *An. marshalli* (67) are proposed as secondary vectors of malaria in the area as they constituted up to 10.7% (545/5079) of the population of Anophelines caught. The biting cycle of Anopheles species overall as well as both indoor and outdoor were slightly similar for the major malaria vectors, with overall biting peaks for *An. gambiae complex, An. funestus, An. nili, An. hancoki* and *An. moucheti* at 2 - 3 am, 5 - 6 am, 9 - 10 pm, 8 - 9 pm and 11 pm – midnight respectively. Most *Anopheles* species across all three altitudinal zones and both seasons were parous, with the highest parity rate in communities with the highest proportion of individuals with malaria parasite infections. *An. gambiae* remains the major malaria vector in the area and *An. cinctus* possibly an additional secondary vector of the disease. The seasonal and altitudinal vector distribution has implications for the transmission of malaria and its control intervention strategies in the area. Targeted control interventions in the 'hotspots' may be indispensable in curbing the prevalence of the infection and the incidence of disease in the area and region as a whole.

ABS-477

Behaviour and abundance of anophiline vectors associated with human malaria transmission in the highlands and lowlands of Plateau state, Nigeria.

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Background & Objective: Malaria which is caused by infection with a parasite of the genus Plasmodium and transmitted by Anopheles mosquitoes remains a major public health disease in Nigeria. These Anopheles species differs in population, feeding and resting behaviours in relation to prevailing weather conditions in the locality. An entomological survey was carried out to generate a Web-based Malaria Information System (Web-MIS) and investigate the abundance, feeding and resting behaviours of major anophiline mosquitoes found in the highlands and lowlands of Plateau State, Nigeria.

Materials & Method: Determination of malaria vector species composition and behaviours in the study sites was carried out using the Pyrethrum spray collections (PSC) and CDC light trap collection methods. Data collected was transferred real time to the web-based application hosted on the cloud using a mobile application (Eldacap). Chi-square test was used to compare the differences in numbers between species, sites, and housing types. A Poisson regression was used to test the effect of temperature and relative humidity on mosquito abundance, accounting for differences between sites. Results & Discussion: The results show that the abundance of mosquitoes indoors and outdoors differed significantly between locations ($c2 = 7.902$, $p=0.027$). More mosquitoes were collected indoors in the lowlands compared to the highlands. In relation to housing types, higher number of mosquitos were collected in tukul houses with thatched roofs compared with houses with corrugated iron roofs ($c2 = 5.71$, $p=0.030$). The relationship between temperature and number of mosquitoes followed a polynomial fit in all locations: $Y=\alpha+\beta X+\beta X2$ while for relative humidity, it differs significantly between locations ($p=0.0001$).

Conclusion & recommendation: Our study highlights important aspects of the behaviour of anopheles species which is required for implementation and evaluation of vector control interventions in Plateau state.

Keywords: Malaria transmission, Anopheles species, Plateau, Nigeria

ABS-591

Larval Habitat Diversity, Distribution and Abundance of *Anopheles gambiae s.l.* in the City of Accra, Ghana.

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Background: Understanding the diversity and characteristics of breeding habitats of malaria vectors in densely populated urban cities is very important in shaping malaria control programmes. This study identified and characterized the different larval habitats of *Anopheles gambiae s.l.* in the city of Accra, Ghana, during the dry season.

Methods: Larval surveys were undertaken to determine the spatio-temporal distribution and characteristics of larval habitats and abundance of *An. gambiae s.l.* in fifteen sites within the city of Accra, Ghana. These sites were categorized into five (three sites per category). The categories were irrigated urban farming sites (IUF), lower (LS), middle (MS) and higher (HS) socioeconomic status sites, and peri-urban (PU) sites. The WHO standard dipping technique was used to collect all larvae from their breeding habitats. and raised into adults in the insectary for identification.

Results: A total of 9881 mosquito larvae were collected from 263 breeding habitats, of which 4988 (50.48%) of the mosquitoes were *Anopheles gambiae* s.l. larvae and 4893 (49.52%) Culex larvae. Drainage ditches which carried effluents from households were the most productive habitats encountered (31.94%, 84/263). There was a significant association between habitat type and the presence of Anopheles larvae ($\chi 2 = 22.721$, df = 8, $P = 0.004$). Larval habitat type was significantly associated with site category ($\chi 2 = 228.13$, df = 32, $P = 0.000$). Land-use type was significantly associated with the presence of larvae ($\chi 2 = 20.197$, df = 5, $P = 0.000$).
Conclusion: A rainy season survey is being undertaken together with measurement of physico-chemical parameters such as temperature, turbidity, pH, conductivity, salinity. These will be reported and discussed.

ABS-669

Bionomics and importance of malaria vectors in two sentinel sites in northern Côte d'Ivoire, Bouna and Odienné

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Context: In Côte d'Ivoire, malaria is the leading cause of mortality and hospitalisation in health facilities. Thus, basic data on the parameters of malaria transmission in the cities of Bouna and Odiénné are necessary to implement vector control actions and to monitor the control strategies implemented in the field.

Objective: To study the level of malaria transmission in the towns of Bouna and Odienné.

Methods: Mosquitoes were sampled in the localities of Bouna and Odiénné during the rainy and dry seasons. Adult females were collected by capture on human bait inside and outside dwellings in urban and rural areas, by intra-domiciliary capture. In the laboratory, the different species of the *Anopheles (An) gambiae* complex were determined. The ELISA (Enzyme-Linked Immuno-Sorbent Assay) technique allowed the detection of the circumsporozoite protein (CSP) specific to *Plasmodium (P.) falciparum*.

Results: Molecular identification of the *An. gambiae* complex revealed the presence of both *An. gambiae* and *An. coluzzii* vectors. The main malaria vectors identified during this study were *An. gambiae s.l*, and *An. funestus* with respective infection rates of 5.6% and 5%.

Conclusion: This study shows that malaria is a major problem for the populations of Bouna and Odienné. It is therefore essential to strengthen preventive control measures that would significantly reduce the risk of malaria.

Keywords: Malaria, *Anopheles gambiae*, *Anopheles funestus*, Ivory Coast

ABS-386

Pyrethroid insecticide susceptibility status of anopheles mosquitoes population, availability and use of long-lasting insecticide treated nets(llins) in Binduri, Talensi and Builsa South Dist

Christiane Donkeu

Background: The World Health Organization (WHO) estimates that there were 655,000 malaria deaths in 2010, with 86% occurring in children under 5yrs (WHO,2011). Malaria deaths are declining with the massive scaling up of control measures, of which insecticide treated bed nets (ITNs) are a major component. ITNs reduce deaths in children (Lengeler C. (2004) and provide personal protection to the user, and at scale they provide community-wide protection by reducing the number of infective mosquitoes in the vicinity where ITNs are used (Jones CM et al. (2012) and Okia M, Ndyomugyenyi R. et al. (2013). Between 2008 and 2010, 254 million ITNs were supplied to countries in sub-Saharan Africa, and the proportion of African households in possession of a net rose from 3% in 2000 to 50% by 2010 (WHO, 2010). Nets, when in good condition and used correctly, are effective, simple to use, easy to deliver to rural communities, and cost-effective when used in highly endemic malarious areas (Okumu FO et al. (2012). On account of their low mammalian toxicity, speed of action, and high insecticidal activity, pyrethroids (Briet OJ et al. (2013) are the only insecticide class recommended by the WHO for use in ITNs (Hougard JM et al. (2003). The control of malaria vectors with insecticides remains an essential component in the fight to eliminate or eventually eradicate malaria. Malaria vector control is intended to protect individuals against infective mosquito bites and reduce the intensity of local malaria transmission (WHO, 2009). In Ghana the National Malaria Control Program (NMCP) has embarked on a rapid distribution of ITN's countrywide in a recent LLIN Point Mass Distribution campaign 2018, a total of 653,863 LLINs were distributed to households in the Upper East (Malaria Report UER 2018) as part of the strategies aimed at achieving the millennium development goals. Several sectors have also adapted to the vector control in reducing malaria burden and also to control mosquito nuisance. However, the development of pyrethroid resistance in populations of *Anopheles gambiae* has become a serious threat to the effectiveness of these two vector control measures (Santolamazza, 2003). According to the recent World Malaria report for 2011, mosquito resistance to pyrethroid insecticides has been reported in 27 African countries and 41 countries worldwide.

Objective of the study: The main objective is to determine Pyrethroid insecticide susceptibility status of local malaria vector species, knowledge on LLIN benefits, availability and use of LLIN in three selected districts (Binduri, Talensi and Builsa South) with inconsistent OPD malaria cases from 2015-2018 using the Ghana Health Service DHIMs information in the Upper East of Ghana.

Methodology: Household Survey and Pyrethroid *Susceptibility Test.* A questionnaire was used to collect information on the knowledge, availability and use of LLIN in households within the study districts. Susceptibility of the local *Anopheles* species to the pyrethroid insecticides was tested by exposing the Anopheles Mosquitoes to a 0.05% Alphacypermethrin pyrethroid insecticide in communities within the selected districts.

Results: From the study results 83% of households surveyed had LLINs, 17% of the household did not have LLIN in the households and 99.1% of the individual surveyed had knowledge on the importance and use of LLIN. Mosquitoes sampled from all the three districts showed considered resistance to pyrethroid(Alphacypermethrin 0.05%).

Conclusion: The results of the study shows that the knowledge on LLIN benefits and availability/access was good but the results on the use of LLIN which will help prevent Malaria is very low thus the information from the study will help the Upper East Regional malaria control team restructure their malaria control efforts to meet the lapses on the usage of LLINs and liase with National Malaria Control Programme(NMCP) to relook at the efficacy of pyrethroid since the study shows local vector resistance to pyrethroid which can compromise the malaria vector control strategy of LLINs(reducing the vector density).

ABS-398

Observation and characterization of known and undescribed Anopheline mosquitoes' regarding residual malaria transmission in the Western Kenya Highlands

Shehu Awandu

Background: The western Kenyan highlands have witnessed a sustained reduction in malaria incidence over the years because of effective therapeutics and use of long-lasting insecticide impregnated nets (LLINs). However, there is ongoing residual malaria transmission partly attributed to gaps in protection and intervention coverage based on mosquito behaviour. Here, we systematically collected and documented temporal anopheles species composition and bionomic traits as they relate to intervention effectiveness in the highlands of western Kenya.

Methods: We conducted sentinel collections in 3 sites in Nandi Highlands in Western Kenya. To assess adult vectors and their bionomics, we deployed standardized human landing catches (HLC) and CDC light traps both indoors and outdoors; and pyrethroid spray catches (PSC). For human behaviour observations, we enumerated the number of household inhabitants inside and outside every household every hour and their use of LLINs parallel to the HLCs. After morphological identification, molecular characterization was done through sequencing the ribosomal DNA internal transcribed spacer region 2 (rDNA ITS2) and mitochondrial DNA cytochrome oxidase subunit 1 (mtDNA CO1) loci.

Results: During May 2019–October 2020, we captured 98 female *Anopheles spp*. mosquitoes, primarily from indoor and outdoor HLC. Of these, we identified 30 (30.6%) as *An. gambiae s.s* and *An. funestus s.s* and the rest as secondary vectors. CDC-LT and PSC caught a total of 1342 female mosquitoes that were sequenced. Of the female Anopheles mosquito specimens sequenced; the vast majority, 1030 (72.75%) could not be matched (<90% identity) to any of the published ITS2 or CO1 published sequences of anopheline vectors or nonvectors.

Conclusion: The identification of undescribed Anopheles species in western Kenya highlands, highlights the shortcomings of the morphological identification in natural settings. The outdoor activity of these mosquitoes' points to the potential pitfalls in the current control strategies that target mainly indoor biting and resting mosquitoes.

