

MEETING REPORT

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Report of the 2023 Asia Pacific Conference on Mosquito and Vector Control: “reimagining vector control—innovations for a changed world”

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Abstract

The Asia–Pacific region has had decades of progress in reducing malaria cases and deaths. The region is now accelerating its efforts towards malaria elimination by 2030 using a science-based approach by applying evidence-based best practices alongside existing tools. However, there are concerns of knowledge gaps and external factors challenging this goal. The COVID-19 pandemic served as reminder of the need for a holistic approach. This report summarizes the outcomes of the discussions from the “Asia Pacific Conference on Mosquito and Vector Control” held in Chiang Mai, Thailand from 27 to 30 November, 2023. The conference aims to provide insights into recent research, cutting-edge tools, and the strength of the Asia–Pacific regional mosquito and vector control capacity post-COVID-19 pandemic era. The conference featured discussions on mosquito surveillance, monitoring and control; enabling the resolution of local problems with local expertise and forging new partnerships; and exploring recent research advancements in vector control strategies. More than 500 experts from 55 countries attended.

Keywords Mosquito control, Recent research, Surveillance, Local expertise, Partnerships, Thailand

Background

The coronavirus disease 2019 (COVID-19) pandemic has caused a significant impact on the health systems around

the world [1]. At the peak of the pandemic, many public health workers were, inevitably, required to switch their roles to focus on COVID-19 [2]. Major disruptions in medical and public health research were noticeably significant effects due to travel restrictions. These disruptions had a significant impact on the management of vector-borne diseases (VBDs) [2–4] which disproportionately affect ill-equipped public health systems of the world that includes the Asia–Pacific region [5]. In this regard, countries hit by both COVID-19 and VBDs were urged not to disengage on the latter [6]. Concerns remain in Asia–Pacific countries over the conflicting low and high levels of VBDs recorded throughout the COVID-19 period from 2020 to 2022 and the alarming epidemics after the period [7].

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The Asia Pacific Conference on Mosquito and Vector Control (AMV)-2023 was a significant occasion as it marked the first in-person scientific meeting on mosquito and vector control since the challenges posed by the COVID-19 pandemic. In collaboration with the Department of Disease Control, Ministry of Public Health (MoPH), Thailand, and the Thailand Pest Management Association, Kasetsart University hosted AMV-2023 from November 27th to 30th at the International Convention Center, the Empress Hotel, Chiang Mai. The conference aims to strengthen the Asia–Pacific regional mosquito and vector control capacity and network, forging new partnerships, and exploring new technologies and approaches to address the rapidly changing landscape for mosquito control in the region. It was an honor to have world-class researchers join in exchanging information and providing knowledge and guidelines for controlling mosquitoes and vectors worldwide.

The conference provides insights into both traditional and state-of-the-art techniques in various aspects of mosquito and vector surveillance and control. This is expected to encourage innovation by strengthening connections between countries and regional networks to exchange expertise and knowledge. Furthermore, AMV-2023 encourages innovations in research practices that address the inequality faced by Asia–Pacific scientists and enabling the resolution of local problems with local expertise. This includes combining translational research into practice rather than relying solely on external agendas and strategies. Global collaboration and sustained funding emerged as essential elements in the fight against vector-borne diseases, given their transboundary nature.

AMV-2023 received over 200 abstract submissions and featured 23 separate symposiums, two plenary sessions, four keynote lectures, poster presentations, and remote links. In addition, we hosted a pre-workshop organized by the Global Biodiversity Information Facility, funded by the TDR. Throughout the conference, we explored the latest advancements in vector control strategies, disease surveillance, and public health policies. The conference attracted a diverse and substantial global audience, with a total of 565 participants. The attendance breakdown revealed both online (48) and onsite (517) participation. Noteworthy, participants came from all major continents, including Africa, Asia, Australia, Europe, North America, and South America. Analysis of the registration data revealed a diverse range of presenters, with 154 speakers contributing to the oral sessions, including academic faculty, researchers, master's and doctoral level students, government officers, representatives from non-government organizations, and individuals from the private and commercial sectors.

This report highlights the key outcomes of the AMV-2023 event which have been discussed under three themes composing of: (1) Plenary lectures; (2) Keynote lectures; and (3) Symposium presentations.

Plenary lectures

Dr. Raman Velayudhan, from the Vector Control and Environment Unit, of the Global Neglected Tropical Diseases Programme of the World Health Organization (WHO) highlighted that dengue affects 130 countries, with over 4 billion people at risk and is endemic in over 100 countries. Dengue lacks effective treatments, vaccines, and long-term vector control. Cases surged during the COVID-19 pandemic and have increased eightfold since 2000. In 2023, nearly 5 million cases and 5000 deaths were reported. Dengue fever has been categorized as a Level 3 emergency disease by the WHO, which denotes a severe, large-scale, sudden-onset humanitarian disaster that necessitates system-wide mobilization to increase response and improve overall assistance. The current responses guided by WHO Global Vector Control Response 2017–2030, which focus on collaboration, community engagement, and surveillance, are scaling up tools for dengue control. This talk highlighted that dengue thrives in varied conditions, as seen in Bangladesh's floods and Brazil's drought. Climate change and water stress impact dengue while urbanization, especially in Africa, poses future challenges.

Prof. Donald Roberts (Uniformed Services University, Bethesda, MD, USA) commented on the adaptability of *Aedes aegypti*, which was thought incapable of surviving in colder latitudes in the USA, but it is now a permanent resident as far north as Washington, D.C. [8]. These mosquitoes are thought to use extensive underground spaces for overwintering. In warm months, high population densities can be found in intensely used human spaces, for example, in popular outdoor eating places. Comparisons between colonies of *Ae. aegypti* Rockefeller and *Aedes albopictus* USUHS confirmed that these two strains exhibit very different egg-hatching strategies.

