RBM Partnership To End Malaria

Vector Control Working Group

Theme: Vector Control at a Crossroads
Innovating for Impact In a Resource-Constrained Era

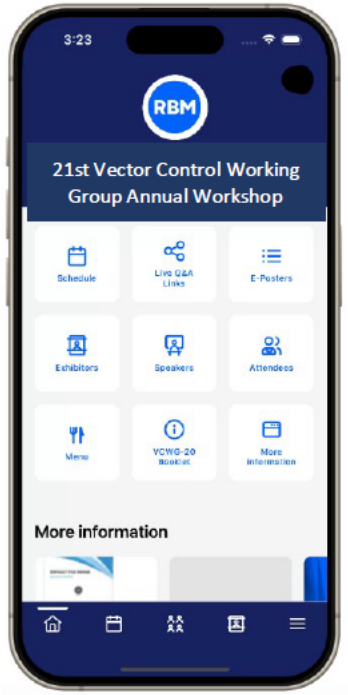
Welcome to the 21st Annual Workshop

4th March 2026, Nairobi, Kenya

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- E-Poster list
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- List of Participants
- Useful information

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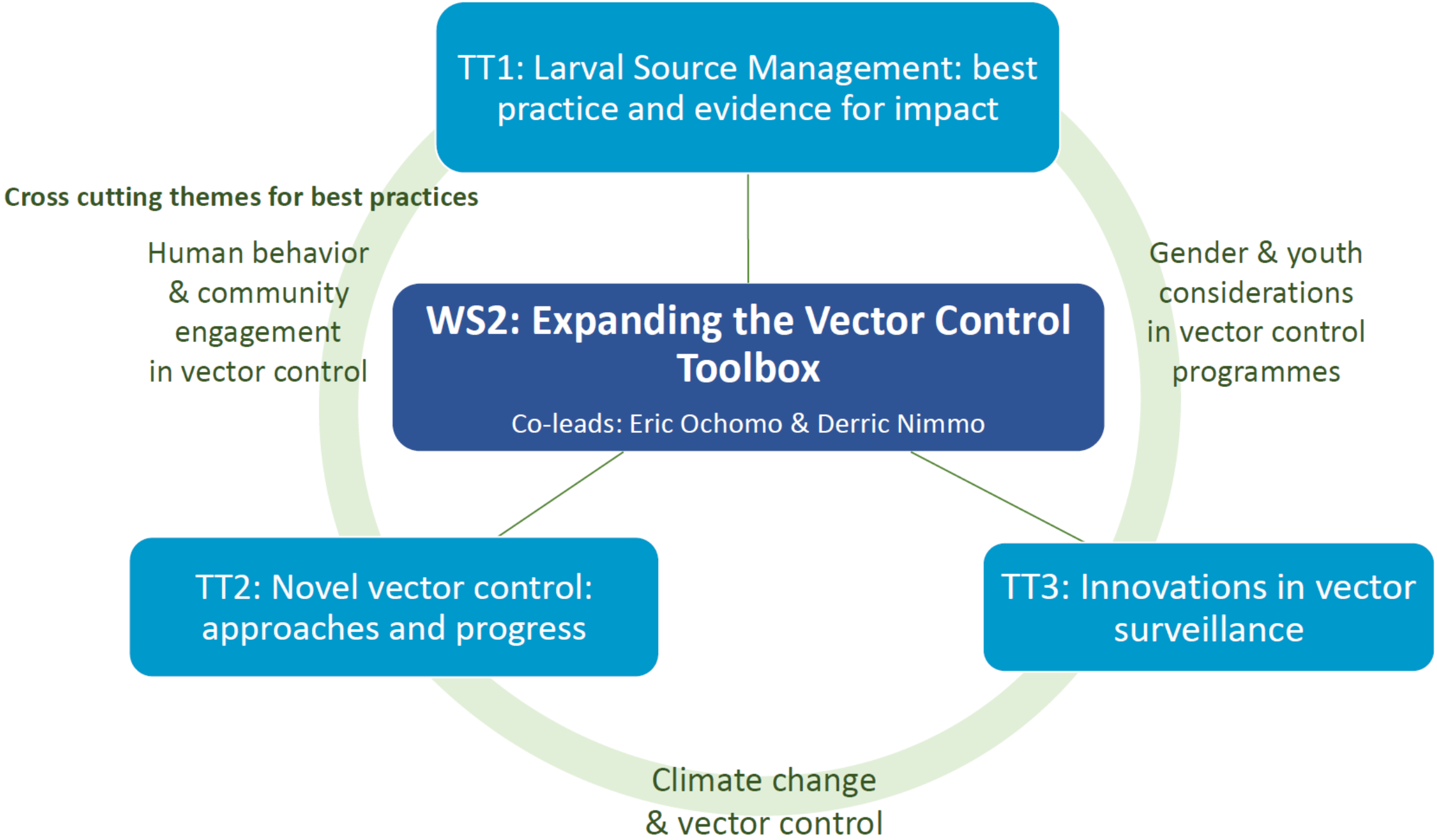
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Work Steam 2 – Expanding the Vector Control Toolbox

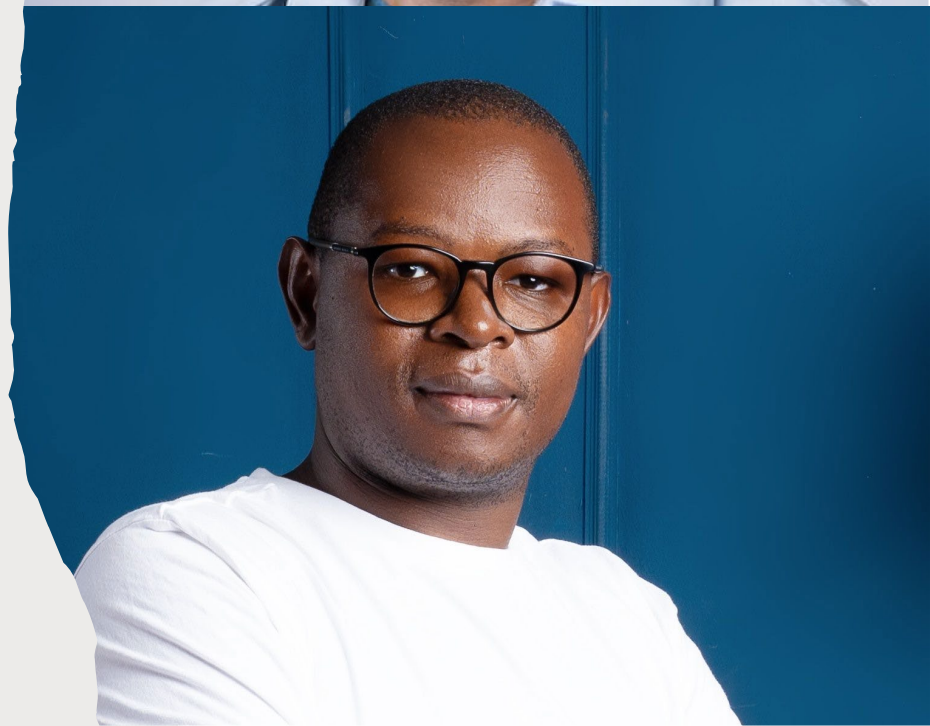
Co-Leads: Derric Nimmo & Eric Ochomo


TT1: Larval Source Management: best practice and evidence for impact
Cross cutting themes for best practices
Human behavior & community engagement in vector control
Gender & youth considerations in vector control programmes
WS2: Expanding the Vector Control Toolbox
Co-leads: Eric Ochomo & Derric Nimmo
TT2: Novel vector control: approaches and progress
TT3: Innovations in vector surveillance
Climate change & vector control

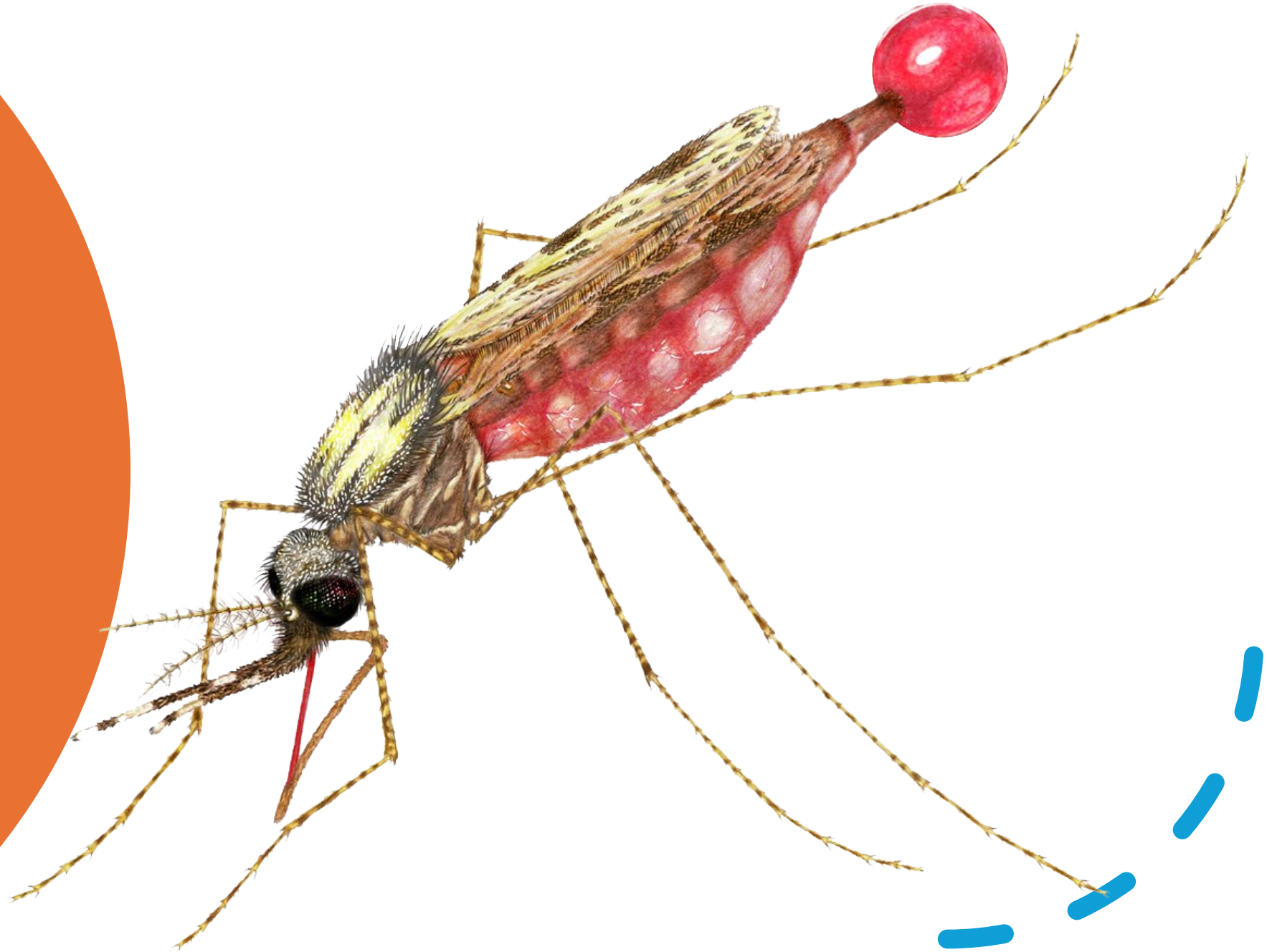
Expanding the vector control toolbox

- **Primary Aim:** To provide a robust platform to convene meetings and workshops highlighting the innovations, evaluation, scale-up, and impact of novel vector control approaches and advances in surveillance technology beyond core interventions
- **Theme for 2026:** “How innovation across LSM, biological/genetic tools, and surveillance can expand the vector control toolbox in resource-constrained settings”.
- **The Big Picture:** Exploring how the tools across our three Task Teams complement each other to overcome shared bottlenecks like data, capacity and funding.





Thank You



Task Team 1 - Larval Source Management (LSM)



- **TT1 Leads:** Edward Thomsen & Elijah Juma
  - Goal for This Year: Produce a landscape analysis to consolidate existing knowledge and gaps pertaining to LSM implementation, identifying countries currently implementing LSM, challenges, successes, and highlighting drones/AI technology.
- **Agenda Highlights:**
  - Presentations on large-scale larviciding operations and the revised WHO Operational Manual on LSM.
  - A panel discussion on emerging themes in LSM: tech-enabled larviciding, community engagement, and innovative financing.



Task Team 2 - Novel Vector Control: Approaches and Progress

- **TT2 Leads:** Tullu Bukhari, Samantha O'Loughlin, Rinki Deb
    - Goal for This Year: Share an inventory of new tools and approaches (including repellents, endectocides, ATSBs, SIT, and genetic control) to serve as a database for the community.
- **Agenda Highlights:**
    - Modelling the impact of gene drive releases and exploring Microsporidia MB-based transmission-blocking strategies.
    - Lightning talks on Wolbachia and African-led innovations from Transmission Zero.
    - A panel on the practical challenges in the development and implementation of genetic and biological tools in Africa.







Task Team 3 - Innovations in Vector Surveillance



- **TT3 Leads:** Yang Hu & Evelyn Olanga
  - Goal for This Year: Sharing a comprehensive inventory of novel vector surveillance tools and approaches.
- **Agenda Highlights:**
  - Presentations on the Malaria Vector Genome Observatory and the Entomology for Impact Initiative.
  - Lightning talks on operationalising eDNA detection and using Mid-Infrared Spectroscopy with AI for cost-effective surveillance.
  - A panel focusing on maintaining the quality of entomological surveillance in a resource-constrained environment.



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4 March 2026

Task Team 1: Larval source management

Introduction

Edward Thomsen & Eliah Juma (TT1 co-leads)

Task Team 1 - Larval Source Management (LSM)

- **TT1 Leads:** Edward Thomsen & Elijah Juma
  - Goal for This Year: Produce a landscape analysis to consolidate existing knowledge and gaps pertaining to LSM implementation, identifying countries currently implementing LSM, challenges, successes, and highlighting drones/AI technology. Survey still open
- **Agenda**
  - Presentations on, larviciding evaluation framework, large-scale larviciding operations, OMM and the revised WHO Operational Manual on LSM.
  - A panel discussion on emerging themes in LSM: tech-enabled larviciding, the place of WHO policies, innovative/sustainable financing
- **Outputs**
  - Report on best practices related to:
    - Technology in LSM
    - Sustainability in LSM
  - Priorities for 2026 (webinar topic/community of practice)

Landscape survey





2026 workplan priority survey

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4 March 2026

Presentation: Comprehensive Larviciding Evaluation and Assessment Framework

Edward Thomsen, Malaria Elimination Initiative, UCSF



The University of California, San Francisco

Malaria Elimination Initiative (MEI)

CLEAR
The Comprehensive Larviciding Evaluation and Assessment Framework

RBM VCWG

04 March 2026

UCSF Institute for Global Health Sciences

Context

DEMAND

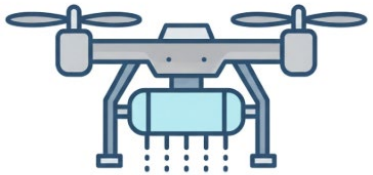
Gaps in protection

Political will

Tech innovations

Historical precedent



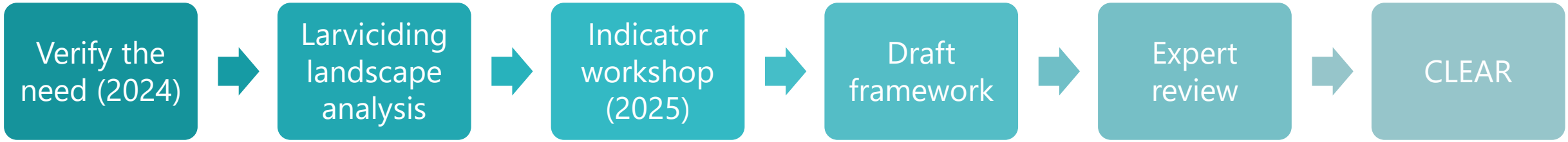




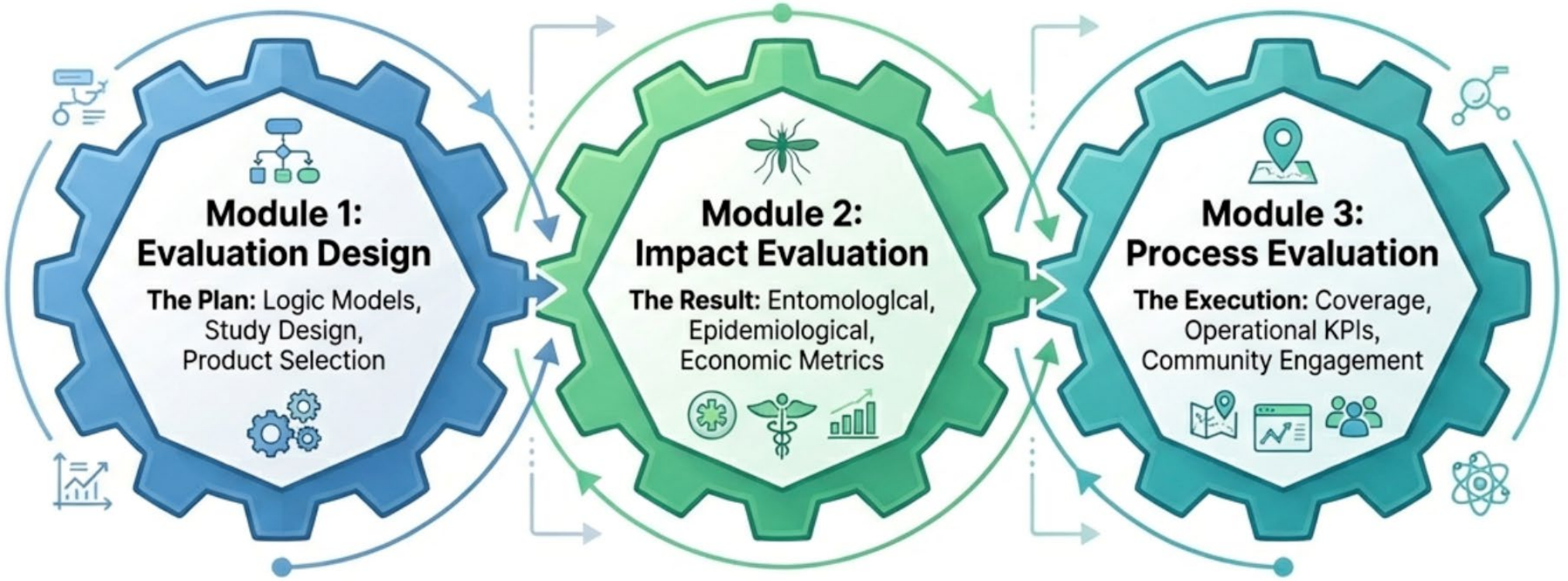
The Barrier: Donors favor ITNs/IRS due to historical evidence gaps. Programs struggle to demonstrate context-specific effectiveness

The CLEAR solution: A structured framework to generate robust effectiveness and cost-effectiveness data donors need to unlock investment.

Approach


Verify the need (2024)
Larviciding landscape analysis
Indicator workshop (2025)
Draft framework
Expert review
CLEAR

CLEAR – **C**omprehensive **L**arviciding **E**valuation and **A**ssessment F**r**amework



Target Audience: National Malaria Programs (NMPs), researchers, and implementation partners

Module 1: Evaluation Design

Logic model



- Baseline data
- Staff
- Larvicides
- Equipment
- Maps

- Larviciding application
- Community engagement

- Implementation quality
- Coverage
- Treatment frequency

- Reduced larval density →
- Reduced adult density →
- Reduced exposure

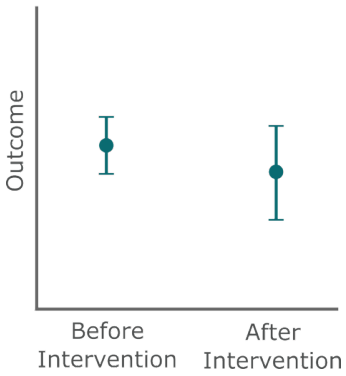
- Reduced malaria incidence and prevalence

Module 1: Evaluation Design

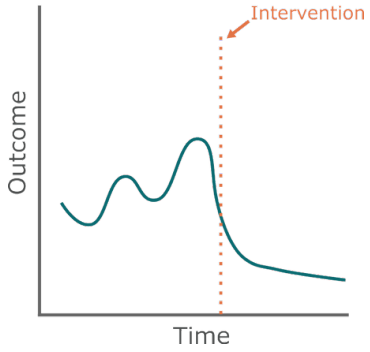
Quasi-experimental designs

Cluster randomized trials infeasible for NMPs – need for practical and rigorous alternatives

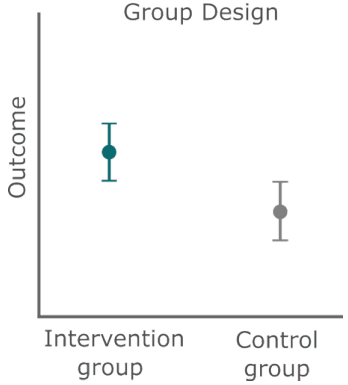
Before / After Study



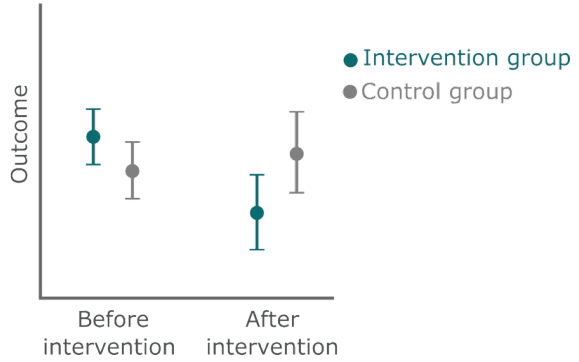
Interrupted Time Series (ITS)



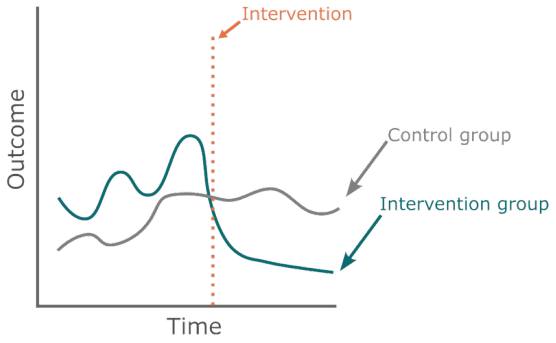
Non-equivalent Control Group Design



Controlled Before / After using Difference-in-difference (DiD) analysis



Controlled Interrupted Time Series (CITS)



Module 1: Evaluation Design

Product selection

Active ingredients

Microbials (Bti/Bs)

Safe, fast-acting (24-48h).

Insect Growth Regulators (IGRs)

Prevent emergence (Pyriproxyfen). Longer residual.

Films

Suffocate larvae. Good for resistance management.

Formulations

A



Granules

Use for habitats with emergent vegetation (penetrates to surface).

B



Films/Liquids

Use for clean, open water.

C



Briquettes

Use for permanent water (wells). Long residual reduces re-application needs.

Product choice influences the process indicators used

Module 2: Impact Evaluation

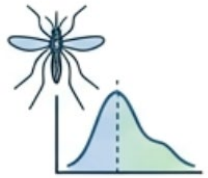
Entomological impact

Key metrics

1. Adult mosquito density: primary indicator
   a) Species-specific

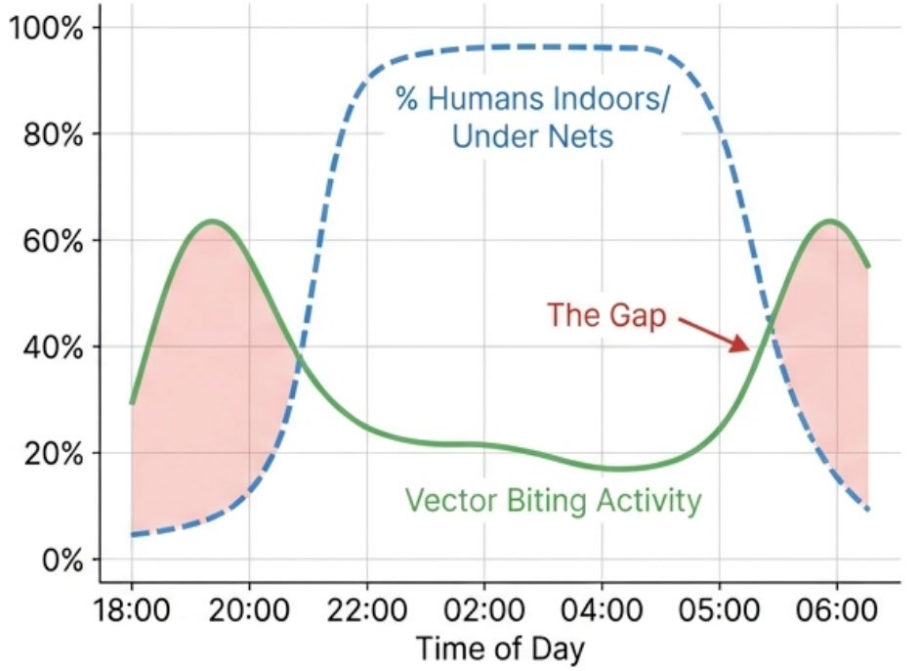


   b) Biting behavior



   c) Adjusted for human behavior (human behavior observations)

Gaps in protection



EIR is supplemental

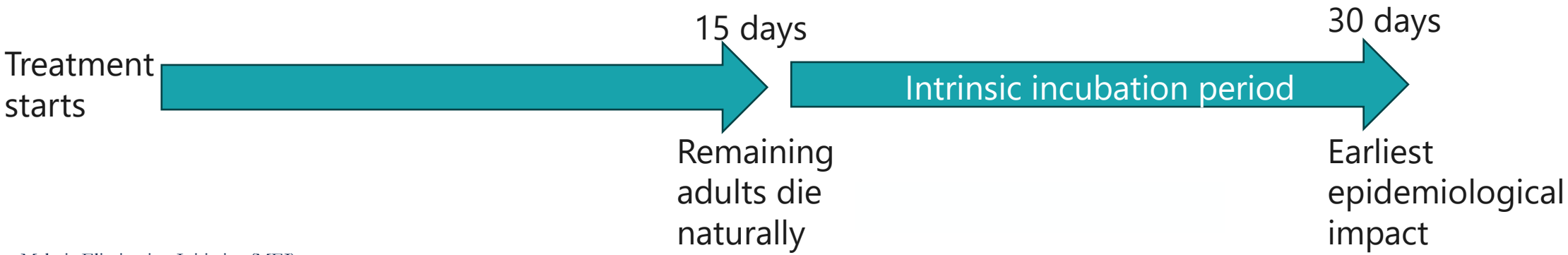
Module 2: Impact Evaluation

Epidemiological impact

Key metrics – Incidence vs prevalence

Indicator	Source	Pros	Cons
Incidence (cases/pop/time)	Routine HMIS data	Fast signal, compatible with cost-effectiveness analysis	Dependent on data quality
Prevalence (% infected at a given time)	Cross-Sectional Surveys	Can capture asymptomatic burden	Slow, expensive (extra activity)

Lag to impact



Module 2: Impact Evaluation

Cost-effectiveness

Key metric

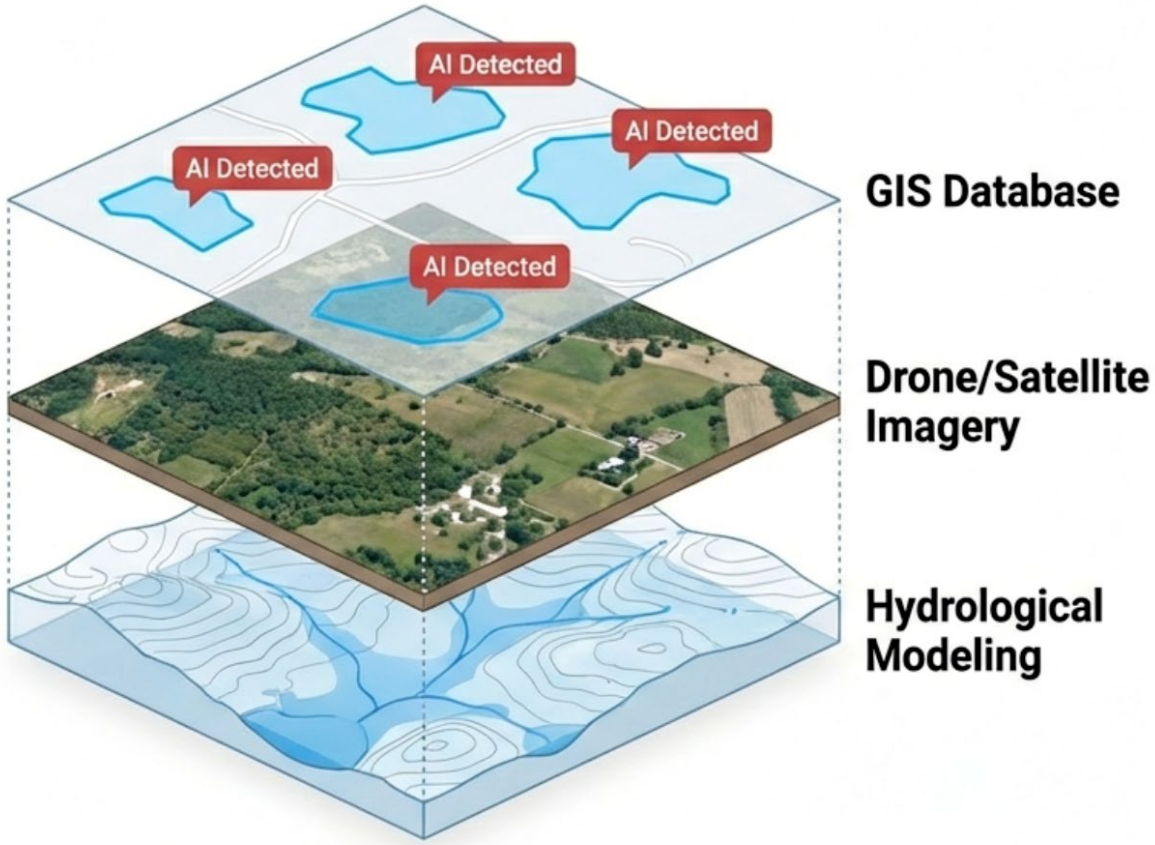
Incremental cost-effectiveness ratio

$$\text{ICER} = \frac{\text{Cost of larviciding}}{\text{Additional cases averted}}$$

Caution: use of cost per person protected can overinflate benefits if the intervention is poorly implemented

Module 3: Process Evaluation

You cannot treat what you cannot find



The Challenge:

- Moving beyond "Few, Fixed, and Findable" to handle cryptic habitats.