ABS-661

Larval habitats and species composition of mosquitoes in two urban neighborhoods of Lagos, Southwest Nigeria

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Mosquitoes are of considerable public health importance in different parts of the world. Proper identification of their potential breeding sites and its elimination are among the successful strategies in combating mosquito-borne disease worldwide. In the present study, we conducted mosquito larval surveys in two urban neighbourhoods, Surulere and Apapa, in Lagos, Nigeria between July and October 2021. The aim was to investigate mosquito species composition and habitats utilized by these species with overall goal of generating useful information to guide mosquito surveillance and control activities targeting vector species. Mosquito larvae and pupae were collected using dipping technique and emerged adults were identified using standard morphological keys. Mosquito abundance, diversity and habitat types were assessed. The total number of immature mosquitoes collected from both areas was 2,696 of which 90.3% (2,434) was collected from Surulere. *Aedes aegypti*, *Culex pipiens* complex and *Anopheles gambiae* complex were found in both Surulere and Apapa. One mosquito species identified as *Lutzia tigripes* was found only in Apapa. In Surulere, the mosquito species with significantly ($p<0.05$) the highest relative abundance (59.8%) was *Cx. pipiens* complex while the lowest (2.2%) was *An. gambiae* complex. In Apapa, *Ae. aegypti* had the highest abundance (68.7%) while *Lt. tigripes* had the lowest (6.9%) though there was no significant difference between them. Gutters, ground pools and man-made containers especially used tyres were the habitat types encountered in both neighbourhoods. Larval densities varied significantly ($p<0.05$) among species, and habitat types only in Surulere. The variations seen in mosquito species composition and abundance between the two neighbourhoods suggest different risk for specific mosquito-borne diseases. Institution of integrated vector management tactics targeting mosquito larvae are recommended.

Keywords: Mosquito species, diversity, abundance, habitat types, urban neighbourhoods

ABS-354

Identification of 3,3′-O-dimethylellagic acid and apigenin as the main antiplasmodial constituents of *Endodesmia calophylloides Benth* and *Hymenostegia afzelii* (Oliver.) Harms

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Background: This study aimed at identifying antiplasmodial natural products from selected crude extracts from *H. Afzelii* and *E. calophylloides* and to assess their cytotoxicity.

Methods: The extracts from *H. afzelii* and *E. calophylloides* were subjected to bioassay-guided fractionation to identify antiplasmodial compounds against the chloroquine-sensitive 3D7 and multi-drug resistant Dd2 strains of *Plasmodium falciparum* using the SYBR green I fluorescence-based microdilution assay. Cytotoxicity of active extracts, fractions and compounds was determined on African green monkey normal kidney Vero and murine macrophageRaw264.7 cell lines using the Resazurin-based viability assay.

Results: The hydroethanolic extract of *H. afzelii* stem bark ($Hasb^{HE}$) and the methanolic extract of *E. calophylloides* stem bark ($Ecsb^{M}$) exhibited the highest potency against both *Pf*3D7 and *Pf*Dd2 and were not cytotoxic. The biological activity-guided fractionation led to the identification of two antiplasmodial active compounds namely apigenin (compound **1**) from $Hasb^{HE}$ and 3,3′-*O*-dimethylellagic acid (compound **6**) from $Ecsb^{M}$. Interestingly, both compounds exhibited negligible cytotoxicity against both *Vero* and *Raw* 264.7 cell lines with selectivity indices greater than 9.

Conclusions: This study led to the identification of two potent antiplasmodial natural compounds, 3,3′-*O* dimethylellagic acid and apigenin that could serve as starting points for further antimalarial drug discovery.

Keywords: 3,3′-*O*-dimethylellagic acid, Apigenin, Antiplasmodial activity, Bioguided fractionation

ABS-530

Genetic Diversity of *Plasmodium falciparum Merozoite Surface Protein*-(Pfmsp) 2 in Blood and Saliva Samples from Cameroon

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Background: Continuous monitoring of the genetic diversity of malaria parasites is a strategy that could guide decision-making in the selection of suitable drugs and vaccines within a locality. The “merozoite surface protein (*MSP*) 2” of *P. falciparum* is a ligand involved in erythrocyte invasion and is one such marker used to monitor genetic diversity in *P. falciparum*. However, existing technology used in genetic surveillance has invasive sampling methods, are costly, and are unsustainable for the LMIC context. This study aims to investigate using an in-house cost-effective method, the genetic diversity of *Pfmsp-2* gene in blood and saliva specimens from patients with *P. falciparum* malaria in the Mfou health district of Cameroon.

Methods: Twenty-seven archival saliva and 50 contemporary blood specimens were collected from patients who tested positive for malaria using a rapid diagnostic test. Genomic *Plasmodium* spp. DNA was extracted from 50 dried blood spots using the Chelex-20 extraction method and 30 red cell pellets as well as all saliva samples using the column extraction method (NucleoSpin®). After standardizing an in-house method, nested-PCR was used to detect the presence of *P. falciparum* and the different alleles of *Pfmsp-2* in blood and saliva samples.

Results: *P. falciparum* PCR positivity rate was 94% (47/50) and 88.88% (24/27) in blood and saliva respectively. Altogether, 14 alleles of the *Pfmsp-2* gene with sizes ranging between 279-1178bp were detected in blood. The genetic diversity and multiplicity of infection (MOI) of *Pfmsp-2* were 10.61% and 2.81 respectively in blood. In contrast, 6 alleles of the *Pfmsp-2* gene with sizes ranging between 450-708pb were detected in saliva. The genetic diversity of *Pfmsp-2* gene and the multiplicity of infection was 35.29% and 1.33 respectively. Quadruple allelic infections were predominant (29,78%) in blood, while single allelic infections were predominant in saliva (86,67%).

Conclusion: The extensive genetic diversity observed in Mfou could herald the rise and spread of drug-resistant strains of *P. falciparum* as well as the undesirability of MSP2-based vaccines in this locality. Our findings initiate the use of saliva as a promising alternative in monitoring genetic diversity but warrant further investigations.

Keywords: *Plasmodium falciparum,* Malaria, Saliva, Genetic diversity, *Pfmsp-2*, Mfou, cost-effective.

ABS-625

Efficacy of a novel three-dimensional window screening technology in capturing and reducing malaria vectors: results from an experimental hut semi-field trial from north-eastern Tanzania

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Background: In a growing scenario of insecticide resistance, demand for a sustainable insecticide-free malaria control method is higher than ever. We have been working on a novel strategy focusing on blocking mosquito-host contact to reduce malaria by using a state of the art screened (3D screens) window traps developed in Finland. In laboratory studies (2015), one 3D prototype captured 92% of the mosquitoes in a double screen setup. To further elucidate the efficacy of this technology, we conducted phase II trials in Muheza, Tanzania where the efficacy of 3D screen was tested in semi-field condition.

Methods: Three experimental hut trials were conducted between 2016 and 2017 under VCAG recommendations which tested the efficacy of 3D single, and 3D window double screen trap (3D-WDST) under open and closed eaves condition (Trial I), 3D-WDST in huts with and without baffles (Trial II) and, locally made, and industrially made 3D-WDST (Trial III). Capturing efficacy was compared to standard exit trap which served as a control.

Results: Experiments from trial I demonstrated a superior trapping efficacy of 3D-WDST (34.66% in open and 74.44% in closed eaves) compared to 3D single screen setup (6.52% in open and 18.33% in closed eaves). Capturing efficacy of 3D-WDST in huts with and without baffles was comparatively similar (73.94% and 68%). Overall, comparison of 3D screens and control setup with non-parametric analyses suggested a similar efficacy of 3D screens and standard exit trap.

Conclusions: 3D screens performed effectively by trapping host-seeking mosquito vectors under semi-field condition. Performance of double screen was superior to the single screen setups. The outcome suggests a promising application of this novel technology and could potentially be an effective solution in insecticide resistant areas. A large-scale community trial to evaluate its epidemiological, entomological, and social impact is recommended.

ABS-521

Observing the distribution of mosquito bites on humans to inform personal protection measures against malaria and dengue vectors

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Background: Understanding mosquito biting behaviours is important for designing and evaluating protection methods against nuisance biting and mosquito-borne diseases (e.g. dengue, malaria and zika). We investigated the preferred biting sites by *Aedes aegypti* and *Anopheles arabiensis* on adult volunteers in standing or sleeping positions; and estimated protection limits affordable from either protective clothing or repellent-treated footwear.

Methods: Adult volunteers dressed in shorts and t-shirts were exposed to infection-free laboratory-reared mosquitoes inside screened chambers from 6am to noon (for day-biting *Ae. aegypti*) or 6pm to midnight (for night-biting *An. arabiensis*). Attempted bites on different body parts were recorded. Comparative observations were made on the same volunteers while wearing sandals treated with transfluthrin (a vapour-phase pyrethroid that kills and repels mosquitoes).

Results: *An. arabiensis* bites were mainly on the lower limbs of standing volunteers (95.9% of bites below the knees) but evenly-distributed over all exposed body surfaces when the volunteers were on sleeping positions (only 28.8% bites below knees). *Ae. aegypti* bites were slightly concentrated below the knees of standing volunteers (47.7% below knees), but evenly-distributed on sleeping volunteers (23.3% below knees). Wearing protective clothing that leave only hands and head uncovered (e.g. socks + trousers + long-sleeved shirts) could prevent 78-83% of all bites during sleeping, and at least 90% of bites during non-sleeping hours. If the feet are also exposed, protection declines to as low as 36.3% against *Anopheles*. Transfluthrin-treated sandals reduced *An. arabiensis* bites by 54-86% and *Ae. aegypti* bites by 32-39%, but did not change overall distributions of bites.

Conclusion: Biting by *An. arabiensis* and *Ae. aegypti* occur mainly on the lower limbs, though this proclivity is less pronounced in the *Aedes* species. However, when the hosts are on sleeping positions, biting by both species is more evenly-distributed over the exposed body surfaces. High personal protection might be achieved by simply wearing long-sleeved clothing, though protection against *Anopheles* particularly requires covering of feet and lower legs. The transfluthrin-treated footwear can reduce biting risk, especially by *An. arabiensis*. These findings could inform the design and use of personal protection tools (both insecticidal and non-insecticidal) against mosquitoes and mosquito-borne diseases.

ABS-788

Structural modification of parthenin for malaria transmission-blocking

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Background: Malaria continues to be a major cause of morbidity and mortality in sub-Saharan Africa. Thus, concerted efforts are needed to sustain malaria control. Amongst them are strategies that disrupt development of malaria parasite within its mosquito vector. Recently, we isolated parthenin, a sesquiterpene lactone as is artemisinin, from the invasive weed *Parthenium hysterophorus* and found it to arrest malaria parasite development in the mosquito. Parthenin however, was found to be cytotoxic to humans. This study was designed to investigate the potency and safety profiles of synthetic derivatives of parthenin.

Methods: Parthenin was isolated from *P. hysterophorus* by soaking powdered leaves in MeOH at 25°C for 24 hrs; followed by concentrating under reduced pressure at 40°C and purifying using various chromatographic methods. Thereafter, the structure of parthenin was modified to obtain different derivatives. The structures of these compounds were then determined by Gas Chromatography (GC)-Mass spectrometry (MS), Liquid Chromatography Quadrupole Time-of-Flight Mass spectrometry (LC-QTOF-MS) and 1- and 2-D (13C and 1H) Nuclear magnetic resonance (NMR). Thereafter, the compounds were subjected to standard membrane feeding assays (SMFA) and cytotoxicity text using Vero cell lines.

