RESOURCE HUB *Correspondents*

9th PAMCA Annual Conference and Exhibition: "Reorienting surveillance and management in the context of emerging threats of disease vectors"

Complete series

MESA Correspondents bring you cutting-edge coverage from the 9th PAMCA Annual Conference and Exhibition

17 - 21 September 2023

Addis Ababa, Ethiopia

The MESA Alliance would like to thank Zawadi Mboma(Grants and Contracts Officer / Senior Research Scientist, Ifakara Health Institute, Tanzania) and Billy Tene (PAMCA Cameroon Chapter Executive Member / Research Scientist, Center for Research in Infectious Diseases, Cameroon), for providing senior editorial support.

The MESA Alliance would like to acknowledge the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo, Ndey Bassin Jobe, Temesgen Ashine and Leslie Diane Nkahe for their coverage of the conference.

RESOURCE HUB *Correspondents*

Table of contents

Opening Ceremony - Sunday, 17th September 2023

Opening Ceremony Remarks

The opening ceremony of the 9th Pan-African Mosquito Control Association (PAMCA) Annual Conference and Exhibition was held on September 17, 2023, and was attended by PAMCA delegates from many countries around the world, and from diverse sectors including mosquito and mosquito-borne disease researchers, representatives of National Malaria Control Programs (NMCPs), policy makers and several partners (both national and international). The opening remarks were delivered by **Delenasaw Yewhalaw** (PAMCA Country Chapter Chairperson for Ethiopia), **Emma Orefuwa** (PAMCA Ag. Executive Director) accompanied by **Prosper Chaki** (PAMCA Executive Director) and finally **Charles Mbogo**, the PAMCA president. They all commended this year's turnout, extended a warm welcome to all participants, and encouraged them to embrace this year's annual meeting proceedings in the beautiful setting of Ethiopia's Skylight Hotel. They also highlighted the need to search for and implement innovative solutions to eradicate vector borne diseases (VBDs) such as malaria in the African continent. This was done in a friendly atmosphere accompanied by light refreshments.

Keynote Speech

The Keynote address was delivered by **Beyene Petros** (Policy Study Institute, Ethiopia). Petros' address delved into the conference theme of **"**Re-orienting surveillance and management in the context of emerging threats of disease vectors". He commended the PAMCA secretariat for bringing together different stakeholders whose main work is centered around the eradication of VBDs in Africa. Petros discussed the current threats VBDs pose, from emergence to re-emergence and resurgence. He highlighted the challenges in vector control such as the development of insecticide resistance and the invasion of new species like *Anopheles stephensi*, and further recommended that PAMCA remain steadfast in addressing these challenges. He further noted that PAMCA has reinforced its capacity to support African countries in their efforts to eliminate malaria and other VBDs. He then concluded by encouraging everyone to continue to promote the one health approach in the control of VBDs, taking climate change, integrated VBDs surveillance, and capacity development of African scientists in data analysis and interpretation into account.

This report is brought to you by the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo Odero, Ndey Bassin Jobe and Temesgen Ashine, with the support of a former correspondent Leslie Diane. Senior editorial support has been facilitated by Zawadi Mboma & Billy Tene.

Day 1 - Monday, 18th September 2023

Plenary Talk - Living with mosquitoes: Inevitable reality or an African fallacy? A call to action

Manuel F. Lluberas (Mosquito Den LLC, Puerto Rico) in his plenary talk urged the audience to explore thinking out-of-the-box while seeking solutions against mosquito species. He highlighted that the eradication of malaria in the South American Region was achieved in the mid-1950s. However, the elimination gains were not sustained due to policy failure to control disease-carrying insects. On the other hand, Africa was not included in the malaria eradication arrangement. Malaria causes a serious disease burden in Africa, while the dengue burden in America still far exceeds other viral diseases. He emphasized on finding a way to eliminate vectors that transmit diseases regardless of the species and combine strategies not only within countries but also across borders, perhaps globally. He urged entomologists to continue to work together as first responders in order to be able to deal with any emergencies. He concluded by encouraging National Malaria Control Programs (NMCPs) to rebrand their programs and set up advisory boards involving multi sectoral representation to draw on resources beyond health for comprehensive vector management.

Parallel Scientific Sessions

Parallel Scientific Session 1 - LLINS, IRS, and insecticide resistance management

Session Chair: **Basiliana Emidi;** Co-chair: **Magellan Tchouakui**

Magellan Tchouakui (Centre for Research in Infectious Diseases, Cameroon) presented their research work on new nets designed to mitigate pyrethroid resistance. The main objective of their study was to evaluate the performance of new generation nets (NGN) against pyrethroid resistant malaria vectors compared to pyrethroid-piperonyl butoxide (PBO) based and pyrethroid only nets. To do this, they conducted both cone/tunnel tests and experimental hut trials. The study results showed that the Interceptor® G2 net, a type of NGN, was the most efficient net against *An. funestus* in the region of Elende, Cameroon. He concluded by calling for an urgent need to implement a suitable resistance management plan to preserve the efficacy of the Interceptor® G2 net.

Joseph D. Challenger (Imperial College London, United Kingdom) argued that experimental hut trials are key in assessing mosquito control interventions and are increasingly used to inform policy and product development. For better outcomes of experimental hut trials, there is a need to assess the level of variability. Using simulation-based methods, they were able to explore and establish variations in the number of mosquitoes entering the huts among others. Due to this finding, plans are underway to develop tools to improve the outcomes of experimental huts trials.

Ole Skovmand (MCC47, France) presented on improved test methods for Long Lasting Insecticidal Nets (LLINs) in laboratory evaluations. It was highlighted that the current methods used to evaluate Insecticide Treated Nets (ITNs) for prequalification do not support the improvements in the quality of ITNs. Net sampling should reflect production methods to ensure that the before and after tests yield accurate results. He recommended three alternative methods which are (i) chemical analysis, (ii) using bioassay median knockdown time only for insecticides with knockdown effect, and (iii) using a

sufficiently resistant strain where mortality does not reach 100%. He concluded that the wash interval of bed nets must follow the chemical regeneration.

Olukayode Ganiu Odufuwa (Ifakara Health Institute, Tanzania; London School of Hygiene and Tropical Medicine, United Kingdom; and Swiss Tropical and Public Health Institute, Switzerland) presented on the use of house modification tools (i.e., insecticide-treated eave nets (ITENs) and insecticide-treated window screens (ITWs)) for malaria control. Although the majority of malaria vectors bite indoors, house design influences the exposure of humans to mosquito bites. They used a 4x4 latin square design to assess the efficacy of unaged ITENs and ITWs, aged ITENs and ITWs and aged Olyset Plus ITNs by measuring the feeding inhibition of mosquitoes (*An. arabiensis, An. funestus, Culex quinquefasciatus* and *Aedes aegypti*). The results of their study showed that unaged ITENs and ITWs performed better than aged Olyset Plus ITNs. He concluded that ITENs and ITWs are efficient tools for additional protection against vectors of malaria and dengue.

Parallel Scientific Session 2 - Vector bionomics: vector biology, ecology, taxonomy and population genetics

Session Chair: **Diego Ayala;** Co-chair: **David P. Tchouassi**

Diego Ayala (Institut Pasteur, Madagascar) presented on the importance of human settlements on the adaptation of malaria vectors. Human settlement was found to create a suitable environment that facilitated the adaptation of malaria vectors. Although stable populations of *An. gambiae* and *An. coluzzii* are still found in areas far from human settlement, still outstanding phenotypic and genetic plasticity of *An. coluzzii* was observed across gradients of sylvatic and domestic settings. More importantly, malaria vectors adapt to new areas, while they remain stable in their host preference. In addition, natural areas can act as refugees for malaria mosquitoes escaping vector control measures and representing an epidemiological risk for zoonotic vector borne diseases.

Etienne Fondjo (PMI VectorLink, Cameroon) presented his team's research aimed at assessing the biting and resting behavior of malaria vectors in Cameroon. Entomological sampling was made bimonthly in five sites that represented different geographical areas. Human landing and pyrethrum spray catches were used as collection methods. The result indicated that malaria vectors were observed biting both indoors and outdoors during the night, with indoor biting continuing during the morning. The malaria vectors, *An. gambiae* s.l. exhibited endophagic behavior in two of the study sites. These findings can help assist Cameroon's NMCP in selecting appropriate and targeted vector control tools to reduce malaria burden.

Parallel Scientific Session 3 - Vector surveillance: surveillance systems, community-based surveillance, epidemiology, disease control programs and global health

Session Chair: **Neil Lobo;** Co-chair: **Givemore Munhenga**

Karine Mouline (Research Institute for Development - IRD, France) presented her study which aimed at addressing the issue of low mosquitocidal plasma concentration of ivermectin in hosts, causing a reduction in efficacy and necessitating repeated dosing of this systemic insecticide. To achieve this, she tested a long-acting injectable ivermectin formulation (LAIF) which delivered the drug with a

controlled kinetics. Calves were exposed to *An. dirus* and *An. minimus* after a single dose of LAIF. The study revealed that this single dose was able to kill mosquitoes that blood-fed on treated calves compared to untreated calves during a period of three months.

Mgeni M Tambwe (Ifakara Health Institute - IHI, Tanzania) assessed the reliability and performance of various malaria diagnostic tools i.e., malaria rapid diagnostic tests (RDT), light microscopy (LM) and quantitative polymerase chain reaction (qPCR) in detecting asymptomatic *Plasmodium falciparum* in school children (6-14 years) capable of infecting mosquitoes. Blood from *P. falciparum* positive children was fed via direct membrane feeding assays (DMFAs) to female mosquitoes. The results showed that positive asymptomatic *P. falciparum* children were able to infect mosquitoes and mRDTs detected 95% infected mosquitoes comparatively to LM (84%). Tambwe's investigation reveals that asymptomatic infections with low gametocyte densities that can infect mosquitoes and maintain malaria transmission, can be accurately detected by RDTs.

Betwel John Msugupakulya (Ifakara Health Institute - IHI, Tanzania), conducted a systematic review to assess the contribution of different vectors in malaria transmission in eastern and southern Africa years after the implementation of ITN and IRS. Studies published between 2000 and 2022 were selected from three online databases. The proportional contribution of each species to malaria transmission was calculated using data extracted from these studies i.e., biting rates, sporozoites infections, and entomological inoculation rate (EIR). The results suggested that *Anopheles gambiae* was the major vector before 2010, beyond which, *Anopheles funestus* took the lead. These same trends were equally observed with the entomological inoculation rate. The review also showed that the vector composition in eastern and southern Africa has changed after the implementation of vector control tools.