The Tech Stack:

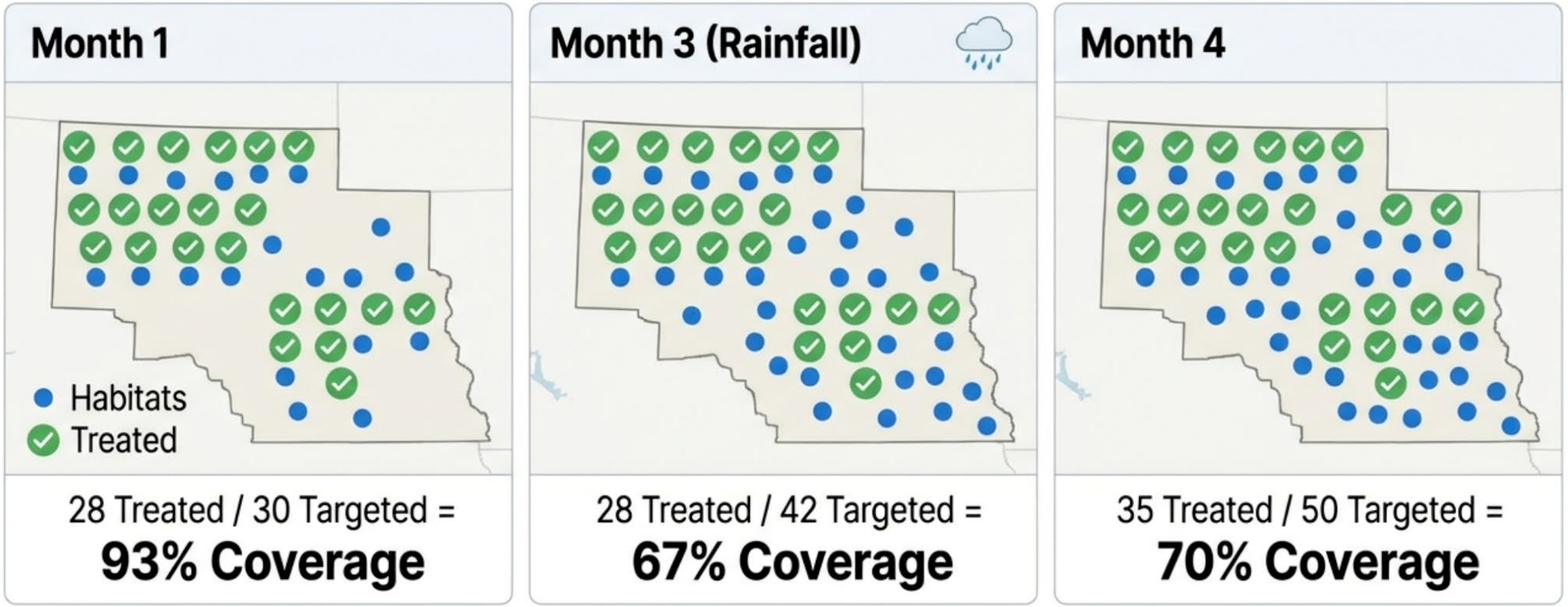
Drones/UAS for high-res imagery.

AI Detection for water body identification.

GPS Apps for field validation.

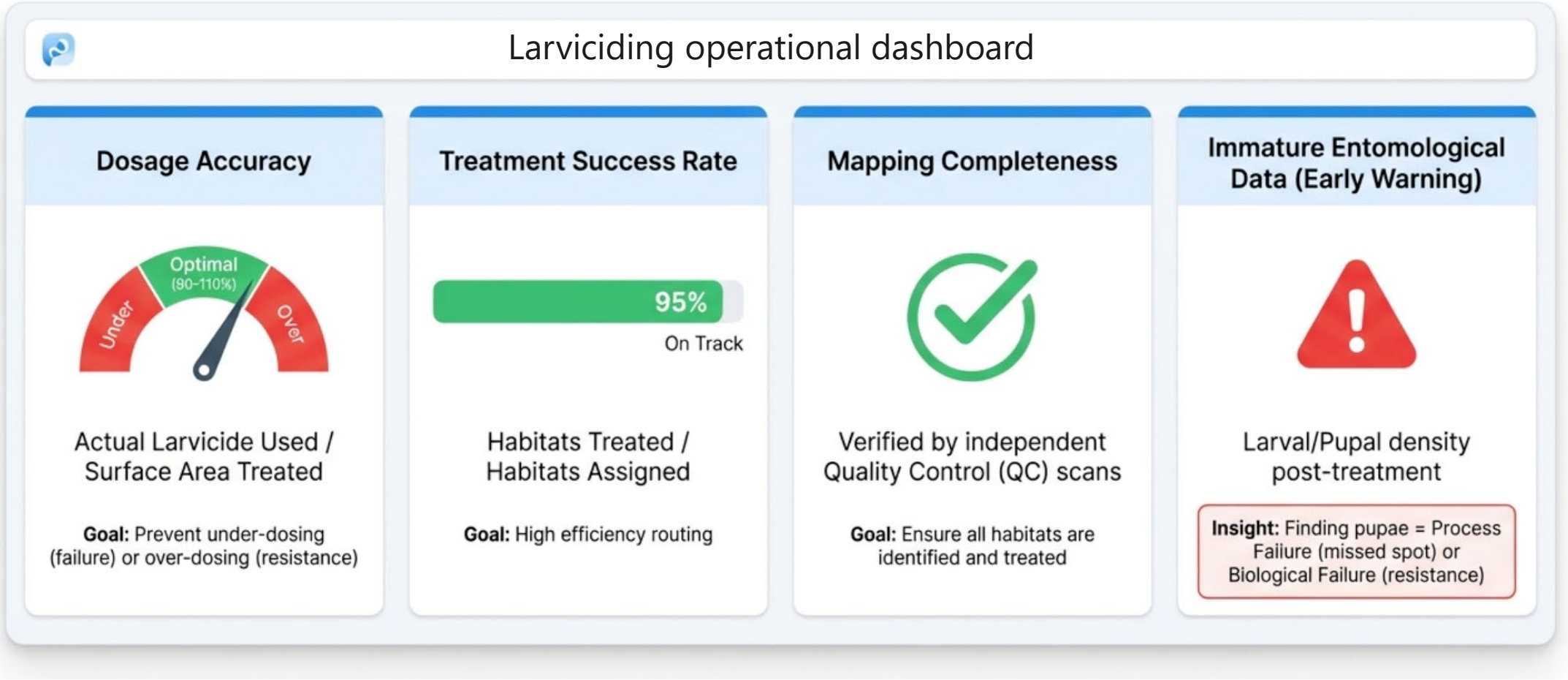
Module 3: Process Evaluation

Dynamic nature of coverage



Module 3: Process Evaluation

Use operational data to guide implementation



Module 3: Community engagement



Summary of key indicators

Category	Indicator	Metric
Impact - Entomological	Adult biting rate	Bites per person per night/hour
Impact - Entomological	Adjusted biting rate	Bites adjusted for human behavior
Impact - Epidemiological	Incidence	Cases per 1000 population per year
Impact - Epidemiological	Incremental cost effectiveness ratio	Cost per case averted
Process – Operational performance	Coverage	% of targeted habitats/surface area treated
Process – Operational performance	Dose accuracy	Actual vs target dose
Process – Operational performance	Treatment success rate	% of assigned habitats treated
Process – Quality control	Larval/pupal density/emergence inhibition	Larvae/pupae per dip or % pupae that fail to emerge
Process – Quality control	Mapping completeness	% of actual habitats that are mapped
Process – Community engagement	varies	

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Outdoor mosquito management for sustainable mosquito control in Africa

Elijah Juma & Silas Majambere, Valent Biosciences LLC

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Outdoor mosquito management for sustainable mosquito control in Africa

Elijah Juma, Silas Majambere

RBM Meeting, Nairobi

March 3-5, 2026

The case for OMM in Africa

- Mosquito changing behavior: outdoor biting and resting
- Insecticide resistance to most indoor insecticides
- Invasive vectors (*An. stephensi, An. albopictus*): container breeding, urban, peri-urban and outdoor feeding
- Unplanned settlements in peri-urban areas will increase mosquito population and disease risk



The case for OMM | Africa

- Frequent dengue & sporadic yellow fever, chikungunya outbreaks, especially in east & west Africa
- Climate change and natural disasters will continue to exacerbate arbovirus problem
- Humanitarian situations (refugee camps and internally displaced persons) increasingly expose populations to threat of mosquito-borne diseases



Outdoor mosquito management strategies

OMM Strategies| LSM

- Tackle mosquitoes at source:
  - Concentrated
  - Immobile
  - Accessible
- Is a more cost-effective and sustainable mosquito strategy



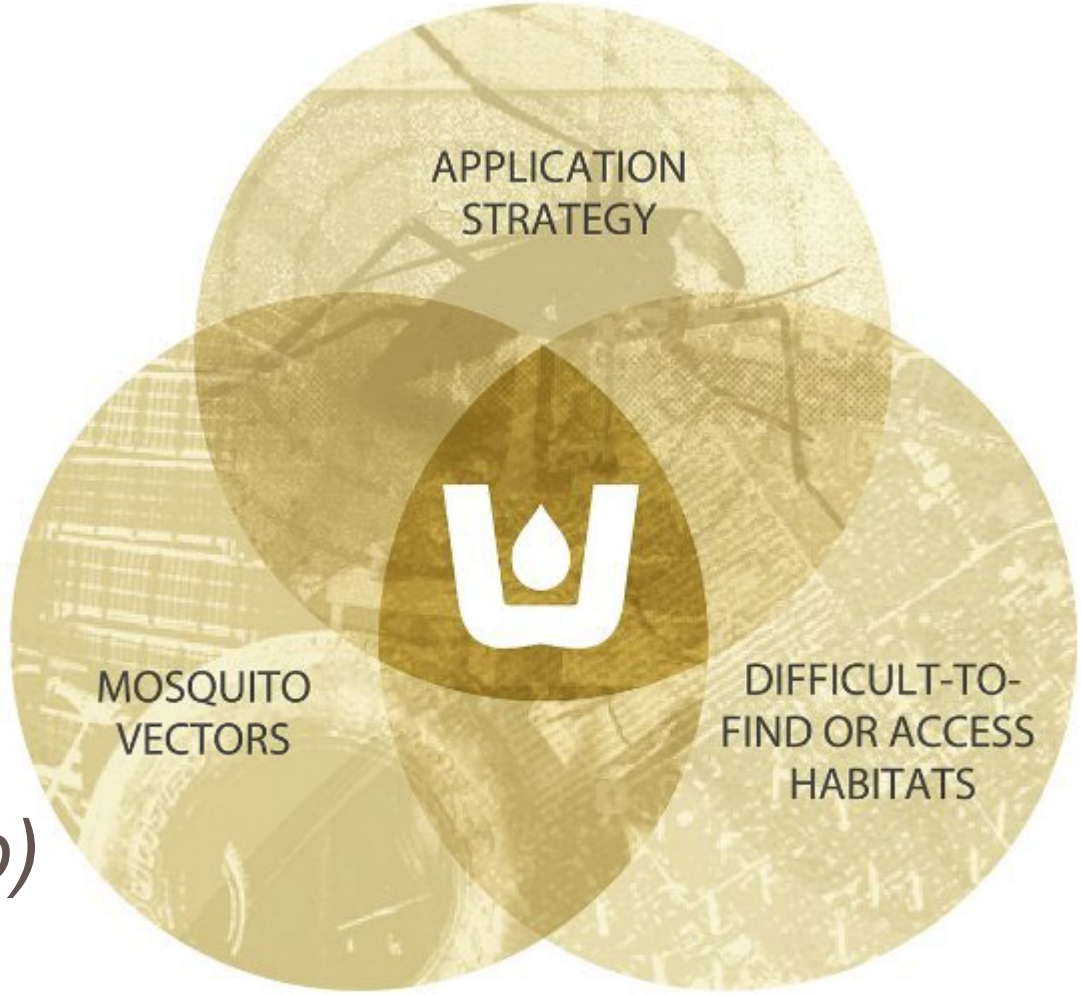
OMM strategies| LSM

- Larvicide application technologies have greatly advanced
  - Mapping
  - Application
  - Monitoring implementation
  - Evaluating impact
- Wider area coverage, accessibility, operational efficiency



OMM strategies| WALS

- WALS technology is designed for:
  - Container-dwelling mosquitoes
  - Generates droplet sizes in the EF/VF/F droplet sizes
  - Small cryptic habitats
- Wide geographic coverage
- Ideal for targeting urban vectors (*An. stephensi, Aedes sp, Culex sp)*



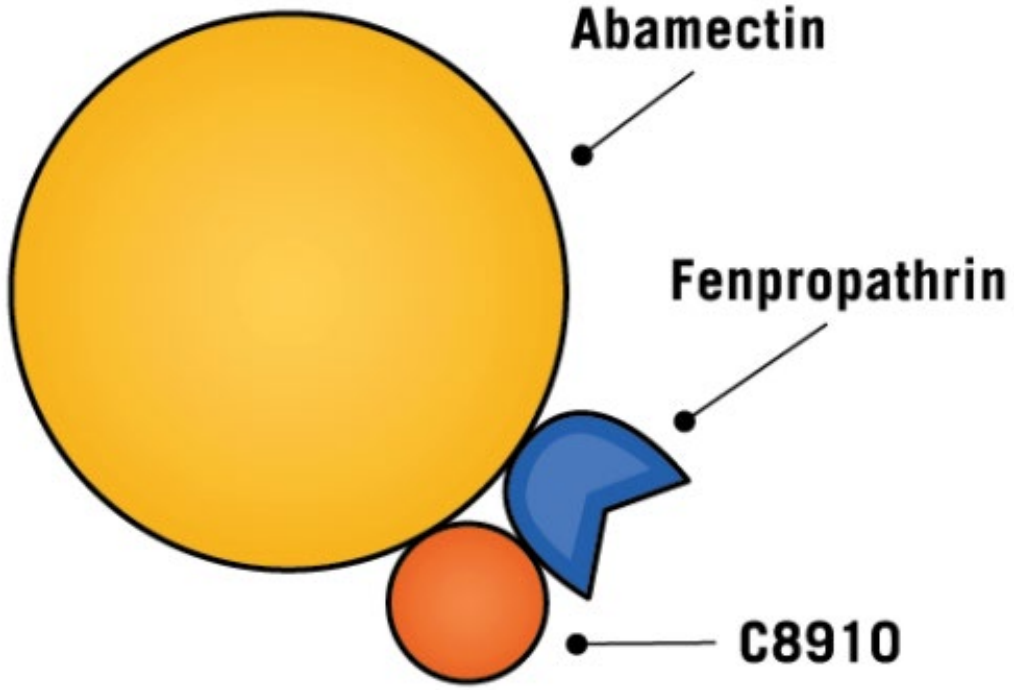
OMM strategies| Aerial treatment

- Drones are becoming more accessible in Africa
- Could cover large blocks of land with fewer man-power, shorter time, cost effectively
- NB: In public health for mosquito control penetration still low



OMM strategies| Adulticiding

- OMM is not limited to aquatic mosquito stages
- New adulticide space sprays with new AIs other than pyrethroids are entering the market
- Target both malaria and arbovirus vectors, addressing epidemics



Advancing OMM solutions in Africa and making it sustainable

Community-based OMM

- Integrate OMM programs into communities and cultural practices
- Co-design OMM solutions with the community
- Mobile technology and citizen science
- Leverage growing middle-class in urban settings



Photo by Atiko Aikins on Unsplash

Multisectoral partnership

- Agriculture: the biggest contributor to mosquito aquatic habitats.
- Land management
- Mining
- Public works



Funding and sustainability

With proper education and responsive tax regimes, funding from:

- Agriculture
- Mining
- Tourism/hospitality industry
- Property taxes



Image by Towfiqu barbhuiya on Unsplash



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Thank You!

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Presentation: Large-scale larviciding in Tanzania

Tegemeo Gavana, Ifakara Health Institute
Denis Kailembo, Swiss TPH

United Republic of Tanzania

Ministry of Health

Entomological and Epidemiological results of a large-scale community-based biolarviciding intervention in Tanga Region, Tanzania

Tegemeo Gavana – IHI

Denis R. Kailembo – Swiss TPH

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Embassy of Switzerland in Tanzania
Ubalozi wa Uswisi Tanzania

National Malaria Control Program

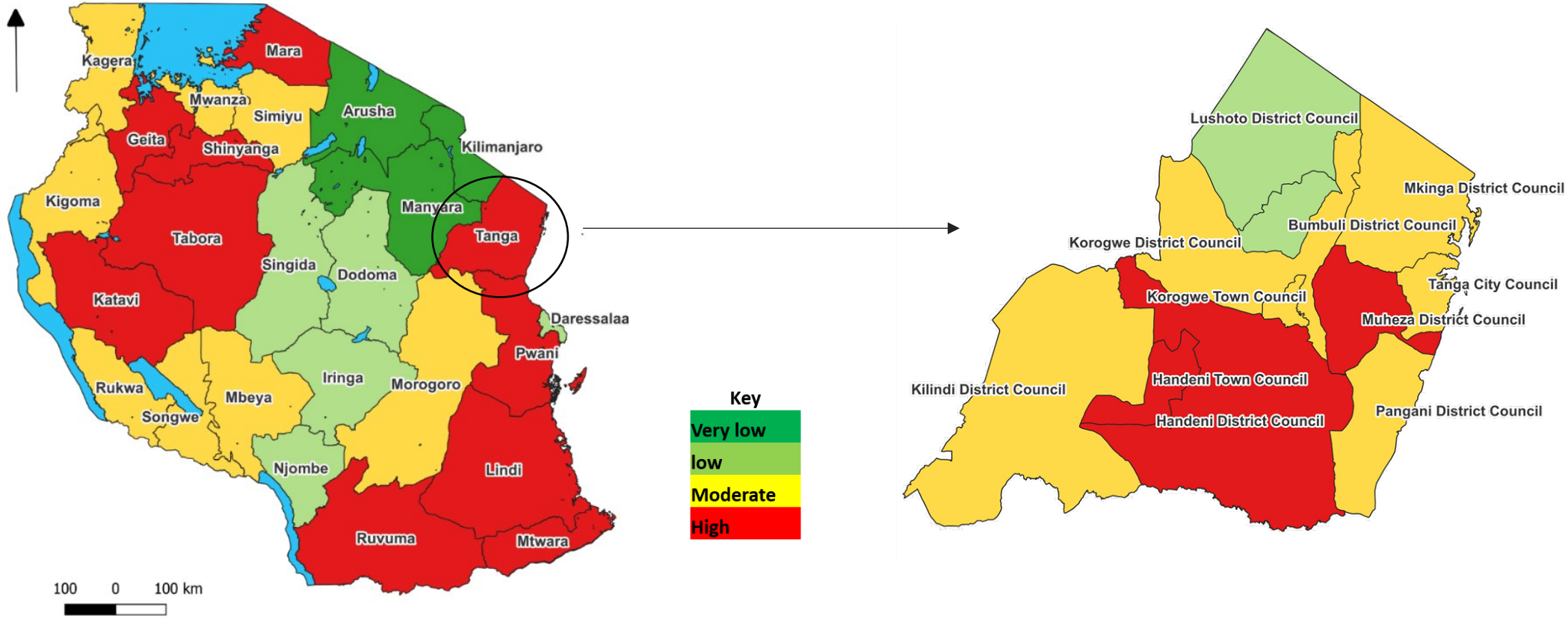
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Swiss TPH

Contents

1. Background – malaria in Tanzania and Tanga Region
2. Set-up of the larviciding intervention
3. Methodology: Entomological and Epidemiological evaluation
4. Findings: Entomological and Epidemiological evaluation
5. Discussions and conclusions

Background – Malaria risk stratification (1/1)

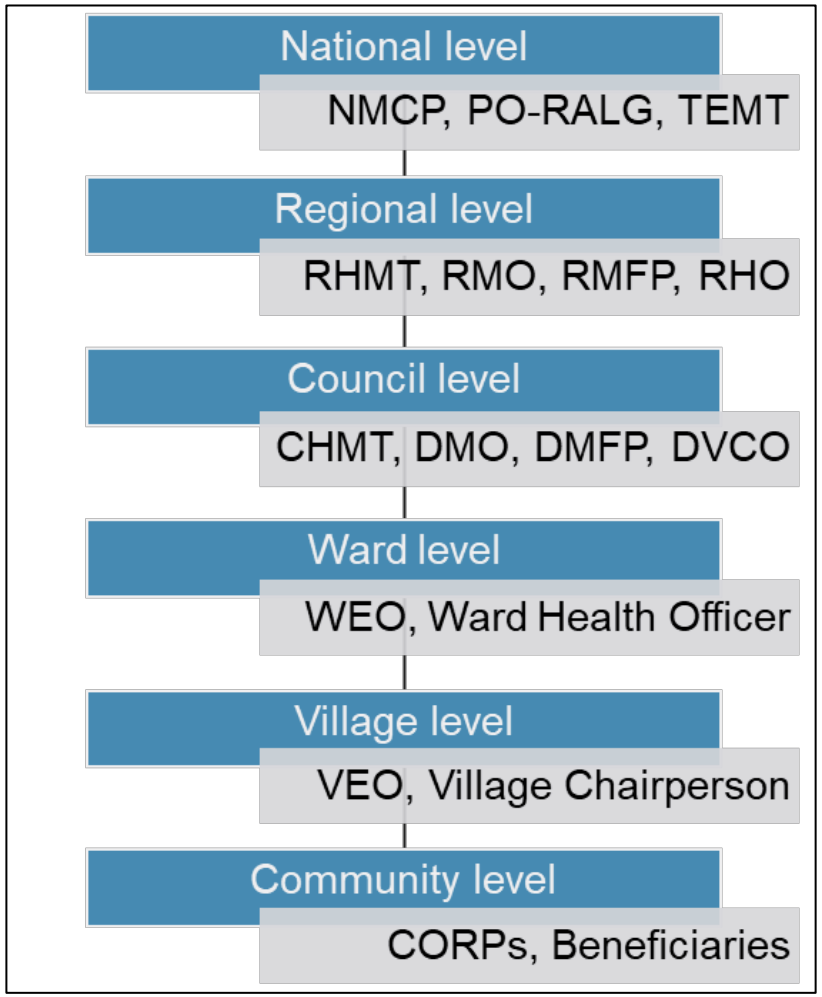


Malaria risk stratification (2023):
Tanga Region: high malaria risk; with high heterogeneity among its councils

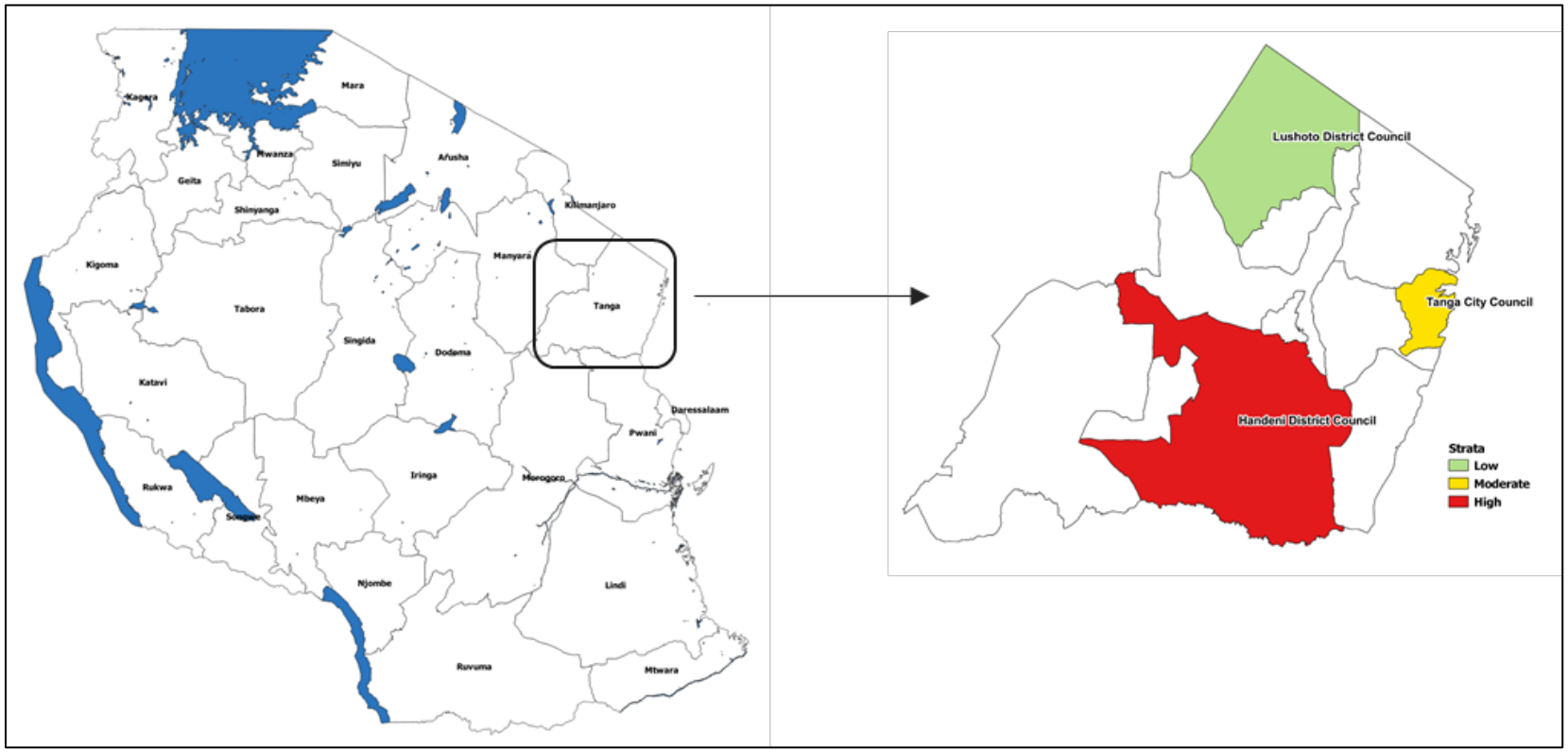
Source – National Malaria Strategic Plan – Mid-Term Review - 2023

Set-up of the larviciding intervention (1/2)

Organizational structure



Selection of councils



Set-up of the larviciding intervention (2/2)

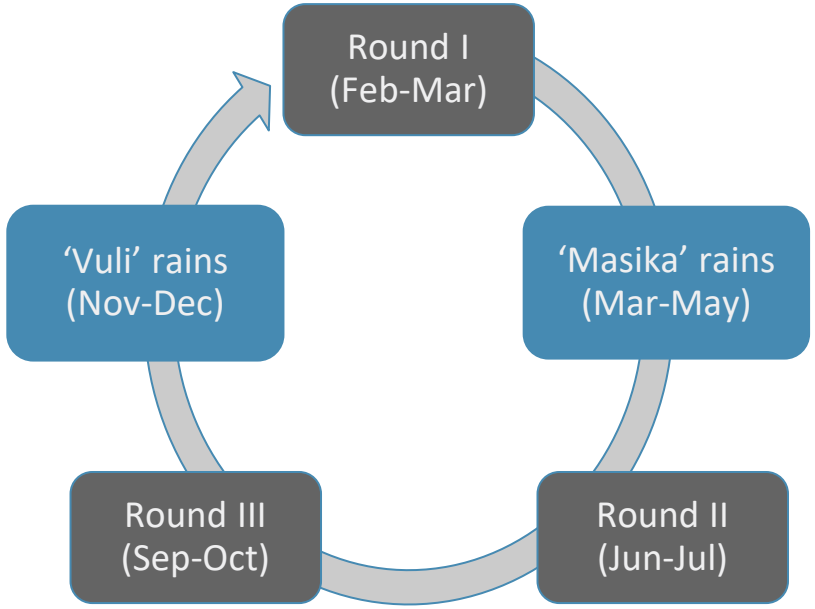
Types of biolarvicide

- Produced in-country (TBPL)
- Used both *Bti* and *Bs*
- Larvae mortality at 24-48 hours:
  - Bti: > 91%; Bs: > 96%
- Highly selective (only mosquito larvae)
- Safe to humans, animals and the environment