Results: Structural modification of parthenin resulted in two derivatives. The derivatives were found to block development of oocysts in mosquito midgut when tested at a dose of 6.3µg/mL. Additionally, the derivatives when tested at dose of 10µg/mL were found to completely block ex-flagellation in male gametes. Cytotoxicity assays revealed the two derivatives to exhibit 20- and 7-fold lower cytotoxic activity than the parent compound parthenin.

Conclusion: These results show the potential of parthenin derivatives as malaria transmission blocking agents. The compounds can be exploited as scaffold for developing drugs that block transmission of malaria parasite via the mosquito host.

ABS-543

Biting pattern of *anopheles arabiensis* and human behaviour in irrigated site in Western Kenya

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Background and Objective: Knowledge on the host-seeking behaviour, indoors or outdoors biting preference and biting times is important in understanding malaria transmission dynamics and effectiveness of vector control interventions. This

study assessed the biting patterns of malaria vectors and human behaviour in an irrigated site with ongoing malaria vector control program.

Materials and Method: Adult mosquitoes were sampled in a study site representing the irrigated agroecosystem in western Kenya using human landing catches. The mosquito samples were speciated using polymerase chain reaction. Human behavioural surveys were conducted to understand night activities and sleeping pattern, and where they overlap with vector behaviour.

Results and Discussion: *Anopheles arabiensis* was identified as the major malaria vector in the study site. There was a significant difference in the indoor and outdoor biting proportion of *An. arabiensis* mosquitoes with over 60% of the bites observed indoors. Indoor biting activity of *An. arabiensis* varied significantly across the hours and showed a peaked plateau early in the evening between 2000 and 2200 hours before the local community went to sleep. Data on human behaviour and mosquito activity indicate that there is a risk of transmission in the evening and at dawn when people are not under the protection of nets. Outdoor biting occurred throughout the night however the greater proportion of the population was indoor from dusk to dawn hence a low risk of outdoor malaria transmission.

Conclusions and Recommendations: These findings demonstrate that there was a higher risk of malaria transmission indoor, however transmission also occurred outdoors in the irrigated scheme. The study highlights the need to complement the existing malaria vector interventions with additional strategies such larval source management and novel tools targeting indoor and outdoor host-seeking vector populations.

ABS-701

Understanding entomological parameters to restrategize malaria control in the private sector: a case of First Quantum Minerals supported areas in Solwezi and Kalumbila districts, Zambia

Godwill Mlambo

Background and Objective: Zambia embarked on a tremendous malaria elimination campaign targeting Zero Malaria by 2021. Several strategies were put in place and private sector was key in this fight. First Quantum Minerals joined the fight as malaria cause man-hour loses limiting mineral production. For any malaria elimination programme to be successful there is need to have a robust entomological surveillance programme to assist or direct in decision making especially in vector control programming.

Materials and Methods: Robust field larva collections were done in Solwezi and Kalumbila districts during June to July 2021. F1 adults were exposed to pirimiphos methyl (0.25%), DDT (4%), bendiocarb (0.1%) and clothianidin (2%) using WHO protocols. Preliminary morphological identification was done to a total of 916 exposed mosquitoes which were then randomly shared between KEMRI (470) and NICD (446) laboratories in Kenya and South Africa respectively. PCR species identification, *kdr* tests, *Ace-1* analysis, target site mutation screening and ITS2 were conducted. Results from the two laboratories were compared for quality assurance.

Results and discussions: Morphological identification needs proper expertise and experience as discrepancies were noted between preliminary identification and molecular species PCR results especially on the anopheles funestus group. On other anopheles species such as Anopheles somalicus, Anopheles njombiensis, Anopheles obscurus and Anopheles wellcomei there was little cohesion with second opinion at the reference laboratories. Just a two-year use of DDT in Solwezi managed to confer knock down resistance(kdr) to the predominant Anopheles gambiae species matching to the WHO susceptibility tests that were at 31% 24-hour mortality to DDT. Kdr-east and kdr-west were confirmed present in the Anopheles gambiae species. Situation was different, just 120kms away in Kalumbila where the predominant species Anopheles funestus was highly susceptible to DDT. All the mosquito samples were susceptible to G119S mutation differing with WHO susceptibility tests that stood at 91% 24hr mortality on carbamates. Clothianidin delayed mortality was confirmed with highest 144hr mortality reaching 94% on tube assays. Main challenge was to hold controls for too long especially in a field adapted insectary. Pirimiphos methyl reached a 24-hr mortality at 97% but had a very good 1-hour knockdown at 90%. These results indicate different susceptibility levels of

the various anopheles species to the tested insecticides as completely different susceptibility results to pirimiphos methyl and clothianidin were recorded during the wet season where 100% mortality was realised on both papers and CDC bottle assays respectively.

Conclusions and recommendations: There is always a need to routinely refresh entomologists on morphological identification so that discrepancies with PCR species identification is reduced. It is also a scientific tool to compare results between two or more reference laboratories as each laboratory has its strengths and weaknesses. For example, another laboratory had no capacity to do Ace-1 mutation tests and ITS2 PCR tests. Although a scientific argument exists on the efficacy of clothianidin in reducing malaria transmission, its delayed mortality needs to be explored as some mosquitoes continued to survive even 7 days after exposure. This can be the reason why Zambia failed to meet the 2021 malaria elimination target. Although, pirimiphos methyl didn't reach the minimum 24-hour mortality threshold to full susceptibility status, it stands as good candidate to replace clothianidin which has been in use for more than 4 years. Main advantage is that it has a high 1-hour knockdown rate. Because collections were done in the driest part of the year, there is need to do adult mosquito collections during the wet season using aspirators and light traps to determine indoor and outdoor preferences, host preference and sporozoite infection rates.

ABS-645

Evaluation of two sampling techniques for assessing key malaria transmission indices in *anopheles gambiae* s. L. In Nassarawa Eggon local government area, Nasarawa State, North Central Nigeria

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The continuous need for complimentary, substitutionary, as well as alternative techniques in malaria vectors surveillance cannot be over emphasized. Thus, a study on evaluation of two sampling techniques for assessing key malaria transmission indices in *Anopheles gambiae s. l.* in Nassarawa Eggon L.G.A., Nasarawa State, North Central Nigeria was carried out from June 2016 to April 2018. Mosquitoes were collected at day time from 0600 to 0900 hours using Prokopack Aspirator Catch (PAC) and Pyrethrum Spray Catch (PSC) techniques respectively. Thirty houses were randomly selected for each the sampling technique. Samples collected were then sorted and morphologically identified in the laboratory using standard identification keys. A total of 2,843 mosquitoes were collected in which the anopheline group was dominant 2,774 (97.57%) over the culicines 69 (2.43%) and varied significantly ($c^2 = 2573.7$, df = 1, $P < 0.0001$). A very high significant difference ($c^2 = 10659$, df = 4, $P < 0.0001$) was observed in relation to the abundance of the five mosquito species recorded in which *An. gambiae s. l.* was the most dominant 2,770 (97.43%). Over 60% (1,650) of the pooled female *Anopheles* mosquitoes collected were from PAC whereas PSC only yielded 39.78% (1,131) individuals which resulted in a very high significant difference ($c^2 = 118.73$, df = 1, $P < 0.0001$) in female *Anopheles* abundance between the two sampling techniques. The number of female *An. gambiae s. l.* caught positively associated with the number of people that slept indoors the previous night prior to collection ($t = 4.7677$, df = 294, $P < 0.0001$, $r = 0.27$). Almost all the female *An. gambiae s. l.* caught were blood fed 96.43% (2,646). The indoor resting density of female *An. gambiae s. l.* in the area was 5.72 mosquitoes per house per night, and a man biting rate of 1.47 bites per night was observed. In conclusion, the high mosquitoes catch obtained from Prokopack Aspirator possibly suggests its recommendation for consideration for wide usage in entomological surveillance to either compliment or substitute the PSC technique.

Keywords: Malaria vectors surveillance, Prokopack aspirator catch, Pyrethrum spray catch, Indoor resting density, Man biting rate

ABS-655

Spraying applied against mosquito swarms in southwestern Burkina Faso

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The outdoor biting constitutes a major limitation of the current vector control based primarily on long-lasting insecticidal nets and indoor residual spraying, which both are indoor interventions. Consequently, malaria elimination will not be achieved unless additional tools are found to deal with the residual malaria transmission and the associated vector dynamics. In this study we tested a new vector control approach for rapidly crashing mosquito populations and disrupting malaria transmission in Africa. This method targets the previously neglected swarming and outdoor nocturnal behaviors of both male and female *Anopheles* mosquitoes. This was involved accurate identification and targeted spraying of mosquito swarms, to suppress adult malaria vector populations and their vectorial capacities. The Impact of Targeted spraying was compared to the broadcast spraying which was evaluated simultaneously. The effects of the two interventions were very similar, no significant differences between targeted spraying and broadcast spraying were found for effects on density, insemination or parity rate. However, we found targeted spraying to be significantly more effective than broadcast spraying at reducing number of bites per person. The two interventions both had a highly significant impact as expected upon all parameters measured but the targeted swarm spraying require less insecticide quantities.

Keywords: Target swarm spray, Broadcast space spray, Malaria vectors control, Swarm-killing intervention, Burkina Faso

ABS-717

Lessons learnt from PIIVeC, a capacity strengthening programme for control of vector borne disease.

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The Partnership to Increase the Impact of Vector Control (PIIVeC) was established in 2017 with the overall objective of increasing the capacity to generate high quality evidence to control vector borne disease, and to increase the utilization of this evidence in national policy making. To achieve this goal the programme invested in individuals and institutions in three countries, Cameroon, Malawi and Burkina Faso, and supported multiple short operational research projects (many in collaboration with government departments) and longer term fellowships for emerging leaders in vector control. Technical Vector Control Advisory Groups were established with a wide range of stakeholders across different sectors, and capacity assessments of the partner research institutes were conducted and resources made available to help address some of the most urgent needs. In this presentation we will showcase some of the major outputs from the programme and discuss the key enablers, and lessons learnt in the hope that this will inform future capacity strengthening programmes. We will also describe the efforts, and successes and failures, to ensure that the legacy of the project exceeds the duration of the funding available.

ABS-502

Malaria vector survival and infectivity: a longitudinal cohort study in high transmission area in western Kenya.

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Longevity of malaria vectors determines the number of repeat blood meals during their lifespan. Parasite transmission requires serial feeding on human hosts with at least 10-14 days interval between an infected host and a susceptible one to permit completion of sporogonic development. We report data on mortality and infectivity of wild-caught malaria vectors from an area of high long lasting insecticidal nets (LLINs) coverage in western Kenya. Prokopack technique was used to collect mosquitoes between 6.00am and 8.00am once a month from 75 households across five villages between Jan 2020 to March 2022. The captured mosquitoes were reared in captivity and daily mortalities recorded from day 0 up to day 7 after which surviving mosquitoes were sacrificed. *Anopheles gambiae* group sibling species and infectivity were determined using PCR technique. A total of 712 female anopheles mosquitoes were captured indoors. *An. gambiae* group comprised 52.4% while 39.8% were *An. funestus*, and the remainder were other anophelines. Within *An. gambiae* group, 79.3% were *An. gambaie sensu stricto*, 4.3% *An. arabiensis* and 16.4% neither or unidentified. About 61.2% of the anophelines survived up to day 7 with the least mortality recorded on day 5 of captivity, coincidentally the same day oocysts rate was highest (16.7%), but this declined to 7.6% on day 7 probably because oocyst maturation is inimical to malaria vectors' survival. Survivorship was slightly different between the vector species (Pearson X^2; p=0.019), and across villages (Pearson X^2; p=0.000). Village-level mosquito density was correlated with early mortality, possibly due to damage inflicted by overcrowding during collection or due to small larval size in crowded breeding sites, which results in weak and short-lived adult mosquitoes. Leveraging our rich longitudinal dataset, we also explore the possibility that higher LLIN use in the 24 hours before mosquito capture increases mortality on days 1 and 2.