Keynote lectures

Assoc. Prof. Christina Liew (NEA, Singapore) highlighted that Singapore employs a comprehensive strategy to address dengue occurrences, emphasizing the importance of communication in igniting community action, through mainstream, online, and social media. Although the *Aedes* House Index has decreased since the 1960s, recent dengue cases are increasing, with 8,734 cases and 3 deaths reported in 2023 by week 46. The control strategy involves four pillars: surveillance, sustainable prevention and control, outbreak management, and public

communication and advocacy [9]. Project *Wolbachia* Singapore employs a suppression strategy, with widespread publicity and stakeholder consultation targeting academia, the medical community, students, and government agencies. According to a post-release household perception survey, 70% of households had heard of the project, and over 90% of households expressed no concerns about the *Wolbachia-Aedes*' ongoing release [10].

Dr. Chusak Prasittisuk addressed challenges and opportunities in mosquito vector control in Asia and the Pacific for the next decade. Dengue, Chikungunya, Zika, Japanese Encephalitis, and Lymphatic filariasis remain significant concerns. Urbanization is altering dominant vectors and disease risk, with specific issues noted in India. This talk also highlighted that high diversity and increasing spread of vectors, insecticide resistance, land use reforms, climate change, cross-border malaria citing an example of Thailand-Myanmar border crossings, pose additional challenges to reducing disease burden. Opportunities exist in training, vector identification, collaboration, planning, partnerships, implementation, monitoring and evaluation. The closing message underscored that mosquito vector control is everyone's responsibility.

Prof. Elizabeth McGraw (Pennsylvania State University, USA) focused on "Thermal stress interactions with *Wolbachia* and dengue virus in *Ae. aegypti*", highlighting that *Ae. aegypti* serves as an excellent system for studying viruses. Important takeaways from this talk include: *Wolbachia pipientis*, spreading through cytoplasmic incompatibility, reduces virus replication and works against various viruses, including CHIKV, ZIKV, WNV, YFV, and *Plasmodium*; both *Wolbachia* and DENV infections lead to approximately fivefold faster KD time and thermal sensitivity; *Wolbachia* does not protect against DENV-mediated effects on KD. Notably, HSP expression may not always be useful during heat stress, and *Ae. aegypti* shows resilience to frequent, short heat exposures, with high heat reducing DENV loads. In conclusion, she reasoned that high heat may reduce viral loads and affect transmission and that thermal sensitivity may affect the geographical range over which *Wolbachia* can be deployed.

Prof. Chow-Yang Lee (University of California, Riverside, USA), addressed the global resurgence, insecticide resistance, and management of bed bugs in his talk. He highlighted recent media reports of bed bugs in various countries, expressing concern about the long-standing issue of bed bug resurgence. Key points from his presentation include the characteristics of adult bed bugs, their obligate blood-feeding behavior, and the absence of disease transmission. Globally, two major species of public concern are the common bed bug (*Cimex lectularius*) and the tropical bed bug (*Cimex hemipterus*). Bed bug

management strategies involve chemical control, with insecticide rotation and insecticide mixtures recommended for resistance management. However, the availability of effective active ingredients is limited. The true challenge is controlling bed bugs in their "reservoirs" such as homeless shelters.

Symposium presentations

Epidemiology and control of arthropod-borne diseases

The conference highlighted significant progress in understanding the epidemiology and control of vector-borne diseases. One study employed reverse genetics and detailed intra-host infection kinetics to investigate the function of viral genetic determinants in relation to vector tropism. They identified 11 amino acid residues on pRM, E, NS3, NS4B, and NS5 that are conserved within a subgroup of flaviviruses sharing the same vector (*Aedes*-borne, *Culex*-borne, and tick-borne). Detailed infection kinetics analyses suggested that the genetic loci are involved in several infection steps, including virus stability in mosquito midguts, as well as infectivity and maturation during mosquito infection.

In a separate discussion, malaria parasites, vector demographics, and human behaviours in Lao PDR were linked to an increased risk of malaria transmission. Staying outdoors from 18:00 to 22:00 h and 3:00 to 6:00 h increased human exposure to mosquito bites in villages. Variations in *Anopheles* vector species, ecotypes, and seasons exacerbated the risk of transmission.

A talk on zoonotic diseases underscored an upsurge of simian malaria, which is attributed to increased human intrusion into forests. The loss of the "dilution effect" due to biodiversity changes, leads to amplified vector-borne disease transmission between humans and other animals. Although the first natural infection of *P. knowlesi* occurred in Pahang in 1965, simian malaria was expected to remain in the macaques because the vector *An. hackeri* was only zoophagic. Today, several vectors and parasites have been identified. Currently, *P. knowlesi*, *P. cynomolgi*, *P. inui*, and *P. fieldi* have been reported in humans.

Implication of climate in relation to vector distribution and control

The conference addressed the impact of climate change on vector dynamics. Changing environmental conditions are altering the distribution and behaviour of vector species, presenting new challenges for control efforts. Adaptive strategies that consider these changes are necessary to maintain effective vector control. Using dengue data from 2002 to 2019, a climate-driven spatiotemporal predictive model for dengue was created for four provinces in Thailand and Laos. This model allows for the study of the influence of climate change on dengue. According

to the model, there is a discernible rise in temperature between the current decade and the predicted future. In Thailand's Ubon Province, the temperature was predicted to rise by 1.5 °C in 2020 compared to 2000, then by 3 °C by 2050 and 6 °C by 2090. The discussions underscored the interconnectedness of climate, human activities, and vector ecology in shaping VBD transmission patterns.

Vector control research and beyond

The iDEM (Intervention for Dengue Epidemiology in Malaysia) project which employs a proactive integrated vector management (IVM) approach was discussed. This approach emphasizes the use of auto-dissemination devices for larviciding, targeted outdoor residual spraying for adulticiding, and community engagement activities to control dengue. A 29% reduction in dengue cases during 'outbreaks' and a 43% reduction in 'hotspots' were recorded. In Malaysia, an outbreak is defined as the presence of two or more dengue cases that occur within a 200-m radius within 14 days of the first case notification date. A dengue hotspot is defined as an outbreak lasting more than 30 days following the start of the outbreak. The iDEM project's operationalization during COVID-19, together with the difficulties faced and solutions found are among its highlight features [11].