Frequency of application



One Round = comprised 8 weeks of application

One year = 3 Rounds / 24 weeks of application (out of 52)

Implementation was conducted for 2 years (6 rounds), from June 2022 to April 2024

United Republic of Tanzania
Ministry of Health

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Embassy of Switzerland in Tanzania
Ubalozi wa Uswisi Tanzania

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Methodology: Entomological evaluation (1/2)

Study setting

High strata	Moderate strata	Low strata
Intervention councils		
Handeni DC	Tanga CC	Bumbuli DC
Control councils		
Muheza DC	Pangani DC	Bumbuli DC

Study design

- Longitudinal (weekly) collection of larvae and adult mosquitoes

Larval collections

- In 20 villages per council
- 6 larval habitats per village = 120 per council
  - 4/6 were sentinel habitats
  - 2/6 were randomly searched every week

Adult mosquito collections

- 16/20 villages and 1 house per village
- 1 CDC-LT per village
- Weekly throughout the project timeline

Data analysis

- Negative binomial regression

Methodology: Epidemiological evaluation (2/2)

Study setting

High strata	Moderate strata	Low strata
Intervention councils		
Handeni DC	Tanga CC	Bumbuli DC
Control councils		
Muheza DC *	Pangani DC *	Bumbuli DC *
Handeni TC	Kilindi DC	Bagamoyo DC
Kibiti DC	Korogwe DC	Kibaha TC
Kisarawe DC	Korogwe TC	Kiteto DC
Mkuranga DC	Mkinga DC	
	Chalinze DC	
	Rufiji DC	

Study design

- Controlled Before-After (CBA)

Epidemiological indicators

1. Malaria incidence
2. Fever TPR
3. ANC-PR

(monthly collection derived from DHIS2)

Data analysis

- Negative binomial and logistic regressions

Findings: Entomological results (1/3)

Larvae species	Larval stage	High risk Handeni DC vs Muheza DC		Moderate risk Tanga CC vs Pangani DC		Low risk Lushoto DC vs Bumbuli DC	
		IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Anopheline	Early	0.38 (0.22; 0.64)	<0.001	0.94 (0.46; 1.89)	0.845	0.78 (0.50; 1.21)	0.277
	Late	0.20 (0.12; 0.35)	<0.001	0.51 (0.26; 1.01)	0.041	0.40 (0.24; 0.68)	<0.001
Culicine	Early	0.70 (0.40; 1.22)	0.194	0.61 (0.34; 1.09)	0.085	1.14 (0.83; 1.58)	0.433
	Late	0.49 (0.28; 0.84)	0.008	0.31 0.17; 0.54	<0.001	0.86 (0.61; 1.22)	0.392

Findings: Entomological results (2/3)

Mosquito species	High risk Handeni DC vs Muheza DC		Moderate risk Tanga CC vs Pangani DC		Low risk Lushoto DC vs Bumbuli DC	
	IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
An. gambiae s.l.	0.94 (0.37; 2.43)	0.901	0.09 (0.02; 0.32)	<0.001	0.29 (0.10; 0.78)	0.020
An. funestus s.l.	1.96 (0.29; 11.20)	0.439	1.05 (0.32; 3.47)	0.932	8.82 (0.81; 95.77)	0.074
Culex species	1.343 0.762; 2.377	0.307	0.80 (0.76; 0.85)	<0.001	0.54 (0.34; 0.86)	0.010

Findings: Epidemiological results (3/3)

1:n regression results	High strata: Handeni DC vs control councils		Moderate strata: Tanga CC vs control councils		Low strata: Lushoto DC vs control councils	
	IRR (95% CI)	p-value	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Incidence						
All ages	1.16 (0.98; 1.37)	0.079	0.86 (0.72; 1.02)	0.081	0.96 (0.76; 1.22)	0.738
Under-fives	1.12 (0.94; 1.34)	0.190	0.88 (0.74; 1.04)	0.133	0.85 (0.64; 1.14)	0.271
Above 5 years	1.20 (1.01; 1.42)	0.039	0.84 (0.70; 1.02)	0.078	0.97 (0.76; 1.25)	0.839
Fever-TPR	0.93 (0.83; 1.05)	0.231	0.98 (0.83; 1.16)	0.822	1.07 (0.70; 1.62)	0.739
ANC-PR	1.03 (0.90; 1.16)	0.700	0.59 (0.36; 0.94)	0.033	1.07 (0.42; 2.53)	0.887

Discussions and Conclusions (1/3)

Key findings – Entomological evaluation

1. Most breeding habitats were man-made
2. Intervention was associated with declines of late-stage larvae densities – all strata
3. Decline of adult mosquitoes varied by strata and mosquito species
4. Rebound of both larvae and adult mosquito densities after each round

Key findings – Epidemiological evaluation

1. High risk stratum – no association between larviciding and malaria epidemiological parameters
2. Moderate and Low strata – the association mostly tended to be in the direction of a reduction, but was not statistically significant

Discussions and Conclusions (2/3)

Additional findings from other aspects of the evaluation

- Biolarvicide efficacy
  - biolarvicides were efficacious against the vector species
- Operational evaluation
  - low detection rates of breeding habitats and mosquito larvae among CORPs
  - high treatment coverage of identified breeding habitats
- Community perception
  - the intervention was accepted by community members
- Costing assessment
  - cost pppy was less than 1 USD across all councils (average: 0.66 USD)
  - main cost drivers: procurement of biolarvicide, operational costs

Discussions and Conclusions (3/3)

Recommendations

- The use of CORPs and existing local government structures increases ownership and ensures successful implementation
- Complement larviciding with environmental management through multi-sectoral collaboration – to reduce larviciding cost and maximize impact
- Verify breeding habitats identified by CORPs with an expert team – to reduce risk of missed habitats
- Adopt a continuous year-round application - to avoid the rebound of larvae and adult mosquitoes
- Consider use of technological innovations where available, applicable, and feasible
- Ensure collection of adequate baseline data - to facilitate effectiveness of the assessment
- Increase the number of clusters and allocate intervention and control areas through randomization
- Deploy different financial strategies – to ensure sustainability of the intervention

Thank You! Asante Sana!

United Republic of Tanzania

Ministry of Health / PO-RALG

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Embassy of Switzerland in Tanzania
Ubalozi wa Uswisi Tanzania

Swiss TPH

National Malaria Control Program

TBPL
We destroy mosquito larva

National Institute for Medical Research

ISO 9001:2015 certified
IFAKARA HEALTH INSTITUTE
research | training | services

RBM Partnership
To End Malaria

4 March 2026

Presentation: Revised WHO Operational Manual on Larval Source Management (remote presentation)

Seth Irish, WHO MNT

Operational manual on larval source management

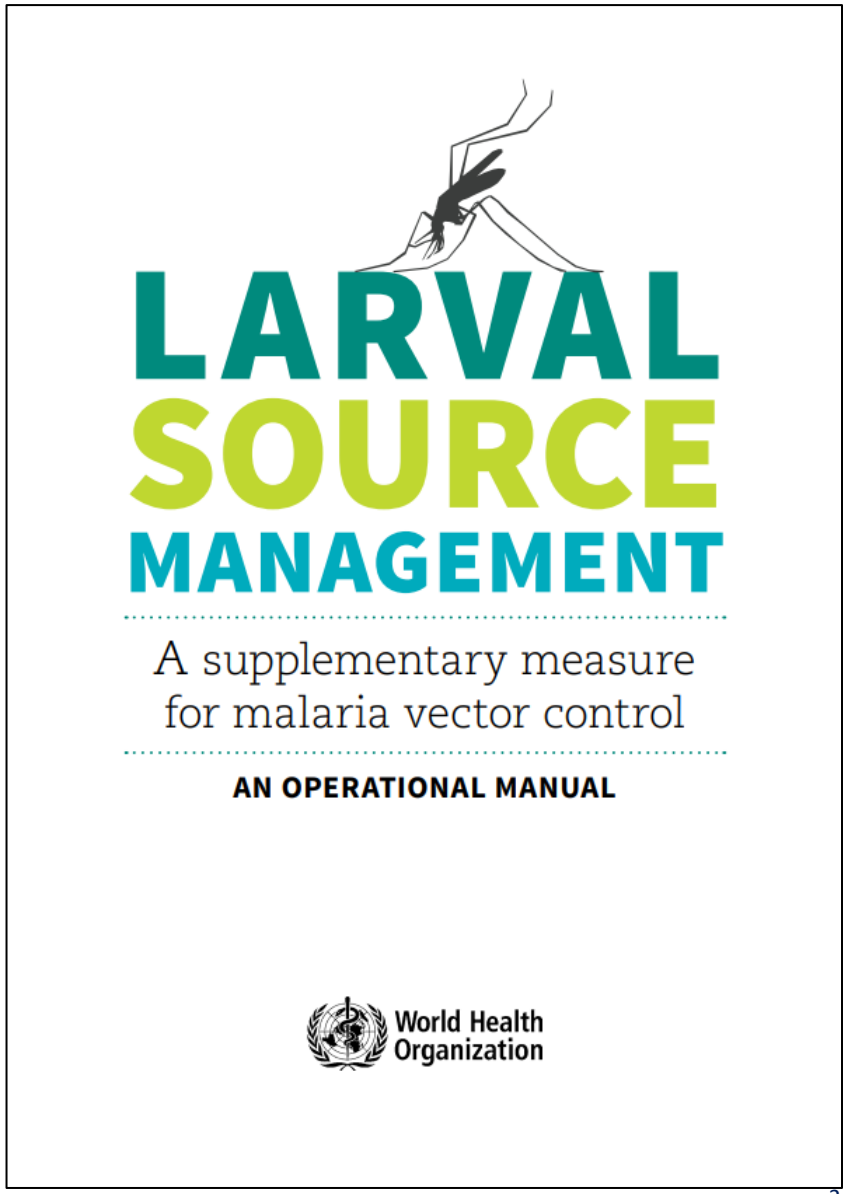
Control of *Anopheles* and *Aedes* mosquito vectors

Seth Irish

World Health Organization

Background

- Last operational manual was published in 2013
- Need for updates
  - Inclusion of guidance for *Aedes* larval source management
  - Technological updates (ie. drones, remote sensing)

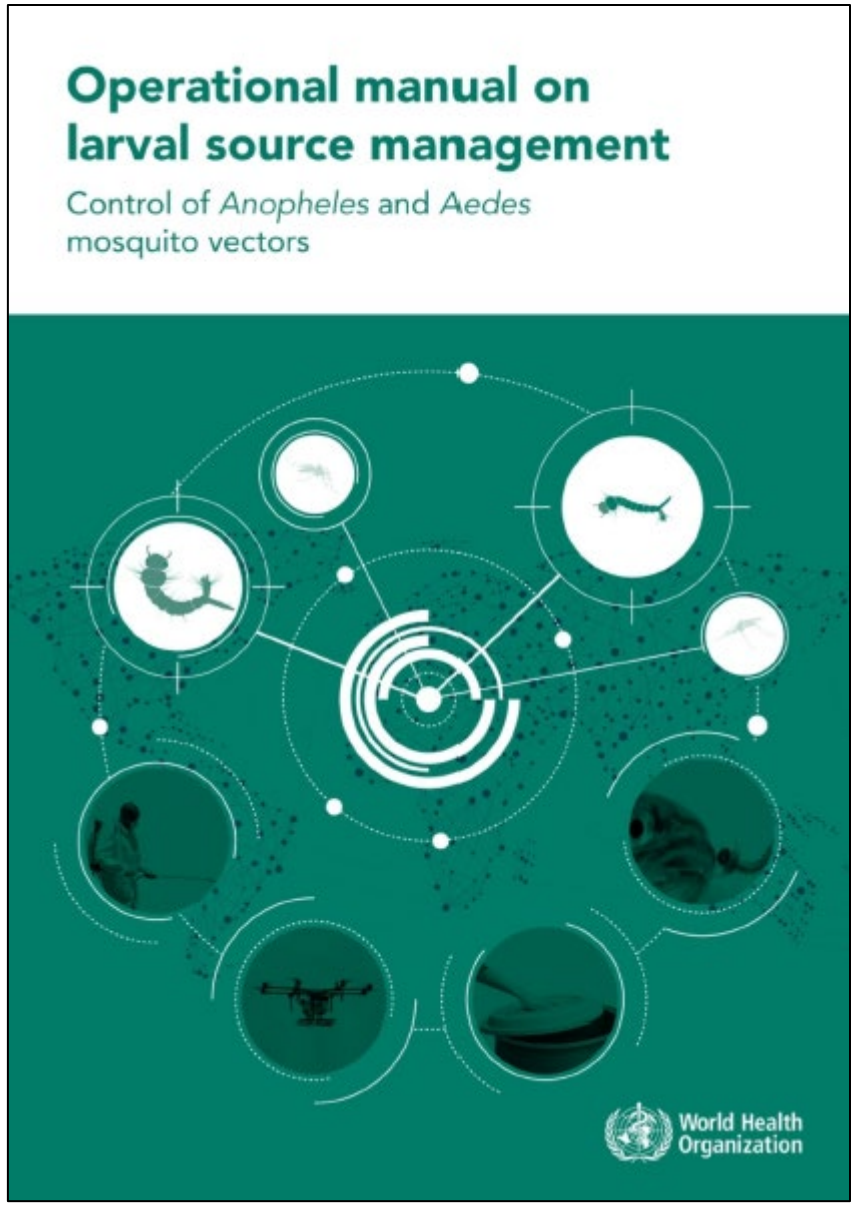


World Health Organization

Structure

- **Chapter 1**: Concepts of LSM
- **Chapter 2**: Requirements for establishing and managing an LSM programme
- **Chapter 3**: Planning for LSM
- **Chapter 4**: Operational methods of conducting LSM
- **Chapter 5**: Monitoring and evaluation for LSM

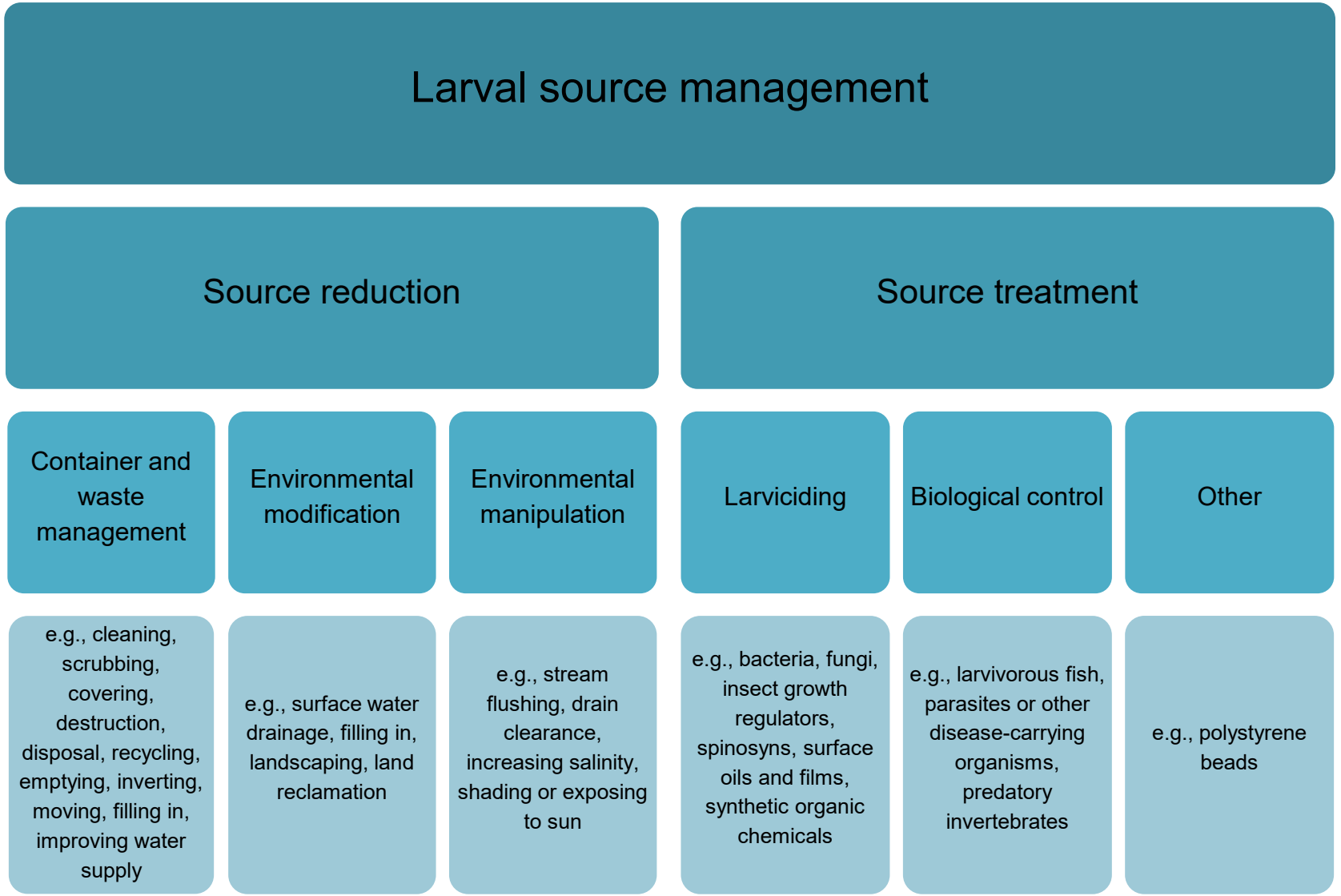
- **Annexes**
  - Country case studies
  - Generic forms
  - Additional tools



World Health Organization

Types of LSM

- Habitat modification
- Habitat manipulation
- Larviciding
- Biological control
- Container and waste management



World Health Organization

Approaches

- National disease control programme
- Community efforts
- Urban or private vector control schemes
- LSM as part of infrastructure/construction projects, agricultural practices, etc.

Key components of implementation

- Strong leadership and political will
- Good management and resourcing
- Trained and skilled personnel
- Robust baseline information and surveillance systems
- Community acceptance, support and participation
- Collaboration between sectors
- Considering all mosquito species



https://prd.wb.gov.in/schemes/detail/91b05b53-20e4-455c-9481-1e039bd897a9

World Health Organization

Programme structure

Fig. 2. Simplified LSM programme structure for an urban area

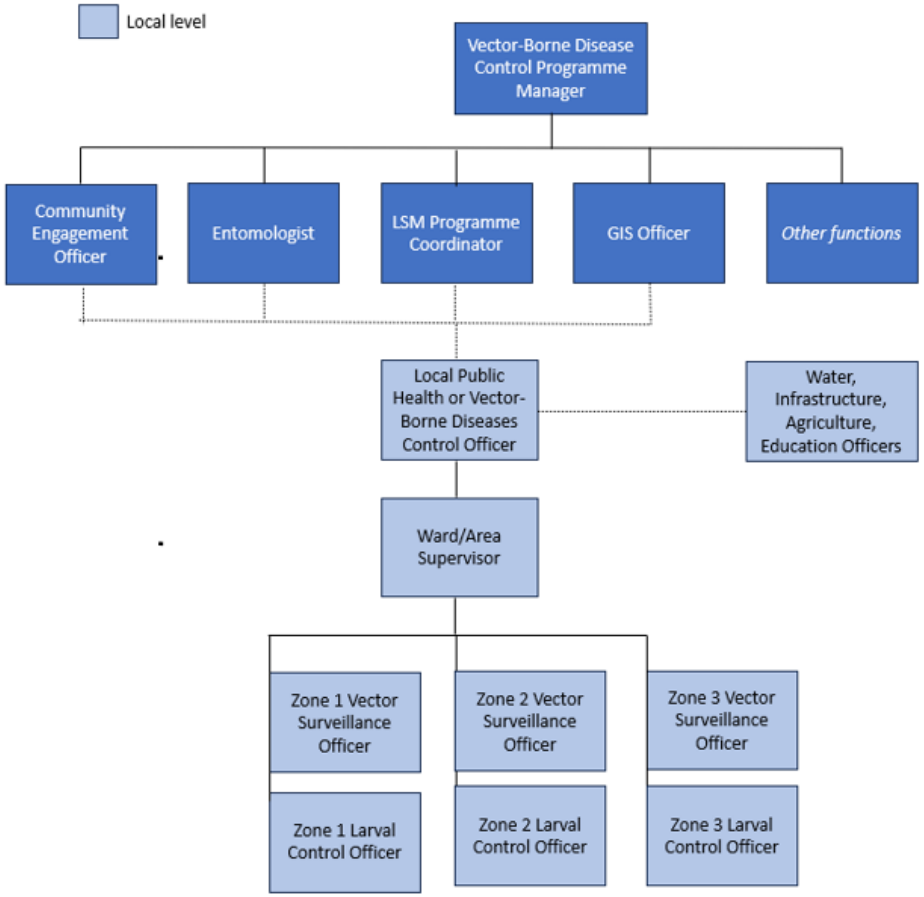
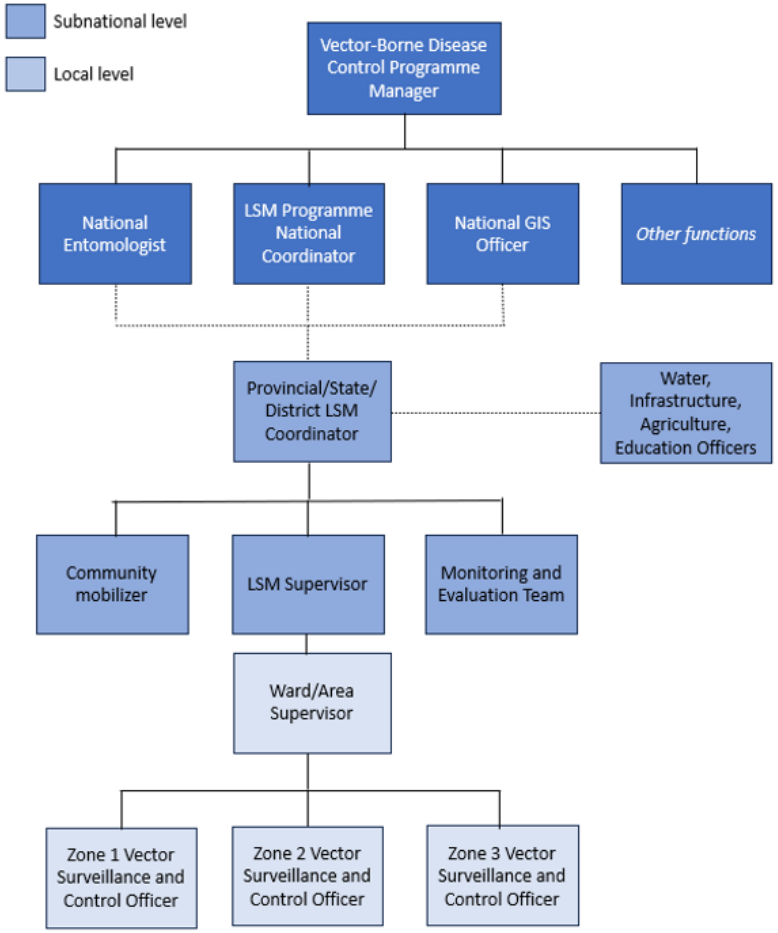


Fig. 3. Simplified LSM programme structure for a rural area



World Health Organization

Implementation strategies

- Community-led household clean-up
- Municipality-led and –enforced source reduction
- Large-scale environmental management
- Larviciding of all potential aquatic habitats
- Targeted control of key habitats
- Integrated mosquito control
- No introduction of LSM





https://fieldreport.caes.uga.edu/news/community-clean-ups-are-an-important-part-of-mosquito-management/



Photo credit: Chris Atta-Obeng

Planning for LSM

- Compiling data
  - Physical environment, larval ecology, and hydrology
  - Vector resistance
  - Economics
  - Health system and national control programme capacity
- Analysing information
- Assessing applicability
- Baseline mapping
- Selecting interventions
- Developing a plan of action

- Synthetic organic chemicals
- Bacterial larvicides
- Spinosyns
- IGRs
- Oils and surface films
- Fungi
- RNA interference
- Biological control



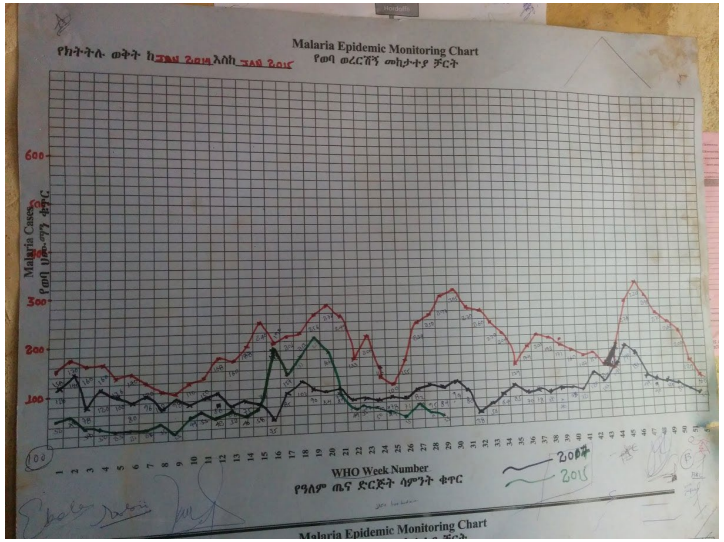
World Health Organization

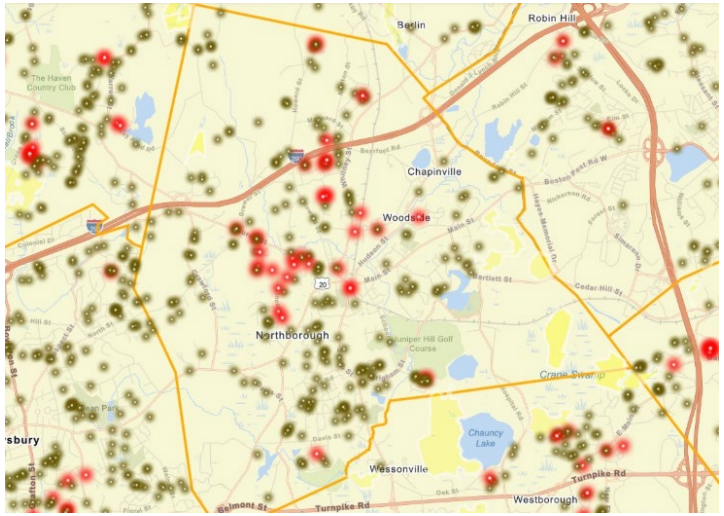
Conducting LSM

- Container and waste management
  - Solid waste management
  - Improved water supply and storage
  - Built environment introducing street cleaning
  - Filling in
- Environmental modification
  - Irrigation systems
  - Natural streams
  - Landfilling and grading
  - Drainage
  - Open ditches
  - Subsoil drainage
  - Coastal swamp drainage
  - Vertical drainage
  - The Lido system
  - Eucalyptus trees
- Environmental manipulation
  - Controlling water levels
  - Stream flushing or sluicing
  - Shading
  - Clearing aquatic vegetation and algal mats
  - Straightening and steepening shorelines
  - Changing water salinity
- Larviciding
  - Application of larvicides
  - Dosage
  - Equipment
  - Application of liquid sprays
  - Care of equipment
  - Safety considerations
  - Frequency and timing of application
  - Storage and distribution of larvicides
- Biological control agents
  - Predatory fish
  - Predatory invertebrates
  - Parasites and other disease-causing organisms
- Other forms of treatment
  - Polystyrene beads
- Community engagement and involvement
  - First household visit
  - Follow up household visits
  - Communication priorities

Monitoring and evaluation

- Monitoring and evaluation
  - Design of M&E programme
  - Data management
- Review
  - Annual operational review
  - Strategic review and recommendations
- Evidence gaps





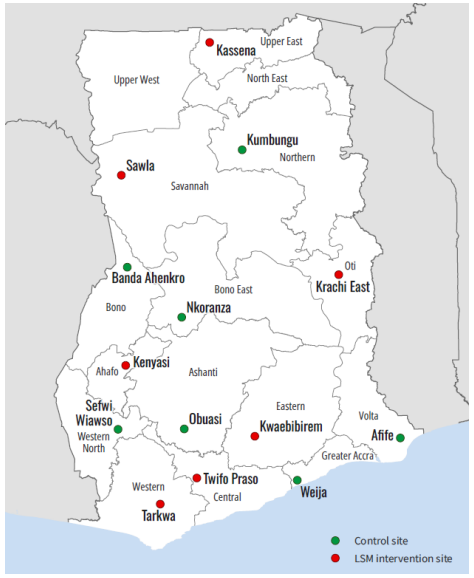
World Health Organization

Country case studies

- LSM for *An. stephensi* in Ethiopia
- LSM in rice fields in Madagascar
- LSM in rural and urban Rwanda
- LSM in Ghana