ABS-630

Experimental test of OviTraps effectiveness for *Aedes mosquito* control in five urban sites in Mali.

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Aedes are incriminated as major vectors of the transmission of several arboviruses including yellow fever, zika disease, dengue, Chikungunya, etc. Mali, like other countries in sub-Saharan Africa, due to its eco-climatic conditions remains very suitable to the growing of *Aedes* mosquitoes. This country already suffers from major public health problems due to *Anopheles*. If the

arboviruses become the same as malaria it will significantly increase death in the community. The aim of this study was to compare the success of using Ovicups (OviTraps) for *Aedes* control in 5 differents urban sites in Mali: Kayes, Sikasso, Ségou, Mopti and Bamako. Black attractant pots of about 1L containing filter paper and 200ml of infusion of dry mango leaves for 72 hours were placed as OviTraps under vegetation or other hidden places. These OviTraps were checked every day to note the number of positives. Overall, 5-10% of OviTraps were positive the first night, 25-60% the second night, and 70-95% the third night. The number of eggs per OviTraps varied from 15 to 250. The most productive sites were respectively Sevare, Kayes, Bamako, Ségou and Sikasso. Dark to black colored nests and filter papers, vegetation, and host availability were considered favorable factors for OviTraps performance. In view of their good performance, oviTraps can make an impressive contribution for the control of arbovirus vectors (*Aedes* mosquitoes).

Key words: *Aedes, OviTrap, Urban site, Mali*

ABS-647

Malaria prevalence among different age groups and gender in subsistence crop farming and fishing communities in greater Kamuli district, Uganda

Fredrick Kabbale [1,3], Aggrey Batesaki [2], Samuel Waiswa [4]

Background and objective: Malaria remains a major health threat in Uganda. This study aimed at comparing the malaria prevalence rates among different age groups and gender between subsistence crop farming and fishing communities in greater Kamuli District, Uganda.

Materials and methods: Malariometric surveys covering 519 people (224 adults and 295 children) living in 70 households at Bukungu fish landing site and Nabwigulu crop farming communities were carried out using rapid diagnostic tests.

Results and discussion: overall, 25.1% (130 out of 519) of the people screened in the two sites combined had malaria. Malaria burden was found to be higher (46%) among the subsistence farming community compared to the fishing community (26.3%). Generally, males had the same risk of malaria infection as females among the fishing communities, while in the subsistence farming communities, males (26.7%) had higher malaria prevalence than females (18.3%). The prevalence (58.3%) of malaria among school-going children (6 to 11 years) in the subsistence farming community was similar to that of <5 years old (53.8%). Malaria prevalence was lowest among children 12 to 17 years (17.6%). Children under five years apparently had the highest malaria prevalence in the fishing community (43.3%). Overall, adults (>18 years) had a malaria prevalence of 47.4%. Malaria transmission risk factors include poor cultivation and fishing-related activities, poor housing, and the lack of collective malaria control and prevention efforts among the communities were responsible for the high malaria burden.

Conclusion and recommendations: Livelihood-related factors in the study area played a big role in malaria transmission among the different age groups and gender. Community sensitizations on malaria transmission risk factors are recommended, while safety measures against malaria risk should be considered for all age groups and gender in both livelihoods. Malaria control and prevention action plans with collective efforts among both communities are recommended.

Key words: MALARIA, AGE, GENDER, SUBSISTENCE FARMING, FISHING

ABS-715

Blood meal survey reveals insights into vector-borne diseases on the island of Santiago, Cabo Verde

Aderitow Goncalves

Background: Transmission of pathogens by blood-sucking insects to humans and other animals depends on vector-host interactions. Herein, we aimed to explore through blood meal analysis the relationship between mosquito's species and common hosts in Santiago's Island, Cabo Verde.

Methods: Blood meal composition was accessed through Enzyme-Linked Immunosorbent Assay (ELISA) from engorged female mosquitoes collected from May 2016 to December 2017. Human Blood Index (HBI) and relative frequencies of blood meals (including cryptic meals) were estimated.

Results: We were able to determine that single-host blood meals were commoner than mixed ones in *Aedes aegypti*, *Anopheles arabiensis* and *Culex pipiens* s.l. Humans, dogs and chickens were the most common hosts across all blood meals. The greatest overall HBI (0.98) was observed in *Ae. aegypti* and the lowest in *An. arabiensis* (0.55). In general, mixed blood meals were dominated by 2 hosts and cryptic meals were found mostly from humans. Significant positive and negative associations were obtained, respectively, for two interactions: humans and *Cx. pipiens* s.l. (LOR=0.85; $p<0.05$); humans and *An. arabiensis* (LOR=-2.44; $p<0.05$).

Conclusions: Overall, our findings demonstrated, for the first time, a lack of feedings preference in *Culex pipiens* s.l., compared to *Ae. aegypti* and *An. arabiensis*. These results provide insights on how to possibly curb parasites transmission and pathogens spillover/spillback, which threaten human/animal health and economy in Cabo Verde.

ABS-732

Association between malaria transmission vector species' densities and malaria prevalence in Busia county, western Kenya

Brenda Omala

Introduction: Entomological inoculation rate (EIR) is one of the direct measures of malaria transmission. However, it is unclear how density of vector species is a pointer to malaria transmission at different transmission levels and seasons. The study aimed at determining if there is a relationship between malaria vector species' densities and malaria prevalence as depicted on health records from selected health facility in Busia County in Western Kenya.

Methods: Mosquito collection was done by CDC light traps in three study cluster sites: Akiriamas, Koruruma and Odeketkamor for entomological indicators' data. Health facility outpatient (OPD) epidemiological data for under five and over five patient categories were used. OPD data from Akiriamas health facility was used to obtain epidemiological data for the three study cluster sites. Both malaria vectors and epidemiological data were collected between the months of March and June in 2021. Vector species identification was done by both morphological identification keys (Coetzee et.al., 2020) and polymerase reaction chain. Data analysis was performed in R software. Cumulative malaria prevalence for every cluster was calculated per month. Malaria vector species density for every cluster was also calculated on a monthly basis between the same months as that of prevalence data.

Results: A decreasing trend in disease prevalence over time was observed for Akiriamas and Koruruma but not for Odoketkamor. High densities of both *Anopheles Funestus s.l*, (47.1%) and *An. gambiae s.l* (52.9%) during the month of April was observed in Odeketkamor. On correlation analysis between prevalence rates and species densities there was a strong association between disease prevalence and *Anopheles funestus s.l* density with $R^2=1$ ($p=0.022$), *An. gambiae s.l*, showed a weak association $R^2 = 0.9$ ($p=0.27$) in the month of March. Association obtained in the subsequent months were as follows; April, *An. funestus s.l*, $R^2= -1$ ($p=0.047$), *An. gambiae s.l,* $R^2= -0.94$ ($p=0.23$); May, *An. funestus s.l* $R^2=0.93$ ($p=0.24$) and *An. gambiae s.l* $R^2= 0.18$ ($p=0.89$); June, *An. funestus s.l* $R^2= 0.07$ ($p=0.96$) and *An. gambiae s.l* $R^2= 0.049$ ($p=0.97$).

Conclusion: The study results suggest that there is a strong and weak association between malaria disease prevalence and densities of *Anopheles funestus s.l* and *An. gambiae s.l*, respectively. Malaria prevalence in the endemic in Busia County, Western Kenya could therefore be used to inform control interventions of malaria transmission vector.

Key words; Malaria, OPD, *Anopheles gambiae s.l*, *Anopheles funestus s.l*

ABS-360

Human landing catches (HLC) are an accurate approximation of bite reduction for the evaluation of volatile pyrethroid spatial repellents

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Background: Human landing catches (HLC) where a human volunteer collecting mosquitoes that land on them before they can bite is often used to measure the protective efficacy (PE) of bite prevention interventions such as volatile pyrethroid spatial repellents (VPSR). However, VPSR have multiple actions including biting inhibition meaning mosquitoes may not bite even if they find a host and land. Here, the PE of a transfluthrin VPSR measured by either HLC or blood-feeding was compared.

Method: The study was a fully balanced, two-arm crossover design conducted in a 6x6x2 metre netted cage- Ifakara large ambient chamber test (I-LACT) within a semi-field system (SFS). Hessian fabric soaked in 5g, 10g, 15g, and 20g of transfluthrin was evaluated against three strains of laboratory reared Anopheles as well as Aedes aegypti mosquitoes. Six replicates were performed per dose using either HLC or allowing landed mosquitoes to blood-feed. The difference in landing or feeding was analysed using negative binomial regression, and agreement of PE by method was compared by Bland-Altman (BA).

Result: For Anopheles, fewer mosquitoes blood-fed than landed both in the control (IRR=0.90 (0.82-0.97) P<0.01) and this difference was more pronounced in the transfluthrin arm (IRR=0.82 (0.74-0.91) P<0.001). Similar trend was observed for Aedes aegypti mosquitoes in the control (IRR=0.70 (0.64-0.76) and transfluthrin (IRR=0.56 (0.46-0.67). However, BA comparison showed a good agreement between feeding and landing for both Anopheles and Aedes mosquitoes. For example, for Anopheles mosquitoes, the mean difference was -4.75 %(-25.57-16.07).

Conclusions: HLC slightly overestimated the PE. However, the PE calculated by either method closely agreed when tested by BA so they can be used interchangeably. Considering the difficulties of measuring the number of blood-fed mosquitoes in the field setting, the HLC provides a useful proxy of PE for evaluating volatile pyrethroids.

ABS-740

Evidence of outdoor transmission of malaria parasite: implication on the current malaria vector control strategy in Nigeria

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Background: Programmatic malaria vector control in Nigeria is largely dependent on the use of Long-lasting Insecticide treated Nets (LLINs) with over 202million nets distributed. Nigeria remains the country with the highest burden of the disease, however, proper monitoring of mosquito transmission dynamics would be instrumental towards achieving a malaria-free Nigeria. Therefore, we examine the indoor and outdoor malaria transmission dynamics in three geopolitical zones of Nigeria.

Methods: Malaria vectors were sampled indoor and outdoor on a monthly basis in Kano, Niger and Osun States for 24months between 2020 and 2021 using the human baited CDC light trap method. All samples collected were identified morphologically and followed by molecular analysis of species complexes. Sporozoite ELISA was conducted on all species to determine sporozoite infectivity.

Results: In total, 22,196 anophelines were collected of which 92.99% were Anopheles gambiae s.l. Other species collected were An. funestus, An. coustani, An. phaorensis An. nili, and An. rhodosiensi. Only Anopheles gambiae s.l. was found in the 3 study

locations. Molecular analysis of An. gambiae complex revealed An. coluzzii as the major sibling species in the 3 study locations. Human biting rate was highest in Kano with an average of 21.54b/p/n followed by Niger (4.10b/p/n) and then Osun (0.71b/p/n). In 2020, the annual indoor/outdoor EIR ratio for the dominant An. gambiae s.l. was determined as 1:1, 11:1 and 1:1 for Kano, Niger and Osun respectively while in 2021 EIR was 11:1 for Kano, 1:1 for Niger and 1:1 for Osun. This indicates an almost equal indoor/outdoor transmission pattern which calls for concerted efforts against outdoor transmission.