Parallel Scientific Session 4 - Larval source management and integrated vector management, New and re-emerging vectors

SessionChair: **ManuelFLluberas;** Co-chair: **PatriciaL.V. Belisse**

Patricia Lucie Vanessa Doumbe Belisse (OCEAC, Cameroon) presented on the impact of larviciding in malaria transmission and vector dynamics in the city of Yaoundé, Cameroon. To do so, a two-arm cluster randomized trial study was conducted with a total of 26 clusters, 13 clusters each for both control and treatment. During the intervention period, they achieved over 70% mosquito density reduction, an impact that was observed during both wet and dry seasons. Findings also indicated a decrease in malaria prevalence from 24% to 13.16%. She concluded that larviciding is a potential tool for sustaining the strides made in malaria control.

Ace North (University of Oxford, United Kingdom) modeled the impact of gene drive releases on the burden of malaria in West Africa. The study was carried out in 15 representative Central and West African countries using a combined entomological-epidemiological model to estimate the impact of gene drive on the reduction of the mosquito population density. Results showed a great and sustained vector population suppression in the most populated sites. This suppression contributed to a decrease in the disease prevalence. In addition, modeling the association between RTS-vaccine/gene drive implementation and the shift from pyrethroids to novel PBO-nets was found to be beneficial for high-risk settings.

Dereje DA Alemayehu (Alameda County Mosquito Abatement District, United States) presented on Mosquito Abatement Through Empowerment (MATE), a program developed to use a donated tractor for community farming. MATE aims to eliminate stagnant water that might serve as potential breeding habitats for mosquitoes. In the long run, funds obtained from community farming will be used to support vector control interventions such as buying nets, housing improvement, and assisting in capacity building in mosquito biology and surveillance. Alemayehu concluded his presentation by insisting that community empowerment extends beyond bed nets to achieve malaria control and elimination.

Stephen O. Okeyo (Kenya Medical Research Institute - KEMRI, Kenya) spoke on a new spatial repellent transfluthrin base intervention which used transcriptomic data to identify potential markers of transfluthrin insensitivity in *Anopheles gambiae* ss. The authors used a high throughput screening system on Kisumu, susceptible; and a local resistant strain to determine the spatial activity index of transfluthrin-treated surfaces. The main results showed varying responses from one strain to another. The comparison of metabolic expression of monooxygenase genes between non responder and responder mosquitos revealed an over-expression of CYP12F2, suggesting a possible transformation of transfluthrin by cytochrome-P450 resulting in an absence of olfactory responses.

Cynthia CAO Odhiambo (Kenya Medical Research Institute - KEMRI, Kenya) presented a study that aimed to identify insecticide resistance markers in A*nopheles arabiensis* and *Anopheles gambiae*. The Weighted Gene Co-Expression Network Analysis (WGCNA) algorithm was used to identify genes showing similar expression patterns and identify genes that can be used as markers for insecticide resistance surveillance. Phenotypic resistance to permethrin, alphacypermethrin, and deltamethrin insecticides was assessed for both species. Overall, in both mosquito species, four resistance markers were identified: serine protease, E3 ubiquitin-protein ligase, cuticular protein RR2, and leucine-rich immune protein. However, Odhiambo suggested that the functional validation of these findings is required.

Helen Nnenaya Nwanosike (MESA, Spain) commenced her presentation with an introduction to MESA Track, MESA's open knowledge platform for global malaria projects, catering to researchers, NMCPs, funders, and policymakers. MESA Track enhances project visibility and facilitates comprehensive landscaping reviews on selected subjects. She then introduced MESA's "Landscaping Review on *Anopheles stephensi*", which analyzes research on *An. stephensi* since its 2012 invasion into Africa. This review encompasses examination questions, participating countries, institutions, and principal investigators. Helen concluded by emphasizing identified research and funding gaps, including the necessity for impact studies examining the correlation between An. stephensi invasion and malaria burden, evaluating the effectiveness of current surveillance methods and control strategies like gene modification and larviciding, and investigating the influence of climate change on *An. stephensi* distribution.

Parallel Symposium Session 1 - A new tool to enable more efficient delivery of indoor residual spraying.

Organizer: **Inigo Garmendia,** PhD

Iñigo Garmendia (Goizper S. Coop, Spain) presented the IK Smart Light, a new tool to enhance the use of indoor residual spraying (IRS) in national malaria control programmes. The IK Smart Light addresses issues of over- and/or under-dosing, a lack of training equipment, variations in working conditions, a lack of supervisory employees, time and resource constraints to train teams. Its design prioritizes simplicity, speed, and cost-efficiency, guiding spray operators on the correct spraying distance and speed, while facilitating spray quality and quantity evaluation by supervisors. The IK Smart Light comprises three tools: 1) an electronic device (incorporating a beeper, laser, and three-color LED), 2) a smart phone app and 3) a cloud-based digital platform. The beeper determines spraying speed, the laser measures spraying distance, and the LED lights signal whether operators are under or overdosing. The electronic device (tool one) assists operators, while supervisors can assign and rate workers via the smartphone app along with gathering information and evaluating quality of daily output. The third tool visualizes global statistics for malaria control programmes. This invention promises significant improvements in IRS program training, supervision, data gathering and analysis, and overall effectiveness during implementation.

Parallel Symposium Session 3 - Larval Source Management, a Tale of Two Continents: Integrated Vector Management in North America and Africa

Organizer: **Ary Faraji,** PhD

Ary Faraji (Salt Lake City Mosquito Abatement District, United States) shared his experience in integrated vector management in a mosquito abatement district in Salt Lake City, that covers an area of 13,000 hectares of wetland habitats. With an $8 million budget, 13 full time staff and 40 seasonal staff (entomologist, biologists, ecologist, virologist & molecular biologist), state-of-the-art laboratories and equipment. They have become experts at mosquito control in predictable flood water habitats, salt marshes, and bogs. Their integrated vector management integrates research, training and operations, public education, control, and surveillance. He concluded by stating that their efforts have ended the need for the population to use ITNs or IRS. Further, he also asserted that if larval source management (LSM) was doable with 13,000 hectares of wetland in Salt Lake City, it can be implemented in Africa too.

Mark Breidenbaugh (Northwest Mosquito and Vector Control District, United States) presented his work on LSM in Southern California. This independent agency was formed in 1959 with the goal of eliminating vectors over an area of 350 sq. miles with a population of approximately 900,000. Their team comprises 20 full-time and 10 seasonal employees for 8 zones and each assigned with 1 full-time technician. The work is performed in 7 communities and a dedicated wetlands zone for larval sampling, identification, and treatments. Treatment decisions are made by the technicians often on-the-spot which consist of dumping/draining, application of larvicides (oil, liquid, granules, sachets, etc.), and biological control (fish). The principle behind their work is to manage mosquito larvae in the early stage in order to prevent adult mosquitoes from impacting public health.

Marc Clifton (North Shore Mosquito Abatement District, United States) presented their LSM work at the North Shore Mosquito Abatement District established in 1927 to control *Culex restuans* (Theobald) and *Culex pipiens (*Linnaeus). It covers 70 sq. miles and serves 14 communities totaling 300,000 people. The team comprises 7 full-time staff and 14 seasonal staff who undertake larval control treatment of 61,865 stormwater catch basins, 4,538 mosquito breeding sites and 723 acres of floodwater multiple times per year. The control materials they use are VectoLex, VectoBac, BVA 2 larvicide oil and Sumilarv 0.2 g which are highly specific to mosquitoes with human and environment safety profiles. To address logistical challenges involved, they have developed a digital geographic information system (GIS) infrastructure for field surveillance of larval habitat. In addition, residents also report information by mobile technology of potential habitats in their areas. This has been key for mosquito control in this setting.

Mark Smith (Metropolitan Mosquito Control District, United States) walked the audience through their integrated vector management program which focuses on surveillance and species identification, snow melt/floodwater mosquito control (*Aedes*), cattail mosquito control (*Cq. perturbans*), vector control and surveillance (*Culex*), public education and outreach, tick surveillance, and black fly (biting gnat) control. It is a local government program with a budget of $19 million and covers 7 counties, 182 communities and townships serving 3 million people. They have adopted their integrated pest management to accommodate for each species of concern and regional larval control programs, surveillance-based larvicide operations using mobile technology, and efficient control operations by use of helicopters and drones. In conclusion, surveillance of larval habitats can be effectively coordinated with efficient operations. They work on the principle of organization and consider it the key to success.

Dennis Wallette (Tangipahoa Mosquito Abatement District, United States) walked the audience through the larviciding equipment and techniques used in Louisiana in rice fields, cypress swamps, coastal marshlands and roadside drainage ditches which are the main breeding areas for *Culex quinquefasciatus,* a primary vector of West Nile virus in the Southeast U.S. Methoprene mineral oil and granules are used to treat drainage ditches. They use Wide-Area Larviciding (WALS) technique, spray equipment such dynafog LV-8, A1 mist sprayer and the Buffalo Turbine. They also use drones and aircrafts to facilitate larviciding. They acknowledge having the right equipment is key for LSM.

Mohamed Traore (University of Bamako, Mali) presented a first of its kind pilot study on integrated vector control management in Mali. This was a collaboration between two mosquito control districts of the USA and Africa. He highlighted the performance challenges of core intervention strategies (ITNs and IRS) and proposed integrated vector management as a solution to achieve eradication. Collaboratively, the USA and Africa partners received training on surveillance, products support and larviciding operations. The results were impressive which demonstrated the added advantage of integrating LSM in their national malaria programs despite the challenges around funding, limited capacity and equipment, and vector resistance. He concluded with a thought-provoking question for the global partners on huge spendings on the core malaria interventions (ITNs and IRS), when greater public health gains can be achieved by redirecting the same efforts towards LSM.

Christian Atta-Obeng (National Malaria Elimination Program, Ghana) presented their experience with LSM managed by a private sector entity, Zoomlion Ghana Ltd, and supervised by the government. He highlighted the serious challenges faced by the core vector control strategies (ITNs and IRS) that

shifted their approach towards integrated vector management (IVM). The IVM approach integrates vector control, entomological surveillance, novel new tools, and multisectoral collaboration to control malaria. They also engaged stakeholders at all levels, trained workers, performed mapping of water bodies and larviciding, recruited spray operatives, and trained people from implementing communities. The use of mobile applications for data capture was key in the success of the program. Delays in receiving payment from the Government for the recruited spray operatives, and in procurement and shipment of larvicide presented a major challenge. However, debt financing from commercial banks and early initiation of procurement helped to overcome these challenges.

Emmanuel Hakizimana (Rwanda Biomedical Centre, Rwanda) centered his presentation around the reasoning for the co-deployment of LSM with the ITNs. The presenter highlighted that Rwanda experienced a 20-fold increase in malaria cases between 2011 – 2016 hence the need for LSM which was deployed on 93, then 336 and finally on 946 hectares of rice field, intercrop drains, mining pits and water paddles. The deployment of LSM complemented ITNs, harnessed community support and attracted government and local partners. On the other hand, non-targeted peri-domestic breeding sites sustaining mosquito density (*Culex spp*) and limited resources for scale up for managing community expectations posed some challenges. Future plans to scale-up LSM in Rwanda include combination of drones and hands-based application of larvicides and community engagement to control peri-domestic breeding sites.