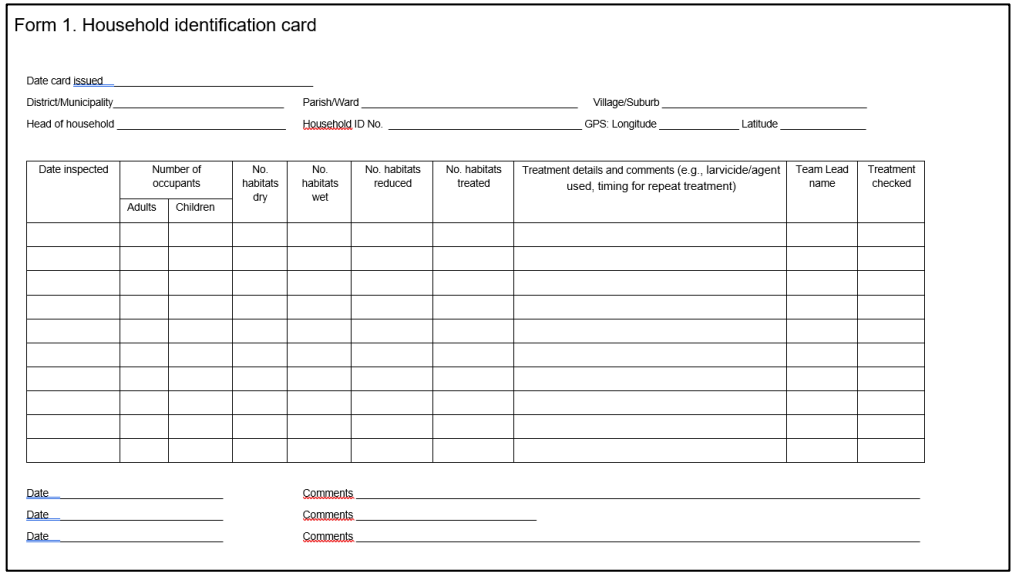




World Health Organization

Forms

- Form 1: Household identification card
- Form 2: Household habitat and LSM survey form
- Form 3: Community habitat and survey forms
- Form 4: Daily LSM team form
- Form 5: Weekly LSM supervisor form



Form 1. Household identification card

Date card issued _____

District/Municipality _____ Parish/Ward _____ Village/Suburb _____

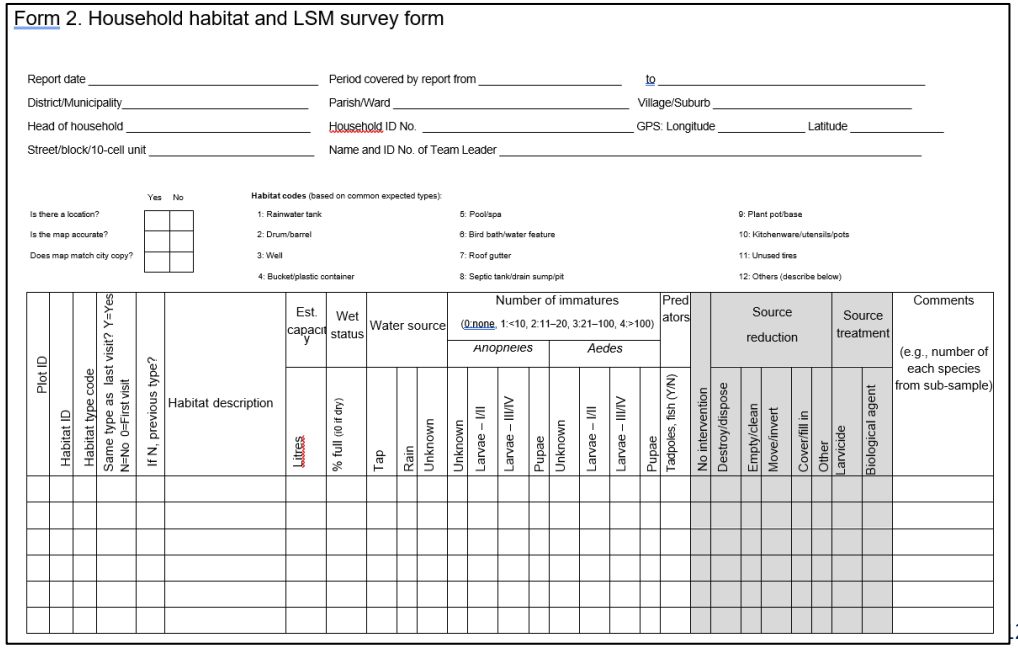
Head of household _____ Household ID No. _____ GPS: Longitude _____ Latitude _____

Date inspected	Number of occupants		No. habitats dry	No. habitats wet	No. habitats reduced	No. habitats treated	Treatment details and comments (e.g., larvicide/agent used, timing for repeat treatment)	Team Lead name	Treatment checked
	Adults	Children							

Date _____ Comments _____

Date _____ Comments _____

Date _____ Comments _____



Form 2. Household habitat and LSM survey form

Report date _____ Period covered by report from _____ to _____

District/Municipality _____ Parish/Ward _____ Village/Suburb _____

Head of household _____ Household ID No. _____ GPS: Longitude _____ Latitude _____

Street/block/10-cell unit _____ Name and ID No. of Team Leader _____

	Yes	No
Is there a location?		
Is the map accurate?		
Does map match city copy?		

Habitat codes (based on common expected types):

1: Rainwater tank
2: Drum/barrel
3: Well
4: Bucket/plastic container
5: Pool/spa
6: Bird bath/water feature
7: Roof gutter
8: Septic tank/drain sump/pit
9: Plant pot/base
10: Kitchenware/utensils/pots
11: Unused tires
12: Others (describe below)

Plot ID	Habitat ID	Habitat type code	Same type as last visit? Y=Yes N=No 0=First visit	If N, previous type?	Habitat description	Est. capacity	Wet status	Water source			Number of immatures (0:none, 1:<10, 2:11–20, 3:21–100, 4:>100)								Predators	No intervention	Source reduction						Source treatment		Comments (e.g., number of each species from sub-sample)
											Anopheles				*Aedes*														
						Litres	% full (0 if dry)	Tap	Rain	Unknown	Unknown	Larvae – I/II	Larvae – III/IV	Pupae	Unknown	Larvae – I/II	Larvae – III/IV	Pupae	Tadpoles, fish (Y/N)		Destroy/dispose	Empty/clean	Move/invert	Cover/fill in	Other	Larvicide	Biological agent	

Additional tools

- LSM programme timeline planning tool
- LSM programme supervision checklist
- SOP for container-inhabiting larvae and pupae collections

Tool 1. LSM programme timeline planning tool

This was adapted from the "Race to the starting line" tool developed by USAID/PMI (24).

	Weeks until start of spray campaign									0	Name of	Notes
Country: X Date Updated:	9	8	7	6	5	4	3	2	1	Start date	person responsible	
Due Date (Deadline)												
Activity												
Headquarter procurement of larviciding supplies and equipment												
Local procurement of supplies and equipment												
Susceptibility tests for insecticides												
Residuality tests for insecticides												
Pre-season environmental compliance assessment for each operation site: x operation sites (health centres) in x municipalities (x days)												
Micro-planning meeting with Ministry of Health and health centres (x days)												
Work plan to address environmental compliance deficiencies: (x days at the most, included x health centres)												
Vehicle usage and transport plan												
Logistics/materials distribution & dispatch plan (x days)												
Seasonal personnel payment plan												
Solid waste storage & disposal plan												

World Health Organization

Thank you

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RBM Partnership
To End Malaria

Panel Discussion: Explore emerging themes in the LSM space: Tech-enabled larviciding, Community engagement, Innovative financing mechanisms

Moderators: Edward Thomsen & Elijah Juma, VCWG Task Team leads

Panelists:
Chris Atta-Obeng NMEP Ghana,
Mary Esema NMEP Nigeria,
Emmanuel Hakizimana Rwanda, SORA Technology

RBM Partnership
To End Malaria

4 March 2026

Morning break

RBM Partnership
To End Malaria

4 March 2026

Task Team 2: Innovations in vector control

Introduction

Tullu Bukhari, Samantha O'Loughlin, Rinki Deb

RBM Partnership
To End Malaria

4 March 2026

Presentation: Modelling the impacts of gene drive releases on the burden of malaria in West African settings

Penelope Hancock, Imperial College London

TARGET MALARIA

A Vector Control Research Alliance

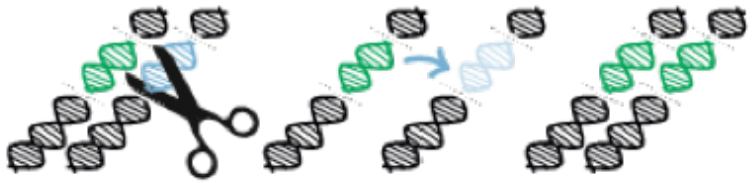
The potential of gene drives to control malaria in African environments

Penelope Hancock

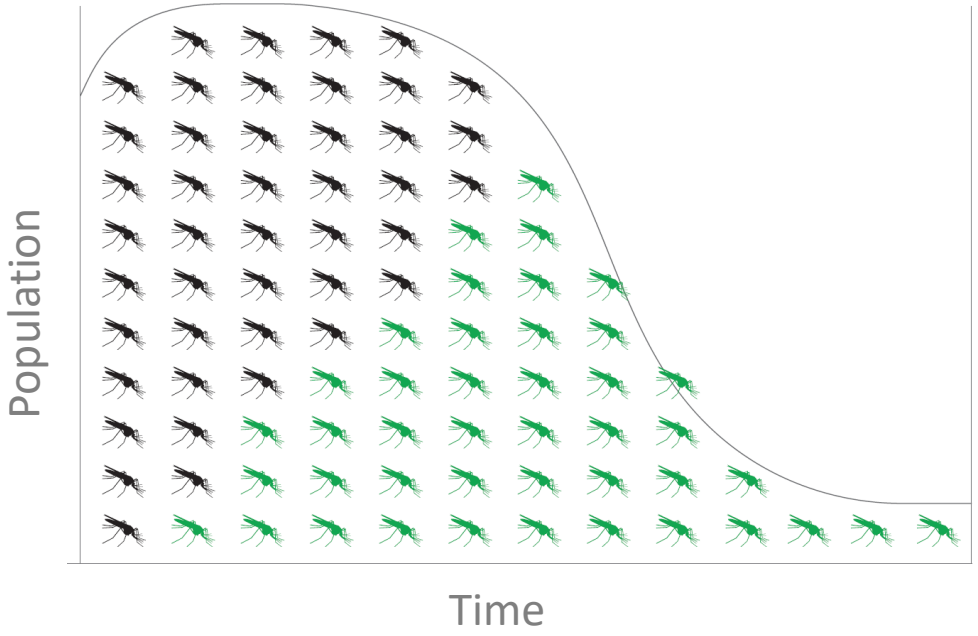
Imperial College London

A gene drive for vector population suppression

Gene drive converts heterozygotes to homozygotes



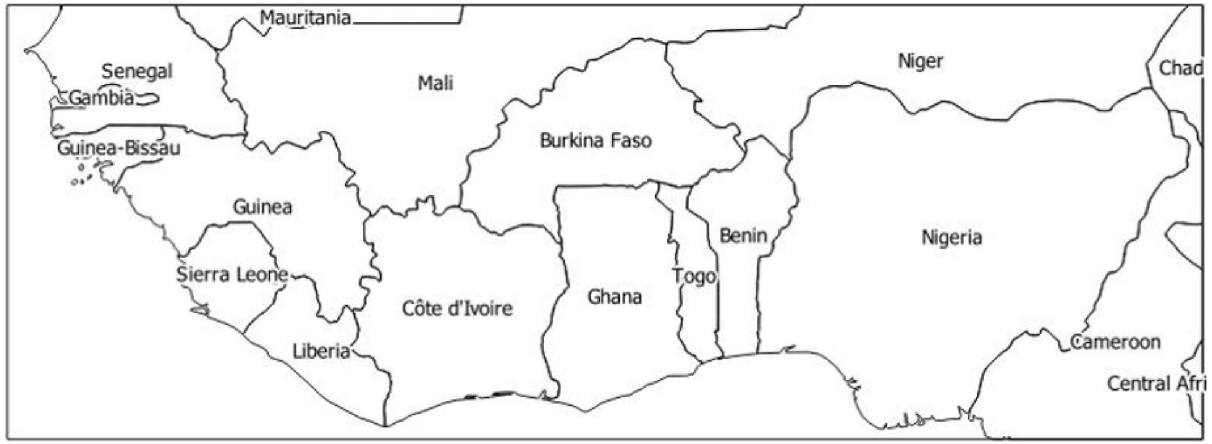
CRISPR Cas9 gene editing



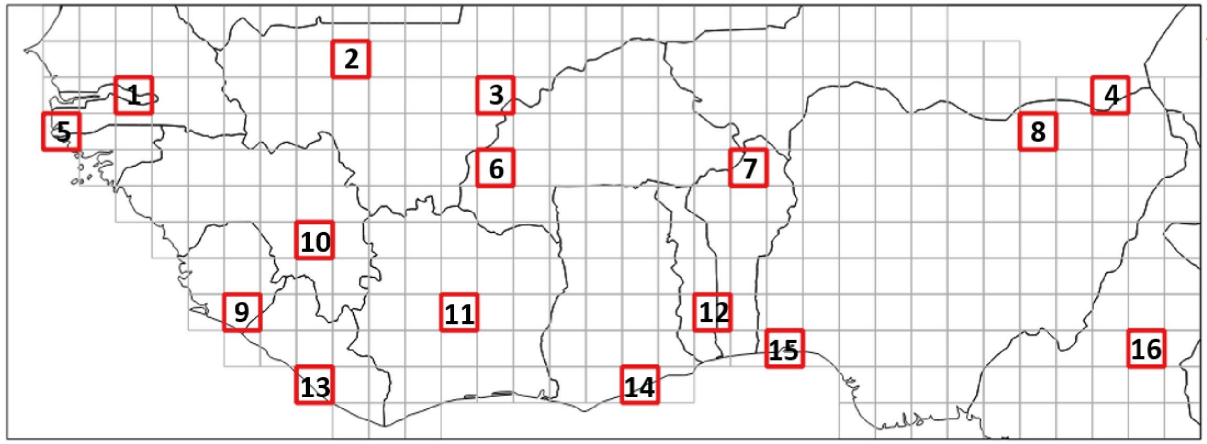
- Targets female fertility
- Prevents human biting
- Small numbers of mosquitoes released
- Sustainable: persists in the population
- Impacts targeted species or species complex

Modelling impacts of gene drive releases in west African settings

Selecting representative areas

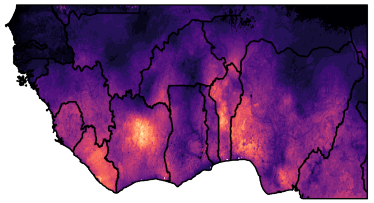


1 degree graticule:

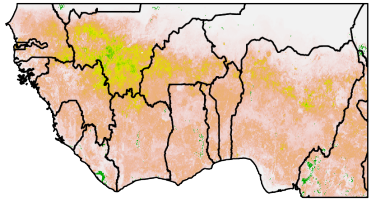


Captured variation in 5 variables

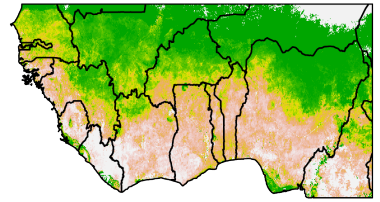
P. falciparum prevalence



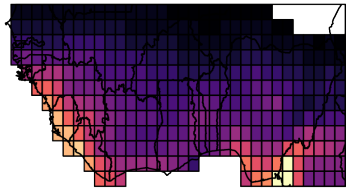
Relative abundance of *An. funestus*



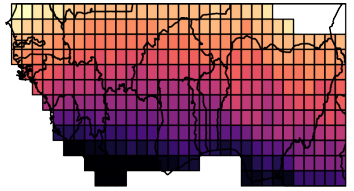
Relative abundance of *An. arabiensis*



Mean rainfall

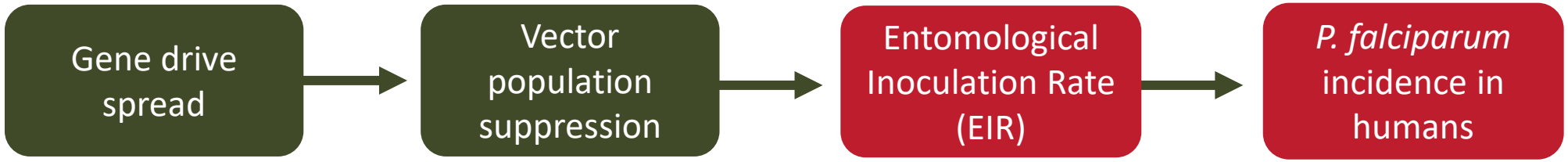


Max dry weeks



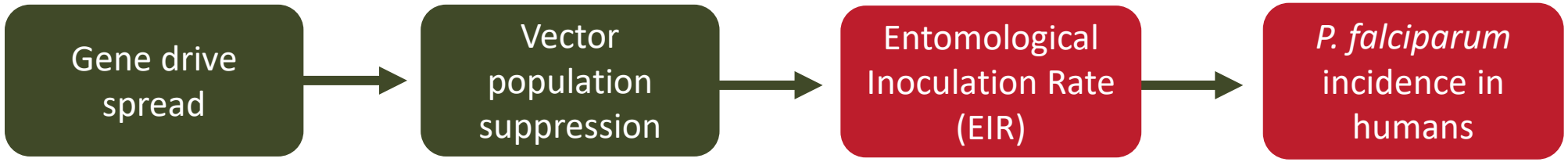
Modelling impacts of gene drive releases in west African settings

Combining entomological and epidemiological models



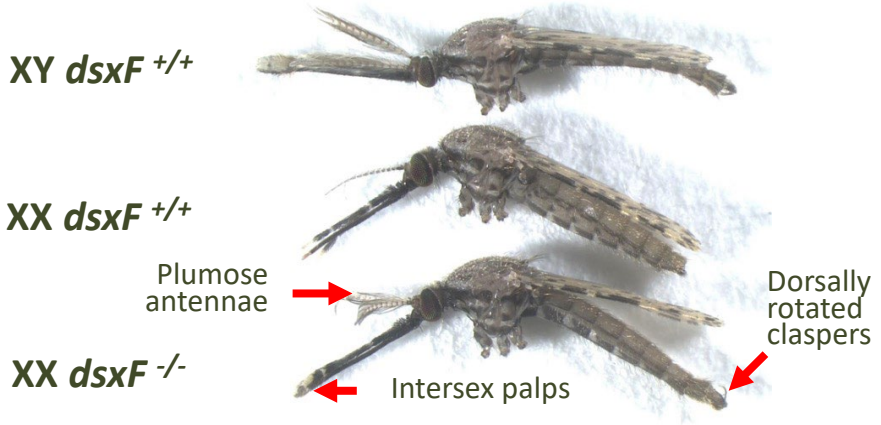
Modelling impacts of gene drive releases in west African settings

Combining entomological and epidemiological models



Gene drive targeting *doublesex*

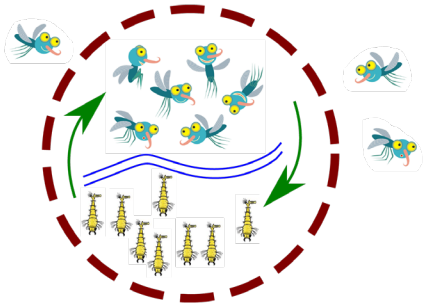
- Homozygous females are sterile
- Homozygous females cannot bite or transmit malaria
- Fitness cost in heterozygous females = 0.35
- Homing rate = 0.95



Modelling impacts of gene drive releases in west African settings

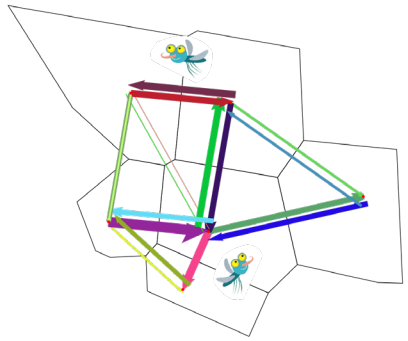
Representing local ecology and epidemiology across African settings

Local mosquito dynamics



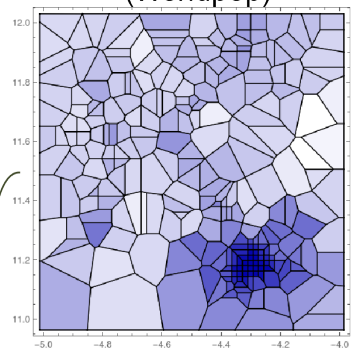
- A mosquito population is located at each site.
- The populations are regulated by larval habitat.

Movement between populations

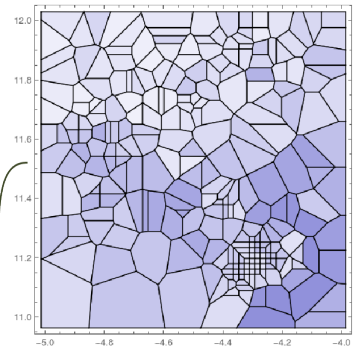


- Adult mosquitoes move between regions
- Regions are connected if they are near enough or share a border

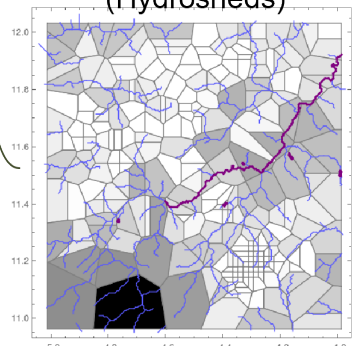
Human density
(Worldpop)



Species proportion
(e.g. An. gambiae ; Sinka et al.)



Rivers and lakes
(Hydrosheds)

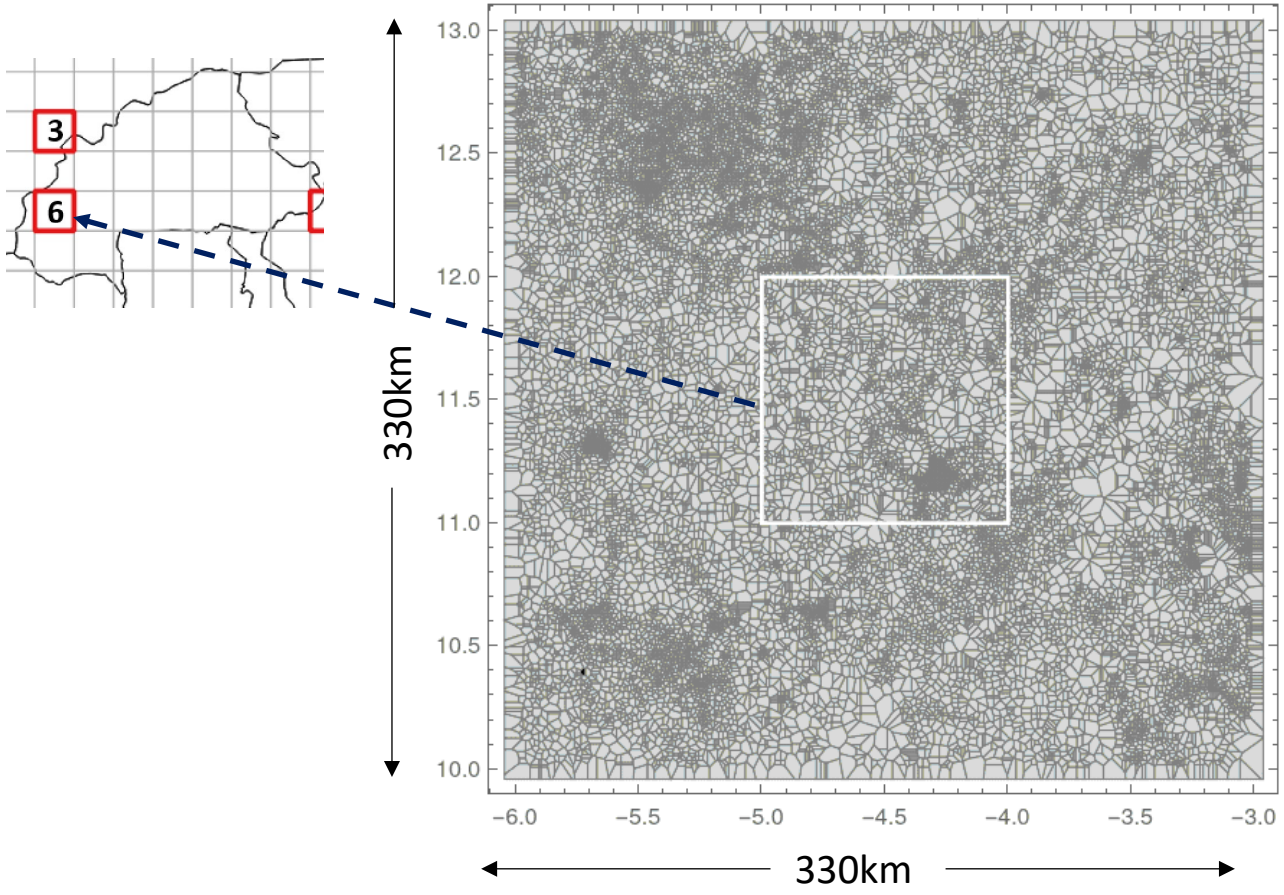


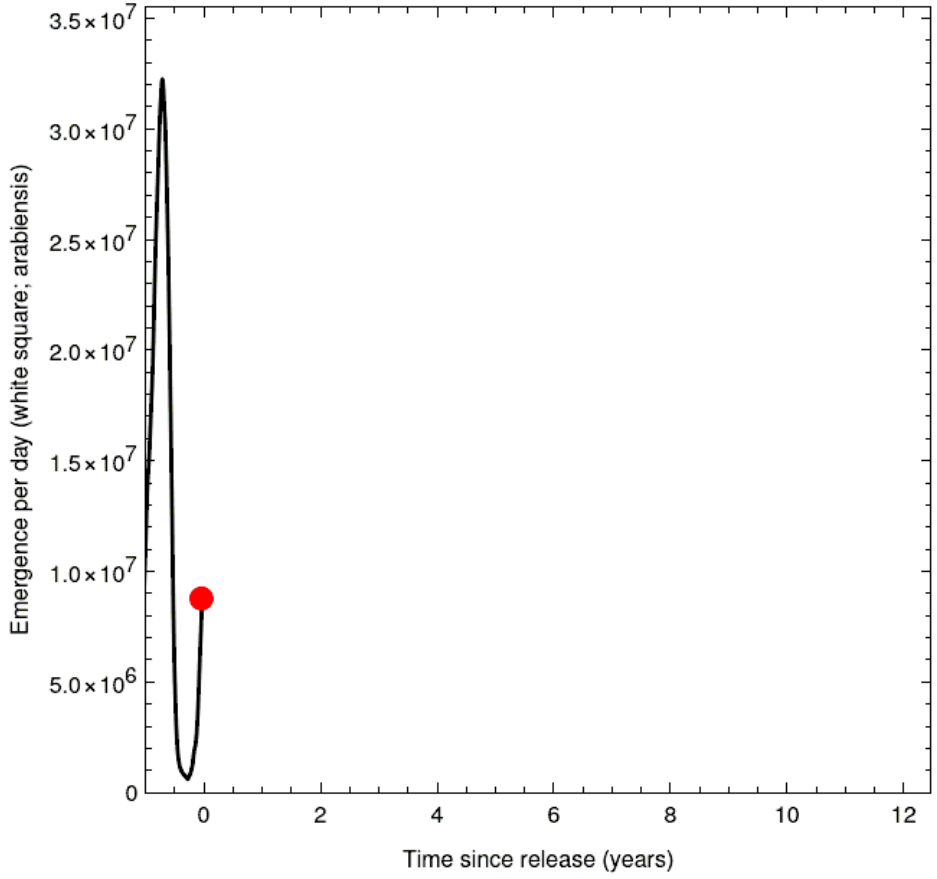
Seasonal rainfall
(historical data)