Conclusions: An. gambiae s.l remain the most efficient malaria vectors in Nigeria. Malaria transmission indoor is complemented with outdoor transmissions and this calls for a robust integrated approach towards malaria vector control in the country.

ABS-514

A field bioassay for assessing ivermectin bio-efficacy in malaria vectors

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Background: Ivermectin (IVM) mass drug administration is currently under evaluation as a complementary malaria vector control tool. Mosquitoes ingesting blood from treated hosts suffer reduction in survival. Estimating IVM bio-efficacy on wild-caught mosquitoes requires they ingest IVM in a bloodmeal either through a membrane or directly feeding on a treated host. The latter, has ethical implications, and the former results in very low feeding rates. Therefore, there is need to develop a safe and effective method for monitoring IVM bio-efficacy in wild mosquitoes.

Methods: Insectary-reared *Anopheles gambiae s.s* were exposed to five IVM doses: 85, 64, 43, 21, 11 and 0 ng/ml (control) in three different types of solutions: i) blood, ii) 10%glucose, and iii) blood mixed with 10%glucose in four ratios: 1:1, 1:2, 1:4, and 1:8 fed through a filter paper. Mosquito survival was monitored for 28-days. Shortly after ingesting the meal, a pool of mosquitoes was sacrificed and weighed to determine mean weight of each meal type.

Results: Regardless of solution used, higher IVM doses resulted in significant reduction in survival. However, mortality rates for each IVM dose differed by solution. IVM was more lethal in bloodmeal and least lethal in 10%glucose. When administered in sugar-blood mixture resulted in effects closer to bloodmeal. Larger bloodmeals were ingested than sugar or sugar-blood mixtures. However, meal size of mosquitoes fed on different solutions were similar despite pronounced difference in mortality rates.

Conclusion: IVM bio-efficacy differs depending on meal type used to deliver the drug. Meal volumes do not explain differences in lethality of IVM when comparing different meal types. None of the solvents tested here performed better than blood but 1:4 sugar-blood mixture was comparable to blood. Given the assay is sugar feeding based and wild mosquitoes readily sugar feed, this mixture, is a good candidate for field-based bio-efficacy monitoring.

ABS-570

Factors influencing the prevalence of malaria in pregnant women in Sud Ubangi province, Democratic Republic of Congo

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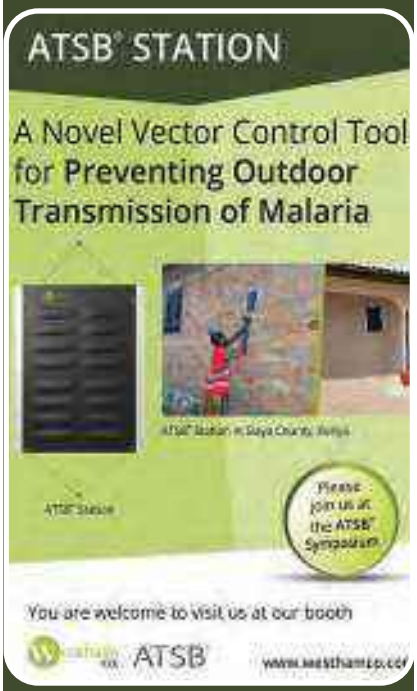
Malaria during pregnancy remain a major public health challenge. It is associated with maternal anaemia and perinatal mortality. As part of a study to assess bednet effectiveness, this province-wide study assessed factors associated with the occurrence of malaria in pregnant women attending their first antenatal clinic appointment (ANC1) in Sud Ubangi, Democratic Republic

of Congo. A longitudinal study was conducted from June 2020 to December 2021 in 112 Health Facilities of the 16 health zones in Sud Ubangi. Pregnant women, attending ANC1s were enrolled in the study. Prevalence of malaria was assessed using RDTs, and behavioural, anamnestic and socio-demographic data recorded via questionnaires. Over 44,000 pregnant women were enrolled with a mean age of 25.6 years. Many households were large with few less than 6 people, and 99% reported possession of bednets (mean 3.4/house). Net usage rates for ANC1 visitors were reported to be very high (98%) and use of other mosquito control methods low (<5%). The median prevalence of malaria in ANC1 visitors was 0.33 with a range of 0.17-0.43 across the 16 health zones in the province, with no significant difference between wet and dry seasons. Factors significantly positively associated with malaria were large household size and a later time to bed, whilst regular net use and the number of previous pregnancies had a protective effect. This study shows a substantial risk of malaria during pregnancy in Sud Ubangi, and illustrates the need to understand socio-demographic factors to predict and reduce malaria rates. In addition to efforts to maintain high IPTP coverage and the regular net distribution campaigns, actions to influence human behaviour through enhanced information campaigns could be considered as additional approaches.



ABS-722

Pathogen's Niche: a new approach for infectious diseases control

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Background and objectives: During the last century, WHO have led public health interventions that resulted in spectacular achievements such as the worldwide eradication of smallpox and the elimination of malaria from the Western world. However, besides major successes achieved in control of infectious diseases, most elimination/control programs remain frustrating in many tropical countries where specific biological and socio-economical features have prevented implementation of disease control over broad spatial and temporal scales. Emblematic examples include malaria, dengue, yellow fever, measles and HIV. This study is based on existing data on the city of Bobo in order to complete them for modeling and to consider an innovative application in public health to fight against vector-borne diseases that represent a significant burden of morbidity in southern countries

Materials and method: To assess, prevalence rate and the proportion of asymptomatic people

we conducted Standard Membrane Feeding Assays on blood samples from 404 children aged 0-15 years from 30 to 50 randomly selected households in four (4) neighbourhoods of Bobo Dioulasso, Burkina Faso. A total of 16717 *Anopheles* were dissected on day seven after membrane feeding and oocysts were detected by microscopy in mosquito guts.

Results: We found that prevalence in Tounouma appears to be lower than those measured in other neighborhoods (0.05) and prevalence in Dogona appears to be highest (0.11). We also found that the peak prevalence was in the 10-13 age group.

Conclusion: These results confirmed that Dogona has the highest prevalence

compared to other neighborhoods and that the contribution of the share of asymptomatic persons on transmission is real as it has a strong influence on the transmission dynamics.

Key words: *Plasmodium*, transmission, control, Membrane Feeding

ABS-353

Design and Performance Evaluation of a Reverse Transcription-based Loop Mediated Isothermal Amplification Method for Plasmodium falciparum Diagnosis"

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Background: Light microscopy and RDT are the two commonly used methods for malaria diagnosis. However, both methods do not have the level of sensitivity required for malaria diagnosis in cases of low-density parasitaemia. This study aimed to design and evaluate a whole blood-based RT-LAMP method for point-of-contact diagnosis of *Plasmodium falciparum* infections in resource-limited environments.

Methods: A simple, rapid and field applicable RT-LAMP method was designed and evaluated in comparison with thick smear microscopy, multiplex PCR and an antigen-based rapid diagnostic test (RDT), among three population groups in Cameroon.

Results: The optimized RT-LAMP method detected *Pf* infections in 0.25ng of total parasite RNA, and exhibited a detection limit of 8000 parasites/μL for the Pan-pLDH antigen band than correspond after ½ dilution at 0.08 parasites/μL when tested on infected whole blood lysates, By generating a composite reference standard based on the microscopy, RDT and RT-LAMP results, the clinical sensitivity of RT-LAMP was 92.92%, specificity 41.94, PPV and NPV 91.63%, 46.43%, and the overall accuracy was 86.42%.

Conclusion: The data highlight the benefits of targeting high abundant RNA transcripts in molecular diagnosis, and the usefulness of whole blood RT-LAMP in malaria diagnosis, particularly in these settings.

Keywords: *P. falciparum*, molecular diagnosis, RT-LAMP, low parasitaemia.

ABS-580

Level of contribution of different malaria vector complexes to malaria transmission in the Cove, Ouinhi, Zangnanado health area

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Malaria remains a major public health issue in Benin, and its transmission is ensured by *Anopheles* mosquitoes. The present study investigated the contribution of different malaria vector complexes to the disease transmission in the Cove, Ouinhi and Zagnanando health area. Pyrethroid resistance intensity in the predominant vector complex was also assessed. During the trial, 60 villages were surveyed over four rounds of collections, between September 2019 and January 2021. Mosquito sampled indoors and outdoors through human landing catches, were morphologically identified. ELISA CSP test was used to look for the *Plasmodium falciparum* sporozoite infection in the different malaria vector complexes. Species identification was conducted within the same vector complexes using PCR. WHO susceptibility tube test was performed by exposing the most abundant malaria vector complex that were field-collected as larvae from 6 villages, to alphacypermethrin 1x, 2x, 5x and 10x.

An. gambiae s.l. (89.6%) was the main malaria vector complex, followed by *An. funestus* gr (1.9%), and *An. nili* gr (0.6%). *An. gambiae* s.l. was comprised of *An. coluzzii* (61.4%), *An. gambiae s.s.* (34%), and a few hybrids (0.1%). *An. funestus* gr was made of *An. funestus s.s.* (93.2%), *An. leesonii* (5.2%) and *An. rivulorum-like* (1.6%). Only *An. nili* s.s. was found within the *An. nili* group. Indoors, biting rates were 16.3 bites/person/night (95% CI: 15.3-17.3) in *An. gambiae* s.l., 0.4 b/p/n (95% CI: 0.3-0.6) in *An. funestus* gr, and 0.1 b/p/n (95% CI: 0.03-0.2) in *An. nili* gr. Similarly, the indoor EIRs were 40.6 infected bites/person/month (95% CI: 38.9-42.4), 2.8 ib/p/m (95% CI: 2.2-3.5), and 0.008 ib/p/m (95% CI: 0-1.2), in *An. gambiae* s.l., *An. funestus* gr, and *An. nili* gr, respectively. Outdoors, the trend was globally the same. Mortality rates observed in *An. gambiae* s.l. with alphacypermethrin 10x, at the diagnostic time of 30 minutes ranged between 87.6% (95% CI: 79.8-93.2) and 100% (95% CI: 96.7-100), indicating moderate-high resistance intensity. The present study showed that *An. gambiae* s.l. was by far the main contributor to malaria transmission in the Covè, Ouinhi, Zangnanando health area. This vector complex displayed moderate to high resistance intensity. Secondary vector complexes include *An. funestus* gr and *An. nili* gr.

Keywords: Vector complexes, biting rate, EIR, resistance.

ABS-608

Contribution of different malaria vector complexes to malaria transmission in the Cove, Ouinhi, Zangnanado health area

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Malaria remains a major public health issue in Benin. The present study investigated the contribution of different malaria vector complexes to the disease transmission in the Cove, Ouinhi and Zagnanando health area. Pyrethroid resistance intensity in the predominant vector complex was also assessed.

Between September 2019 and January 2021, four rounds of mosquito collection were done using human landing catches in 60 villages. *Anopheles* collected indoors and outdoors, were morphologically identified and a sub sample tested for *Plasmodium falciparum* sporozoite infection. PCR was conducted to identify species from the different complexes. WHO susceptibility tube test was performed by exposing *An. gambiae* s.l., to alphacypermethrin 1x, 2x, 5x and 10x the diagnostic concentration

An. gambiae s.l. (89.6%) was the main malaria vector complex, and was comprised of *An. coluzzii* (61.4%) and, *An. gambiae s.s.* (34%). From the *An. funestus* group collected 93.2% were *An. funestus s.s.*, followed by *An. leesonii* (5.2%) and *An. rivulorum-like* (1.6%). Indoors, biting rates were 16.3 bites/person/night (95% CI: 15.3-17.3) in *An. gambiae* s.l., 0.4 b/p/n (95% CI: 0.3-0.6) in *An. funestus* gr, and 0.1 b/p/n (95% CI: 0.03-0.2) in *An. nili* gr. Similarly, the indoor EIRs were 40.6 infected bites/person/month (95% CI: 38.9-42.4), 2.8 ib/p/m (95% CI: 2.2-3.5), and 0.008 ib/p/m (95% CI: 0-1.2), in *An. gambiae* s.l., *An. funestus* gr, and *An. nili* gr, respectively. Outdoors, the trend was globally the same. Mortality rates observed in *An. gambiae* s.l. with alphacypermethrin 10x, ranged between 87.6% (95% CI: 79.8-93.2) and 100% (95% CI: 96.7-100), indicating moderate-high resistance intensity. The present study showed that *An. gambiae* s.l. was by far the main contributor to malaria transmission in the Covè, Ouinhi, Zangnanando health area. This vector complex displayed moderate to high resistance intensity. Secondary vector complexes include *An. funestus* gr and *An. nili* gr.