Parallel Symposium Session 4 - Scaling up malaria elimination: Public-private partnership and evidence-based programming to boost and accelerate progress in north-western Zambia.

Organizer: **Buumba P Bubala.** PhD

Buumba P Bubala (Ministry of Health, Zambia) started the symposium by briefing the situation on malaria prevalence in Solwezi. A district located in North-Western Zambia. She added that, despite the robust strategic plan for malaria elimination in place, inadequate funding, and little capacity building contributed to derailing its implementation. This necessitates the need to seek a different sustainable way to control the transmission. The public-private partnership (PPP), with First Quantum Minerals Limited (FQML), identified among potential stakeholders has been seen as a potential solution. Since 2021, a drastic decrease in malaria cases has been observed as the result of a PPP established. Bubala pinpointed major factors that contributed to their success, these include community participation, skilled human resources, the presence of the regional malaria end councils, as well as partnership and funding from FQML. He concluded by stating, PPP is the key to supporting and strengthening malaria elimination.

Mumba Temple (First Quantum Minerals Limited, Zambia) discussed their partnership with the Ministry of Health that was launched in 2020. In order to create this site-based malaria control, various parameters were assessed including malaria risk, a review of vector control strategies employed, case management, and funding. The main audit revealed that malaria accounted for the highest cause of sick offs, the support from the District Health Office (DHO) comprised mainly monetary and material assistance, parasitological and entomological surveillance were not localized, larval source management were not implemented and there was no standardized case management at health facilities.

Godwill Mlambo (First Quantum Minerals Limited, Zambia) presented actions taken by FQML from 2021 to address gaps identified by Mumba Temple. These actions include increasing budget allocation, capacity building, improving data management systems, implementing LSM and the creation of a local malaria control center (MoH/FQM) for sample processing. The progress of each of these actions have been monitored according to specific indicators. Consequently, annual entomological surveillance has been conducted, which includes recording species composition/distribution and assessing insecticide susceptibility. Mlambo concluded, emphasizing that entomological data should guide the selection of the most effective vector control method or insecticides and help monitor the impact of vector control interventions.

Herbert Tato Nyirenda (Copperbelt University, Zambia) presented a study titled "Malaria parasite prevalence survey in school children in Solwezi District". A quasi-experimental study design was used, where a simple random sampling was done to enroll pupils aged 5 – 14 years for both FQML-supported catchment (intervention) and non-FQML-supported catchment (control). Lab-RDT and thick blood smear for microscopy analysis were done for each participant to determine malaria infection status. Findings suggest that malaria prevalence was nearly double in the intervention group compared to control. Furthermore, no significant difference was observed in malaria prevalence in the control between initial and subsequent assessments. Tato concluded his talk by pointing out that malaria is still a burden, emphasizing the need for increased efforts to curb asymptomatic malaria and highlighting the important role of the private sector in malaria control.

Parallel Symposium Session 5 - Vector genomics surveillance program in Africa: opportunities, progress, and future outlook

Organizer: Elijah Juma, PhD; **Co-organizer:** Alistair Miles, PhD

Elijah Juma (PAMCA), introduced in a broad manner the need for genomic surveillance to control malaria vectors. With the potential emergence of new resistant variants and species, it is an important task for African scientists to better equip themselves to respond to any challenges arising from anomalies they may encounter reviewing phenotypic data. As such, PAMCA, in collaboration with MalariaGen and other groups dealing with genomic data analysis such as G-AVENIR have implemented a big data analysis platform where genotype data are stored and are ready for analysis by anyone with a keen knowledge on genomic data analysis. A training course is available at: 'https://anopheles-genomic-surveillance.github.io/home.html'. He emphasized that understanding phenotypes on a genomic level can inform decision making by competent authorities, leverage communication and advocacy between countries, and enhance the importance of implementing genomic data surveillance in routine entomological surveillance. Future prospects in this aspect include capacity building to enable young scientists to be more knowledgeable on data analysis, securing funding to support both sequencing and storage platforms in Africa, and fostering partnerships between genomic epidemiology and genomics for synergy.

Kwi Pilate Nkineh (Pan-African Malaria Genetic Epidemiology Network - PAMGEN, Cameroon) presented findings on the diversity, transmission dynamics and resistance of malaria vectors around the slopes of Mount Cameroon. The results showed that *An. gambiae* complex and *An. funestus* are the predominant *Anopheles* species. Additionally, *An. cinctus* was identified for the first time as a possible secondary vector for malaria. Biting patterns of *Anopheles* species were similar both indoors and outdoors, with the exception of *An*. *nili.*

Edward Lukyamuzi (PAMCA) demonstrated the importance of including genomic surveillance in routine surveillance. Using mosquitoes collected from Kwi Pilate's study, DNA was extracted, and sequencing conducted. The genomic data analysis revealed that *Anopheles coluzzii* in the country formed two clusters, differentiating mosquitoes from the north and the south regions. Furthermore, within mosquitoes from the south two clusters were identified, with different levels of resistance confirmed by the presence of alleles conferring resistance to one population. This shows that within the same region, the same control methods cannot effectively manage all vectors present. This highlights how important including genomic surveillance could enhance both vector surveillance and vector monitoring.

Parallel Symposium Session 6 - Field Trials of Malaria Vectors Engineered with Gene-Drive: If Not Now, When?

Organizer: **Ana Kormos,** PhD

Ana Kormos (University of California Malaria Initiative - UCMI, United States) emphasized the need to reassess traditional vector control methods like IRS and ITNs due to various challenges such as vector and parasite resistance, financial investment limitations, distribution issues and environmental changes. She introduced the potential of genetically engineered mosquitoes and discussed the University of California Malaria Initiative (UCMI). One UCMI objective is to contribute to malaria eradication through mosquito population modification. As this progress is slow, the symposium aimed to emphasize the importance of fieldwork to advance this technology further.

Adionilde Aguiar (Ministry of Health, Sao Tome and Principe) provided an overview of malaria epidemiology in Africa, particularly in Sao Tome and Principe (STP). Recognizing insecticide resistance as a significant challenge. STP is considering trials of genetically engineered mosquitoes (GEM) as a safe and sustainable approach to eliminate and prevent malaria resurgence. Success in STP could encourage other African countries to adopt this tool as they strive to achieve the malaria free goal.

Greg Lanzaro (Vector Genetics Laboratory, United States) gave a brief outline of the framework guidance for testing genetically engineered mosquitoes (GEM). Phase 1 of the testing pathway has been ongoing since 2004. He stressed the ongoing burden of malaria and the importance of seizing the opportunity for eradication to prevent fatigue among investors, scientists, and communities. Lanzaro called for government stakeholder commitment to conduct GEM trials, assess efficacy in natural environments, evaluate risks if they do occur, and allow room for improvement.

Joao Pinto (University of California Malaria Initiative - UCMI, United States;Portuguese Institute of Hygiene and Tropical Medicine - IHMT, Portugal) reported on the use of Mark-Release-Recapture method used to estimate population size and characterize the population structure of *Anopheles*

coluzzii as well as other non-target living organism within the mosquito breeding sites. Their aim was to evaluate the potential environmental impact of GEM in Sao Tome and Principe, to evaluate the first site of potential release and finally evaluate whether the GEM mosquitoes will be resistant to insecticide. They found Sao Tome and Principe to be the most appropriate for a first release and noted that the released GEM would likely have resistance due to local mosquito populations' high insecticide resistance.

Lodney Nazare (University of California Malaria Initiative - UCMI, United States)**,** introduced the Relationship-based Model (RBM) as an engagement framework strategy developed for gaining community acceptance of genetically engineered mosquitoes (GEM) trials in Sao Tome and Principe. In that settlement, RBM messages are specifically addressed at the community level to get their perception regarding the GEM implementation. They are delivered to schools to inform students and to the stakeholders for engagement. The preference of the community to get information is then assessed, scientific workshops and booklets are shared in schools, regular meetings with stakeholders take place, and the national media reports on the UCMI plan contributing to the goal of malaria eradication.

Parallel Symposium Session 7 - Pan African *Vivax* and *Ovale* network (pavon): scoping the burden and transmission of *P. vivax* and *P. ovale* in Africa.

Organizer**: Isaac Quaye**, PhD

Bruna Djeunang (Pan African *Vivax* and *Ovale* Network - PAVON, Cameroon) on behalf of Isaac Quaye (PAVON) gave a brief introduction on PAVON, a consortium of 14 African countries, aiming at sustaining surveillance, standardizing procedures, and training in *Plasmodium vivax* and *Plasmodium ovale* research in Africa. She added that the absence of tests to detect cryptic and hypnozoite infections, the lack of a strategy for testing and treating asymptomatic infections, and the invasion of *Anopheles stephensi* in Africa, an efficient vector of *P. vivax*, needs to be addressed as part of the goals to achieve malaria elimination. She concluded by stressing the need for sustained research, looking for new strategies and innovation for surveillance and improvement of countries' infrastructural capabilities to better understand the biology of *P. vivax* transmission.

Laurent Dembele (University Of Science Of Technical And Technology De Bamako, Mali) discussed tackling the relapsing Plasmodium species along with *Plasmodium falciparum* to enable malaria elimination. He highlighted that *P. vivax* and *P. ovale* can undergo dormant liver stage "hypnozoites'' that escape treatment and cause relapsing infections. Although studies to understand the biology of these species and their susceptibility to reference and novel antimalarial drugs are ongoing, the discovery of *Plasmodium* Liver-Specific Protein 2 (LISP2), an early marker for liver stage development, brings hope for radical cure drug discovery against *P. vivax*. However, new antimalarial drugs have shown promising results against *P. ovale*. Dembele concluded the talk by emphasizing the need for innovative diagnostic tools and treatment against *P. vivax* and *P. ovale* hypnozoites for the effective control of *P. vivax* and eventual elimination.

Bruna Djeunang (PAVON, Cameroon) presented a literature review on the profile of vectors involved in the transmission of *P. vivax* and *P. ovale* in Africa. She pointed out that while the transmission process of *P. ovale* in Africa is well known, the epidemiology of *P. vivax* remains unclear. Additionally, the predominant vector of *P. vivax* in Africa remains unknown. Local African malaria vectors, *An. arabiensis, An. pharoensis, An. gambiae s.s, An. coluzzii* and *An. funestus* were found to be infected with *P. vivax*. Meanwhile, Africa is facing a new threat, the invasion of a new and efficient malaria vector *An. stephensi* in recent years. She added that studies showed non anopheline mosquitoes might also be involved in the transmission of *P. vivax*. Strengthening research and collaboration, as well as creating a database that will facilitate decision-making for vector control in Africa was highlighted as a gap that remains to be addressed.