A meta-analysis on volatile pyrethroid spatial repellents against mosquitoes showed that metofluthrin and transfluthrin were the main active ingredients studied, evaluated by either human landing catch or trap density. An overall protective efficacy was 48% (95% CI 41–55%) with higher protective efficacy measured using human landing catch (74%; 95% CI 73–76%) and passive fabric interventions showing the highest efficacy (64%; 95% CI 63–66%). Susceptibility varied across mosquito species, with the highest efficacy seen in *Aedes* species that were not *Ae. aegypti* and the lowest in *An. funestus*. Product format, active ingredient, mosquito species, study type, weather, and study design were highlighted as the evidence gaps. Important technologies discussed consisted of attractive toxic sugar baits, biological pesticides such as *Bacillus thuringiensis* var. *israelensis* (*Bti*), *Pseudomonas entomophila*, and *Beauveria bassiana*, *Wolbachia*, and sterile insect technique (SIT).

Community engagement for vector control

Through various presentations, there was unanimous agreement that community engagement plays a crucial role in the implementation of vector control strategies. Some presenters highlighted community engagement as a crucial part of IVM and climate change-driven vector management. In Cambodia in particular, where the National Malaria Control Program (CNM) and local task forces coordinate efforts, community engagement

has made it possible to utilize insecticide-treated bed nets (ITNs) efficiently. Advice is given on cleaning, drying, and storing the nets—all of which are essential for maintaining their integrity and sustainability. Whereas the application of communication for behavioural impact (COMBI) Model to a pilot study delivering volatile pyrethroid spatial repellents and etofenprox insecticide-treated clothing highlighted user preferences. Community-led deployment of a spatial repellent product against *Ae. aegypti* in Mexico was noted with high satisfaction and efficacy in households. The talk on Singapore's experience in public engagement for *Wolbachia*-based dengue control highlighted that emphasis on education, consultation, involvement, and feedback were crucial in the rollout of *Wolbachia* technology. High levels of awareness and acceptance were observed.

Improved targeting and delivery of vector control and surveillance tools: NextGen technology

The presentations highlighted the state-of-the-art technology in use or under development in vector control and management of VBDs. Cutting-edge technologies, including genetic modification, sterile insect techniques, machine learning, artificial intelligence, and novel insecticides, were showcased as promising tools in vector surveillance and control. Delving into the intricacies of the "Gene Drive for Vector Control" project, the significance of population genetics in developing genetic insecticides through CRISPR/Cas9 technology was emphasized. Population genetics is important for target site selection, understanding the spread of transgenes, population size, and identification of cryptic species. The gene targets for vector control consist of behavioural and sensory genes, immune genes, sex determination genes, and fertility genes.

In Singapore-based studies, presenters demonstrated the use of computational tools and AI-based models for forecasting and spatial risk determination of dengue. The use of machine learning support for *Wolbachia* releases, focusing on dynamic adjustments based on data has shown considerable gains in closing the time gaps and reducing mosquito density.

In a separate talk, a web-based surveillance for *Ae. albopictus* and *Culex quinquefasciatus* was demonstrated, utilizing the "MS-300" mosquito monitor that can specifically and efficiently capture the vectors and monitor their density automatically in real-time. A digital version of the Entomological Surveillance Planning Tool (ESPT), a decision-support tool for planning entomological surveillance activities, interpreting entomological data, and guiding programmatic vector control decisions.

Table 1 Selected topics and presenters at the Asia–Pacific Conference on Mosquito and Vector Control

Presenter's name	Title presented	Affiliation
SYMPOSIUM 1: EPIDEMIOLOGY & CONTROL OF ARTHROPOD-BORNE DISEASES		
Florence FOUQUE	TDR activities on multisectoral approaches for the control of arthropod-borne diseases	WHO, The Special Programme, TDR, Avenue Appia, Geneva, Switzerland
Simone L. SANDIFORD	The hunt for arboviruses and the evaluation of endemic plants with mosquitocidal activity in Jamaica	Mosquito Control and Research Unit, The University of the West Indies, Mona
Brij Kishore TYAGI	'Desert malaria': an emerging malaria paradigm, with emphasis on controlling the dominant vector species, <i>Anopheles stephensi</i> , and tackling malaria in hard-to-approach populations in the great Indian Thar desert	Advisor, SpORIC, VIT University, Vellore—632014 (TN), India
Nigel W. BEEBE	<i>Wolbachia</i> as an adaptable mosquito control apparatus for <i>Aedes</i> mosquito population replacement and removal	School of the Environment, University of Queensland, Brisbane, Australia
Mitra SAADATIAN-ELAHI	The IDEM trial (Intervention for Dengue Epidemiology in Malaysia) to measure the effectiveness of integrated vector management on the incidence of dengue in urban Malaysia: a cluster randomized controlled trial	Service Hygiène, Epidémiologie et Prévention. Centre Hospitalier Hôpital Edouard Herriot, Hospices Civils de Lyon, 69437 Lyon Cedex, France
Rui-De XUE	Evaluation of three essential oils and boric acid as active ingredients in attractive toxic sugar baits against <i>Aedes aegypti</i>	Anastasia Mosquito Control District, St. Augustine, FL 32092, USA
Brij Kishore TYAGI	Dengue in India: challenges and innovations in vector control, an eco-bio-social assessment	Advisor, SpORIC, VIT University, Vellore—632014 (TN), India
Sébastien MARCOMBE	Linking mosquito vector bionomics and human behaviors to evaluate malaria risk transmission in Laos	VCC-SEA, Vector Control consulting, Vientiane, Lao PDR
Pojakorn DANPANICHKUL	Elderly populations and the escalating rates of dengue: two decades trend from the global disease burden study	Department of Microbiology, Faculty of Medicine Chiang Mai University, Thailand
Arissara PONGSIRI	Using entomological surveillance to evaluate dengue transmission preventive actions at household level in Kamphaeng Phet Province, Thailand	Department of Entomology, Armed Forces Research Institute of Medical Sciences
SYMPOSIUM 2: VECTOR CONTROL RESEARCH AND BEYOND		
Kok-Boon NEOH	Effects of attractive toxic sugar bait on male mosquitoes and its field efficacy for reducing <i>Aedes albopictus</i> population in community farms	Department of Entomology, National Chung Hsing University, Taiwan
Chun-xiao LI	Intelligent identification of vector mosquito species using a SWIN transformer model	State Key Laboratory of Pathogen and Biosecurity, Beijing, China
Ingrid CHEN	Volatile pyrethroids against mosquitoes: a meta-analysis of the association between mosquito exposure to volatile pyrethroid-based spatial repellents and mosquito bite prevention	University of California San Francisco, 550 16th Street, 3rd Floor San Francisco, CA 94158, USA
Hee-IL LEE	Development of mosquito surveillance system with Artificial Intelligence (AI) techniques	Korea Disease Control and Prevention Agency, Chungju, Korea
Meng-Chieh CHIU	Boric acid toxic sugar bait suppresses male <i>Aedes aegypti</i> : the allee effect, flight activity, wing beat frequency and amplitude	Department of Entomology, National Chung Hsing University, Taiwan