Keywords: Vector complexes, biting rate, EIR, resistance.

ABS-627

Evaluation of attractive sugar bait (ASB) against *Anopheles* mosquitoes in a controlled semi field system environment in Tanzania.

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Background. Sugar feeding behaviour is an essential aspect of mosquito life history that may be exploited for mosquito control

by adding insecticides to sugar attractants in attractive sugar baits (ASB). To optimise the delivery of ASB in the community, bait stations need to be optimally attractive at short and longer range. This study aimed at developing a bioassay to evaluate the olfactory and gustatory attraction of ASBs with different attractants over different distances against female and male *Anopheles gambiae* and *Anopheles funestus* in a controlled environment.

Method. A standard comparator was developed that contained 20% sucrose. Mosquitoes were exposed ASB in choice or no choice experiments. In non-choice experiments, each ASB station was placed into each cage, while in choice experiment, two ASB stations with different attractant blends were placed in the same cage. Cages were 2mx5mx2m cage to test short range responses or 2mx40mx1.6m to test long range responses. Mosquitoes were exposed overnight and assessed for olfactory attraction using a fluorescent powder marker placed on the ASB.

Results. Both male and female mosquitoes responded to the ASB, with no difference between sex (Odds ratio (OR)= 0.93, 95% Confidence Interval (95% CI): [0.80-1.08], p=0.34). Older mosquitoes (3-5 days old) were 6 times more responsive to ASB OR=6.28, 95%CI: [5.34-7.37], p<0.001 than younger mosquitoes (0-1 day old). No difference was observed in the responsiveness of *An. gambiae* and *An. funestus* OR=1.00, 95%CI:[0.87-1.15), p=0.99) (no-choice). ASB v1.2.1 showed higher intrinsic attraction (no-choice) than ASB v1.1.1 at short range (OR=2.1, 95%CI: [1.79-2.49], p<0.001] and greater relative attraction compared to ASB station v1.1 at long-range OR=1.29, 95%CI: [1.21-1.38], p<0.001), although the two versions were similarly attractive at short range in choice experiments.

Conclusion. Bioassays for ASB should be performed in choice and no-choice experiments on 1) older mosquitoes, 2) both sexes, 3) over long and short range.

Key words: Attractive sugar bait, *Anopheles gambiae, Anopheles funestus*, Olfactory attraction.

ABS-712

Three consecutive years monitoring of malaria vector transmission in Kénieroba rural village in Mali.

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Malaria remains a real public health problem in Mali despite the great progress made in the control of this disease over the past decade. Vector transmission is the main way of malaria infections in endemic areas as Mali. The aim of this study was to monitor malaria vector transmission during three consecutive years in the rural village of Kénieroba. Repetitive monthly survey was carryout throughout 2016 to 2018 to determine annual and seasonal variation of Entomological Inoculation Rate (EIR). Sampling was based on the collection of Anopheles mosquitoes in human dwellings using mouth aspirators. A total of 5430 *Anopheles* were collected among them 1605 *An. gambiae* s.l. The PCR identification show that, 95.5% are *An. coluzzii*; followed by 2.5% *An. arabiensis*; 1.3% *An. gambiae* and 0.7% hybrids (M/S). A positive correlation between density and rainfall was found (R=0.7459 ; Spearman r). Human biting rate was highest in the rainy season. *An. gambiae* s.l. was more than 50% anthropophilic. *An. arabiensis* and hybrids (M/S) were present in both dry and wet seasons with different proportions. However, *An. gambiae* was more present in the rainy season. Infections were observed in the rainy season and also in dry season. The average Entomological Inoculation Rate in 2016, 2017 and 2018 was respectively 3.8; 5.3 and 2.6 bite/human/year. This study shows that, malaria transmission is stable and permanent through the year with *An. coluzzii* and *An. Arabiensis* as major vectors in the study area.

Key words: Malaria transmission, *Anopheles gambiae s.l.*, EIR, seasonality.

ABS-615

Light traps underestimate the entomological impact of the Mosquito Shield™ spatial repellent against bites from *Anopheles arabiensis* in Tanzania

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Background

Spatial repellents, which disperse insecticides in the air to deter mosquito bites, provide an alternative strategy for control or may supplement existing malaria control interventions in endemic areas. In this study, we evaluated which technique between measuring blood-feeding reduction, Centre of disease control miniature light trap (CDC-LT), and Human landing catches (HLC) best estimates the personal protection conferred by the Mosquito Shield™ (a spatial repellent manufactured by SC Johnson).

Methods The study was conducted at the Ifakara Health Institute phase II trial experimental huts located in Lupiro village (8.385°S and 36.670°E) in Ulanga District, south-eastern Tanzania. A 3 by 3 Latin Square replicated twice per method was applied for 18 nights in total (i.e. 6 rounds each 3 consecutive nights). The emanators remained fixed in the huts for the entirety of the study, whilst the volunteers rotated nightly, and trapping methods were rotated after every three nights (experimental round). There were no window exit traps in the huts where CDC-LT and HLC were used. In the blood-feeding reduction set up volunteers slept under a torn untreated bed net with eight 4×4 cm holes: two on the roof, one on each short side and two on each long side.

Results The personal protection calculated (control vs treatment) varied by method and showed there was no difference in the protection efficacy (PE) estimates between HLC (gold-standard) and blood-feeding reduction; but there was a difference between PE estimated via CDC-LT and the other methods i.e. HLC 77% (64 - 86%), Feeding inhibition 84% (58 – 94%) and CDC-LT 30% (0 – 56%). A negative binomial regression analysing the interaction between treatment and experimental method showed a non-significant rate ratio of 0.73 (0.25 – 2.12); p=0.568 between PE estimated via HLC and blood-feeding reductions. However, there was a significant difference between HLC and CDC-LT 3.13 (1.57 – 6.26); p=0.001.

Conclusions HLC (landing inhibition) and blood-feeding reduction (feeding inhibition) can be used alternatively in estimating the personal protection conferred by passive emanators that are applied indoors. Using a light trap will significantly underestimate the indoor personal protection conferred.

ABS-699

Asymptomatic malaria parasitaemia and clone stability in an area with high stable transmission of P. falciparum in Cameroon

Biabi a Bite Marie Florence[1,2*], Fogang Balotin[2], Essangui SAME Estelle[4], Donkeu Christiane[2], Cheteug Glwadys[2], Kapen Marie[2], Keumoe Rodrigue[2], Kemleu Sylvie[2], Maloba Mvo[2], Assam Assam Jean Paul[3], Etoa Francois Xavier.[3], Ayong Lawrence[2]

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Introduction: Despite the considerable efforts to eliminate malaria, incidence and mortality rates continue to rise in endemic area. This may be related to the lack of epidemiological monitoring as well as the neglect of asymptomatic infections, which facilitate maintenance of transmission of the malaria parasite. Longitudinal tracking of parasite populations is essential to understanding the disease transmission dynamics. We therefore aim in this study to monitor parasite clonality amongst asymptomatic carriers in an area with high transmission of *P. falciparum* in Cameroon.

Methodology: From November 2018 to January 2019, 62 individuals with asymptomatic infections were follow up in the community of Esse health district. A locality situated in the Center region of Cameroon. During the follow-up, 3 rounds of blood collections were performed at week 1, week 4 and week 11. The polymorphism of *Plasmodium falciparum* was identified amongst positive samples by nested PCR of the msp2 gene or RFLP targeting the *Pfcrt* drug resistance marker.

Results: A total of 25 alleles were identified during the first collection, 19 identified during the second collection and 20 during the third collection. New alleles were found during follow-up and the Multiplicity of infection (MOI) was 1.7, 2.5 and 1.9 at weeks 1, 4 and 11 of sample collection, respectively. Parasitemia significantly increased with time ($p = 0.0020$). Furthermore, a negative correlation was observed between parasitemia and age as well as MOI and age. The sensitive allele K76 was found abundantly over time (82%, 67.92%, 84.32%), the resistant allele 76T was mostly found in children (<15 years).

Conclusion: Together, these findings show significant increase in clone diversity over time, and its association with blood parasitaemia, that which induce early clinical conversion in some asymptomatic carriers.

Keys words: Asymptomatic malaria, Msp2, *Pfcrt*, MOI

ABS-651

An funestus s.s emergence and it's threat to Malaria elimination efforts in Ndola District, Copperbelt Province of Zambia.

Westone Hamwata

Background: The primary malaria vectors in Zambia are *An. funestus* and *An. gambiae* complexes[1]. *An. funestus s.s* is predominant malaria vector in 8 of the 10 provinces of Zambia. *An gambiae s.s* and *An arabiensis* are the predominant malaria vectors on the Copperbelt and Southern Province respectively [2]. However, implementation of vector control activities could lead to a shift in the abundance and distribution of malaria vectors over time[3–6]. As such, this study assessed the abundance and distribution of malaria vectors in Ndola, Zambia during the dry season.

Methodology: Mosquito collection was done using CDC-LT, PSC, Aspiration and larval collection from a total of 225 collection efforts. The study was conducted in 4 sites Musalu (urban, high density, gardening activities); Mapalo (urban, medium density); Kamalasha (rural, high density, farming activities). Mosquitoes collected were morphologically identified and determination of the sibling species was done using multiplex PCR[7–9].

Results: A total of 737 malaria vectors were collected. *An gambiae s.s* (83%) was the most abundant malaria vector and *An funestus s.s* was 17% of the Collections. All the four sites had the two primary vectors. From Kamalasha and Pima over 70% of the vectors were *An funestus s.s.* Further, 90% of the malaria vectors collected from Musalu were *An gambiae s.s* whereas 65% of the malaria vectors from Mapalo were *An funestus s.s*.

Conclusions: All *An funestus s.l* and *An gambiae s.l* were molecular identified as *An funestus s.s* and *An gambiae s.s* respectively. *An gambiae s.s* is the most abundant malaria vector but *An funestus s.s* was predominant in three of the four sites sampled. The emergence of *An funestus s.s* pose a threat of sustaining malaria transmission in both the wet seasons and dry seasons (when *An gambiae s.s* densities are low) in Ndola District.

ABS-751

Assessment of malaria entomological indicators and efficiency of double net mini trap in Ulanga District, South-Estern Tanzania

Alex J. Limwagu [1,2], Betwel Msugupakulya[1], Masoud Kilalangongono[1], Fredros Okumu[1], Issa Lyimo[1] and Bill Ngasala [2].

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2. *Parasitology and Medical Entomology, Muhimbili University of Health and Allied Science, MUHAS.*

Efforts to control malaria are challenged by persistent transmission maintained by mosquitoes that are not responsive to primary malaria control intervention such as LLINs and Indoor Residual Spray (IRS). Development of effective interventions requires a fully understanding of entomological parameters including vector distribution, feeding behavior, abundance, host preference, human-biting, and infection rates, which determine the vectorial competence of natural mosquito population.