Parallel Symposia Session 8 - From research to impact: steps in the development, registration and deployment of a new insecticide chemistry to help tackle the growing threat of insecticide resistance in malaria vectors in sub-Saharan Africa.

Organizer: **Ayumi Kawase**

Ayumi Kawase (Mitsui Chemicals Crop & Life Solutions, Inc, Japan) presented on the development and use of an Indoor Residual Spraying (IRS) product called VECTRON T500, containing a TENEBENAL insecticide. TENEBENAL affects a newly discovered site on the $GABA_A$ receptor of the insect nerve. By stopping the nerve signal, the insecticide causes the death of the mosquito upon contact. The product has long residuality, meaning it stays long on sprayed surfaces. It has also been evaluated to have long-term efficacy on various surfaces such as mud, concrete, painted cement, tile, and dung. Additionally, it is an odourless and non-toxic ingredient which is important for community adherence. She concluded by sharing that VECTRON T500 met WHO prequalification on March 11, 2023. As of September 2023, 18 countries in Africa have registered to possibly use the product.

Renaud Govoetchan (London School of Hygiene and Tropical Medicine - LSHTM, United Kingdom) followed up with a presentation on the community evaluation of VECTRON T500 for malaria control in central Benin. The study was conducted through a two arm non-inferiority cluster randomized trial by comparing VECTRON T500 (also referred to as Arm A) with FLUDORA Fusion (also referred to as Arm B) in 15 villages. The results of their study showed that VECTRON T500 was non-inferior to FLUDORA Fusion in its impact on malaria vector density when applied for IRS at a community level. However, VECTRON T500 remained efficacious in WHO cone bioassays 24 months post-application. It was concluded that this prolonged efficacy means that VECTRON T500 can be applied every two years and may help reduce the operational costs of IRS.

Delenasaw Yewhalaw (Jimma University, Ethiopia) presented their study on the residual efficacy of VECTRON T500 in Ethiopia. They determined the effect of different wall substrate types on the persistence of VECTRON T500, as well as the susceptibility of local mosquito populations to the product. The results of their study showed that the residual efficacy of VECTRON T500 extends up to nine (9) months. The product also performed well across all wall surface types throughout the duration of the study. Furthermore, CDC bottle bioassays showed that *An. gambiae s.l., An. arabiensis* susceptible strain, and *An. stephensi* were found to be susceptible to a range of doses of TENEBENAL.

Mbanga Muleba (Tropical Diseases Research Centre, Zambia) presented research findings from a small-scale community household evaluation of VECTRON T500 as a control tool against malaria vectors in Zambia. Both insectary reared and wild mosquitoes were used for this study. The results showed that VECTRON T500 had 10 months of residual efficacy against susceptible *An. gambiae* s.s. Kisumu strains mosquitoes. Also, VECTRON T500 showed at least 6 months of residual efficacy against resistant wildtype *An. funestus* s.l. mosquitoes. He concluded that since there is widespread resistance of malaria mosquitoes to pyrethroids, new mode of action insecticides such as VECTRON T500 are required to implement insecticide resistance management strategies.

Sydney Abilba (Ghana Health Services, Ghana) presented on the challenge of insecticide resistance in Ghana and the decision-making process to include vector control tools containing insecticides with novel modes of action (e.g., VECTRON T500). Indoor residual Spraying (IRS) and Long-Lasting Insecticidal Nets (LLINs) remain at the frontlines of malaria vector control. However, with the current challenges associated with insecticide usage such as the rapid development of resistance, there is a need to expand our insecticide arsenal. According to him, Ghana is able to review data and incorporate new insecticides such as VECTRON T500 into its current malaria control interventions.

Parallel Symposia Session 9 - Technical updates about the preparedness, gaps, and response to *Anopheles stephensi* in Africa

Organizer: **Ayman Ahmed**, PhD

Ayman Ahmed (University of Khartoum, Sudan), who delivered the opening presentation highlighted technical challenges with *An. stephensi* such as the ability to transmit both *Plasmodium falciparum* and *P. vivax,* the resistance to all common classes of insecticides, the diversity in larval habitats, and the presence in urban, peri-urban and rural settings as the principal technical issues for the control of this vector. Ahmed also pointed out a shortage of trained personnel, and operational and laboratory resources as the major resource gaps. Adding that current vector control policies are out of date, he came to the conclusion that action should be taken to address these challenges and fill the gaps.

Nathan Rose (Oxitec Ltd, United Kingdom) discussed the Djibouti friendly mosquito program, a current project that will be used in the future to manage the invasive species *An. stephensi*. This program consists of using gene drive technology, i.e., to insert two elements into male mosquitoes: a self-limiting gene and a tracking gene. When released, these male mosquitoes' mate with wild female mosquitoes and the female dies, hence reducing mosquito density in the community. The tracking gene will be used to assess the distribution of these modified mosquitoes.

Fitsum Girma Tadesse (Armauer Hansen Research Institute, Ethiopia) presented several factors associated with *An. stephensi* that are daunting. He emphasized that *An. stephensi* is a bigger concern because of the vector's year-round persistence due to its preference for breeding in artificial and natural aquatic reservoirs, its ability to evade standard malaria control measures, its resistance to the insecticides currently used for IRS and LLINS, its ability to switch between human and animal hosts, and indoor and outdoor biting and his vector capacity to transmit both *P. falciparum* and *vivax.*

Seth Irish (Swiss Tropical and Public Health Institute, Switzerland) began with an update on the WHO initiative to stop the spread of *Anopheles stephensi* in Africa. Its five key goals are to promote collaboration, strengthen surveillance, exchange information, develop guidelines, and prioritize research. He gave a brief overview of the WHO Malaria Threats Map which has a section for surveillance of the vector's spread and encouraged researchers to report negative as well as positive detection of *An. stephensi.* He then delved into a deep dive being carried out in India, Sri Lanka and Iran to understand surveillance and control of *An. stephensi* via discussion with researchers and policy makers. Findings indicate IRS was the main control strategy used, with lTNs and larviciding using fish taking a secondary role. He also noted that political situations in a country can hinder surveillance efforts.

This report is brought to you by the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo Odero, Ndey Bassin Jobe and Temesgen Ashine, with the support of a former correspondent Leslie Diane. Senior editorial support has been facilitated by Zawadi Mboma & Billy Tene.

Day 2 - Tuesday, 19th September 2023

Plenary Talk 3 - Special District Model - Reimagining Malaria Control in Africa by Focusing on Local Mosquito Control

Wakoli Wekesa (East Side Mosquito Abatement District, United States) began by sharing a reflection on Africa experiencing a larger portion of the malaria burden even though its vector was discovered more than a century ago. Using historical evidence, Wekesa nailed the sensitive role of mosquito control in the elimination of malaria and other vector-borne diseases (VBD), providing an example of the eradication of yellow fever in Cuba and Panama as well as the eradication of *An. gambiae* in Brazil. He added that African countries should put more effort into vector control than in managing pathogens. He also proposed that African countries should adopt a special district model for effective vector control, such as that employed in the USA. Finally, he issued a wake-up call to African professionals to convert their knowledge to practical efforts for mosquito control, insisting on the adoption of integrated vector management (IVM), changing building codes for housing, and eliminating mosquito breeding habitats.

Plenary Talk 4 - Women Leading the Charge: Breaking the Gender Barrier in Malaria & Vector-Borne Disease Response

Corine Karema (Roll Back Malaria - RBM) gave a talk on "Women Leading The Charge: Breaking the Gender Barrier in Malaria and Vector-Borne Disease Response." She began by emphasizing the importance of support from family and mentors in the development of a female scientist. Karema also stated that whether as patients or caregivers, women bear a disproportionate share of the health, societal, and economic burden of malaria and VBDs. She urged more women to participate in malaria strategy and policy development, recognizing the progress made in terms of women holding such

positions over the years. Karema emphasized the importance of recognizing women's achievements in the field, highlighting an award that was created to honor Mwele Malecela's legacy by mentoring female leaders in NTDs. She encouraged PAMCA to transition from gender-unequal programs to gender-transforming programs and advised women in vector control to take action in order to expand their role and advance their involvement in positions of leadership.

Parallel Scientific Session 7 - Vector surveillance: surveillance systems, community-based surveillance, epidemiology, disease control programs and global health

Session Chair: **Mercy Opiyo;** Co-chair: **Mauro Pazmino**

Steven Gowelo (University of California San Francisco, United States) proposed a replacement of a paper-based Entomological Surveillance Planning Tool (ESPT) with a digital entomological surveillance planning tool (eSPT) for better surveillance outcomes. Despite the crucial role entomological surveillance plays, implementation is always arbitrary, hence exhibiting the need for a digital platform for effective entomological surveillance. Therefore, a digital version of the surveillance tool was developed, tested with stakeholders, and piloted in Ethiopia, Malawi, and Mozambique. The study remarkably increased the acquisition of participants' knowledge and gained confidence in developing entomological surveillance plans, an essential component of entomological surveillance.

Abdoulaye Niang (Research Institute of Health Sciences - IRSS, Burkina Faso) presented the need to engage local communities to achieve better surveillance of malaria vectors in Burkina Faso. They conducted a study, where government stakeholders, researchers, university members, and the NMCP gathered along and decided to train new entomologists within the Ministry of Health for effective entomological surveillance at the country level. Participants were trained in larvae and adult mosquito collection methods in the field, assessment of resistance profiles, morphological identification of mosquitoes, sample conditioning, and others. A pre- and post-test were conducted to evaluate the training; participants lacking in some ways were re-trained while others were deployed in districts for entomological surveillance.

Mauro Pazmino (University of Glasgow, United Kingdom) in his presentation emphasized that vector's age is a crucial component for entomological surveillance as it determines malaria transmission. However, the available working models involving complex and time-consuming dissections are not efficient and are unsuitable for field samples exposed to different temperatures. To address this gap, he proposes an improvement in the infrared spectroscopy-based surveillance generalization model for better age grading, blood meal, and species identification of wild mosquito populations irrespective of their setting. Upon comparison of the age predicted by infrared spectroscopy algorithms against the predictions using the current methods, they were able to demonstrate that infrared spectroscopy with machine models predicted better biological ages. This is a step forward in transforming malaria surveillance without limitations.