Modelling impacts of gene drive releases in west African settings

Example gene drive dynamics: Western Burkina Faso



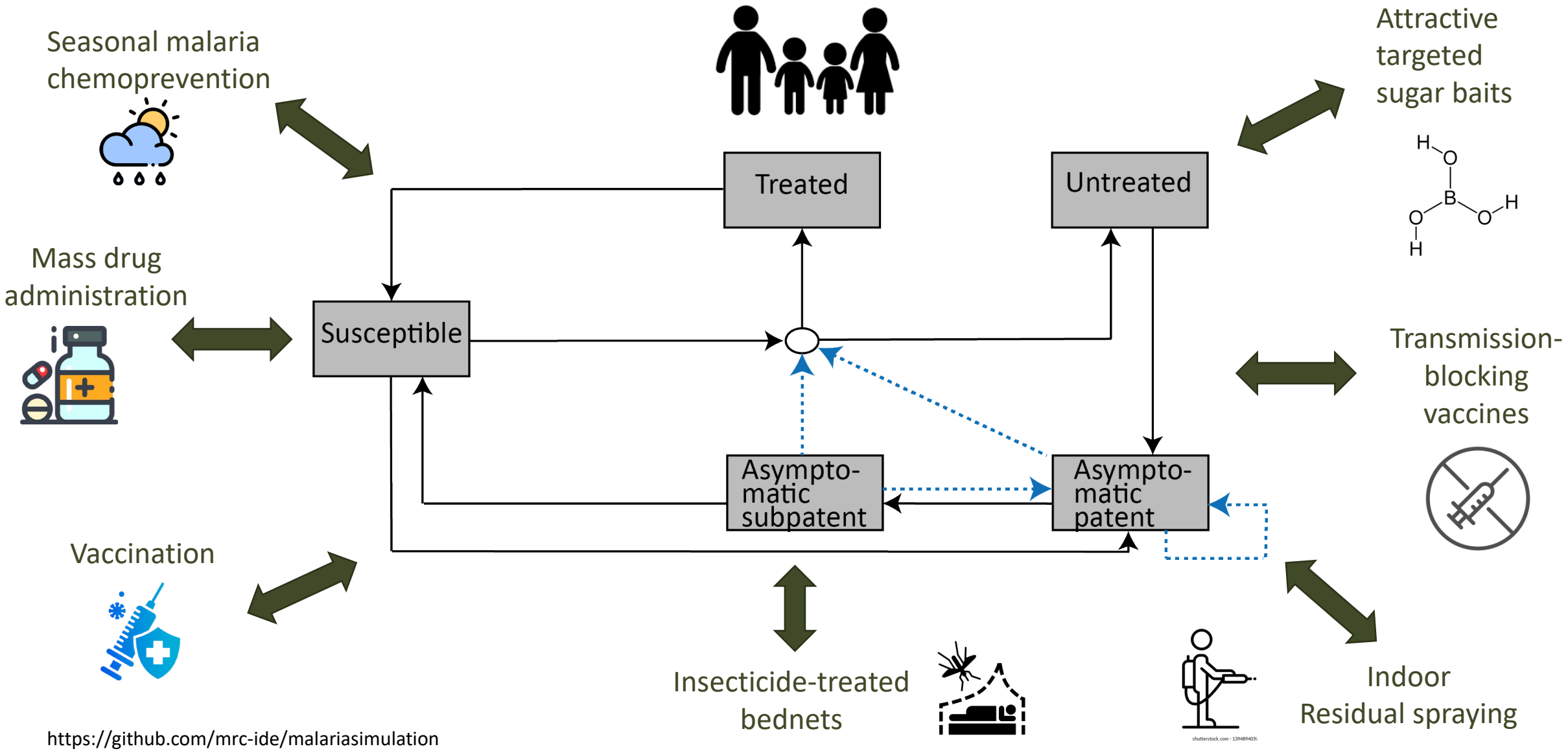


Hancock, P. A, North, A., et al. 2024, *Nat Comms*

Gene drive frequency f

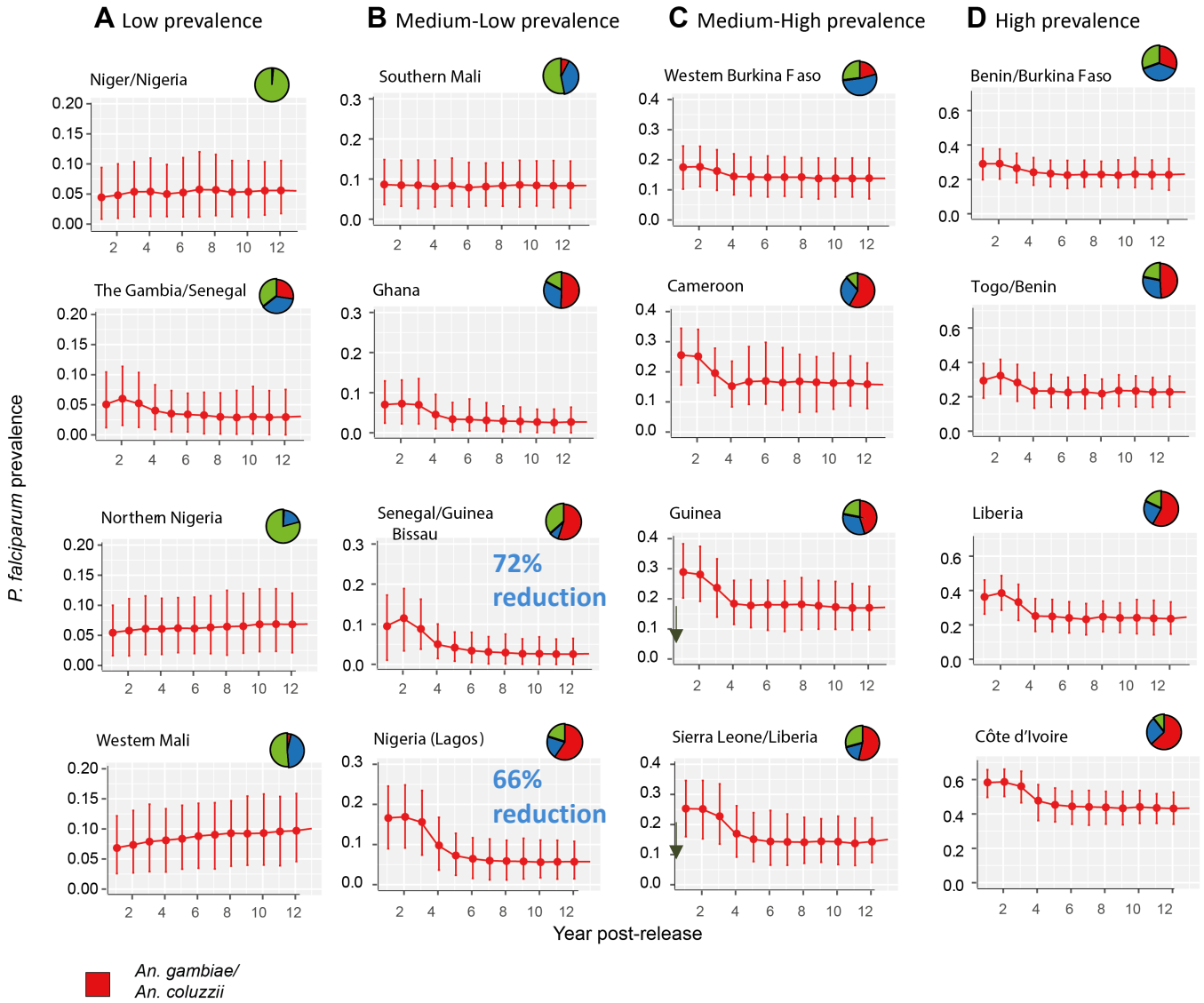
No mosquitoes | 0< f < 0.001 | 0.001< f < 0.01 | 0.01< f < 0.1 | 0.1< f < 0.2 | 0.2< f < 0.5 | f >0.5

Modelling impacts of gene drive releases in west African settings



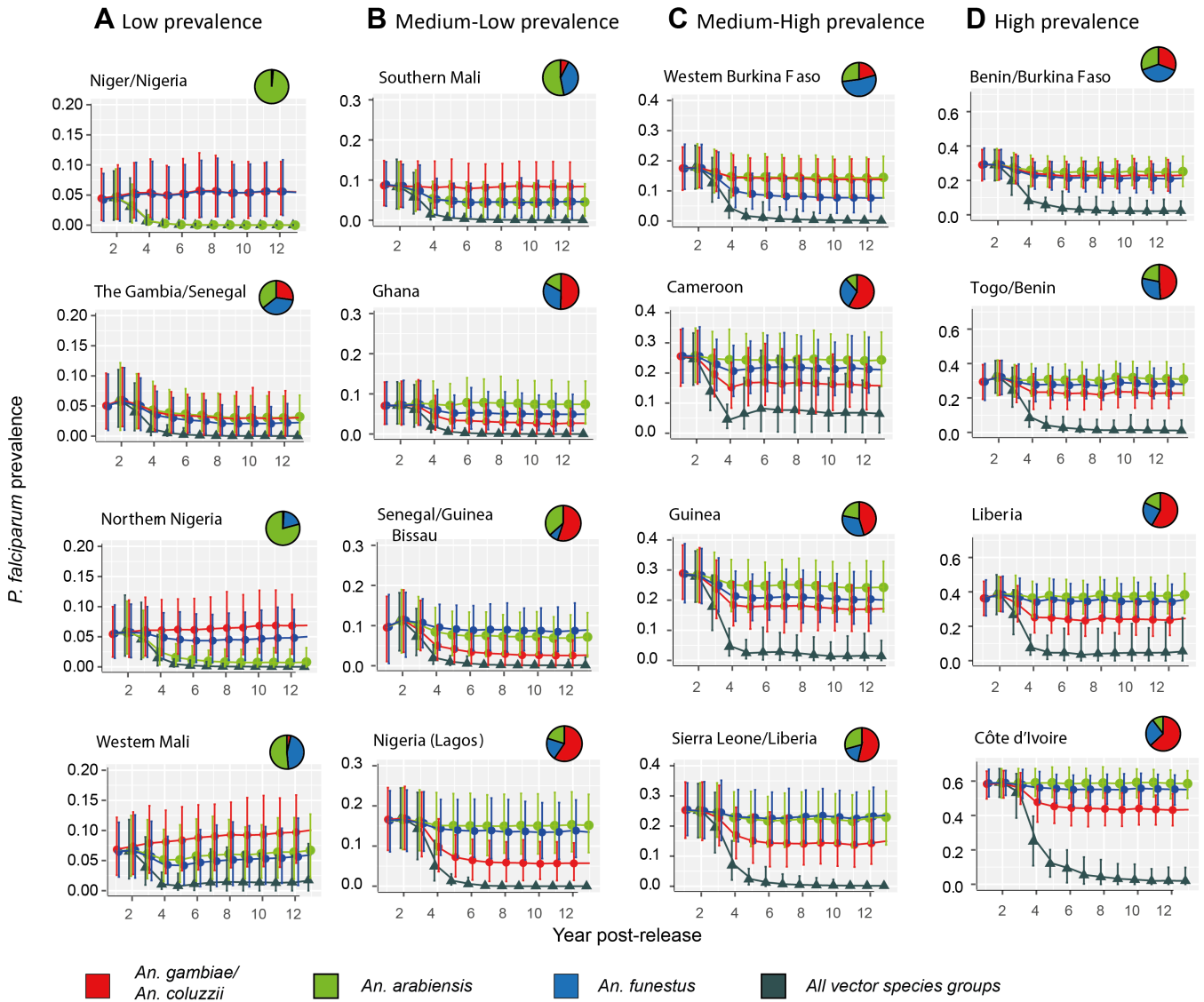
https://github.com/mrc-ide/malariasimulation

Impacts of gene drive releases on malaria prevalence



- Releases in *Anopheles gambiae + Anopheles coluzzii* only
- Impacts are greatest in areas **with high relative abundance of these species**
- Impacts are greatest in areas where **pre-release prevalence is relatively low**

Impacts of gene drive releases on malaria prevalence



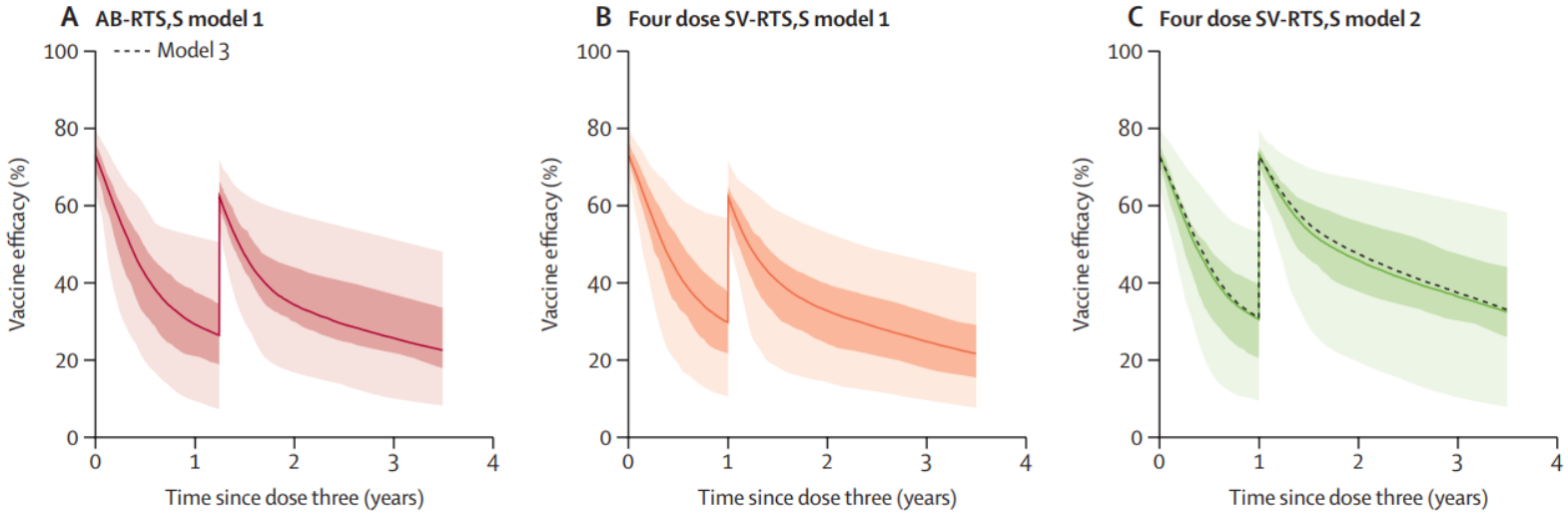
- Releases in **all vector species groups** has a much bigger impact
- Prevalence is reduced by >90% in all areas

Impacts of combining gene drives with other new interventions

Malaria vaccination

Seasonal use case for the RTS,S/AS01 malaria vaccine: a mathematical modelling study

Hayley A Thompson, Alexandra B Hogan, Patrick G T Walker, Peter Winskill, Issaka Zongo, Issaka Sagara, Halidou Tinto, Jean-Bosco Ouedraogo, Alassane Dicko, Daniel Chandramohan, Brian Greenwood, Matt Cairns, Azra C Ghani

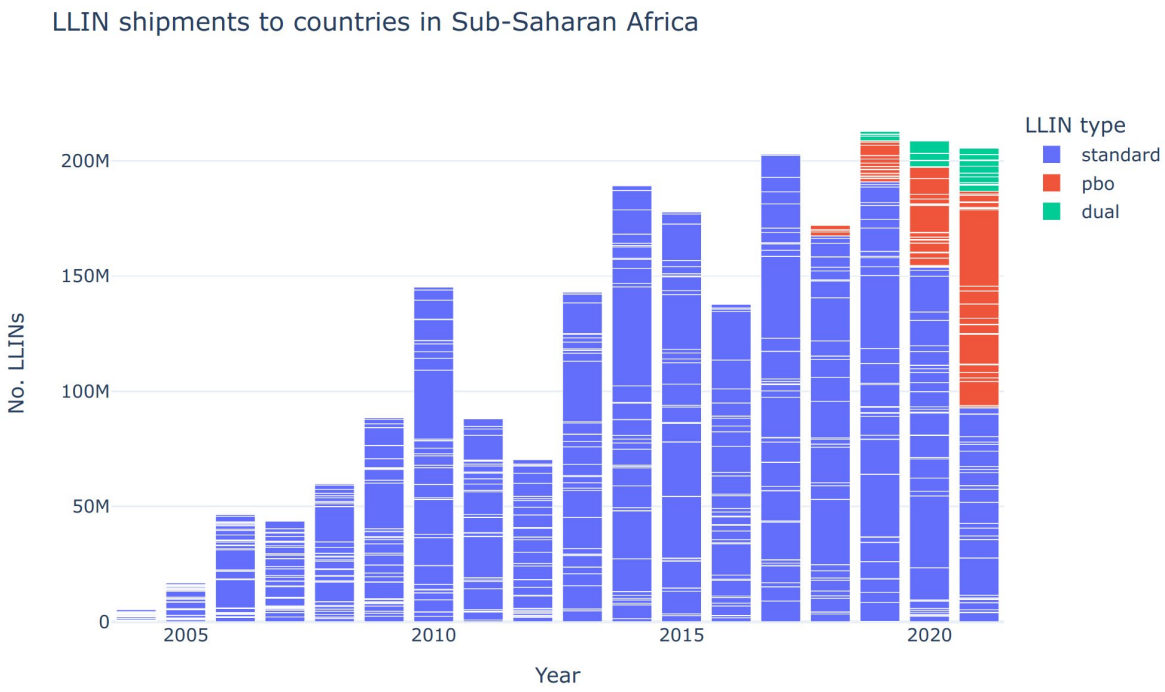


Lancet Glob Health 2022

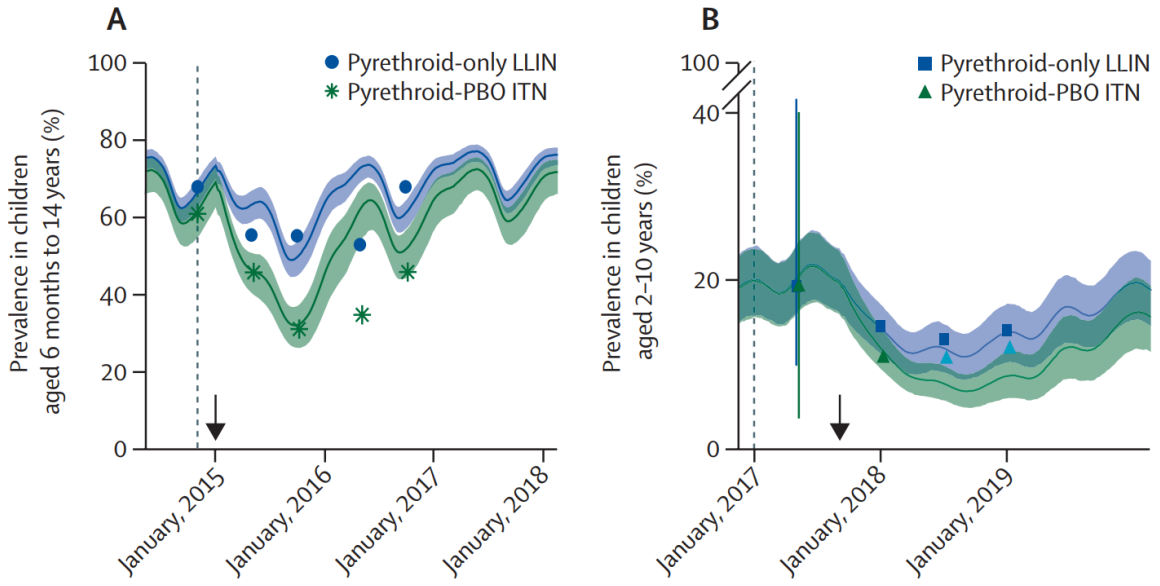
https://github.com/mrc-ide/malariasimulation

Impacts of combining gene drives with other new interventions

Pyrethroid-PBO LLINs



AMP Net Mapping Project
Graphic by Alistair Miles https://twitter.com/alimanfoo

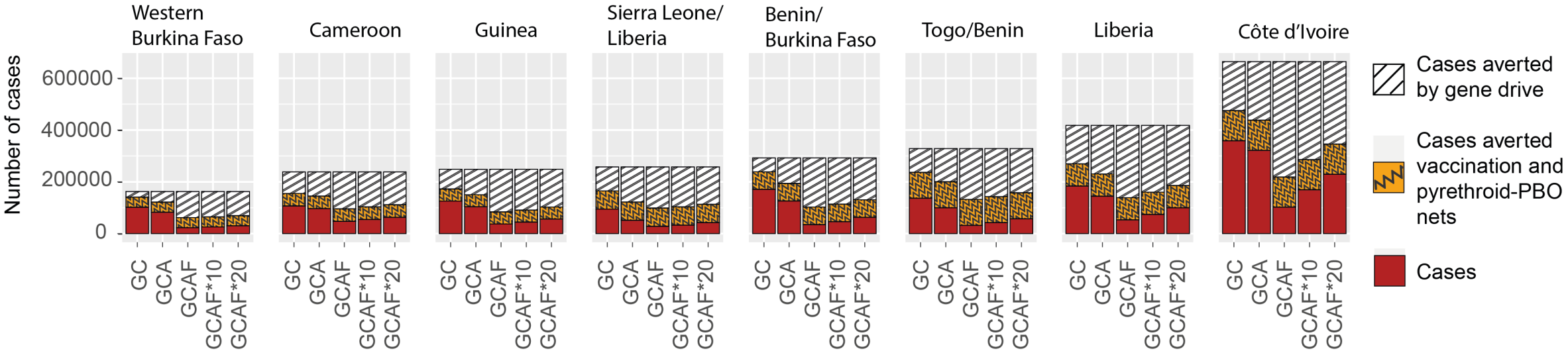


Sherrard-Smith, E. et al. (2022) Optimising the deployment of vector control tools against malaria: a data-informed modelling study, Lancet Planet Health.

https://github.com/mrc-ide/malariasimulation

Impacts of combining gene drives with other new interventions

- Top 50% of areas with the highest malaria transmission intensity
- Gene drive releases combined with RTS,S vaccination and switching to pyrethroid-PBO ITNs

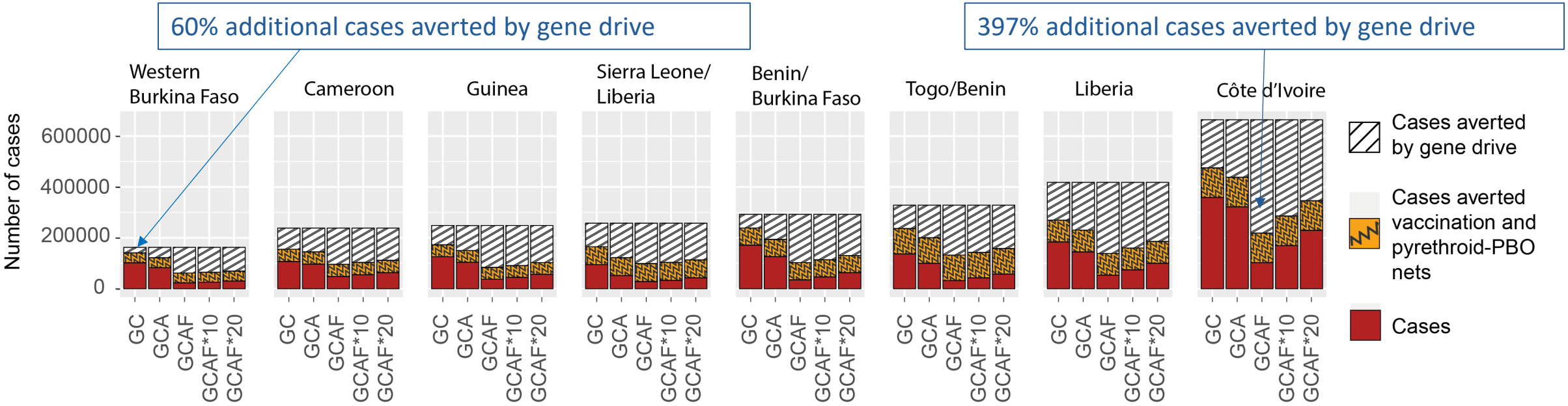


GC: Release in An. gambiae/coluzzii
GCA: Release in *An. gambiae/coluzzii + An. Arabiensis*
GCAF: Release in *An. gambiae/coluzzi + An. arabiensis + An. funestus*

** Presence of an additional non-target vector species*

Impacts of combining gene drives with other new interventions

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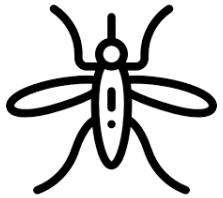


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** Presence of an additional non-target vector species*

Conclusions

Impacts on vectors



- Gene drives can achieve strong suppression of the target vector population across a wide range of parameters describing:

    - mosquito population biology
    - landscapes
    - climate processes

- Chasing dynamics are more pronounced in spatially unconnected, highly seasonal environments

- Our results represent a ‘best case’ scenario, where transgene that has a relatively low fitness cost reaches a high frequency in the target vector population.

Conclusions

Impacts on malaria



- Reductions in malaria burden vary considerably across regions depending on:
  - The vector species present
  - The vector species targeted by gene drives
  - Malaria transmission intensity
  - Coverage of other interventions

- Gene drives act positively in combination with RTS,S vaccines and pyrethroid-PBO nets in reducing clinical cases

- Transmission by non-target vectors limits the malaria control impact of gene drives

Current modelling research

Field

First gene drive field trials are being planned

Estimate

Models can estimate intervention performance in different settings:

- Spatial spread of the gene drive
- Entomological & epidemiological efficacy

Inform

Models can inform trial planning:

- Required no. of release sites
- Required no. of control sites
- Spatial separation of release & control sites

Acknowledgements

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& from **Coefficient Giving** (Open Philanthropy)”

Gates Foundation

Coefficient Giving

Key contributors

Ace North*

Adrian Leach

Pete Winskill

Giovanni Charles

Charles Godfray

Austin Burt





RBM Partnership
To End Malaria

4 March 2026

Presentation: Microsporidia MB-based malaria transmission blocking strategy

Tullu Bukhari, ICIPE

www.icipe.org

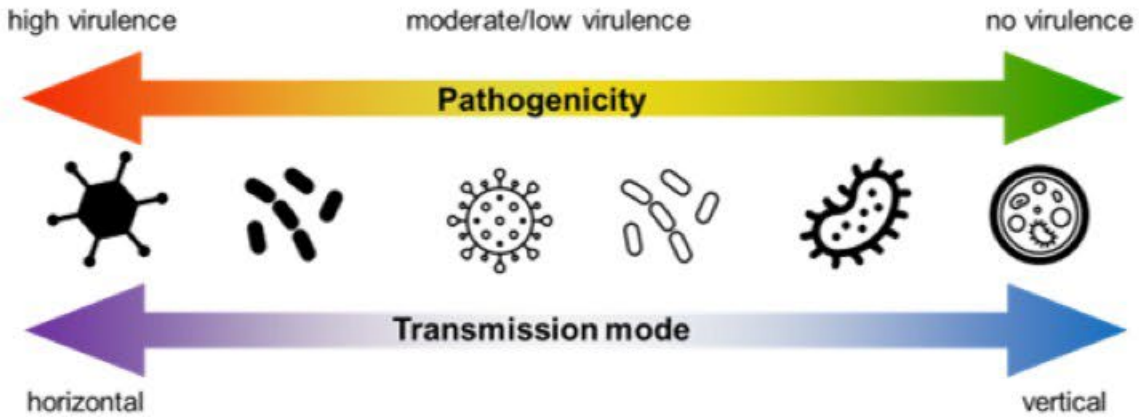
icipe
The TROpical insect Science institute

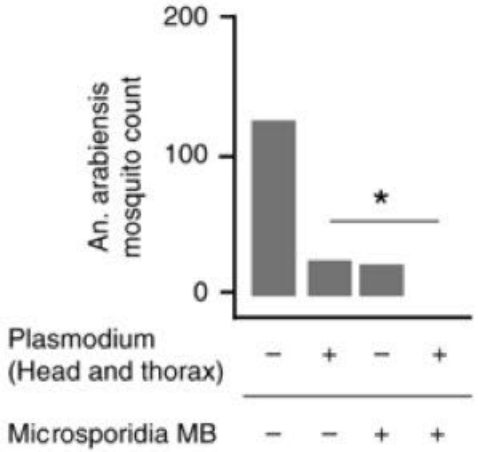
Symbiont-based malaria transmission blocking strategy

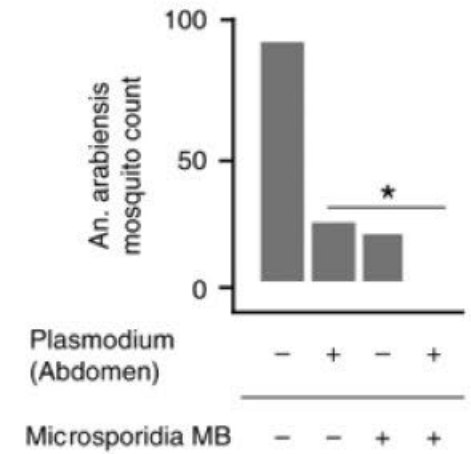
S. Tullu Bukhari

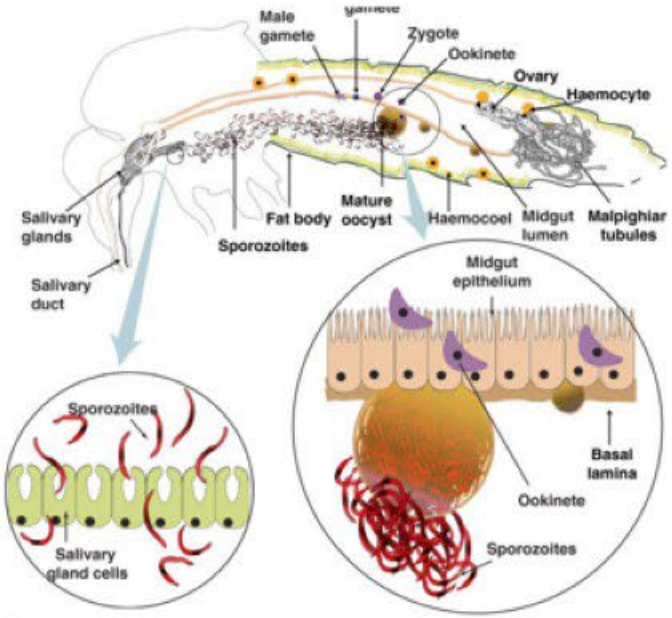
SYMBIOVECTOR

Symbionts: *Microsporidia MB*









Microsporidia MB, was found in geographically dispersed populations of *An. arabiensis* in Kenya.