Table 1 (continued)

Presenter's name	Title presented	Affiliation
Dickson LWETOJERA	Sterilized females of the malaria vector, <i>Anopheles funestus</i> , can auto-disseminate sufficient pyriproxyfen to breeding sites under semi-field settings	Ifakara Health Institute, P.O Box 53, Ifakara, Tanzania
Ganga Gharty CHHETRI Abu Imroz ALI	New tool <i>Bacillus thuringiensis</i> to control mosquito vector in Nepal Advanced larvicide strategies for mosquito-borne disease management: novaluron tablets and eco-friendly silicon spreader	Tribhuvan University, Kirtipur, Kathmandu, Nepal Russell IPM Ltd, Deeside, Flintshire, CH5 2NU, United Kingdom
Stephan KARL	Distribution of insecticide treated nets with low efficacy and the current rise in malaria cases in Papua New Guinea	Papua New Guinea Institute of Medical Research, Papua New Guinea
SYMPOSIUM 3: MOLECULAR BIOLOGY AND GENOMICS		
Catherine WALTON	Phylogenomics of the <i>Anopheles leucosphyrus</i> group reveals origin of the major forest malaria vectors in Southeast Asia	Department of Earth and Environmental Sciences, University of Manchester, UK
Jintana YANOLA	Molecular analysis of knockdown resistance (<i>kdr</i>) mutations in the voltage-gated sodium channel gene in <i>Aedes aegypti</i> from worldwide populations	Chiang Mai University, Chiang Mai, 50200, Thailand
Ketsarin KAMYINGKIRD	Integration of vector-borne parasites diagnosis, prevention and control of vector-borne parasitic diseases in small scale livestock farms in southern part of Thailand	Department of Parasitology, Faculty of Veterinary Medicine, Kasetsart University, Chatuchak, Bangkok, 10900 Thailand
Abadi M. MASHLAWI	The genetic diversity and population structure of <i>Aedes aegypti</i> (Diptera: Culicidae) in the kingdom of Saudi Arabia	Department of Biology, Jazan University, Jazan 45142, Kingdom of Saudi Arabia
Samantha O'LOUGHLIN	Gene drive for vector control; why is population genetics important for the success of this innovative technology?	Imperial College London, Silwood Park Campus, SL5 7PY, UK
Natapong JUPATANAKUL	Molecular determinants of vector tropism in arbo-flaviviruses: insights from genetic and infection kinetics studies	BIOTEC, Pathum Thani, Thailand
Yukiko HIGA	Evidence for two genetically different types in the Japanese encephalitis mosquito vector, <i>Culex tritaeniorhynchus</i> (Diptera: Culicidae)	Department of Medical Entomology, NIID, Tokyo, Japan
Mawra NADEEM	Genetic diversity of <i>Wolbachia</i> endosymbionts in mosquitoes from diverse geographic origins of Thailand	Faculty of Medicine, Chulalongkorn University, Bangkok, 10330, Thailand
Nozomi UEMURA	Does the knockdown resistance allele, L982W + F1534C, in <i>Aedes aegypti</i> results in fitness costs?	Department of Medical Entomology, NIID, Japan
Chatchapon SRICHAROENSUK	Molecular screening of <i>Wolbachia</i> endosymbionts in cavernicolous sand flies collected from the leishmaniasis endemic areas in northern Thailand	Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand
SYMPOSIUM 4: VECTOR CONTROL AND MANAGEMENT		
Siriporn YONGCHAITRAKUL Nongnoot Nonesrichai Tippawan ASURA	Malaria vector control in Thailand: challenges and opportunities Evaluation of chikungunya surveillance in Kalasin Province 2022 Enhancing malaria prevention strategies among the Karen ethnic community in Kaeng Makrut sub-district, Ban Rai district, Uthai Thani Province	Department of Disease Control, MoPH, Thailand Kalasin Provincial Public Health Office, Thailand Uthai Thani Provincial Public Health Office, Thailand
Sopavadee Moonmake	The relationship of insecticide resistant and <i>kdr</i> gene mutation in the <i>Aedes aegypti</i> vector on the outbreak site of dengue fever	Faculty of Environmental Management, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand

Table 1 (continued)