Gift Mwaanga (Macha Research Trust, Zambia)**,** reported on the bio-efficacy of Attractive Targeted Sugar Bait (ATSB) in Western province Zambia. During the Phase III epidemiological trial, ATSBs were placed for seven months on the outside wall of households in twelve selected clusters. Once collected, labeled and conditioned in a pre–designed wooden box for further experiments, new ATSBs were installed. Among collected ATSBs, the non-damaged were used to evaluate the product bio-efficacy. For 48 hours, *Anopheles gambiae s.s (Kisumu)* were left in cages where the removed ATSB was

mounted. Compared to the new ATSB, the results showed that the field-deployed ATSB retained bio-efficacy mortality above 80% even after being deployed for seven months.

Parallel Scientific Session 8 - Precision public health and innovations for VBD elimination: artificial intelligence, entomological databases, genomic surveillance, new and re-emerging disease vectors, climate change, One health

Session Chair: **Josephine Malinga;** Co-chair: **Nick Golding**

Gilles Yemien (Research Institute of Health Sciences - IRSS, Burkina Faso) presented his study on the identification of yellow-g in *Anopheles gambiae*, the gene involved in eggshell formation in *Drosophila melanogaster,* and the design of molecular strategy to study its function in view of genetically controlled malaria vectors. Using the Basic Local Alignment Search Tool (BLAST), CD-Search, and gene expression databases, AGAP005958 was found to be a yellow-g ortholog in *An. gambiae.* He added that AGAP005958 may be involved in *An. gambiae* fertility. However, in vivo studies are required to determine its function in *An. gambiae*, and its suitability as a genetic control target.

Odette Nabasnogo Zongo (Research Institute of Health Sciences - IRSS, Burkina Faso) presented her research, which aimed at designing an in-silico model to study the beta tubulin2 gene in *Anopheles gambiae* related to male infertility. Sheused the FlyBase database to identify and design a guide RNA to serve as CRISPR-Cas9 guide to the target site. Three orthologs for beta tubulin2 in *An. gambiae* (AGAP008622, AGAP010929 and AGAP008623) were identified. The final design may be injected into the mosquito for in vivo testing to evaluate *Drosophila* AGAP008622 function in *An. gambiae* in order to create genetic control techniques against malaria vectors.

Prashanth Selvaraj (Bill and Melinda Gates Foundation - BMGF, United States) presented his study entitled, “Microsporidia MB: Evaluating the impact of symbiont-based malaria vector control via EMOD, an agent-based model of vector genetics and malaria transmission”. Drivers of microsporidia prevalence in vector populations were investigated with conclusive outputs, regarding seasonality, horizontal and vertical transmission, and fitness costs. The model suggested that microsporidia MB can be a valuable tool in the fight against malaria transmission in sub-Saharan Africa even with limited deployment. Future studies should look at refining the model and cost-effectiveness of microsporidia MB deployment.

Josephine Malinga (Swiss Tropical and Public Health Institute, Switzerland) discussed the value and application of modeling to provide evidence that combines data, models, and simulations to answer stakeholders' questions and accelerate product development. She cited projects that used modeling to develop oral chemoprevention drugs, pre-erythrocytic monoclonal antibodies, and also investigated the public health impact of malaria vaccines. Notably, a simulation model in humans is driven by parasite dynamics and immunity and is linked to a model in mosquitoes. Malingaalso presented the outcomes of ongoing projects and emphasized the importance of intervention layering in disease prevention and progress toward malaria elimination.

Nick Golding (Telethon Kids Institute, Australia) presented on mapping the current and potential future distribution of *Anopheles stephensi* in Africa. The spatial model was developed while considering micro-climate suitability, larval habitat preferences, spatial spread, and variable probability of detection. Analysis suggests that Central Africa would be suitable for vector persistence

due to its microclimatic conditions, however, the probability of detection is estimated to be minimal across most of the continent. Golding added that maps can be routinely updated as information grows on *An. stephensi* distribution and surveillance efforts and are disseminated to mosquito control experts through the Vector Atlas.

Dominic P. Dee (Imperial College London, United Kingdom) provided an update on the Malaria INtervention Tool (MINT), an online tool used to determine the most cost-effective interventions used in a region. The update includes new pyrethroid-pyrrole nets and features that allow for multi-region strategies. His methodology included the use of experimental hut trials to characterize the efficacy of modeled ITNs, as well as a suppository simulation to create the interface. He concluded that when combined with real-world data, the MINT tool can assist in selecting the best vector control tool combinations in various settings.

Parallel Scientific Session 9 - Vector bionomics: vector biology, ecology, taxonomy, and population genetics

Session Chair: **Lindelwe Mabika;** Co-chair: **Sanjay Curtis Nagi**

Lindelwe Mabika (KwaZulu-Natal Department of Health, South Africa) and team in a bid to understand the outdoor biting and host seeking behavior of mosquitoes in the *Anopheles gambiae* complex, collected mosquitoes in two sites from September 2022 to June 2023 hourly using mouth aspirator from 5pm to 12am. These mosquitoes were collected in animal shelters, identified first morphologically and then using species specific PCRs. Mabika results unexpectedly revealed that the primary malaria vector was *Anopheles arabiensis* with a peak biting time between 7pm and 10pm in both districts.

David Audu (Federal University of Agriculture, Nigeria) presented his work aimed at evaluating the effect of supplementing sugar meals with either herbal or synthetic antimalarials on the microbiota of *Anopheles* mosquitoes given their role in either preventing or promoting the transmission of malaria. Mosquitoes were collected from Odeda Local Government in Nigeria and once in the insectary, 250 females were split into five groups and exposed to *Morinda lucida*, artemether-lumefantrine (AL), M*orinda lucida* + artemether-lumefantrine, amoxicillin and distilled water for 1 hour in different groups. Gut enzymatic activity and microbial composition will be analyzed 24, 48, and 72 hours after exposure in order to see if differences occur between groups.

Thomas O Onchuru (International Centre of Insect Physiology and Ecology - ICIPE, Kenya) gave a presentation on a symbiont-based approach for malaria control, emphasizing the interaction between *Anopheles arabiensis* and Microsporidia MB. Microsporidia MB has been shown to block the development of *Plasmodium falciparum* to its infective stage, the sporozoite. He highlighted features of this fungi that makes it suitable for vector control such as: horizontal and vertical transmission, avirulent but stable infection of male gonads and the possibility of using both male and female mosquitoes for dissemination. He concluded his talk by providing insights relevant for timing to release Microsporidia MB-infected mosquitoes as a novel strategy for fighting malaria.

Henrique Silveira (Global Health and Tropical Medicine, Portugal) highlighted that bloodless diet is a promising alternative to blood for rearing *Anopheles* mosquitoes. Traditionally, blood from different sources was used for rearing mosquitoes, however, it is either expensive or has ethical issues. He

discussed findings that a bloodless diet had yielded mosquitoes with comparable fecundity, longevity, and infection permissiveness. He presented the preliminary results of an ongoing research that maintained *Anopheles stephensi* colony for 3 years without blood. Silveira indicated that bloodless diet mimics blood, produces viable offspring, sustains long term production of *Anopheles* species and is a breakthrough in *Anopheles* rearing.

Sanjay C. Nagi (Liverpool School of Tropical Medicine, United Kingdom) came up with a novel locus that confers resistance to pirimiphos-methyl (PM) in *Anopheles gambiae s.l.* Whole-genome sequencing of mosquitoes from eight African countries helped to identify two carboxylesterase novel loci (COEAE1F and COEAE2F) for PM insecticide resistance. This gene is overexpressed in resistant *An. gambiae s.l* populations. Orthologs gene from *Culex Pipiens* was found to confer organophosphate resistance and is spread worldwide. Haplotype clustering indicates the occurrence of multiple and distinct selective sweeps on this locus. However, the mechanisms are often convergent across species and complex, so that many different haplotypes are under selection, and it is unclear what they all do.

This report is brought to you by the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo Odero, Ndey Bassin Jobe and Temesgen Ashine, with the support of a former correspondent Leslie Diane. Senior editorial support has been facilitated by Zawadi Mboma & Billy Tene.

Day 3 - Wednesday, 20th September 2023

Plenary Talk 5 - Malaria, eradication and the role of vector control

Helen Jamet (Bill and Melinda Gates Foundation - BGMF, United States) began her presentation by discussing the three strategic principles of the BMGF for malaria eradication in Sub-Saharan Africa which are (i) reducing the burden of malaria, (ii) investing in next generation surveillance systems, and (iii) mitigating resistance to drugs and insecticides. The BMGF budget for malaria is $1.6B and 23% of it goes towards vector control research and development (R&D). The BMGF key priority areas for vector control R&D includes (i) new insecticide active ingredients (AI's) to fight against resistance (e.g., dual AI nets and attractive targeted sugar baits), and (ii) genetic based vector control methods (e.g., gene drive). She highlighted PAMCA's resourcefulness in helping BMGF to collaborate with African researchers towards a common goal of making the continent free of vector borne diseases. Jamet informed, the BMGF remains committed to supporting and investing in initiatives that are geared towards contributing to malaria elimination in Sub-Saharan Africa. She concluded by encouraging the PAMCA chapters and research institutions to provide recommendations for the future of PAMCA's core mandates.

Parallel Scientific Session 11 - LLINS, IRS and insecticide resistance management

Session Chair: **Julien Z.B. Zahouli;** Co-chair: **Mame Niang**

Julien Z.B. Zahouli (Swiss Centre for Scientific Research - CSRS, Ivory Coast) compared the efficacy of washed and unwashed PermaNet Dual®, PermaNet® 3.0 and PermaNet® 2.0, with unwashed nets as control, using experimental huts, then laboratory cone and tunnel bioassays in Tialassé, Ivory Coast. Unwashed and 20 times washed bed nets were exposed to wild *Anopheles gambiae s.l.* Results indicated the inhibition in mortality and blood-feeding for both unwashed and washed nets was higher with PermaNet® Dual compared to the other nets and the control. To conclude, Zahouli stated that the deltamethrin-chlorfenapyr coated PermaNet Dual® represents a promising tool in the fight against pyrethroid-resistant *Anopheles* vectors.

Eliningaya J. Kweka (Tanzania Plant Health and Pesticides Authority, Tanzania) presented research work on the potential new tool, In2Care® EaveTubes, a plastic ventilation sheet with mosquito killing netting to address the now established challenge of insecticide resistance. This tool works by funneling human-scented air when indoors through the eaves tube to lure mosquitoes and when they are blocked, the special static coating in the netting binds mosquitoes to it. To evaluate the efficacy of this promising insecticide candidate, the team carried out a pilot study at the Kagera Sugar Limited premises in Tanzania. The study results showed that the In2care EaveTube caused an overall 58 % reduction in malaria mosquitoes and up to 75% in peak season. A similar study carried out in Ivory Coast and published in the Lancet (link) showed a reduction of malaria cases by 47% in houses treated with EaveTubes. The presenter concluded by requesting a scale up of this new tool, which is still awaiting WHO review, to manage insecticide resistance.