Using a miniaturized double net trap (DN-Mini trap), CDC light trap and Prokopack, we conducted a cross-sectional study to sample indoor and outdoor host seeking mosquitoes to assess entomological indicators such as species composition, densities, feeding and resting behaviour, testing the efficacies of DN-Mini trap in relation to CDC light trap for indoor host seeking, in inside the 37 houses that randomly selected in each of three villages south-eastern of Tanzania. A DN-Mini is a free exposure which enable for monitoring of indoor and outdoor host-seeking mosquitoes without interfering a natural behaviors of mosquitoes. Collection is done by a human volunteer who sits in the middle chamber and collects mosquitoes without direct mosquito contact.

Each village, we selected one house as a sentinel while other 36 houses as a random, Mosquito collected from 18:00hrs to 07:00hrs and collection is done in three days per week, each morning the volunteers collecting mosquitoes indoor and outdoor in the sentinel houses by using a Prokopack aspirator. All mosquitoes retrieved from the traps are stored in the labelled papers cups, then killed, sorted and properly packed into the storage box and sent to laboratory the Polymerase chain reaction (PCR) will be used to detect members of *An. funestus* and *Anopheles gambiae* complexes. Enzyme-linked immunosorbent assay (ELISA) will be used to detect Plasmodium sporozoites in mosquito salivary glands. Statistical analysis will be done and the results will be shared after completing data collection.

ABS-532

Malaria Burden in an Endemic Setting: a two-year survey of a Tertiary Hospital in Otukpo, Benue State, Middle Belt, Nigeria.

Aju-ameh, c.O.; Eze, s.C.; Zakari,h.; Samuel,b.I.; Andy,o.B. Jeremiah e.; Paul, s.; Wahedi, j. A.

Background & Objective: The 2021 World Health Organization report estimates 241 million malaria cases and 627,000 malaria deaths worldwide. Compared to 2019 report, about 14 million more cases and 69,000 deaths were reported in 2020, with most of the increase occurring in the African region. Nigeria still bears the greatest malaria burden (cases-26.8%, deaths-31.9%) in the world. Although seemingly eclipsed by the emergence of Covid-19 in recent years it is still a major public health challenge. The goal is to provide area-specific malaria case estimates for locale-specific incidence tailored intervention.

Materials & Method: A study was conducted to determine a 24 months (2020 and 2021) malaria prevalence based on laboratory registers of febrile outpatients at a tertiary health center. Diagnosis of malaria was done using only Plasmodium falciparum species-specific malaria rapid diagnostic test (mRDT).These dataset was checked for completeness before subjecting them to descriptive statistics using SPSS statistical tool.

Results & Discussion: The data analysis revealed an overall five thousand, five hundred and fifteen (5,515) suspected malaria cases of which only 15% were positive, while 58.3% were negative. The break down shows: Infants [(Age 0-4) 07%+ve, 4.5%-ve]; Childhood [(Age 5-9) 1.14%-ve, 3.6%+ve; Adolescents [(Age 10-19) 1.2%+ve, 1.9%-ve]; Adults [(Age 20 & Above) 11.44%+ve, 72.8%-ve]. This result would be great gain for the malaria control community particularly Nigeria, if rapid diagnostic test is fail proof with zero parasite evolution, and in the absence of vector migration out of their known distinct geographical locations. Microscopy in this setting is imperative.

Conclusion & Recommendation: This dataset on one hand, presents a jumping off point for further investigation into underpinnings of this negative malaria scenario, to sustain and maximize such gain for effective control geared towards malaria elimination. On the other hand, it calls for immunological and ecological investigations beyond vectors and parasites.

ABS-406

Survey of Indoor Adult Malaria Vectors, Knowledge, Attitudes and Practices (KAP) in Relation to the Disease Transmission in Bauchi State, North East-Nigeria.

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[2]*Federal College of Forestry, Jos, Plateau State*

[3]*Department of Biological Sciences, Federal University Lafia, Nasarawa State*

Background & Objective: Malaria remains a major public health concern in Nigeria and the vectors (Anopheles species) can only be control effectively by having good knowledge of its composition and potential for disease transmission. This work aimed at surveying the indoor malaria vectors, Knowledge, Attitudes and Practices (KAP) in relation to the disease transmission in Toro LGA, Bauchi State, North East-Nigeria. Materials & Method: The research was conducted in Chediya community between October and December 2019. Mosquitoes were collected by Pyrethrum Spray Catch (PSC) and were morphologically identified using standard keys. Blood samples were also collected from individuals who slept in the rooms where PSC was conducted. Thick and thin blood smears were made for malaria parasite examination. Questionnaires were also administered to 120 participants for the KAP studies. Results & Discussion: A total of ninety-seven (97) Anopheles mosquitoes were collected and identified as Anopheles gambiae 76(78.35%), An. funestus 20(20.62%) and An. coustani 1(1.03%). Out of the ten (10) Anopheles species dissected, 60% (6) were parous while 40% (4) were nulliparous. The overall malaria prevalence was 15.8%. The KAP studies revealed that measures and treatment seeking behaviours against malaria varied significantly ($P<0.05$) among the respondents. Sleeping under net 55(45.8%), draining of stagnant water 29(24.2%) and use of insecticides 24(20.0%) were some of preventive measures highlighted while treatment seeking behaviours include visit to pharmacy 74(61.7%), direct visit to a doctor 35(29.2%) and use of local herbs 11(9.2%). Conclusion & recommendation: This work revealed that An. gambiae and An. funestus are predominant malaria vectors in the area. The KAP information demonstrated fair knowledge about the disease by the respondents. Therefore, public enlightenment about malaria prevention, control and treatment is recommended in order to address the few but highly negative impact knowledge gaps about malaria.

Keywords: Anopheles species, malaria transmission, Knowledge, Attitudes and Practices (KAP), Bauchi State, Nigeria.

ABS-468

Prevalence of Human Malaria Infection along Altitudinal Gradient in Plateau State, North Central Nigeria.

Abba, O.J1,2., Mwansat, S. G1., Akindgh, T.M1., Nanvyat, N1 and Oguche, S3.

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[2]*Infectious Disease Unit, Jos University Teaching Hospital, Jos*

[3]*Department of Paediatrics, Faculty of Medical Sciences, University of Jos*

Background & Objective: Malaria is a life-threatening disease caused by parasitic protozoa of the genus Plasmodium; they facilitate trauma through bites of infected female Anopheles mosquitoes. There is a widely held view that African highlands transmission of Plasmodium falciparum is limited primarily due to abiotic factors. This study determines the Prevalence of human malaria infection along altitudinal gradient in Plateau State, Nigeria. Materials & methods: This is a longitudinal descriptive cross-sectional study. Intravenous blood sample (1ml) was collected into EDTA bottle and screened for the presence of Plasmodium falciparum malaria using the SD-PAN Ag mRDT. Thick (6µl) and thin (2µl) blood film slides were prepared for microscopy using 10% Giemsa stain and parasite density determined for all positive samples in across seasons from 2018-2019 along altitudinal gradient from Jos South to Pankshin and Shendam Local Government Areas (LGAs) of Plateau State. Results: Microscopic results across the study sites indicates that Pangwasa had malaria prevalence (47.7%) followed by Jing (40.5%) and Vwang (18.8%). Across the seasons, the late wet season had the highest percentage of positive cases (33.6%) followed by early dry season (23.8%). Mean malaria parasite density differs significantly by age group ($P<0.05$) with ages 0-10 and 51-60years having the uppermost mean parasite densities. Mean malaria parasite density also differs significantly across the seasons and altitude levels ($P<0.05$) with the lowest altitude (211m above sea level) having the highest mean parasite density (1400asp/ul). Conclusion & recommendation: This study revealed that while malaria is still endemic on the Jos Plateau, altitude plays a significant role in the occurrence of the disease. The lowest altitude (211m) had the highest prevalence of malaria. These findings will serve as a reference point data for implementation and evaluation of malaria control programmes in the study areas.

Keywords: Altitudes, malaria transmission, parasite density, seasons, Jos Plateau

ABS-644

Molecular surveillance of antimalarial resistance *pfcrt* and *pfmdr1* among febrile patients with high parasitaemia attending government hospitals in Ondo state, South-West Nigeria

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Department of Microbiology, Federal University of Technology, Akure, Nigeria

Malaria remains an important public health concern in countries like Nigeria where transmission occurs regularly. This study evaluated the prevalence of malaria, *Plasmodium falciparum* chloroquine resistance transporter (Pfcrt) and *Plasmodium falciparum* multidrug resistant (Pfmdr1) mutant genes among febrile patients attending Government hospitals in Ondo State, Nigeria. This study was carried out between October, 2018 and August, 2019 the duration which covered both raining and dry season, in Ondo State, Nigeria. A total of 515 blood samples were collected from patients presented with febrile illness consisting of 179 male and 336 female. Malaria test was done by thick blood film microscopy and Polymerase Chain Reaction (PCR) technique. PCR technique was used to detect Pfcrt and Pfmdr1 mutant genes of *P. falciparum*. Pearson's Chi-square test was used for analysis. Out of 515 blood samples tested, 426 (82.72%) were positive for malaria infection, all observed parasite were *P. falciparum.* The prevalence of malaria infection among male and female patients was 155 (86.59%) and 271 (80.65%) respectively with no significant difference (p=0.636). Also, 72(13.98%) of malaria positive patients had parasitaemia greater than 10,000 parasites/µl among which the prevalence of Pfcrt (88.89%) and Pfmdr1 (54.17%) showed no significant difference (p = 0.199). The research revealed high prevalence of Pfcrt and Pfmdr1 mutant genes of *P. falciparum* among febrile patients with high parasitaemia which may be as a result of treatment of malaria with Chloroquine and other medication which the parasite have formed resistance against. The occurrence of these resistant genes in *P. falciparum* threatens malaria control and elimination efforts, and heightens the need for an alternative therapy.

Key words: Malaria, parasitaemia, Pfcrt, Pfmdr1

ABS-663

Evaluation of malaria during pregnancy after a decade of the establishment of an intermittent preventive treatment program in rural area koupela, burkina faso

Alimata kabre[1], Awa Gneme[1], Dramane zongo[2], désiré ilboudo[3], Gustave B. Kabre[1]

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[2]*Centre National de Recherche Scientifique et Technologique (CNRST), Ouagadougou, Burkina Faso.*

[3]*Centre de Recherche en Biomoléculaire Pietro Annigoni (CERBA), Ouagadougou, Burkina Faso*

Background: Malaria is reported as endemic in Burkina Faso. For better control, strategies like intermittent preventive treatment (IPT) with an effective, low-cost drug during pregnancy exist.

Methods: To assess the effectiveness of this chemoprevention of malaria during pregnancy, this study was done. In March 2017, a cross-sectional study was carried out the rural health district of Koupela. Socio-demographic and parasitological data were collected from pregnancy women during antenatal care. Blood samples for by thick film and blood smear were collected for malaria parasite and anemia detection.

Results: A total of 203 pregnant women were enrolled for this study. The species encountered was *Plasmodium falciparum*. The prevalence of malaria was 8.37%; with a mean parasite load of 1682 parasites/µl of blood. Out of the participants, 81.28% have chemo treatment for anemia, 62% receive an antimalarial treatment and 92.61% used impregnated mosquito nets. It was notice that secondiparous were the most infected with malaria; and a significant association between malaria infection and the number of doses taken of chemoprevention was found. Infected women whose received chemoanemia treatment had mild anemia.

Conclusions: These results should be used to raise awareness about the effectiveness of chemoprevention during pregnancy.