Presenter's name	Title presented	Affiliation
Ruchuorn WONGPIROM	The effect of climate change to various species of malaria vector in Ubon Ratchathani and Sri Saket provinces along Thai—Laos borders during 2010 to 2021	The Office of Disease Prevention and Control Region 10th Ubon Ratchathani, Thailand
Wasinee SRIPLONG	Study on efficacy of <i>Bacillus thuringiensis</i> var. <i>israelensis</i> (bti) against <i>Aedes aegypti</i> (L.) and impact on non-target organisms	The Office of Disease Prevention Control 12 Songkla, Songkla 90000, Thailand
SYMPOSIUM 5: IMPLICATION OF CLIMATE CHANGE IN RELATION TO VECTOR DISTRIBUTION AND CONTROL		
Thomas R BURKOT	Megatrends and their impact on vector receptivity in the anthropocene: how human activities including climate change affect malaria vectorial capacity	Australian Institute of Tropical Health and Medicine, James Cook University, Cairns, Australia
Gregor DEVINE	Impact of climate and environment on vector ecology and control in Australia	Mosquito Control Laboratory, QIMR Berghofer Medical Research Institute, Queensland, 4006, Australia
Maquins SEWE	Spatio-temporal assessment and prediction of climate change impacts on dengue incidence rates in four provinces in Thailand and Laos	Department of Public Health and Clinical Medicine, Umeå University, Sweden
Vincent HERBRETEAU	Contribution of space observation to the study of vector distribution and control	Institut Pasteur du Cambodge, Epidemiology and Public Health Unit, Phnom Penh, Cambodia
Thipwara TIANSAWANG	Seasonal distribution of <i>Culex tritaeniorhynchus</i> a main vector of Japanese encephalitis virus in Thailand	Rajamangala University of Technology Suvarnabhumi, Thailand
Seong Uk SON	Preference assessment of new mosquito attractants in varied outdoor environmental conditions	Department of Convergence Science, Sahmyook University, Republic of Korea
SYMPOSIUM 6: VECTOR BIOLOGY AND ECOLOGY		
Catalina ALFONSO-PARRA	The effects of age on the fertility of the dengue vector mosquito <i>Aedes aegypti</i>	Max Planck Tandem Group, Universidad de Antioquia, Medellín, Colombia
Laura HARRINGTON	Mosquito blood feeding ecology and behaviour studies: a review of best practices	Department of Entomology, Cornell University, Ithaca, NY, USA 14853
Elizabeth A. McGRAW	Urbanisation enhances vector competence of dengue virus in <i>Aedes aegypti</i> through larval crowding	The Biology Department, The Pennsylvania State University, University Park, PA 16802, USA
Frank W. AVILA	wme1 <i>Wolbachia</i> alters female post-mating behaviors and physiology in the dengue vector mosquito <i>Aedes aegypti</i>	Max Planck Tandem Group, Universidad de Antioquia, Medellín, Colombia
SYMPOSIUM 7: COMMUNITY ENGAGEMENT FOR VECTOR CONTROL		
Siv SOVANNAROTH	The role of the community engagement in boosting the vector control strategies	National Center for Parasitology, Phnom Penh Cambodia
Li Ting SOH	Public engagement for <i>Wolbachia</i> -based dengue control: the Singapore experience	Environmental Health Institute, National Environment Agency, Singapore
Tanya RUSSELL	Strengthening the capacity of vector-borne disease control in Pacific Island countries	James Cook University, Cairns, Queensland, Australia
Triwibowo Ambar GARJITO	A century of malaria vector control in Indonesia: success stories, problems, and challenges	National Research and Innovation Agency, Indonesia

Table 1 (continued)

Presenter's name	Title presented	Affiliation
Marina TRESKOVA	The effectiveness of mosquito-proof storm drains in urban areas of Barcelona, Spain: aims and methods of the idalert Barcelona storm drain randomised controlled trial	Heidelberg Institute of Global Health, Heidelberg University, Heidelberg, Germany
SYMPOSIUM 8: IMPROVED TARGETING AND DELIVERY OF VECTOR CONTROL AND SURVEILLANCE TOOLS; NEXTGEN TECHNOLOGY		
Shuzhen SIM	Dengue prevention and control in Singapore: integration of new tools	Environmental Health Institute, National Environment Agency, Singapore
Emma FAIRBANKS	A systematic literature search for Asian <i>Anopheles</i> bionomics to parameterise mathematical model identifying key performance properties of novel vector-control tools for reducing malaria transmission	Swiss Tropical and Public Health Institute, Basel, Switzerland
Chia-chen CHANG	Using machine learning to support large-scale release adjustment for <i>Wolbachia</i> -mediated incompatible insect technique in Singapore	Environmental Health Institute, National Environment Agency, Singapore
Lucy de Guilhem de LATAILLADE	Meta-analysis of the mosquito microbiome uncovers new targets for vector control and highlights ecological drivers of the microbiota	The University of Hong Kong, Hong Kong, China
Allison TATARSKY	A digital question-based entomological surveillance planning tool increases knowledge acquisition and self-efficacy in users	The University of California San Francisco, Malaria Elimination Initiative, San Francisco, USA
Gerard DUVALLET	Natural enemies and mass trapping for stable fly management, a new IPM approach	Université Paul-Valéry Montpellier, France
Ekata MWONDO	Strategy for sustainable control of the dissemination of <i>Culicids</i> and their impact on humans worldwide	Agricultural engineering consultant, Forum des affaires, Douala, Cameroon
Nicole VARGAS-GARCÍA	Unraveling the secrets of <i>Anopheles (kerteszia) neivai</i> : a vector involved in the transmission of malaria in the Americas	USAID-Vector Link Project Colombia, Abt Colombia S.A.S., Bogotá D.C., Colombia
Xiao-Guang CHEN	Web-based surveillance on vector mosquitoes, <i>Aedes albopictus</i> and <i>Culex quinquefasciatus</i>	Department of Pathogen Biology, Southern Medical University, Guangzhou, China
SYMPOSIUM 9: INSECT REPELLENTS: FROM LAB DISCOVERIES TO REAL—WORLD PROTECTION		
Neil LOBO	Shifting the conventional paradigm on evaluating interventions	University of Notre Dame, Notre Dame, IN 46556, USA
Hitoshi KAWADA	How knockdown resistance mutations in the voltage-sensitive sodium channel (<i>vssc</i>) affect mosquito repellency?	Institute of Tropical Medicine, Nagasaki University, Nagasaki, Japan
Ingrid CHEN	Applying the com-b behavior change model to a pilot study delivering volatile pyrethroid spatial repellents and insecticide-treated clothing to forest-exposed populations in Mondulkiri Province, Cambodia	University of California San Francisco, 550 16th Street, 3rd Floor San Francisco, CA 94158, USA
Aniket SINGH	Larvicidal, pupicidal and repellence efficacies of <i>Barleria lupulina</i> (Acanthaceae) against vector of dengue <i>Aedes aegypti</i> L	Department of Zoology, Syamsundar College, West Bengal, India, PIN-713424
Hasitha Aravinda TISSERA	A cluster randomized placebo-controlled community trial on spatial repellent in reducing <i>Aedes</i> -borne viruses in the Gampaha district, Sri Lanka	Epidemiology Unit, Ministry of Health, Sri Lanka