Patrick Tungu (National Institute for Medical Research, Tanzania) introduced his talk describing pyrethroid resistance in Tanzania. The study was about experimental hut and community (Phase III) cluster randomized indoor residual spraying evaluation trials of VECTRON™ T500 against malaria

vectors in Tanzania. The mortality to VECTRON™ T500 recorded during experimental hut trials in Moshi was non-inferior to that of Actellic® 300CS, while the ability of VECTRON™ T500 to reduce vector density during the community randomized trial conducted in Muheza was non-inferior to that of Fludora® Fusion. The efficacy of VECTRON™ T500 on mud and concrete walls lasted 12 months post spraying against insecticide susceptible and resistant *An. gambiae* s.s., confirming the long-lasting residual efficacy of VECTRON™ T500. Patrick closed by announcing the validation of VECTRON™ T500 by the WHO in March 2023.

Moussa B.M. Cisse (Laboratory of Applied Molecular Biology - LBMA, Mali) centered his presentation around the need for the deployment of two sets of insecticides Fludora® Fusion 562.5 WP-SB and Ficam®VC against pyrethroid-resistant *Anopheles gambiae s.l* in Mali. He highlighted the serious challenge faced by core vector intervention, IRS, that shifted their focus towards the two novel insecticides. They conducted Phase three trials collecting data through prokopack aspiration, human landing catches, capture with exit, and performed dissections. They also carried out WHO cone test and CDC bottle bioassays on the mosquitoes of interest. The study results showed that both Fludora® Fusion 562.5 WP-SB and Ficam®VC were effective in the control of pyrethroid-resistant strains *An. gambiae s.l.* with residual efficacy of 12 months and 5-6 months respectively. To address this urgent need, the insecticides under consideration should be deployed to combat the challenge of insecticide resistance that is threatening to disrupt progress in malaria vector control in Mali.

Dunia Munyakanage (Malaria and Other Parasitic Diseases Division - MOPDD, Rwanda), on behalf of **Elias Niyituma** (Abt Associates, Rwanda) started his presentation by informing the audience that in 2013, Rwanda adopted an insecticide resistance management strategy due to widespread resistance to pyrethroid insecticides, IRS and ITN being the core vector intervention tools. Based on malaria endemicity and insecticide resistance data, a new generation of insecticide was introduced in 2017 and new PBO nets in 2020. Through a study, the new tools (IRS with Actellic 300CS and new PBO) were evaluated against Interceptor G2 (IG2) nets. IRS, IG2, and PBO nets were deployed in Ngoma, Karongi, and Kicukiro districts respectively. The results showed that entomological inoculation rates were lower after the intervention in all three districts. However, the reduction was higher in the IRS and PBO net districts than in the IG2 net district. Also, IRS with Actellic 300CS was more efficient against *An. gambiae* than PBO nets, thus the need to use new formulations of IRS for effective management of malaria hotspots.

Parallel Scientific Session 12 - Vector bionomics: vector biology, ecology, taxonomy and population genetics

Session Chair: **Penny Hancock;** Co-chair: **Rita Mwima**

Luciano Michaël Tantely (Institut Pasteur of Madagascar, Madagascar) did a nationwide inventory of *Anopheles* species available in Madagascar. With the rise of malaria cases, it was necessary to extend entomological studies by examining potential vector transmitters different from the well-studied *Anopheles gambiae s.l* species. The study was carried out from February to December 2019. It was found in April that, along with *An. gambiae s.l,* an abundance of *An. coustani* and *An. squamosus;* both attracted to humans, were recorded and corroborated with the higher prevalence of *Plasmodium* sp. in that month.

Rocco D'Amato (Innovation, Genomics, Genetics and Biology Hub - Polo GGB, Italy), following the WHO guidelines to evaluate genetically engineered mosquitoes (GEM), used large cages to evaluate a double-sex-targeting gene drive as well as an anti-drive to prevent population collapse and compared the results to those observed in small cages. He found that in both cages' population suppression was effective after the drive insertion, and the anti-drive insertion was also able to inhibit the drive spread. Nevertheless, more fluctuations were observed in gene drive and anti-drive frequency in large cages highlighting the importance of large cage studies prior to field trials.

Esinam Abla Akorli (Noguchi Memorial Institute for Medical research, Ghana) studied the ecological factors associated with the presence of Microsporidia MB in mosquito breeding sites. Her study first highlighted the presence of Microsporidia MB in *Anopheles gambiae* and *Anopheles coluzzii* from Ghana, with the prevalence being higher in males. Further investigation of the breeding sites led her to understand that rice fields were compatible with the growth of this bacteria, while factors such as turbidity, salinity, copper, zinc, and manganese presence in breeding sites were negatively correlated with MB presence. This work informs on ecological factors that need consideration if MB is to be considered as symbiont-mediated malaria control.

Penny Hancock (Imperial College London, United Kingdom) used data from a pesticide spray catch model conducted in 4 villages in Burkina Faso for 6 years to simulate field data trial sets for gene drive implementation. Since gene drive is a method set for imminent trial, it is important to statistically estimate its effects along with how much release will be needed to achieve 90% suppression. The number of mosquitoes collected, their spatial distribution, and the mosquito species collected were used to construct a Bayesian spatiotemporal model for fitting mosquito count. The simulation model shows that to detect 50% suppression, it is necessary for five villages to receive the same drive simultaneously, with this power decreasing if only one mosquito species is targeted. This shows that time series data can inform the design of field trials to detect vector suppression.

Parallel Scientific Session 13: Vector surveillance: surveillance systems, community-based surveillance, epidemiology, disease control programs and global health

Session Chair: **Joel C Mouatcho;** Co-chair: **Brenda Onyango**

Gabriel O Kotewas (Ministry of Health - MoH, Kenya) presented their study on the effectiveness of indoor residual spraying (IRS) on malaria control in Kenya. They conducted a review of the malaria cases among children under five years in Rachuonyo North Sub County, Homa Bay County, from 2019 to 2022. Results showed malaria cases were recorded all year round with two major malaria peak seasons. During the four-year study, the highest number of malaria cases in Rachuonyo North were recorded in 2020 and the lowest number of cases were recorded in 2021. According to Kotewas, the reduction of malaria cases was largely associated with the use of IRS and insecticide-treated bed nets (ITNs) since 2018.

Rock Aikpon (Ministry of Health/National Malaria Control Programme - MoH/NMCP, Benin) presented a study on the effect of IRS interventions withdrawal on malaria transmission in two districts in Benin. Mosquitoes were collected between 2016 and 2018 using the human landing catch technique, identified first morphologically then using species PCR. ELISA tests were performed for sporozoite detection. Results revealed over 3-fold increase in vector abundance with *Anopheles gambiae* being the most predominant vector species. Moreover, they observed that vectors became more endophagic. This study reveals that the withdrawal of IRS confers vulnerability to the population with regards to malaria transmission.

Daniel Nguiffo Nguete (Centre for Research in Infectious Diseases - CRID, Cameroon) presented a study on the contribution of *Plasmodium malariae* to high levels of malaria transmission in a forest savannah transition area in Cameroon. They conducted entomological surveys to identify which vectors were most competent to transmit *P. malariae.* They also evaluated the dynamics of *P. falciparum* and *P. malariae* infection transmission in all age groups. The results of the study showed that the most abundant species was *An. funestus* followed by *An. gambiae*. Infections caused by *P. malariae* or co-infections of *P. malariae* and *P. falciparum* in humans were transmitted mainly by *An. funestus.* Also, children under the age of 5 had a significantly increased density of plasmodium compared to other age groups. Overall, *P. falciparum* infections were the most prevalent (43%) followed by co-infections of *P. malariae* and *P. falciparum* (17%). He concluded that additional interventions should be implemented to tackle *P. malariae* in malaria endemic countries.

Eric Ochomo (Kenya Medical Research Institute - KEMRI, Kenya and Centre for Global Health Research - CGHR, Kenya) presented the first detection of the invasive malaria vector, *An. stephensi*, in Kenya, which was discovered through molecular surveillance. The mosquitoes used in the study were collected from December 2022 to February 2023, and identified using (i) PCR, (ii) morphological identification, and (iii) additional verification of the results through amplicon sequencing. Ochomo concluded that although *An. stephensi* was detected in this analysis, it has not yet been incriminated as a vector of *P. vivax* in this study. Furthermore, surveillance of *An. stephensi* has been scaled up in many counties, led by the Kenya NMCP and PMI.

Joel C Mouatcho (KwaZulu-Natal Malaria Control Programme, South Africa) presented results of entomological surveillance carried out in KwaZulu-Natal in order to understand if residual malaria

transmission is driven by outdoor or indoor biting vectors. Mosquitoes were collected outdoors and indoors using diverse collection techniques. Mosquitoes were also identified by morphology and PCR. Overall, results revealed that 97% of the mosquitoes were collected outdoors, more precisely around animal shelters. *An. arabiensis* was the most predominant vector species. This study highlights the likely implication of outdoor biting mosquitoes in residual transmission of malaria in KwaZulu-Natal.

Domonbabele François de Sales Hien (Research Institute of Health Sciences - IRSS, Burkina Faso) presented a study on the effects of the alkaloid ricinine on the capacity of *An. gambiae* and *An. coluzzii* to transmit *P. falciparum*. They assessed (i) the effect of alkaloid ricinine on the competence of mosquitoes to transmit *P. falciparum,* and (ii) the rate of oocyst development and sporozoite dissemination in salivary glands. Results showed that the consumption of nectar alkaloid ricinine could have effects on the phenotypic traits that govern malaria transmission. However, more studies need to be done to validate the efficacy of alkaloid ricinine as a novel control agent for malaria vectors.

Parallel Scientific Sessions 15: Vector surveillance: surveillance systems, community-based surveillance, epidemiology, disease control programs and global health

Session Chair: **Alison M Reynolds;** Co-chair: **Joel Lutomiah**

Mark Wamalwa (International Centre of Insect Physiology and Ecology - ICIPE, Kenya) presented a study titled 'The Exigent Threat of the Alien Invasive *Anopheles stephensi* in Africa.' This study aimed to assess the risk of malaria transmission in Africa as a result of *An. stephensi* invasion by using a mathematical model. An agent-based compartmental model (ABM) using a bottom-up modeling approach was used while considering parameters such as urbanization, vector bionomics, and climate change scenarios. Findings suggested a shift in the distribution of *An. stephensi* in space and time, and that temperature significantly affects mosquito population growth rates. Wamalwa concluded by insisting on the need for strengthening surveillance, adaptive, and integrated vector control strategies, and improving information exchange.