***V*ertically** and **horizontally** (by mating) transmitted.

No fitness cost

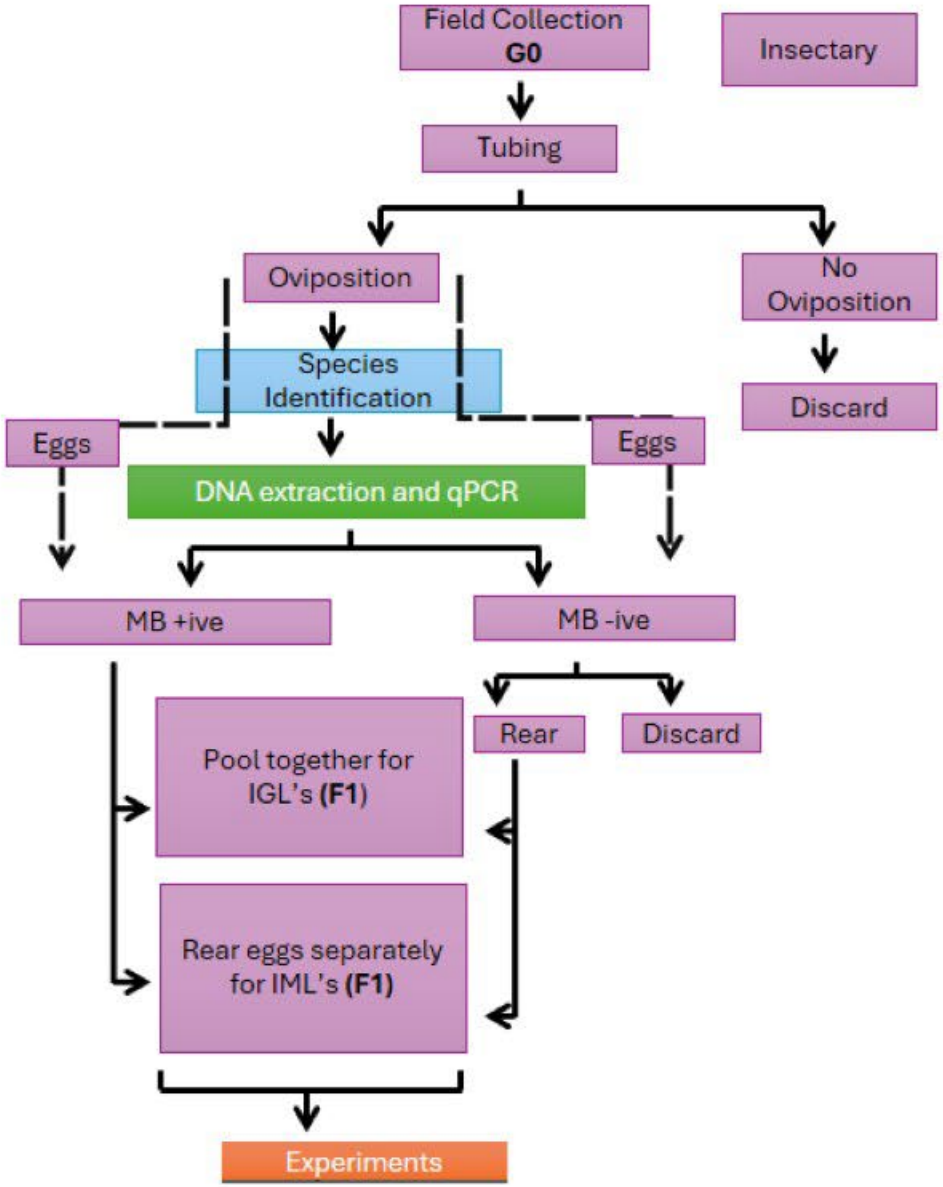
Microsporidia MB* impairs *Plasmodium transmission

Herren et al., *2020. Nat Commun 11, 2187.*
Nattoh G, et al., (2021) Front. Microbiol. 12:647183.

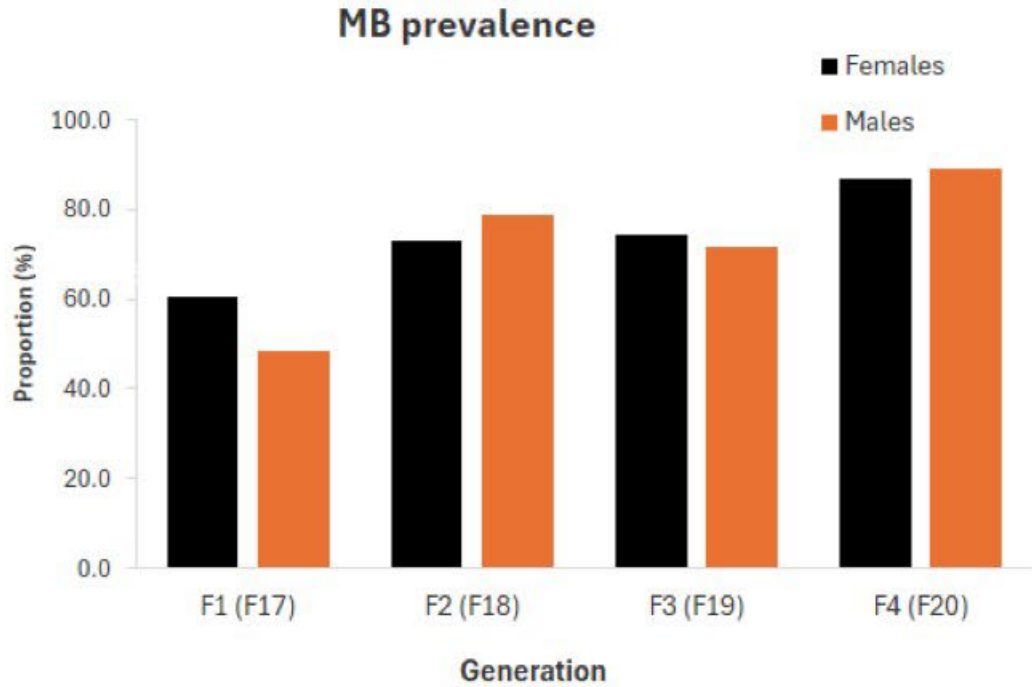
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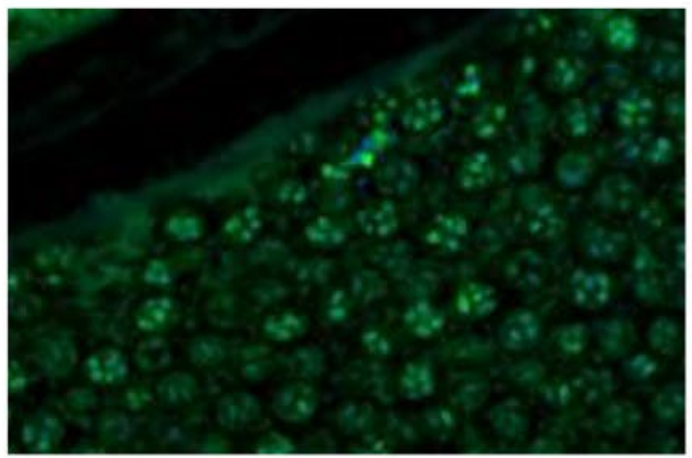
icipe

How do we get infected mosquitoes?



www.icipe.org



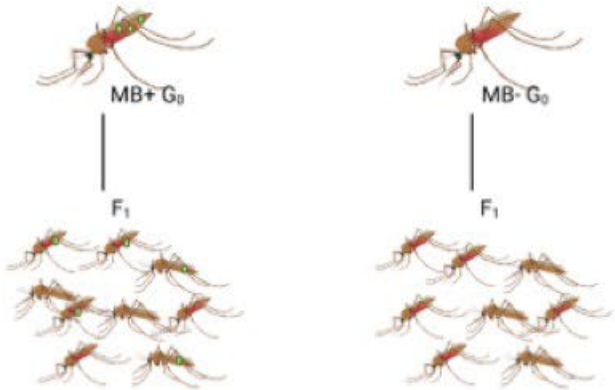


Parry et al., mSphere. 2025 May 22;10(6):e00851-24

SYMBIO VECTOR

icipe

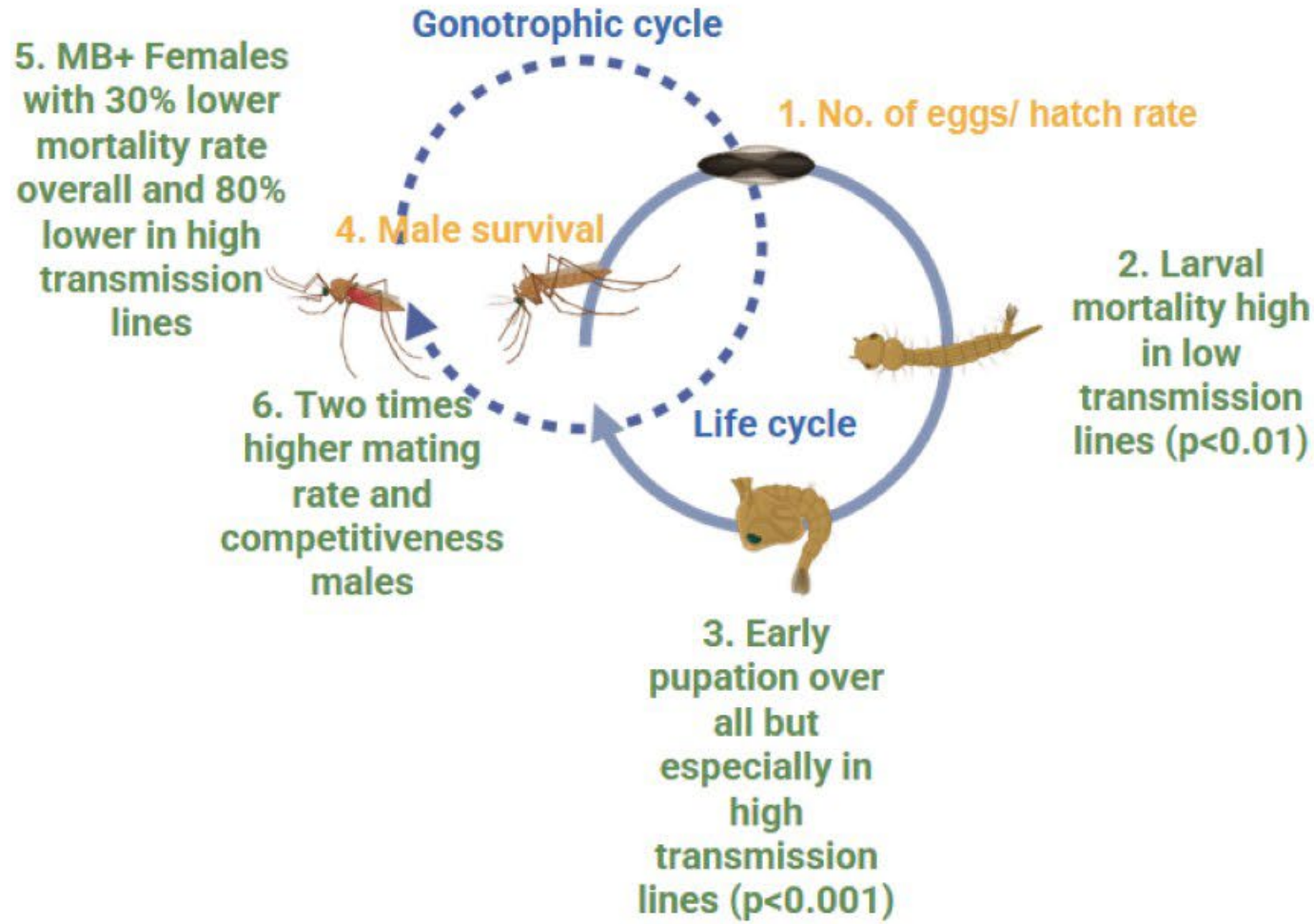
Transmission of *Microsporidia MB in An. arabiensis*



73.5% transmission (3.5-97)

Low transmission lines </= 50%
High transmission lines >50%

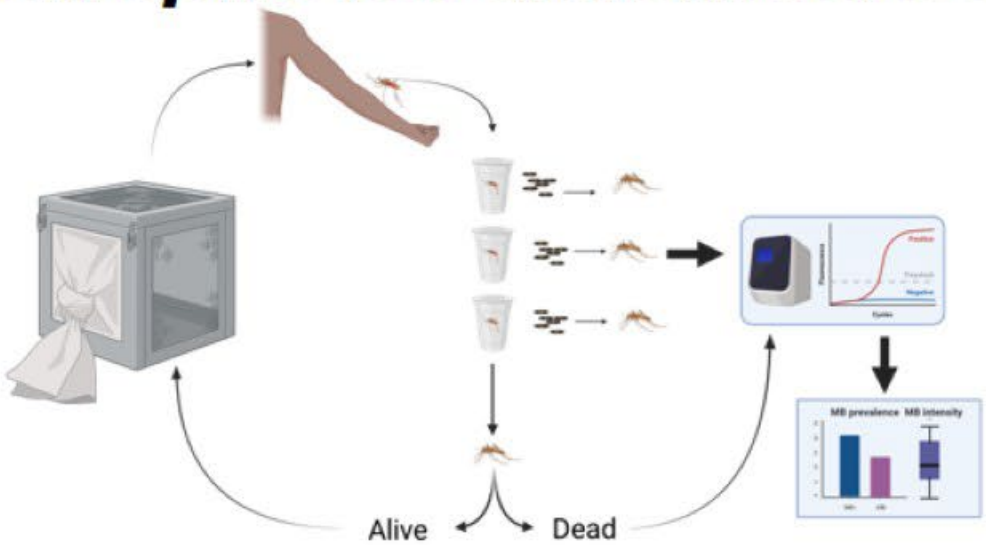
Horizontal transmission rate
Male -> female: 41%
Female -> male 22%

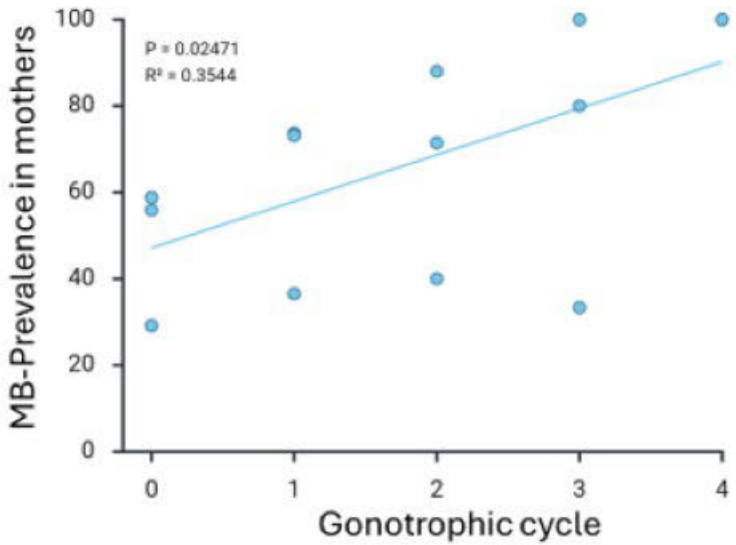


Maina et. al., 2025. Malaria Journal, 24 (1)
Shisia et. Al., in preparation

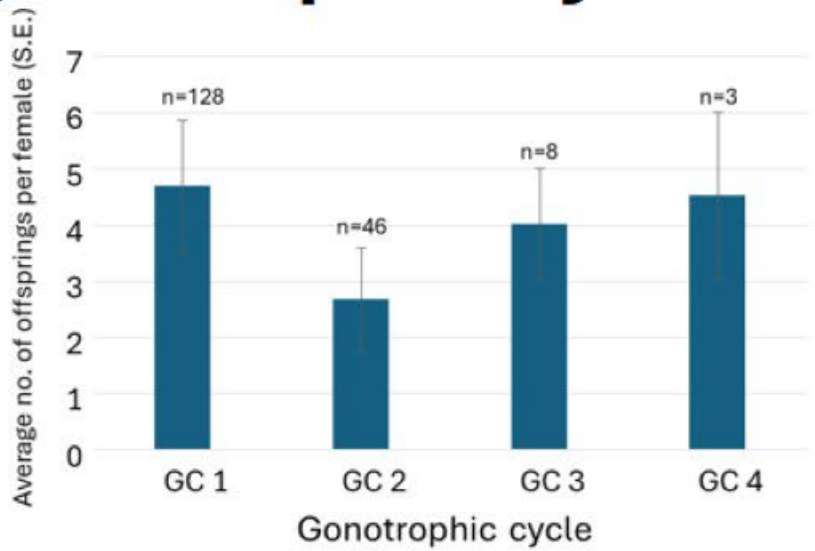
Favors MB
Doesn't favor MB
Neutral

Vertical transmission of *Microsporidia MB*-positive in *Anopheles arabinesis* over gonotrophic cycles





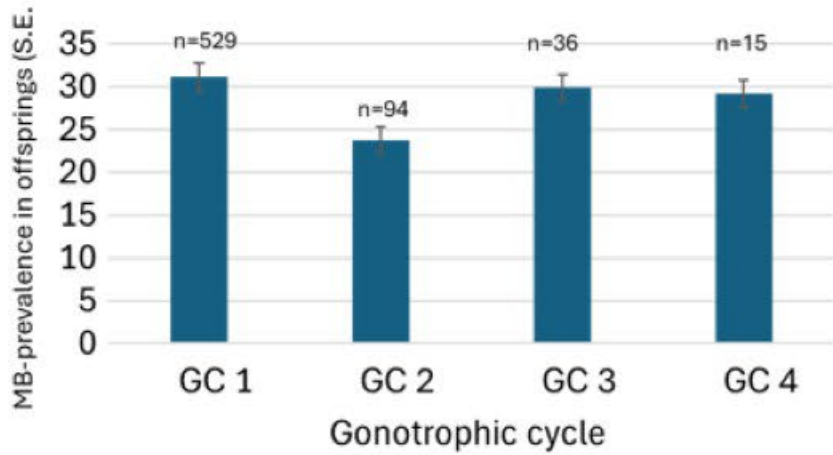
MB-infected mothers contribute more to the late gonotrophic progeny



Favors MB

Doesn't favor MB

Neutral



MB transmission rate remains constant over gonotrophic cycles

Overview of Vertical transmission of *Microsporidia MB*-positive in *Anopheles arabinesis*: *Microsporidia MB*-density

73.5% transmission (3.5-97)

Low transmission lines </= 50%

High transmission lines >50%

Favors MB

Doesn't favor MB

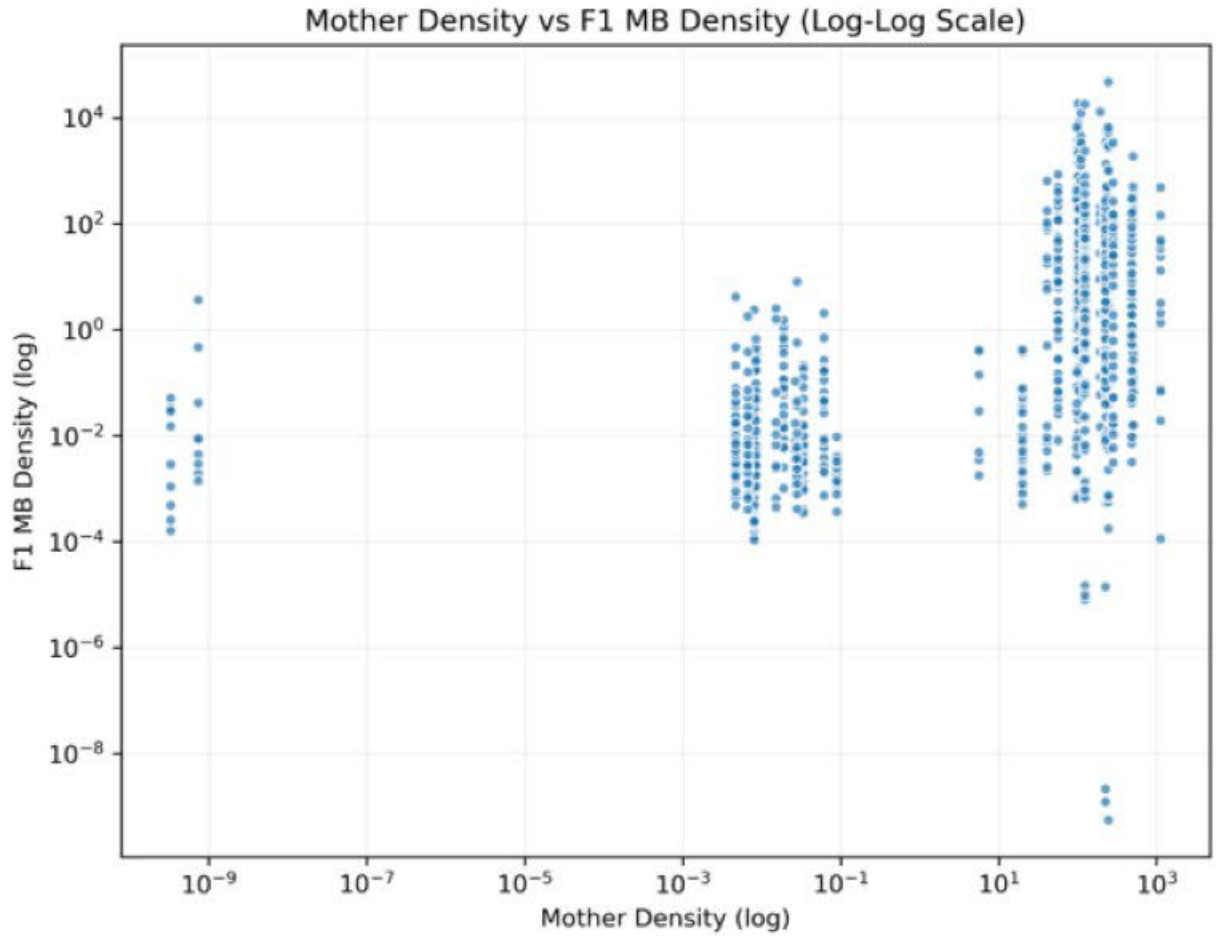
Neutral



QTL analysis of lines with transmission between 70-80% -> MB density is at least partially determined by host genetics

Mothers with high MB-density have offsprings on average with high density MB infection (offspring infections can range from high-low)

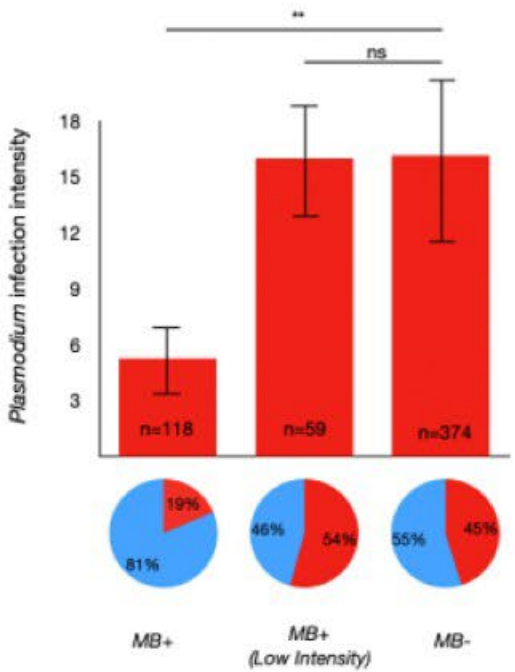
Mothers with low MB density have offsprings on average with low density MB infection (offspring infections stays low)



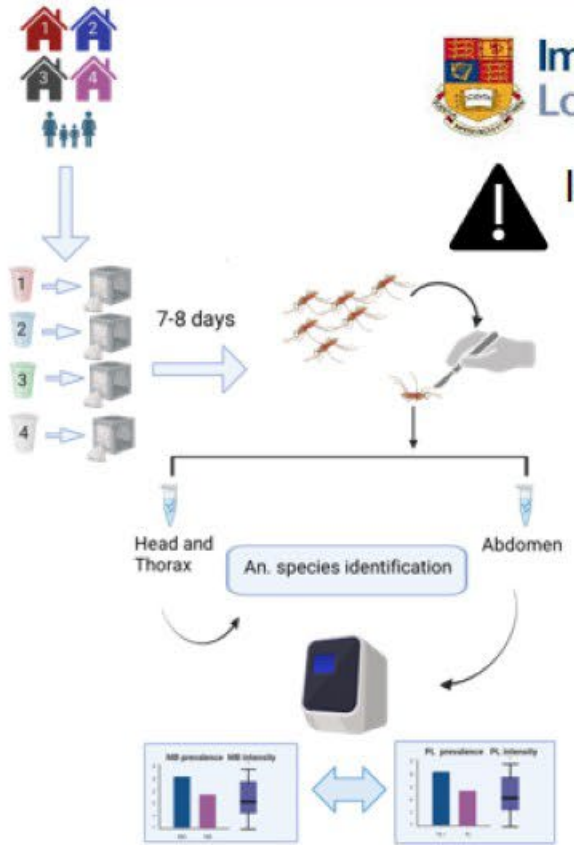
Malaria transmission blocking

Membrane feeding bioassays





House-hold level

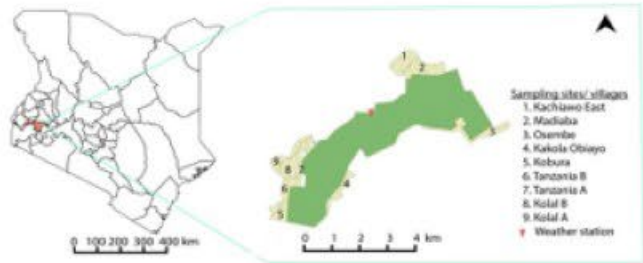


Imperial College London

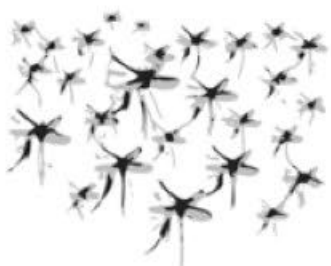
In progress

MB-positive mosquitoes are substantially less likely to be PL+ than MB-negative mosquitoes p = 0.015