Table 1 (continued)

Presenter's name	Title presented	Affiliation
John E. GIMNIG	Shaping policy on use of topical repellents: a case study from the Mekong	U.S. President's Malaria Initiative, US Centers for Disease Control and Prevention, Atlanta, USA
Gregor DEVINE	Community-led deployment of a spatial repellent: product offers protection against <i>Aedes aegypti</i> in Mexico	Mosquito Control Laboratory, QIMR Berghofer Medical Research Institute, Australia
SYMPOSIUM 10: EVALUATION AND EFFICACY OF VECTOR CONTROL OPERATIONS		
Jason RICHARDSON	Reimagining how we evaluate and measure efficacy of vector control operations	IVCC, Pembroke Place, Liverpool, UK
Anne POINSIGNON	Innovative biomarkers of human exposure to mosquito bites: from concept to applications in vector control	MIVEGEC, University of Montpellier, IRD, CNRS, Montpellier, France
Jonathan Wee Kent LIEW	It's black, it's white: modified black-bottom containers for mass egg collection of <i>Wolbachia</i> -infected <i>Aedes aegypti</i>	National Environment Agency, Environmental Health Institute, Singapore
Hadian Iman SASMITA	Pilot trials of sterile insect technique for control of <i>Aedes aegypti</i> in urban settings in Indonesia	Department of Entomology, National Chung Hsing University, Taichung, 402, Taiwan
Nattaphol PATHAWONG	Empowering vector surveillance: field evaluation of lithium-polymer power banks in CDC light traps and Laika traps for mosquito and sand fly collection in Thailand	Department of Entomology, Armed Forces Research Institute of Medical Sciences
SYMPOSIUM 11: GLOBAL BIODIVERSITY INFORMATION FACILITY (GBIF)		
Josiane ETANG	Popularizing data on disease vectors of the African region: challenges and prospects	Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Cameroon
Paloma SHIMABUKURO	Vector research life cycle: from the field to open data	Global Biodiversity Information Facility (GBIF), Brasília, Distrito Federal, Brazil, CEP 70833-040
Lindsay P. CAMPBELL	The utility of global biodiversity inventory facility data for vector surveillance in the black sea region	Florida Medical Entomology Laboratory, 200 9th St SE, Vero Beach, FL 32962, USA
Jessica DENNEHY	The global atlas of medical entomology schooling (games) and a scoping analysis on the opportunity to establish reference centers for training in medical entomology	Arctech Innovation Limited, Yew Tree Avenue, Dagenham RM10 7FN, UK
Gerard RYAN	The importance of open data and absence data in understanding the distribution of mosquito disease vectors	University of Melbourne, Victoria, Australia
SYMPOSIUM 12: ZONOOSES AND EMERGING VECTOR-BORNE DISEASE		
Dániel CADAR	The transformative effect of Metagenomic Next-Generation Sequencing (MNGS) on arbovirus discovery, research, and outbreak prevention/management	Bernhard Nocht Institute for Tropical Medicine, 20359 Hamburg, Germany
Indra VYTHILINGAM	Zoonoses a threat to malaria elimination	Faculty of Medicine, Universiti Malaya
Thibaut LANGLOIS	Epidemiological role of dogs in the transmission of emerging infectious zoonoses in South-east Asia	UMR MIVEGEC 224 IRD, 911 Av. Agropolis 34394 Montpellier FRANCE
Chatuthanai SAVIGAMIN	Arthropods as potential reservoirs for <i>Enterocytozoon bienersi</i> in insectivorous bats	Department of Parasitology, Chulalongkorn University, Bangkok, Thailand
Wachiraphan CHITTHAM	Comparative evaluation of commercially available repellents for protection against mosquito vectors	Department of Entomology, Armed Forces Research Institute of Medical Sciences

Table 1 (continued)