Keywords: Pregnant woman, Malaria, health district, Koupela, Burkina Faso.

ABS-791

RNA-Seq-Pop: Exploiting the sequence in RNA-Seq - a Snakemake workflow reveals patterns of insecticide resistance in the malaria vector Anopheles gambiae

Sanjay C Nagi, Ambrose Oruni, David Weetman, Martin J Donnelly

The majority of transcriptomic studies primarily focus on differential gene expression, not making full use of the underlying sequence data, and often, are not reproducible. Here, we present a scalable *snakemake* workflow, *RNA-Seq-Pop*, which comprehensively analyses RNA-Sequencing data in a reproducible manner, performing quality control and differential expression analyses, as well as calling genomic variants and generating a range of useful statistics. We demonstrate the utility of the workflow by investigating pyrethroid-resistance in the major malaria vector, *Anopheles gambiae,* from Busia, Uganda, that underwent four generations of deltamethrin selections.

The workflow reports allele frequencies of variants of interest, detecting a dramatic shift in frequency of *VGSC*-995S (26→100%) and *Gste2*-119V (11→53%) during selections. *RNA-Seq-Pop* summarises genetic diversity, capturing effects of inbreeding, and estimates regions of the genome under selection, able to detect selective sweep signals over known insecticide resistance loci, such as the VGSC. *RNA-Seq-Pop* can estimate recent ancestry within the gambiae complex; we show that the reference *An. gambiae* Kisumu strain, contains a large degree of *An. coluzzii* ancestry on the autosomes. The workflow can also determine the karyotype of common chromosomal inversions - we show that the 2La chromosomal inversion rose in frequency from 33 to 86% in the Busia strain. The workflow is available here: https://github.com/sanjaynagi/rna-seq-pop. We anticipate that *RNA-Seq-Pop* will provide a useful tool to facilitate reproducible, transcriptomic studies both in *An. gambiae*, and across other taxa.

8th PAMCA Annual Conference & Exhibition | 2022

PRE & POST CONFERENCE EVENTS

Theme:

Harnessing local institutional & community support for the elimination of vector-borne diseases (VBDs)

PRE-CONFERENCE EVENTS

Closed FNIH Meeting

Date: September 22, 2022

Venue: KCC- AD10

Time: 8:00 am – 6:00 pm

Gene Drive Short Course

Date: September 23-25, 2022

Venue: KCC-Mezzanine

Time: 8:00 am – 6:00 pm

PAMCA continues to raise awareness, share knowledge about innovative tools and build the capacity of scientists and stakeholders in vector-control. This course is particularly targeting African graduate students, researchers in biology, medicine, social science, policy makers and health professionals with an interest in genetic biocontrol technologies. The training will support 37 participants from 26 countries across the continent to attend this 3-day workshop.

On completion of this course, participants would have gained basic technical understanding of gene drive technologies and public acceptance, regulator issues and ecological concerns.

Women in Vector Control Effective Communication in Leadership and Professional Development Course

Date: September 23-25, 2022

Venue: KCC-AD1

Time: 8:00 am – 6:00 pm

The complexity of global health problems demands leadership that represents the pluralism in society. It is envisaged that the implementation of a comprehensive approach to vector control will enable the achievement of disease-specific national and global goals and contribute to the achievement of the Sustainable Development Goals and Universal Health Coverage. The aim of this course is to improve the leadership and communication skills of professional women in vector control champions in Africa.

By the end of this course, participants would have gained

- Leadership and competencies skills
- Strategic thinking in leadership
- Confidence building techniques and coaching
- Self-regulation and management tools/practices
- Communication skills and CV writing
- Social media engagement

Professional Development Workshop on Strengthening Vector Control Decision-Making in Africa

Date: September 23-25, 2022

Venue: KCC – 11

Time: 8:00 am – 6:00 pm

This workshop is coordinated together with our partners at GeneConvene particularly targeting researchers and professionals

based in Africa who are interested in using data for decision making. This workshop aims principally at building the capacity of its participants in the use of modelling information to make informed decision within public health.

At the completion of this workshop, participants would have gained

- Valuable skills in decision-making strategies and common barriers to good decision-making.
- Non-modelers and non-mathematicians would also again valuable insights on how to confidently approach and assess models intended to support decision-making.

PAMCA-MalariaGEN Vector Genomic Data Analysis Hackathon

Date: September 25, 2022

Venue: KCC – AD6

Time: 8:00 am – 6:00 pm

PAMCA and MalariaGEN are partnering to deliver a training programme on data analysis for genomic surveillance of African malaria vectors in 2022 under the PAMCA Vector Genomics Surveillance Program. As the training programme is being delivered virtually, the forthcoming 8th PAMCA Annual Conference provides a great opportunity for trainees and the trainers to meet, interact, and network with each other. To provide additional time and space for face-to-face meetings, and to support those who are beginning to work on independent analyses of genomic data, the program is organising a Genomic Data Analysis Hackathon for members of the training programme on September 25, 2022, at the conference venue. To facilitate greater participation at the conference and the hackathon event, PAMCA and its MalariaGEN partners are floating a Travel Award which is open to current participants of the training programme. The Travel Award will provide up to a maximum of £2000 per award to support the recipient to attend the hackathon and the rest of the conference which runs through to September 28, 2022.

Welcome Cocktail

Date: September 25, 2022

Venue: KCC – Terrace 1

Time: 7:00 pm – 10:00 pm

POST-CONFERENCE EVENTS

Field Visit/Demo

Date: September 29, 2022

Venue: Mareba Entomology Sentinel Site

Time: 9:00 am – 12:00 pm

PAMCA Field visit is to understand malaria surveillance and management system in Rwanda, especially Entomology Surveillance at sentinel site/IRS operation management at District level/ Community based entomology surveillance in Bugesera District: Lesson learnt, challenges and Success.

Policy Engagement Workshop

Date: September 29, 2022

Venue: KCC – AD9

Time: 9:00 am – 4:00 pm

The Policy Engagement Workshop aims to raise awareness of the importance of having the scientific community engaged in policy debates and to prepare scientists to have effective engagements with policy makers. This workshop will present an overview of the most relevant international fora for scientists in the vector control field and explore how to make the best of engagement opportunities with policymakers. The session will combine theory and practice to enable participants to experience what it takes to have a successful meeting.

By the end of the workshop, participants will:

- Understand how international policy debates can affect their work
- Feel confident to represent their organisations and speak about their work with non-experts
- Enhance their engagement competencies and be familiar with engagement protocols
- Know how to prepare for and manage meetings with policymakers

PAMCA WOMEN IN VECTOR CONTROL

PURPOSE

- Strengthening the role of women in the control of vector-borne diseases

Create an enabling environment to "Enact a paradigm shift"

WHY

- To develop a structured mentorship program for women in vector control in PAMCA
- To create an expert database and a contact repository of women in control of vector-borne diseases
- To stablish a knowledge management platform and discussion forums for women in vector control
- To build capacity through trainings on communication, leadership and management skills
- To enhance networking, partnership and visibility of WIVC by increasing participation of women during PAMCA conferences and other meetings
- To establish a travel fund for WIVCto attend PAMCA and other key international conferences
- To empower non-professional WIVC and increase visibility of vector control activities in schools

HOW SUCCESS WILL LOOK LIKE

- Motivated and a pace setter community of WIVC
- WIVC in managerial/leadership positions
- WIVC taking up consultancies, jobs, collaborations that were formed from the expertise database
- Women with specific technical skill set
- WIVC securing grants as PIs
- Networking and partnership at country level -
- WIVC working in African countries
- Involvement of African Women online & social media platform
- Implemented anti-harassment/anti-bullying policy

Vision

An Africa free of vector-borne diseases

Mission

Empowering women to combat Vector-Borne Diseases (VBDs)

For more info please visit
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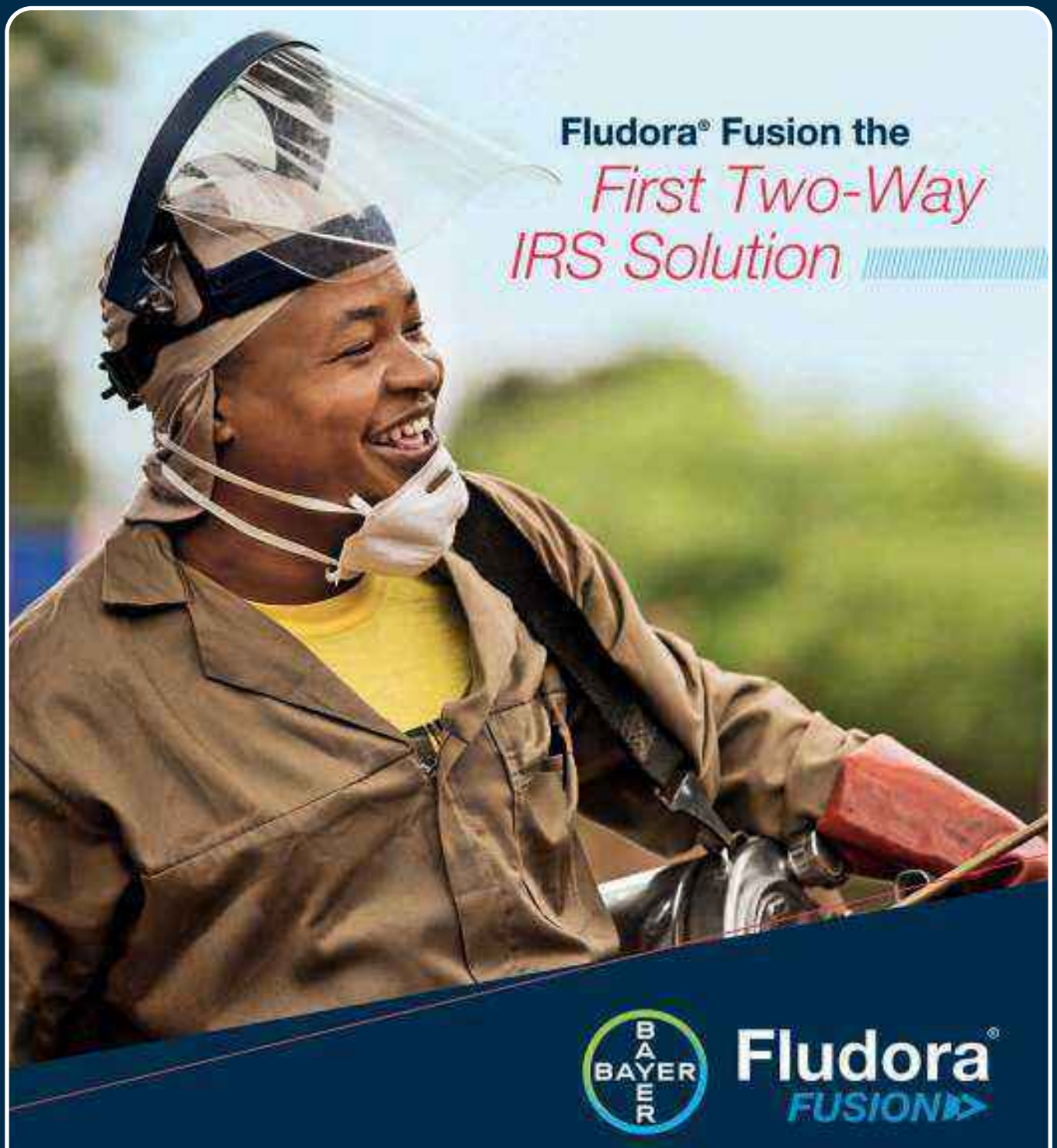

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Dose Rate: 200 mg/m² clothianidin and 25 mg/m² deltamethrin.