Location wide







4 days

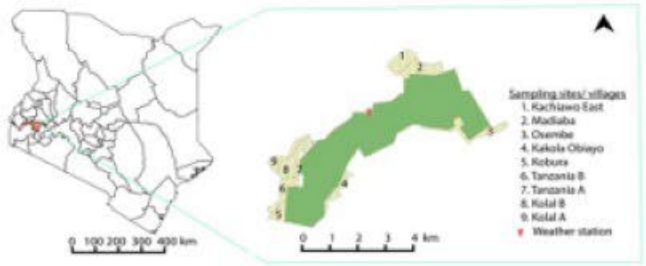
Microsporidia MB

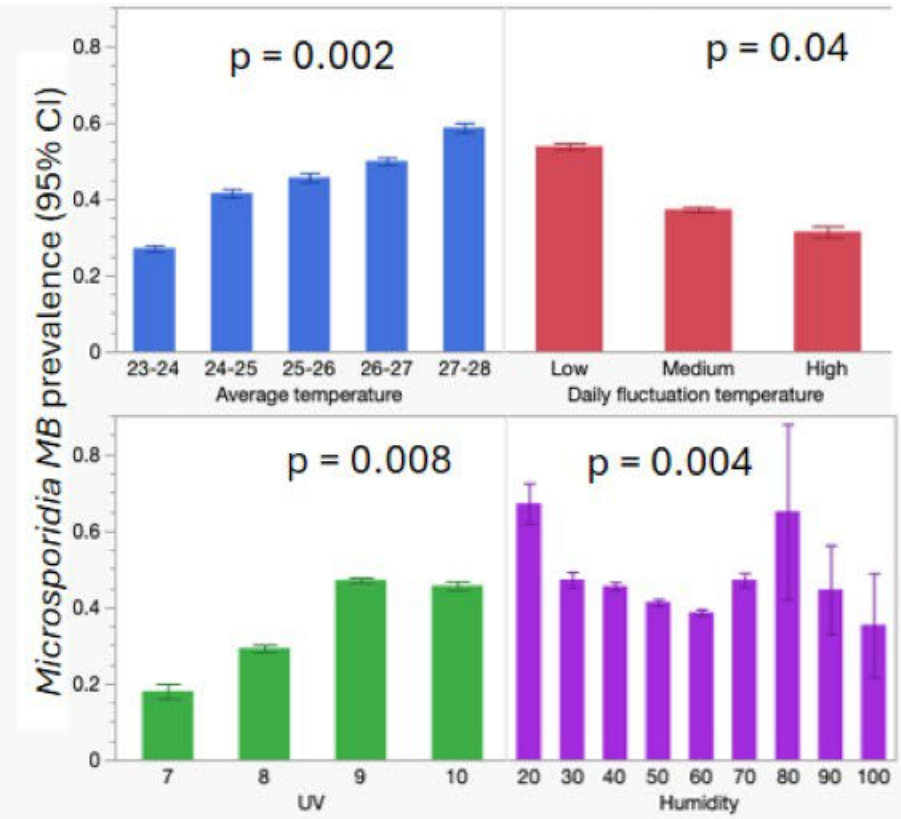
Plasmodium

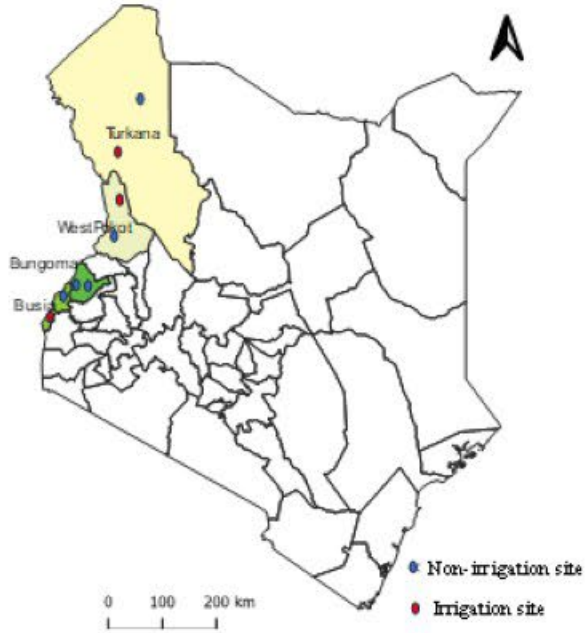
SYMBIOVECTOR

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Microsporidia MB presence











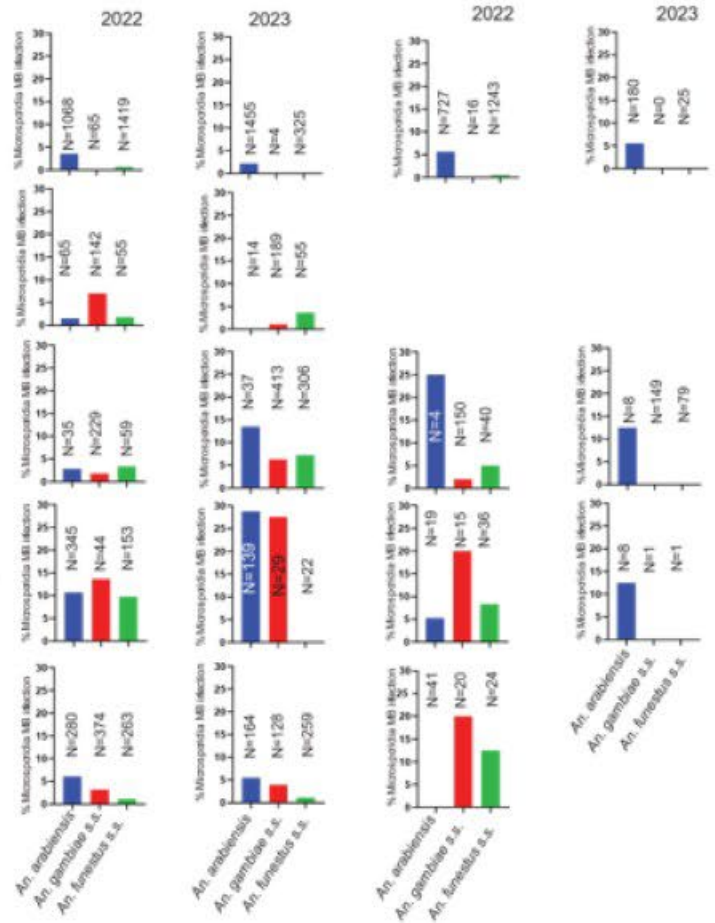
Adults		no.	PL +	MB +	PL prev	MB prev
An. gambiae s.l.	Males	239		2	0	0.84
	Females	234	1	13	0.4	5.56
An. stephensi	Males	171		1	0	0.58
	Females	224	4	18	1.8	8.04



Females



Males



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the African insect science institute

Stakeholder engagement and regulatory pathway

Stakeholder-Informed Development of *Microsporidia MB*-based Malaria Control intervention

Exploratory phase

To understand local perspectives, opportunities, and barriers for malaria control in general, and *Microsporidia MB*-based control in specific, in local communities, county and national health management teams, and regulatory agencies

Formative work
5 locations with diverse culture and malaria epidemiology

Planning phase

Participatory development of locally appropriate communication strategies and regulatory framework to integrate *Microsporidia MB*- based approaches into malaria control interventions.

Community and public engagement activities in target sites with co-researchers to co-develop communication tools and create discussion forums e.g., use of community dialogues / action days or CHPs, village elders/ community theatre groups

Piloting phase

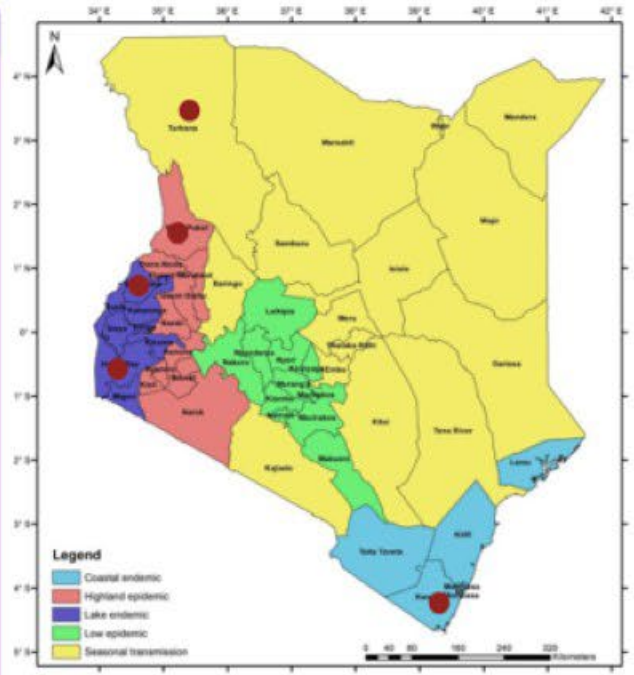
Pre-pilot survey

Community and public engagement activities in target sites to pilot communication tools and create discussion forums

Evaluation phase

Post-pilot survey

Capacity building for symbiont-based vector control and research for national malaria control stakeholders and researchers. community health workers, health management teams, women's groups, and other community gatekeepers.



Data Collection tools:
Open space meetings
Key informant interviews
Focus group discussions
Indepth interviews
Photo voice

554 participants (261 males:293 females)

Communication strategy

Regulatory framework

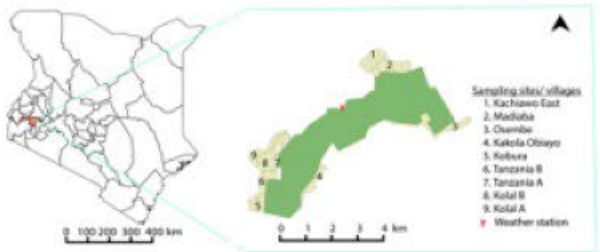


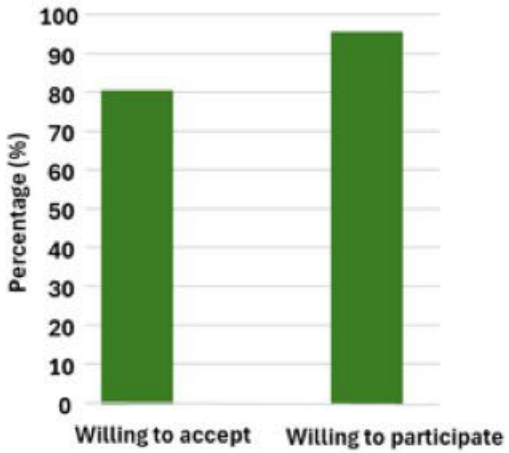






Acceptability and feedback from communities







Microsporidia MB strategy acceptability



Location
Female
Higher Education level
Private business
Perceiving malaria as a low public health issue
No disease experience in the past 6 months
Less knowledge and awareness

Knowledge & Acceptance

- Most participants were unfamiliar with the *Microsporidia MB* strategy.
- Some saw it as a promising malaria control alternative that requires no individual action (Kwale).

Concerns Raised

- Potential health risks to humans, animals, and the environment.
- Genetic mutations and unintended consequences.
- Fear of increased mosquito nuisance after release.
- Doubts about researchers' economic motives.
- Skepticism regarding field trial effectiveness.

Recommendations

- Involve local leaders, health professionals, and key influencers to build trust.
- Continuously assess effectiveness and safety.
- Open communication on trial results and intervention adjustments.
- Customize the strategy to fit socio-cultural and environmental factors. Use local mosquitoes.
- Distribute bed nets and repellents to address immediate malaria concerns.

Additional Suggestions

- Preference for releasing male and female mosquitoes to enhance *Microsporidia MB* transmission.
- Research to increase mating rates of infected male mosquitoes for faster transmission.
- Interest in testing *Microsporidia MB* on sandflies for leishmaniasis control.



Bukhari T., et al 2024, Malaria Journal, 23:113

Acknowledgement

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Vincent Gadi
Paul Okiki
Erick Odoyo
Elizabeth Barasa
Elma Atieno Okeyo
Nancy Mogoi
Vyone Peter
Francis Okomo
Carolyne Owalla
Emmanual Kiprotich
Wiiliam Owigo
Priscille Barreaux
Thomas Onchuru
Rose Marubu
Faith Kyengo

New Members:

Collins Bulinda
Issac Oumar
Kija Nghabi

Former Members:

Joseph Gichuhi
Oscar Mbare

Geremew Guma
Getachew Bokoro
Fekadu Gemechu

Thomas Churcher

Michelle Riehle





Gates Foundation

CIFF CHILDREN'S INVESTMENT FUND FOUNDATION

Coefficient Giving

Donor Acknowledgement



Thank you

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RBM Partnership
To End Malaria

4 March 2026

Lightning talk: African Center for Excellence in Molecular Engineering

Boubacar Tembely, ACEME/USTTB

ACEME
African Center for Excellence in Molecular Engineering

African Center for Excellence in Molecular Engineering

Boubacar Tembely

Research Scientist

btembely@icermali.org

ACEME

Our vision is for African scientists to be at the forefront of developing innovative solutions to fight vector-borne diseases on the continent.



Our vision

Our vision is for African scientists to be at the forefront of developing innovative solutions to combat vector-borne diseases on the continent.



Our mission

We are working to set up a high-level technical team capable of developing genetic vector control tools in Africa..



Outlook

Our platform will help to place African scientists at the heart of the fight against vector-borne diseases, which so severely affect our continent.

ACEME
African Center for Excellence in Molecular Engineering

Who are we?

We are a multidisciplinary team of Malian researchers, which includes specialists in :

- entomology,
- bioinformatics,
- epidemiology,
- ecology-environment,
- regulation,
- stakeholder engagement and communication.



Late Dr Mamadou B Coulibaly



ACEME Team

ACEME
African Center for Excellence in Molecular Engineering

Establishing our Center

At ACEME, we are carrying out the following activities:

1



Regulation

2



Stakeholder Engagement & communication

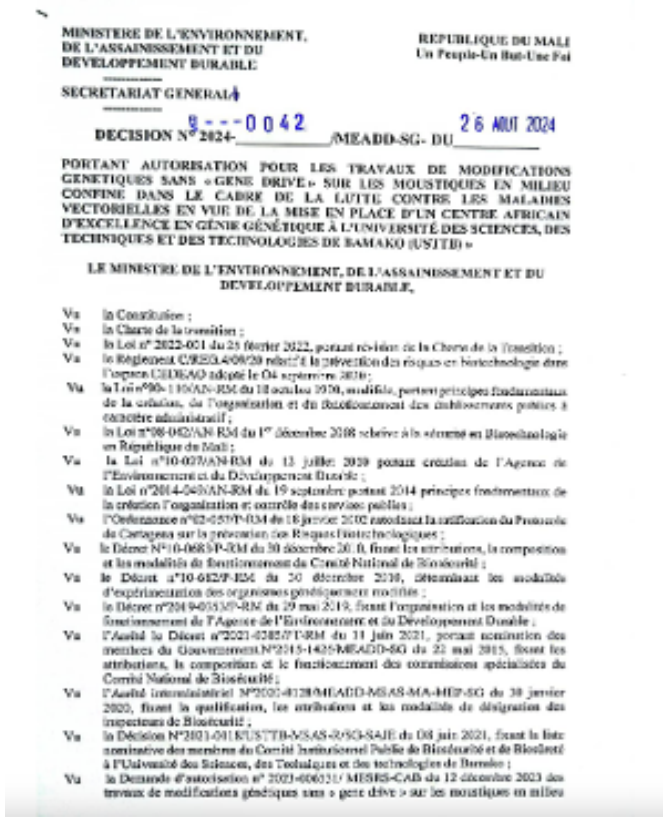
3



Laboratory & Research

ACEME
African Center for Excellence in Molecular Engineering

Establishing our Center: Regulatory



MINISTERE DE L'ENVIRONNEMENT, DE L'ASSAINISSEMENT ET DU DEVELOPPEMENT DURABLE

REPUBLIQUE DU MALI
Un Peuple-Un But-Une Foi

SECRETARIAT GENERAL

DECISION N° 2024-0042/MEADD-SG- DU 26 AOUT 2024

PORTANT AUTORISATION POUR LES TRAVAUX DE MODIFICATIONS GENETIQUES SANS « GENE DRIVE » SUR LES MOUSTIQUES EN MILIEU CONFINE DANS LE CADRE DE LA LUTTE CONTRE LES MALADIES VECTORIELLES EN VUE DE LA MISE EN PLACE D'UN CENTRE AFRICAIN D'EXCELLENCE EN GÉNIE GÉNÉTIQUE À L'UNIVERSITÉ DES SCIENCES, DES TECHNIQUES ET DES TECHNOLOGIES DE BAMAKO (USTTB) »

LE MINISTRE DE L'ENVIRONNEMENT, DE L'ASSAINISSEMENT ET DU DEVELOPPEMENT DURABLE,

Vu la Constitution ;
Vu la Charte de la transition ;
Vu la Loi n° 2022-001 du 25 février 2022, portant révision de la Charte de la Transition ;
Vu le Règlement C/REG.4/09/20 relatif à la prévention des risques en biotechnologie dans l'espace CEDEAO adopté le 04 septembre 2020 ;
Vu la Loi n°90-[illegible]/AN-RM du 18 octobre 1990, modifiée, portant principes fondamentaux de la création, de l'organisation et du fonctionnement des établissements publics à caractère administratif ;
Vu la Loi n°08-082/AN-RM du 1er décembre 2008 relative à la sécurité en Biotechnologie en République du Mali ;
Vu la Loi n°10-037/AN-RM du 13 juillet 2010 portant création de l'Agence de l'Environnement et du Développement Durable ;
Vu la Loi n°2014-040/AN-RM du 19 septembre portant 2014 principes fondamentaux de la création l'organisation et contrôle des services publics ;
Vu l'Ordonnance n°02-053/P-RM du 18 janvier 2002 ratifiant la ratification du Protocole de Cartagena sur la prévention des Risques biotechnologiques ;
Vu le Décret N°10-068/P-RM du 30 décembre 20[illegible] fixant les attributions, la composition et les modalités de fonctionnement du Comité National de Biosécurité ;
Vu le Décret n°10-682/P-RM du 30 décembre 2010, déterminant les modalités d'expérimentation des organismes génétiquement modifiés ;
Vu le Décret n°2019-0[illegible]/P-RM du 29 mai 2019, fixant l'organisation et les modalités de fonctionnement de l'Agence de l'Environnement et du Développement Durable ;
Vu l'Arrêté le Décret n°2021-0285/PT-RM du 11 juin 2021, portant nomination des membres du Gouvernement N°2015-1425/MEADD-SG du 22 mai 2015, fixant les attributions, la composition et le fonctionnement des commissions spécialisées du Comité National de Biosécurité ;
Vu l'Arrêté interministériel N°2020-0128/MEADD-MSAS-MA-MEP-SG du 30 janvier 2020, fixant la qualification, les attributions et les modalités de désignation des inspecteurs de Biosécurité ;
Vu la Décision N°2021-041/USTTB-MSAS-R/SG-SAJE du 08 juin 2021, fixant la liste nominative des membres du Comité Institutionnel Public de Biosécurité et de Bioéthique à l'Université des Sciences, des Techniques et des technologies de Bamako ;
Vu la Demande d'autorisation n° 2021-0006231/ MESRS-CAB du 12 décembre 2023 des travaux de modifications génétiques sans « gene drive » sur les moustiques en milieu

Approval of the Ministry of Environnement/ National Biosafety Committee

- To ensure regulatory approvals and compliance of activities.
- Importation of *Anopheles gambiae* G3 eggs from Keele University, UK to Bamako, Mali.



Reception by NBC & IBC

ACEME
African Center for Excellence in Molecular Engineering

Establishing our center: Research Lab

Mosquito Colony Establishment

↓

Design of the construct

↓

Molecular Cloning

↓

Embryo Microinjection

↓

Transgenic Line Generation





Transgenic larva

ACEME
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Establishing our center: Research Lab

- Training researchers in molecular biology at Keele University, UK,
- A collaboration between:

U.S.T.T-B

Keele UNIVERSITY

ACEME
African Center for Excellence in Molecular Engineering

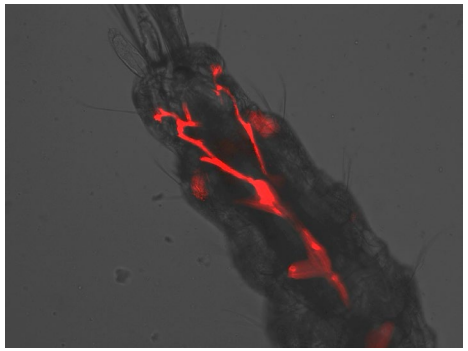
Training and Research Lab



Boubacar TEMBELY

- Generated CRISPR constructs targeting X-chromosome genes in *An. gambiae*
- Disrupted genes involved in Hybrid Male Sterility (HMS)
- Targeted female haploinsufficient genes for functional analysis.

Anopheles eggs embryo injection



Transient larva

Transgenic larva

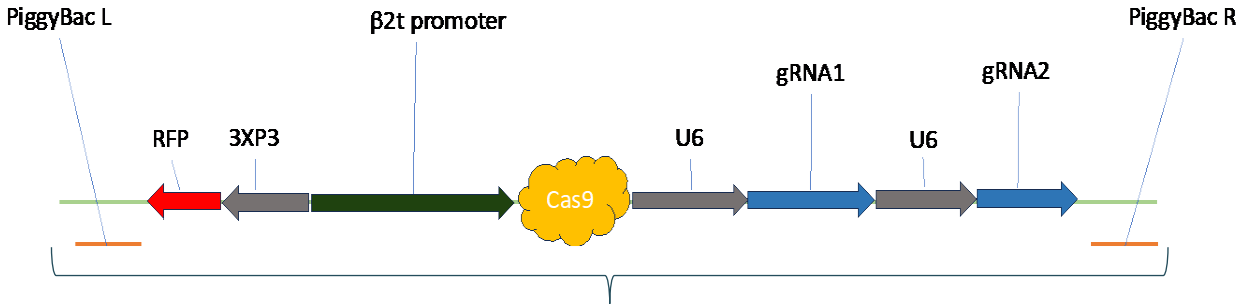
ACEME
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Training and Research Lab



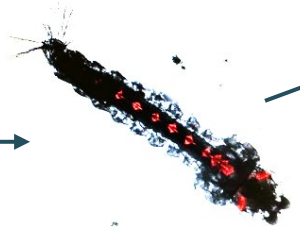
Lakamy SYLLA

- Generated CRISPR constructs targeting the β2-tubulin gene during mosquito male meiosis to impair male fertility
- Developed CRISPR interference (CRISPRi) constructs to suppress gene expression in the mosquito germline and reduce fertility.

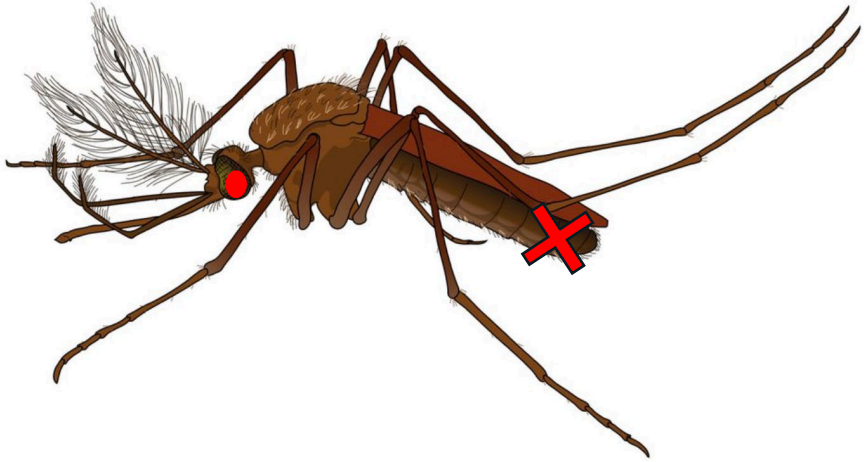




An. gambiae eggs



Transgenic larva



Male fertility affected

ACEME
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ACEME Lab Equipment

We are fully capable of performing molecular cloning and microinjections



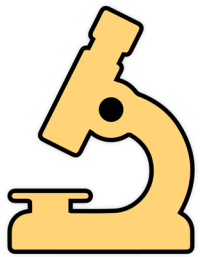
Laboratory



Microinjection station

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African Center for Excellence in Molecular Engineering

Next step



1. Generate non gene drive lines by targeting some genes linked to linked to female fertility in *Anopheles gambiae*

2. Organize short in situ training in Mali for African scientist



3. Receive African underground, MSc and PhD students at ACEME for benchworks.

ACEME
African Center for Excellence in Molecular Engineering

Acknowledgements

U.S.T.T-B

IDMERTC
Infectious Diseases and Medical Entomology Research and Training Center

Keele UNIVERSITY

emerging ag inc.

LSTM
LIVERPOOL SCHOOL OF TROPICAL MEDICINE

Consultant:
- **Cambea consult**

Acknowledgements

ACEME receives core funding from the Gates Foundation.

Gates Foundation

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THANKS

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RBM Partnership
To End Malaria

4 March 2026

Lightning talk: African-led innovation in gene drives: lessons, risks, and opportunities from Transmission Zero

George Christophides, Imperial College London

AFRICAN-LED INNOVATION IN GENE DRIVES:
lessons, risks, and opportunities from Transmission Zero

George K. Christophides

IMPERIAL

transmission zero

Malaria:
Stalled Progress Demands New Thinking

- 250M+ cases, 600k+ deaths annually
- Rising insecticide & drug resistance
- Current tools alone are not enough

Transmission Zero: African-Led Gene Drive Innovation

- Develop gene drive mosquitoes that block transmission
- Generated & tested in Tanzania
- Built on co-ownership & local leadership

From Laboratory Concept to Field-Relevant Validation

- Engineered in Tanzania
- Tested against parasites from infected children
- Strong suppression of transmission potential

Lessons from African-Led Innovation

Scientific Sovereignty

- Decision-making authority matters

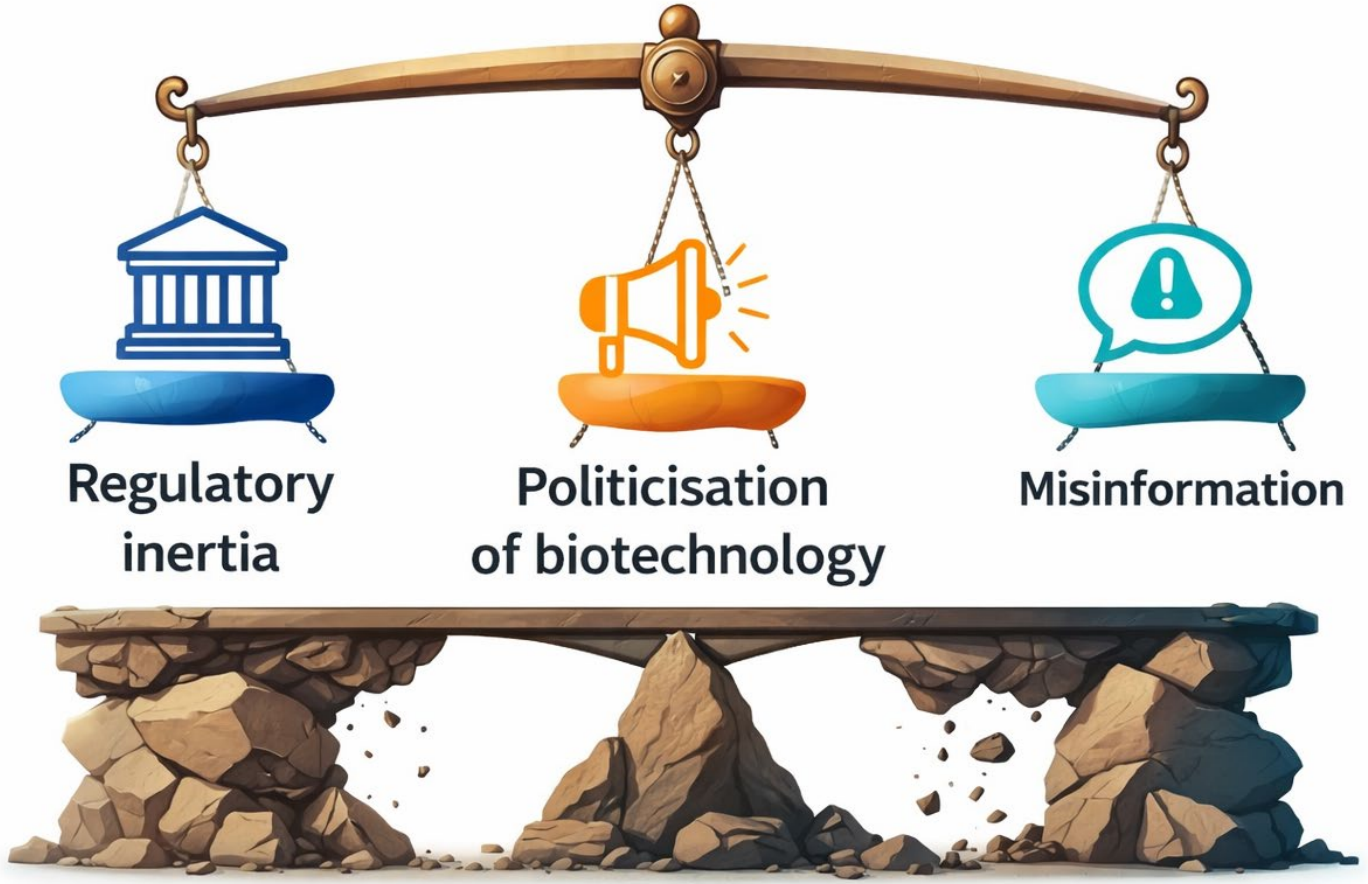
Tiered Regulation

- Fit-for-purpose oversight
- Institutional → National → Deployment

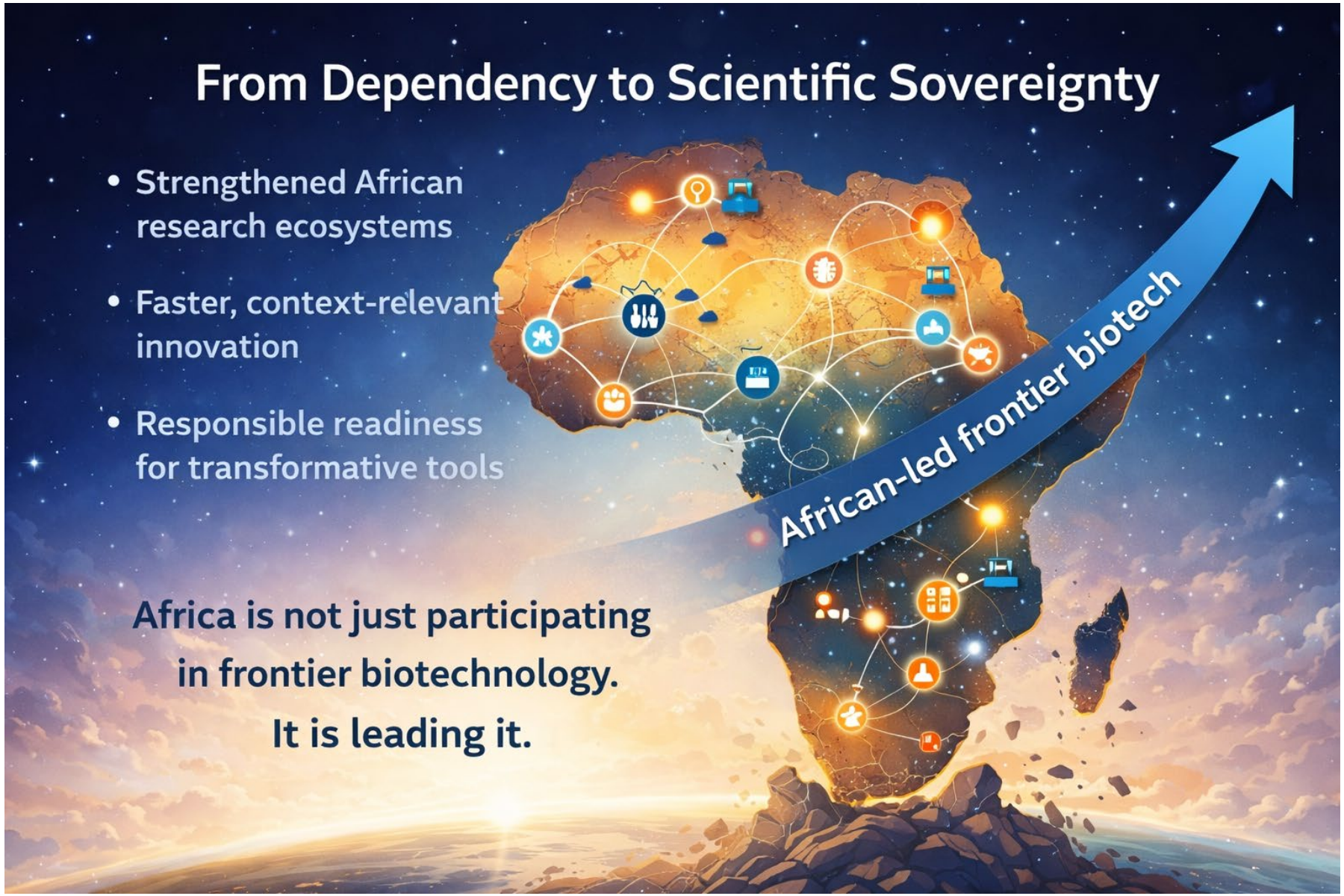
Social Legitimacy

- Continuous dialogue
- Accountable leadership

The Real Risks Are Institutional



Innovation fails when governance lags behind capability.