Joyce Nyirongo (Malaria Alert Centre - MAC, Malawi) presented a study that focused on detection of gametocytes in asymptomatic malaria infections using microscopy. They aimed to quantify the frequency of asymptomatic malaria infections in a study group of 146 participants who were screened for infection. The study's findings revealed that 47% of gametocyte positive participants were between the ages of 6 and 15 years old, consistent with previous research that has identified school-aged children as the primary *P. falciparum* transmitters to mosquitoes. Notably, some participants had multiple positive smears and came from the same household. Nyirongo concluded by highlighting the significance of investigating individual and household-level infection clusters and the transmission potential of asymptomatic gametocyte carriers.

Thiery Nirina Jean Jose Nepomichene (Institut Pasteur of Madagascar, Madagascar) presented on the field assessment of resting boxes for the surveillance of malaria vectors in the Central Highlands of Madagascar. To compare the trapping effectiveness of the Resting Box (RB), a surveillance tool made from locally available materials was compared with Muirhead Thomson pits (MTPs) as a standard method. Although both RB and MTPs were able to catch eight different species of *Anopheles* mosquitoes, both anthropophilic and zoophilic vectors, and sporozoite-infected mosquitoes, RBs

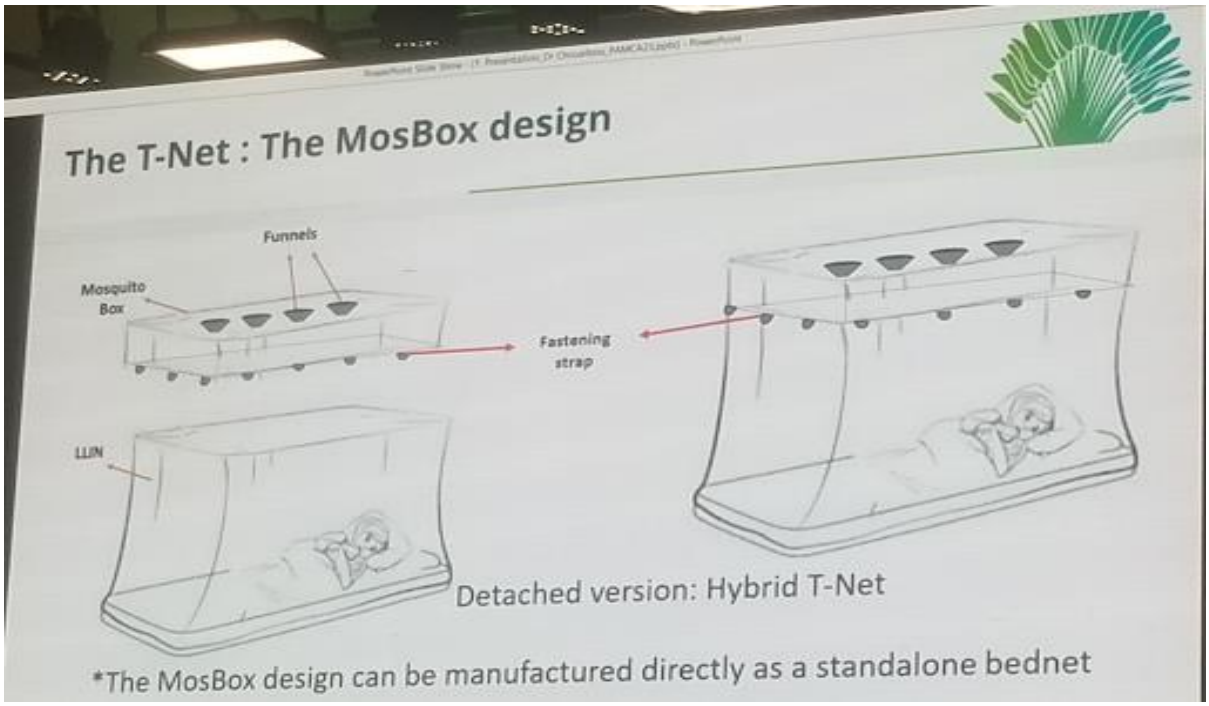
captured approximately 18 times less *Anopheles* than MTPs. Improvement of RB is required, as it would be cost-effective in assisting community-based entomological surveillance.

Jaelsa Mira Goncalves Moreira (Ministry of Health - MoH, Cape Verde) was excited to share that Cape Verde was now eligible to receive a WHO malaria elimination certificate. She stated that this was the third time in the last three decades that they had achieved zero malaria transmission status, recording zero local cases of malaria since 2018. On track to eliminate malaria and get certified as malaria-free, Moreira discussed the Ministry of Health's plans to prevent the reintroduction of malaria into the country. She also emphasized the importance of funding and partnerships that provide standard operating procedures (SOPs) and entomological surveillance to prevent malaria reintroduction. The certification will demonstrate the country's commitment to eliminating vector-borne diseases and will serve as an encouragement to other African countries that it is possible to defeat malaria.

Parallel Symposium Session 12 - Alternative high-potential vector control strategies to mitigate insecticide resistance and reduce the malaria burden

Organizer: **Chouaibou S. Mouhamadou**

Chouaibou S. Mouhamadou (Swiss Centre for Scientific Research - CSRS, Ivory Coast) began by highlighting alternative tools that could complement existing malaria vector control tools. Mouhamadou then discussed the potential of a mosquito-trapping bednet (T-Net) to mitigate insecticide resistance. T-Net is a square-box design net with trapping funnels to be sewn on the top of the bednet. An experimental hut trial conducted in a high-resistance area (Tiassale) showed a 4-fold increase in mortality in untreated T-Net compared to Permanet 2.0. These findings also suggest an increased killing effect of ITNs when insecticide-treated T-nets are used. He added that this tool can limit insecticide-resistance selection pressure on mosquitoes, increase the killing effect of ITNs, and decrease the spread of resistance genes. He concluded by highlighting their goal, which was to generate data to demonstrate the public health value and community acceptability.



Cyrille Ndo (Center for Research for Infectious Disease - CRID, Cameroon) presented a study titled "Keeping the vector out: Re-introducing housing improvement as a sustainable approach to integrated vector control". Ndo pointed out that we need an additional vector control tool that can curtail residual malaria transmission in areas where universal coverage of ITNs is not achieved, where ITNs show limited efficacy due to physical degradation and/or reduced bio-efficacy, and where people are exposed to mosquito bites before going to bed. Housing improvement is the better option. Evidence from field trials in Cameroon suggests that only by screening eaves with wire mesh, indoor mosquito density was reduced significantly; furthermore, there were 4.8- and 5.7-fold reductions in the indoor human biting rate and entomological inoculation rate, respectively. Ndo concluded that housing improvement has the potential to be integrated with other vector control strategies in malaria-endemic areas.

Karine Mouline (Research Institute for Development - IRD, France) presented on embedding malaria control and ecological balance in a one health approach using Ivermectin, a systemic insecticide that could help to manage insecticide resistance. Ivermectin, an endectocide with rapid mosquitocidal effects against *Anopheles* (2-3 days), works both in animals and humans. Therefore, treating animals with long-acting ivermectin formulations (LAIFs) may help reduce the population of zoophilic malaria vectors. She further added that avoiding ecological risks in already fragile environments and agro-ecosystems is imperative. Mouline further discussed that, to embed malaria control using LAIFs in a one-health approach, it is essential to consider the local entomological context, animal breeding practices, agricultural practices, multidisciplinary approaches, and local practices to mitigate environmental toxicity. Despite its potential for malaria vector control, the performance of this approach depends on the animal/human ratio and coverage. Lastly, she pointed out that the 50% lethal concentration (LC50) values for non-targeted species found in sub-Saharan Africa should be established.

Cyrille Ndo (Center for Research for Infectious Disease - CRID, Cameroon) presented the historical success and progress made so far in the research and development of the sterile insect technique (SIT), an alternative high-potential malaria vector control tool to control malaria vectors regardless of their resistance status. SIT involves rearing radio-sterilized male mosquitoes and then releasing them to mate with wild females. As these females do not produce any offspring, the vector population declines over time. He mentioned a few notable successes of this approach in insect pest control and highlighted the progress achieved in research and development with regard to SIT including the development of necessary equipment for mass rearing, sterilizing, sex separation, and female elimination. He concluded by insisting that despite significant strides that have been made over the years, some steps must be completed before its implementation.

Parallel Symposium Session 16 - Controlling Emergent Anopheles stephensi in Ethiopia and Sudan (CEASE)

Organizer: **Alison M. Reynolds, PhD**

Adane Iyasu (Jimma University, Ethiopia) presented on the distribution and characteristics of *An. stephensi* in Ethiopia. They studied the routes of invasion of this invasive species, and explored the most effective vector control strategies that can be used to combat its further spread. The entomological surveillance was conducted in 26 sites. The immature mosquitoes were collected using

standard dippers and the adult mosquitoes were collected using CDC light traps and mechanical aspirators (Prokopack aspirator). The results of their study showed that six (6) sites were positive breeding habitats for *An. stephensi*: 89.3% of the pooled immature samples that were screened and genotyped were confirmed to be *An. stephensi*. Also, they found that the most common blood meal sources for the collected adult *An. stephensi* were animals.

Hmooda Toto Kafy (Federal Ministry of Health, Sudan) presented on the entomological surveillance of *An. stephensi* in Sudan. Their study objective was to identify the route of invasion of An. *stephensi* and its current and potential distribution. The entomological surveillances were conducted in 61 selected sites (10 houses from each site). The study revealed that seven sites had positive breeding habitat for *An. stephensi*. Most of the anopheles mosquito larvae collected from indoor and outdoor water containers were *An. stephensi.* However, adult *An. stephensi* density per house was very low in the majority of positive sites. Furthermore, the study also found that there is a tendency for adult *An. stephensi* to rest outdoors rather than indoors.

Martin Donnelly (Liverpool School of Tropical Medicine, United Kingdom) presented on the diversity, population structure, and demography of *An. stephensi* in Sudan. They investigated (i) signatures of insecticide resistance, and (ii) the impact of *An. stephensi* invasion processes on our ability to use genomic data to guide operational decision making and for understanding how to control the vector. They observed the presence of sub-populations in different states with no sign of insecticide resistance selection. Results on diversity, runs of homozygosity and complicated structures vs native ranges equally suggested invasion from different sites.

Temesgen Ashine (Armauer Hansen Research Institute, Ethiopia) presented a case control study which will assess the impact of *An. stephensi* on urban malaria transmission in Metchara, Ethiopia. To this end, they will select accessible areas with ongoing malaria transmission where *An. stephensi* is present for the study. Study participants will be recruited from health facilities into the case group if they have a fever and positive microscopy/ rapid diagnostic test (RDT) for plasmodium parasite, and into the control group if they have a negative result. Home visits to participants will be conducted 48 hours after enrolment for the collection of malaria risk factor data and entomological surveillance.

This report is brought to you by the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo Odero, Ndey Bassin Jobe and Temesgen Ashine, with the support of a former correspondent Leslie Diane. Senior editorial support has been facilitated by Zawadi Mboma & Billy Tene.