Presenter's name	Title presented	Affiliation
SYMPOSIUM 13: INSECTICIDE RESISTANCE AND MANAGEMENT		
Rajpal Singh YADAV	Management of insecticide resistance in mosquito vectors of disease: technical advances and operational needs	Academy of Public Health Entomology, Udaipur 313 002, India
Shiriji KASAI	Threats of concomitant knockdown resistance mutations in pyrethroid resistant <i>Aedes aegypti</i>	Department of Medical Entomology, National Institute of Infectious Diseases, Japan
Florence FOUQUE	Capacity strengthening on implementation research by TDR: monitoring and networking on insecticide resistance	World Health Organization, The Special Programme, TDR, Avenue Appia, Geneva, Switzerland
Audrey LENHART	Identifying molecular markers of insecticide resistance to improve vector control	Entomology Branch, U.S. Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA
Michael B. MACDONALD	An integrated vector management framework for insecticide resistance management	IVCC, Liverpool School of Tropical Medicine, UK
Ferdinand SALAZAR	Management of insecticide resistance to boost malaria vector control in the Philippines	Department of Medical Entomology, Research Institute for Tropical Medicine, Philippines
Yao-Yu WU	Insecticide resistance profile and knockdown resistance gene evaluation of field <i>Aedes albopictus</i> in north Taiwan	Department of Entomology, National Chung Hsing University, Taichung, Taiwan
Piyatida LEELAGUD	<i>Pseudomonas entomophila</i> : a potential alternative for the management of pyrethroid-resistant <i>Aedes aegypti</i>	Department of Entomology, National Chung Hsing University, Taichung, Taiwan
Patcharee KHONGTAK	Phenotypic insecticide resistance in arthropod-borne disease vectors: a surveillance study in Thailand	Department of Entomology, Armed Forces Research Institute of Medical Sciences
Suk Lan SER	Thermal stress interactions with <i>Wolbachia</i> and dengue virus infection in the mosquito <i>Aedes aegypti</i>	The Biology Department, The Pennsylvania State University, USA
Salum AZIZI	Are the new insecticides for malaria vector control proof to resistance development? outcomes from laboratory exposure of <i>An. gambiae</i> to sub-lethal concentration of chlorfenapyr and clothianidin	Department of Medical Parasitology and Entomology, Kilimanjaro Christian Medical University College, Tanzania
Daeyun KIM	Effects of air-drying time of transfluthrin-treated filter papers on discriminating concentrations against pyrethroid-susceptible <i>Aedes aegypti</i> (Diptera: Culicidae) using a high-throughput screening system	Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
Kentaro ITOKAWA	Genotyping entire coding sequence of the mosquito voltage gated sodium channel gene, <i>vgsr</i> , using hybridization capture enrichment	Department of Medical Entomology, National Institute of Infectious Diseases, Tokyo, Japan
SYMPOSIUM 14: BITE INTERUPTION TOWARD ELIMINATION		
Paipailin JHAIAUN	Semi-field evaluations of the impact of novel bite prevention interventions on <i>Anopheles minimus</i> landing and key life history traits in Thailand	Department of Entomology, Faculty of Agriculture-Bangkok, Kasetsart University, Bangkok, Thailand
Elodie VA-JDA	Integration of human behavior data with entomological data to identify gaps in protection and guide intervention selection, targeting, and tailoring in Mondulkiri and Kampong Speu provinces, Cambodia	Malaria Elimination Initiative, Institute for Global Health Sciences, University of San Francisco, California, US
Dyna DOUM	field evaluation of novel mosquito bite prevention tools against <i>Anopheles</i> mosquitoes in Cambodia	Health Forefront Initiative, Phnom Penh, Cambodia

Table 1 (continued)

Presenter's name	Title presented	Affiliation
Emma FAIRBANKS	Designing and parameterising mathematical models for the impact of novel vector-control interventions targeting gaps in protection to drive malaria elimination using data from semi-field and field studies	Swiss Tropical and Health Institute, Basel, Switzerland
Allison TATARSKY	Shifting the existing paradigm of evaluation of novel mosquito bite protection tools: how do we provide people with the protection they need?	Malaria Elimination Initiative, University of San Francisco, California, USA
SYMPOSIUM 15: IDENTIFICATION OF ARTHROPOD VECTORS		
Marianne E. SINKA	Humbug—developing an acoustic sensor to detect and identify mosquito vectors of disease	Department of Biology, University of Oxford, Oxford, UK
Gerard RYAN	Modelling the spread of a malaria vector into a new continent— <i>Anopheles stephensi</i> in Africa	University of Melbourne, Victoria, Australia
Clarisse GIRAULT	Control of vectors of pathogens causing infectious diseases in live-stock	HSM, Univ. Montpellier, CNRS, IRD, Montpellier, France
Pradya SOMBOON	1. The identity of <i>Anopheles (Anopheles) barbirostris</i> species A3 of the Barbirostris complex (Diptera: Culicidae) 2. A new species of the <i>Anopheles barbirostris</i> complex (Diptera: Culicidae) from Bhutan	Department of Parasitology, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand
SYMPOSIUM 16: TOWARDS EFFECTIVE MOSQUITO-BORNE DISEASE MANAGEMENT: INSIGHTS FROM STUDENT RESEARCH		
Aqsa YASIN	Effects of deltamethrin and clothianidin mixture on life-history of surviving <i>Aedes aegypti</i>	Department of Entomology, National Chung Hsing University, 402 Taichung, Taiwan
Manop SAEUNG	<i>Anopheles</i> vector diversity & spatial-temporal changes—implications for prevention of reintroduction of malaria in Sisaket Province, Thailand	Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
Elizabeth RIANA	Possible involvement of <i>Aedes aegypti</i> , <i>Culex tritaeniorhynchus</i> and <i>Culex quinquefasciatus</i> in lumpy skin disease virus transmission	Faculty of Veterinary Science, Chulalongkorn University, Bangkok 10330, Thailand
Tepyuda YONGSUE	The susceptibility of a field population of <i>Aedes albopictus</i> Skuse (Diptera: Culicidae) against commercial household larvicides and adulticides	Faculty of Natural Resources, Prince of Songkla University, Songkla, Thailand
Thinadda KAMRAM	Interspecific hybridization studies between <i>Anopheles dirus</i> and <i>Anopheles cracens</i> (Diptera: Culicidae) in the laboratory	Armed Forces Research Institute of Medical Sciences, Bangkok 10400, Thailand
Kanchon PUSAWANG	Antennal morphology and sensilla ultrastructure of the malaria vectors, <i>Anopheles maculatus</i> and <i>An. sawadwongporni</i> (Diptera: Culicidae)	Department of Parasitology, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand
Jin-Min YUAN	Description of a suspected novel sand fly species in Thailand: a potential new vector for <i>Trypanosoma</i> sp.	Department of Parasitology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand
SYMPOSIUM 17: ENHANCING INSECT CONTROL STRATEGIES FOR A SUSTAINABLE FUTURE		

Table 1 (continued)