Day 4 - Thursday, 21st September 2023

Parallel Scientific Session 17 - LLINS, IRS and insecticide resistance management

Session Chair: **Camille Dossou;** Co-chair: **Eliningaya J Kweka**

Gonse Marius Zoh (Institut Pierre Richet Vector Control Product Evaluation Centre - IPR VCPEC, Ivory Coast) presented on the need to reduce the dose application area on the Interceptor® G2 (IG2) net without compromising its efficacy. This new generation net has chlorfenapyr + alphacypermethrin as active ingredients (AI) which are effective against pyrethroid-resistant *An. gambiae s.l.* in Ivory Coast. The experimental hut trial in M'Bé, central Ivory Coast compared the efficacy of untreated polyester nets having "IG2 sides"' (IG2 on the side panels only) and "IG2 roof" (IG2 on roof panel only) versus whole IG2 against insecticide resistant mosquitoes. The study established that the use of "IG2 sides" provides similar protection as the whole Interceptor® G2 (Long-Lasting Insecticidal Net) LN. They conclude that this will go a long way in saving the production cost of Interceptor® G2 LN (IG2) net and thus boost community access.

Cyrille Ndo (Centre for Research in Infectious Diseases - CRID, Cameroon) aimed to understand mosquito competence while harboring the metabolic resistant allele L119F-GSTe2. *Anopheles funestus* were collected from two sites in Cameroon. After forced oviposition, the eggs were reared to adult stage. To conduct experimental infection of the mosquitoes, blood of children carrying gametocytes was collected and fed to mosquitoes using artificial membrane feeding. Seven days post-feeding, their midguts were dissected, and oocysts were counted under microscopy. The rest of the body was used to genotype the resistant allele L119F-GSTe2 frequency. The study found that the number of oocysts was higher in the heterozygotes and the resistant mosquitoes, highlighting how vector competence is increased due to the resistant allele presence.

Eliningaya J. Kweka (Tanzania Plant Health and Pesticides Authority, Tanzania) presented their study on the emergence of insecticide resistance in *Anopheles gambiae s.l.* in Tanzania. He argued that faced with the challenge of insecticide resistance and the continued reliance on insecticides for controlling insect vectors, necessitates discovery and development of compounds such as VECTRON™ T500 with novel modes of action to complement or replace the insecticide classes approved by WHO for use in LLINS and IRS. Through experimental hut trials, they assessed the efficacy of VECTRON™ T500 at 100mg AI/m2 against laboratory and wild *An. gambiae s.l.* in Magugu ward, Manyara region, Tanzania. Their findings showed that VECTRON™ T500 induced mortality in both populations of *An. gambiae* on treated surfaces year-round. In a nutshell, strategies to preserve the susceptibility of local vectors and extend the useful life of the insecticides need to be considered before large-scale deployment.

Mouhamadou Bassir Faye (Cheikh Anta DIOP University, Senegal) characterized the resistance profile of *Anopheles funestus* in Nioro and Ndoffane districts of Senegal. Using

WHO tube tests, he found a total resistance of the mosquitoes from both sites to the pyrethroids he used, while they were all susceptible to organophosphates and organochlorines. Further, the pre-exposition of those mosquitoes to the synergist piperonyl butoxide (PBO) showed total susceptibility recovery to the pyrethroids used, except for alpha-cypermethrin. This indicates that metabolic genes were not linked to resistance to that insecticide. Overall, his results support the use of PBO-treated nets to better achieve malaria vector control in those districts.

Tagne Djoko Simeon Carlos (Centre for Research in Infectious Diseases - CRID, Cameroon) presented on the need for genetic knowledge to identify molecular markers in *An. funestus* responsible for insecticide resistance. For him, this is key to the improvement of insecticide resistance. Their study assessed the role of CYP9K1 (P450) gene in conferring resistance to pyrethroid through overexpression and/or allelic variations using DNA-based diagnostic assay in samples collected across Africa in 2020 and compared with those collected in 2014. The results showed a rapid spread of 454A-CYP9K1 haplotype that negatively impacts both LLINs and novel nets. In conclusion, the study's ability to track resistance in the field using a new DNA-based assay is key in improving resistance management strategies that rely on evidence-based decisions.

Javan Chanda (PATH, Zambia) conducted a study to monitor vector species composition and characterize insecticide resistance in three districts of Zambia. Mosquito larvae were collected and reared to adult stage. *Anopheles arabiensis* was the most abundant species accounting for 96% – 98% in those districts. Mosquitoes aged 2 to 5 days were exposed to pyrethroids, carbamates, organophosphates and neonicotinoids. They were susceptible to all these insecticide classes except for pyrethroids. A pre-exposition of those mosquitoes to piperonyl butoxide (PBO) before an exposure to pyrethroids showed a restored susceptibility suggesting that the resistance is driven by metabolic resistance mechanisms.

Parallel Scientific Sessions 19 - Vector bionomics: vector biology, ecology, taxonomy and population genetics & Vector surveillance, new and re-merging vectors, community-based surveillance, epidemiology, disease control programs and global health

Session Chair: **Eric Ochomo;** Co-chair: **Jonathan Kazungu Karisa**

Augustino T. Mmbaga (Ifakara Health Institute - IHI, Tanzania) presented a review on the auto-dissemination approach (ATD), which relies on the resting behavior of gravid mosquitoes to transfer lethal pyriproxyfen (PPF) to their oviposition sites, thereby inhibiting adult emergence. Augustino summarized the success of ATD with PPF in controlling malaria vectors under controlled semi-field settings. Studies to gather empirical evidence and develop biology-informed mathematical models to demonstrate the utility of this approach are underway. He highlighted that the key determining factors for the future introduction of ATD

include scalable ATD devices, optimized PPF formulations, assessing community perception and acceptance, and integrating it into existing vector control interventions.

Brice Natchema Soh Fonkou (Centre for Research in Infectious Diseases - CRID, Cameroon) highlighted the association of L119F-Gste2 gene with entomological parameters of mosquito vectors. Identification of infection, blood meal, and L119F-GSTe2 genotypes were made from wild collected malaria vectors, and the result is used to compare different genotypes of L119F-GSTe2 with entomological indices. *An. funestus s.s.* exhibited a very high entomological inoculation rate and human blood index. *An. funestus s.s.* individuals with 119F/F genotypes had a significantly higher transmission intensity than their susceptible counterparts. He emphasized that *An. funestus s.s.* still sustains an extremely high malaria transmission and is driven by the GSTe2 metabolic resistance.

Mercy J. Tuwei (KEMRI Wellcome Trust, Kenya) spoke about the use of Matrix Assisted Laser Desorption/Ionization time-of-flight Mass Spectrometry (MALDI-TOF MS) to determine the parity status of wild malaria vectors. Age-grading aids in predicting the proportion of potentially infectious female *Anopheles* mosquitoes, which aids in determining the success of a control intervention. Wild mosquitoes were collected in Mozambique using CDC light traps, morphologically identified as *An. gambiae* and *An. funestus* and subjected to molecular and MALDI-TOF MS analysis. Tuwei concluded from her findings that because nulliparous and parous female mosquitoes were distinguished with 81% accuracy, further research with other wild malaria vectors must be conducted, and MALDI-TOF MS is a promising tool for routine vector surveillance.

Mgeni M. Tambwe (Ifakara Health Institute - IHI, Tanzania) spoke about a study that looked at the effect of chlorfenapyr on the development of malaria parasites inside mosquitoes, explaining that chlorfenapyr is converted to tralopyril (CL303268) to reduce ATP production. He presented data from randomized control trials in Benin and Tanzania, where the prevalence of malaria was significantly reduced when chlorfenapyr nets are used. *An. gambiae* resistant mosquitoes were infected a day after an 8-hour exposure in a modified WHO tunnel assay. More infections were recorded in control nets than in chlorfenapyr nets, and there were more oocytes for control exposure in terms of intensity of malaria parasites post-exposure. Chlorfenapyr, he concluded, may further reduce the occurrences of malaria in communities beyond killing mosquitoes.

Closing Ceremony

The closing ceremony of the 9th Pan-African Mosquito Control Association (PAMCA) Annual Conference and Exhibition was co-chaired by **Damaris Matoke** (PAMCA Programme Manager, Capacity Building, Gender Empowerment & Career Progression) and **Jessy Goupeyou** (PAMCA WiVC Regional Coordinator for Western Africa). They both noted that this year's conference has been a great success, and they hope that participants were able to network with fellow scientists on the continent which could potentially lead to research collaboration. They further highlighted that the conference has also provided visibility to African scientists especially women. They concluded by thanking all sponsors of this year's conference, especially Bill & Melinda Gates Foundation, Syngenta, and ENVU.

The closing ceremony began with an introduction of the new PAMCA board members who were warmly welcomed by the executive director and the conference participants. This board is made up of a group of prominent researchers, leaders and entrepreneurs from different countries. The outgoing board members were applauded for their enormous contribution to the association with the handing over of special gifts from the incoming board members.

Short statements were delivered by participants from different countries who expressed their appreciation to the PAMCA secretariat and the scientific committee for organizing the conference and providing such a great platform for African scientists to present their research, network, and foster collaborations.

Closing remarks

The closing remarks were delivered by **Prosper Chaki** (Executive Director of PAMCA), **Emma Orefuwa** (Ag. Executive Director of PAMCA), and **Delenasaw Yewhalaw** (Ethiopia Chapter Chairperson). They all expressed their gratitude and appreciation to the PAMCA - Ethiopia Chapter and the Ministry of Health of Ethiopia for hosting this year's conference. They also thanked and applauded this year's scientific committee as well as the PAMCA secretariat for the incredible work done in the past months to ensure this conference was a success. The sponsors of this year's conference were also recognized, acknowledged and thanked. This was followed by a formal announcement of the 10th PAMCA conference host - Côte d'Ivoire. They highlighted that this year's PAMCA conference was gracefully attended by a total of 810 participants and challenged the Côte d'Ivoire PAMCA chapter to increase this number to 1000 next year. This challenge was gracefully accepted by the PAMCA Côte d'Ivoire chapter.

The ceremony ended with handing over of the host flag to the PAMCA Côte d'Ivoire chapter who expressed their joy, excitement, enthusiasm and preparedness to host the 10th PAMCA Annual Conference and Exhibition in Abidjan, in 2024.

This report is brought to you by the MESA Correspondents Akua Obenewaa Danquah Yirenkyi, Ashu Fred Ayukarah, Augustino Mmbaga, Helga D.M. Saizonou, Julius Ichodo Odero, Ndey Bassin Jobe and Temesgen Ashine, with the support of a former correspondent Leslie Diane. Senior editorial support has been facilitated by Zawadi Mboma & Billy Tene.

Discover more content in the Resource Hub

www.mesamalaria.org