Presenter's name	Title presented	Affiliation
Pongsakorn SADAKORN	AI for ensuring the chemical droplets sizing measurement and verifying the effectiveness of PH sprayers	Department of Disease Control, Ministry of Public Health, Thailand
Chadaporn Nuchjiangreed GORDON	Insecticide susceptibility status of <i>Aedes aegypti</i> populations from Bangkok, Nonthaburi and Chachoengsao provinces by WHO bioassay	Faculty of Allied Health Sciences, Burapha University, Thailand
Robert BAI	Insect repellent IR3535® sustainability and high efficacy performance are well balanced	Merck Display Materials (Shanghai) Co., Ltd., Shanghai 201206, PR.China
Kanlayanee POWCHAI	Discriminating lethal concentrations for transfluthrin and metofluthrin using the WHO bottle assay technique against <i>Aedes aegypti</i> L. for enhanced mosquito control	Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
SYMPOSIUM 18: MONITORING AND SURVEILLANCE		
Quentin NARPON	Changes in the prevalence and species composition of <i>Plasmodium</i> in villagers in Balombo region, Angola	HSM, Univ. Montpellier, CNRS, IRD, Montpellier, France
Areeya KRIENGJUDOM	Socio-ecological approach of dog-borne zoonotic disease in Southeast Asia	Faculty of Veterinary Technology, Kasetsart University, Bangkok, 10900, Thailand
Boonsong JAICHAPOR	A comprehensive study of <i>Anopheles</i> mosquito abundance and species composition along the Thai-Myanmar borders	Department of Entomology, USAMD-AFRIMS, Bangkok, Thailand

Insect repellents: from lab discoveries to real-world protection

The presenters discussed spatial repellents' modes of action and protection gaps, emphasizing their efficacy in areas where LLINs and IRS are impractical. Citing case studies from the Mekong sub-region, a talk on the spatial repellents for malaria control emphasizing trials and challenges and shaping policy on the use of topical repellents.

The bite interruption toward elimination (BITE) project has played a crucial role in the study of insect repellents, particularly, volatile pyrethroid spatial repellents (VPSRs), evaluated in semi-field and field trials as well as modelling studies. Major findings include: (1) In Thailand, all VPSRs, etofenprox-treated forest ranger uniforms and civilian clothing (long trousers), and the combined intervention (VPSR1+treated long civilian clothing), suggest potential to offer community protection by preventing diversion to nearby non-users through mosquito disarming. Treated civilian clothing (short trousers) did not reduce landing but did reduce post-exposure blood feeding success and increase 24-h mortality, also suggesting the potential to provide community protection by disarming and preventing diversion. (2) In Cambodia, all the intervention tools offered protection against mosquito bites but VSPR was the most effective with a 95% reduction in biting. Also in Cambodia, overall, Human Biting Rate (HBR) data demonstrated greater biting pressure outside than inside. However, integration of HBR data with Human Behavioural Observation data indicates that while peak biting measured by HLC occurred later in the evening (21:00–00:00 h), the primary gap in protection is during the early evening hours for people outside, awake, not under an ITN.

Insecticide resistance and management

The discussions offered comprehensive insights into the current situation and ongoing efforts. The WHO testing guidelines and the Global Vector Control Response 2017–2030 were particularly recommended as reference guidelines in the management of insecticide resistance. The five IVM elements of advocacy, legislation, and community engagement; cross-sector collaboration; integrated approaches; evidence-based decision making; and capacity-building provide a comprehensive, all of society approach to insecticide resistance management through the “all pest control options”. The presentations highlighted knockdown resistance (*kdr*) mutations as the major challenge in *Ae. aegypti* control using pyrethroids. The discovery of new mutations such as the L982W mutation, and concomitant mutations, L982W + F1534C and V1016G + F1534C, exacerbates this challenge.

Conclusion

Discussions throughout the conference explored advancements in vector control strategies, disease epidemiology, and surveillance, the impacts of climate change, insecticide resistance, and public health policies, celebrating successes, acknowledging setbacks, and setting a course for the future. Attendees, including students, young scientists, researchers, private sector colleagues, and academia, benefitted from professional development, knowledge expansion, and communication skills enhancement, through oral and poster presentations. The conference facilitated valuable networking opportunities, allowing participants to connect with professionals, leading to potential collaborations, research opportunities, internships, and job offers. Additionally, the conference served as an ideal platform for businesses to reach their target market, expand internationally, and gain visibility through various promotional activities. A summary of selected topics, presenters and their affiliations from different symposiums have been presented in Table 1. The Asia Pacific Malaria Conference on Mosquito and Vector Control is conducted every three years, and the next one is planned for Thailand in 2026.

Abbreviations

AMV	Asia Pacific Conference on Mosquito and Vector Control
KU	Kasetsart University
USUHS	Uniformed Services University of Health Sciences
AFRIMS	The Armed Forces Research Institute of Medical Sciences
BIOTEC	The National Center for Genetic Engineering and Biotechnology
LLINs	Long-Lasting Insecticidal Nets
iDEM	Intervention for Dengue Epidemiology in Malaysia
IVM	Integrated Vector Management
IRS	Indoor Residual Spraying
IVCC	Innovative Vector Control Consortium
MoPH	Ministry of Public Health
NEA	National Environment Authority
TDR	The Special Programme for Research and Training in Tropical Diseases
IRD	The French National Research Institute for Sustainable Development
WHO	World Health Organization
VBD	Vector-borne Diseases
COVID-19	Coronavirus Disease 2019
CHIKV	Chikungunya Virus
DENV	Dengue Virus
ZIKV	Zika Virus
YFV	Yellow Fever Virus
WNV	West Nile Virus
KD	Knockdown
<i>kdr</i>	Knockdown resistance
HSP	Heat shock proteins
ITN	Insecticide-treated net
AI	Artificial Intelligence
HLC	Human landing catch

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Author contributions

TC: Conceptualisation; funding acquisition; resources; project administration; supervision; writing—review and editing. RN: conceptualisation; methodology; visualisation; writing—original draft; Writing—review and editing. AA, JN, MS, MM: conceptualisation; methodology; visualisation; writing—original draft; Writing—review and editing. AP, CS, SN: conceptualisation; methodology; investigation; validation; writing—review and editing.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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