From Dependency to Scientific Sovereignty
• Strengthened African research ecosystems
• Faster, context-relevant innovation
• Responsible readiness for transformative tools
African-led frontier biotech
Africa is not just participating in frontier biotechnology. It is leading it.

RBM Partnership
To End Malaria

4 March 2026

Lightning talk: Transmission mechanisms of a malaria parasite blocking symbiont, Microsporidia MB, in *Anopheles mosquitoes*

Thomas Onchuru, ICIPE

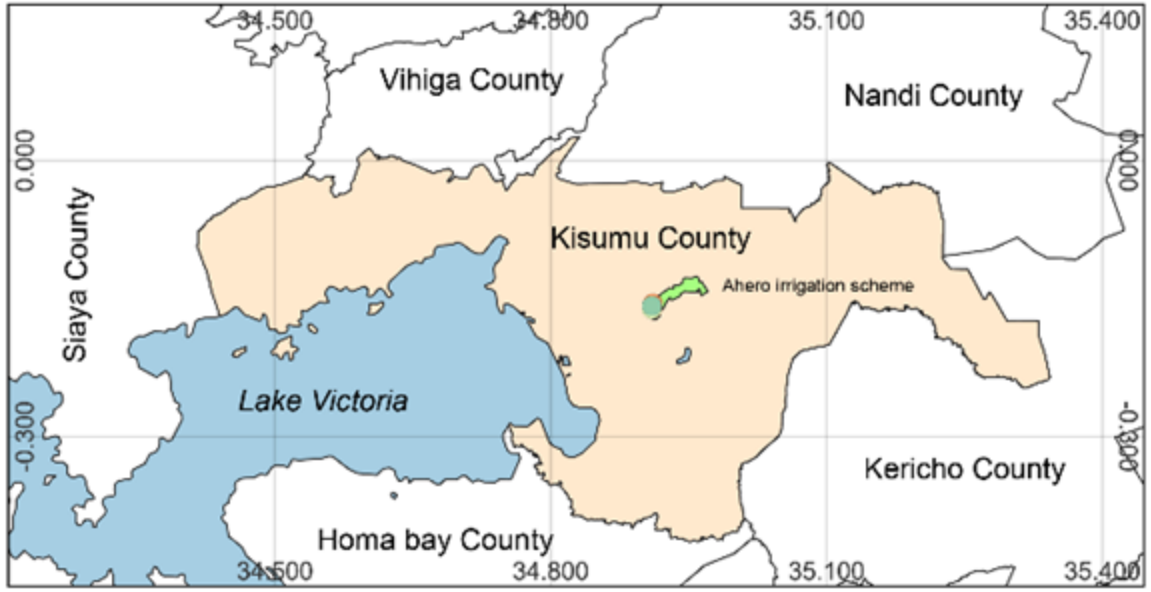
icipe
The TROpical Insect Science Institute

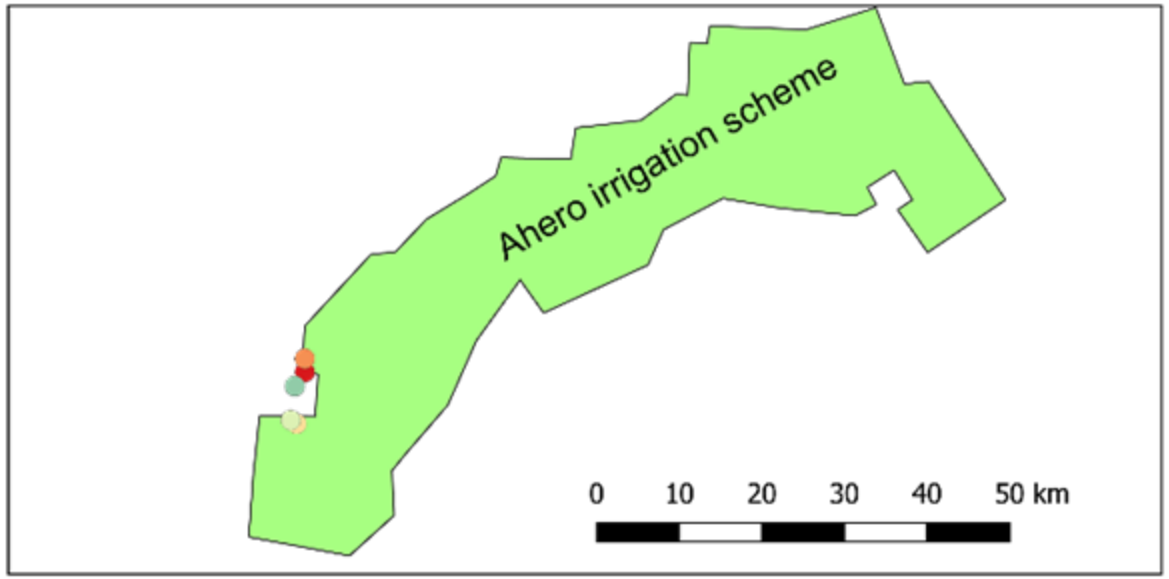
Transmission mechanisms of *Microsporidia MB,* a malaria blocking symbiont

Thomas Onchuru

SYMBIO VECTOR

Microsporidia MB distribution and its effect on *Plasmodium* prevalence in Ahero





Weekly fieldwork for 2.5 years

> 120, 000 *An. arabiensis* collected maintained in the insectary for 4-5 days

~ 40,000 screened for *Microsporidia MB*

~ 20,000 screened for *Plasmodium*

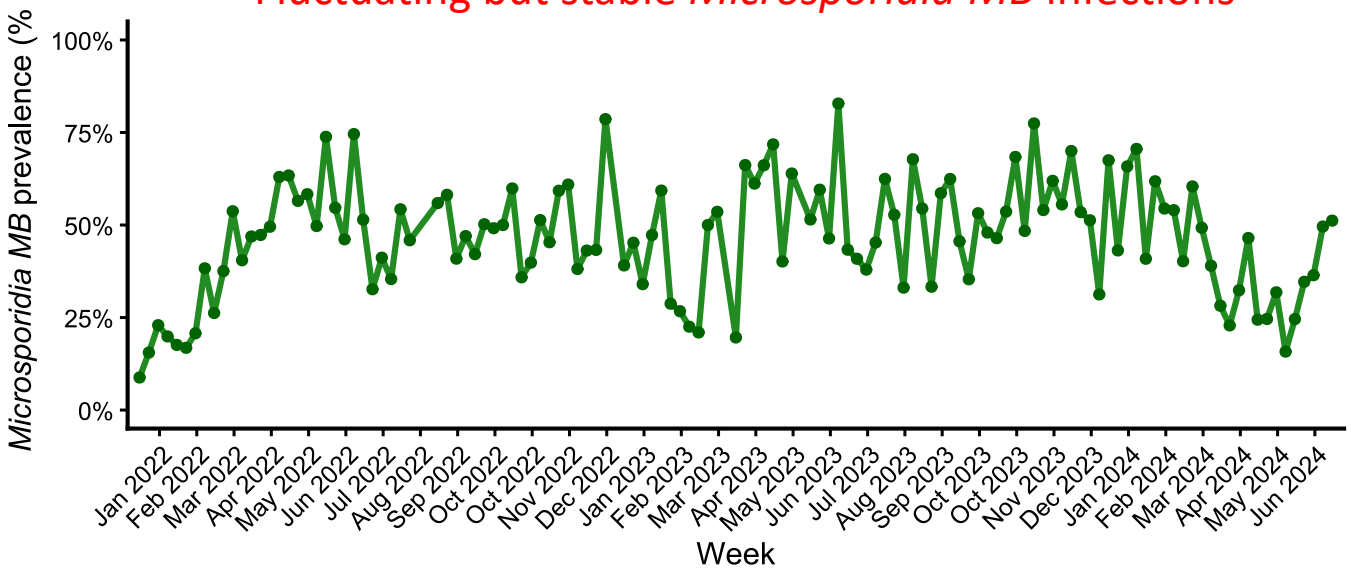
Microsporidia MB distribution and its effect on *Plasmodium* prevalence in Ahero

> 100, 000 *An. arabiensis* collected

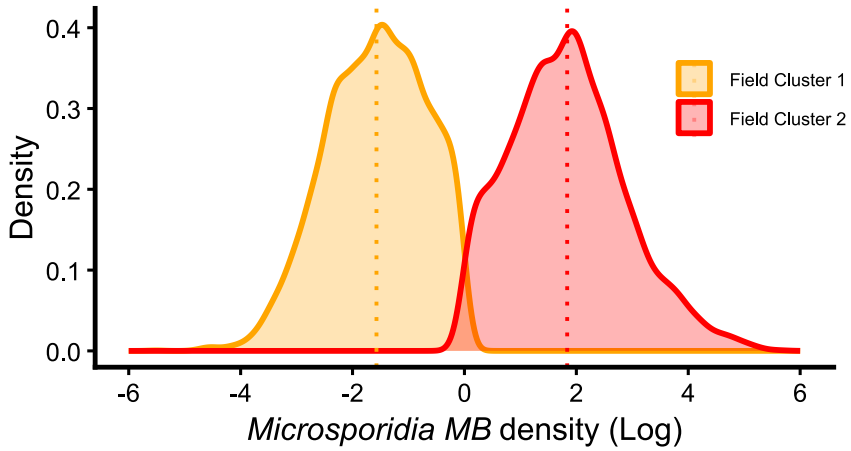
~ 40,000 screened for *Microsporidia MB*

~ 20,000 screened for *Plasmodium*

Fluctuating but stable *Microsporidia MB* infections



High & low intensity infections exist in the wild



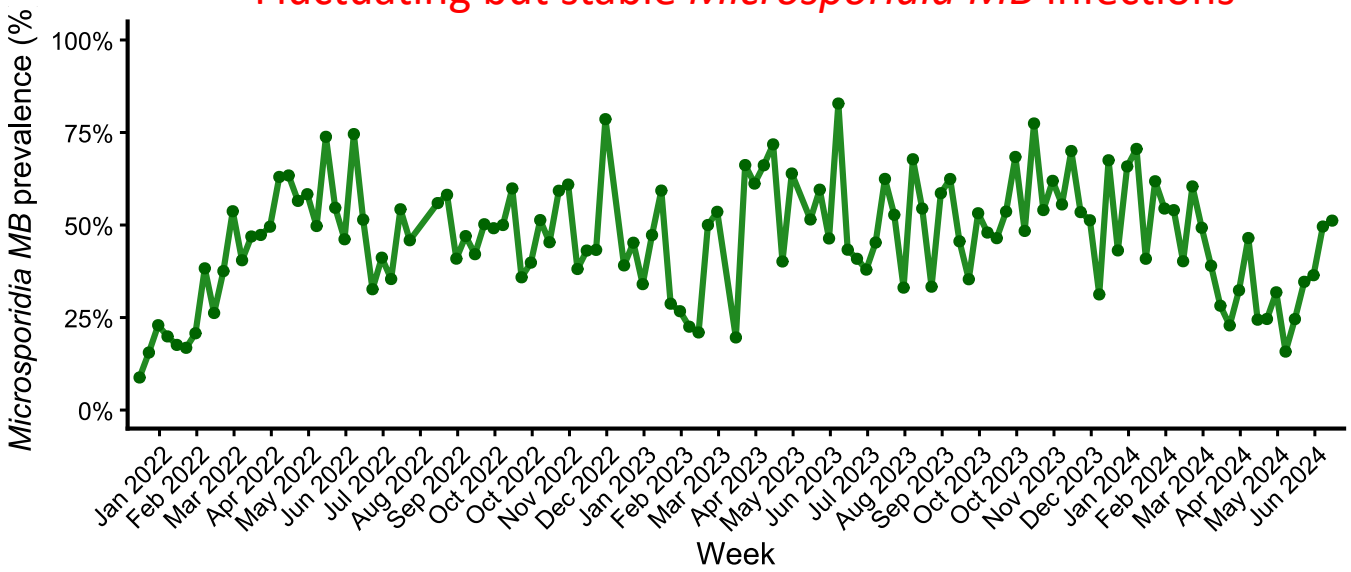
Microsporidia MB distribution and its effect on *Plasmodium* prevalence in Ahero

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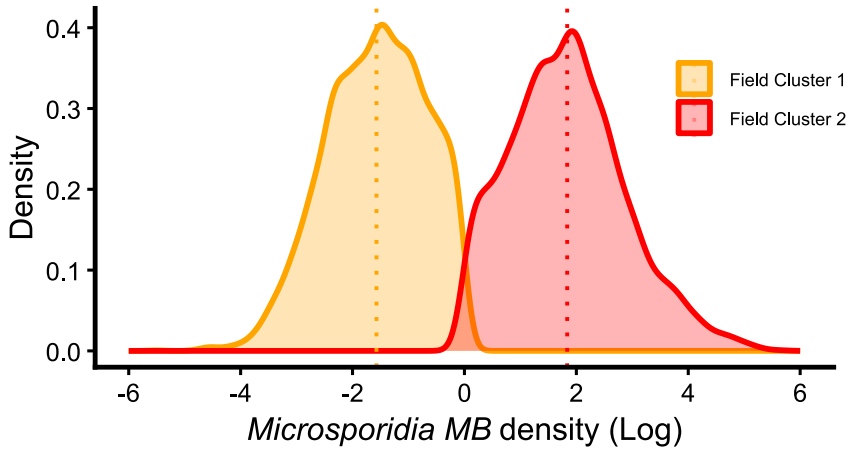
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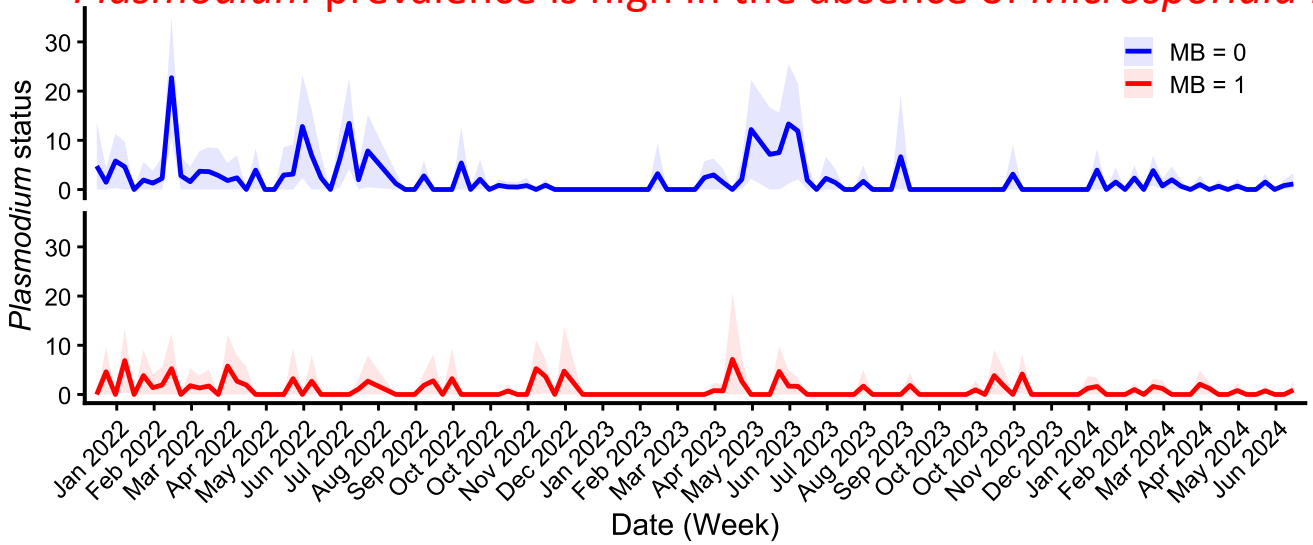
Fluctuating but stable *Microsporidia MB* infections



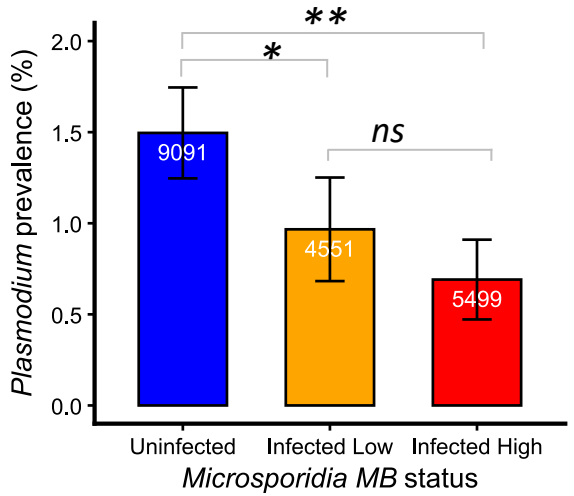
High & low intensity infections exist in the wild

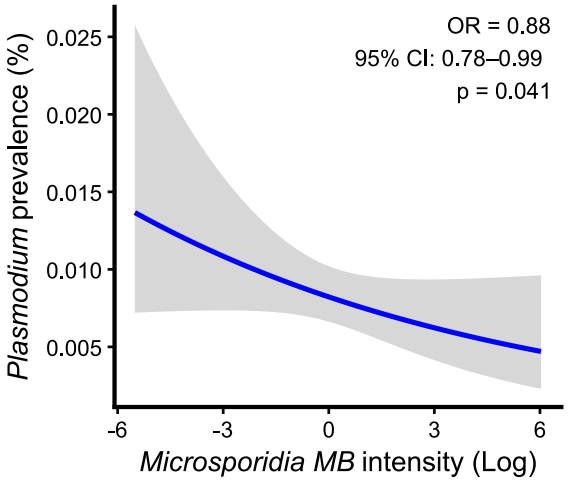


Plasmodium prevalence is high in the absence of *Microsporidia MB*

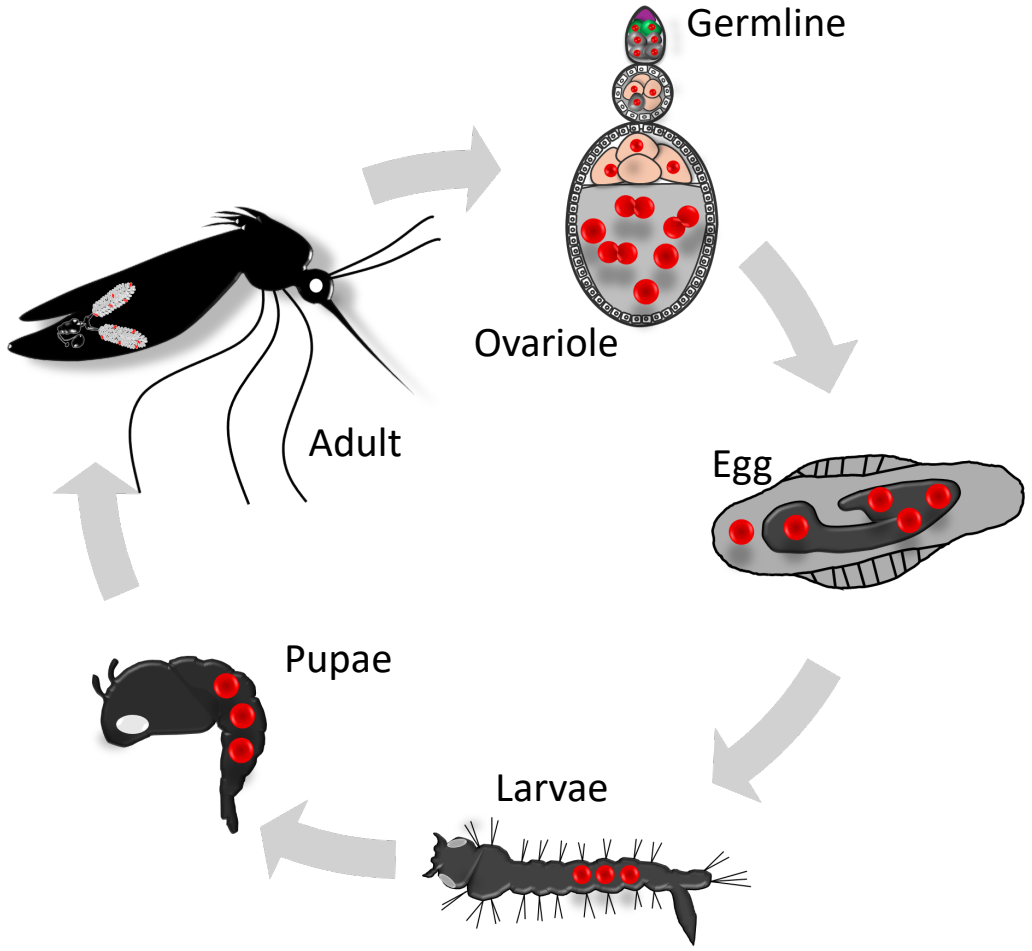


Plasmodium blocking is density dependent



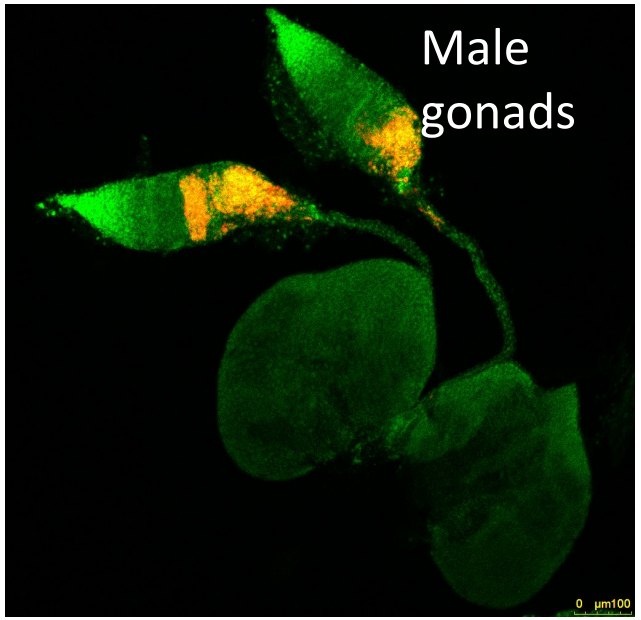


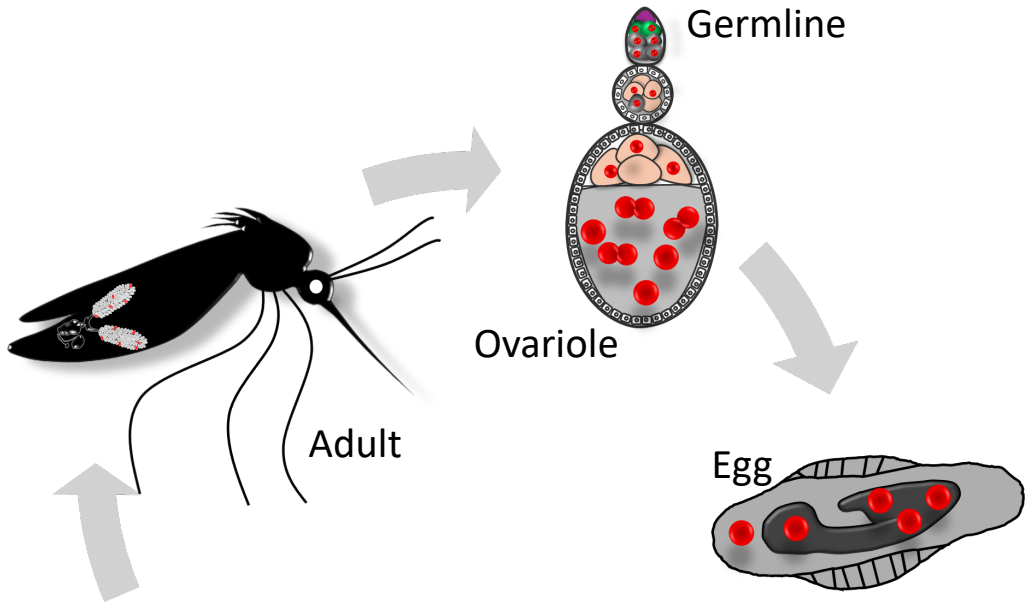
Microsporidia MB spreads naturally from Mother-to-offspring

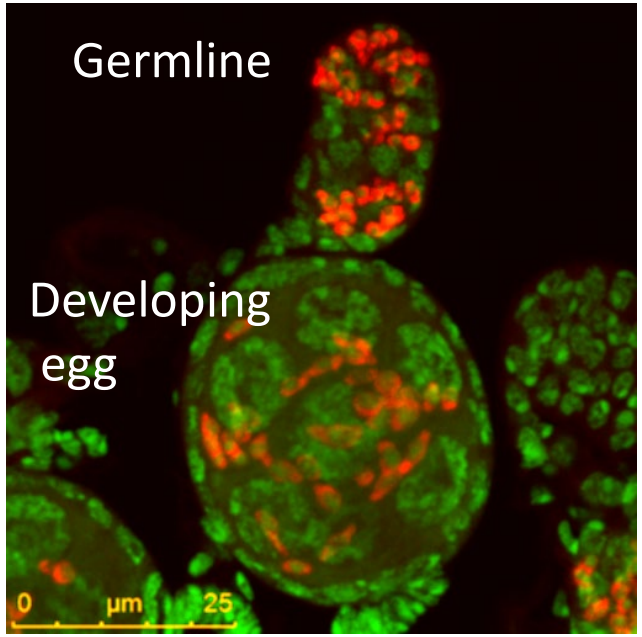


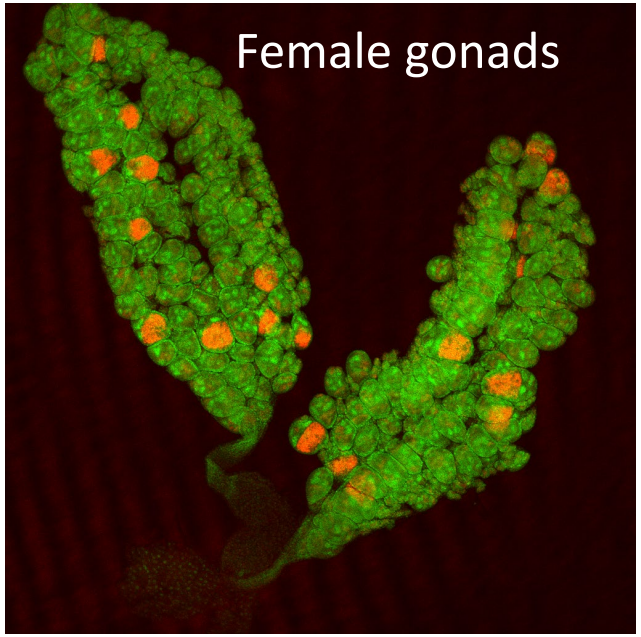
Red = *Microsporidia MB*, Green = DNA

Microsporidia MB spreads naturally from Mother-to-offspring

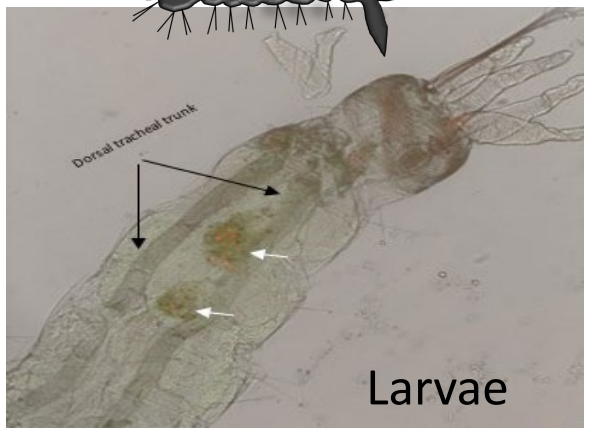


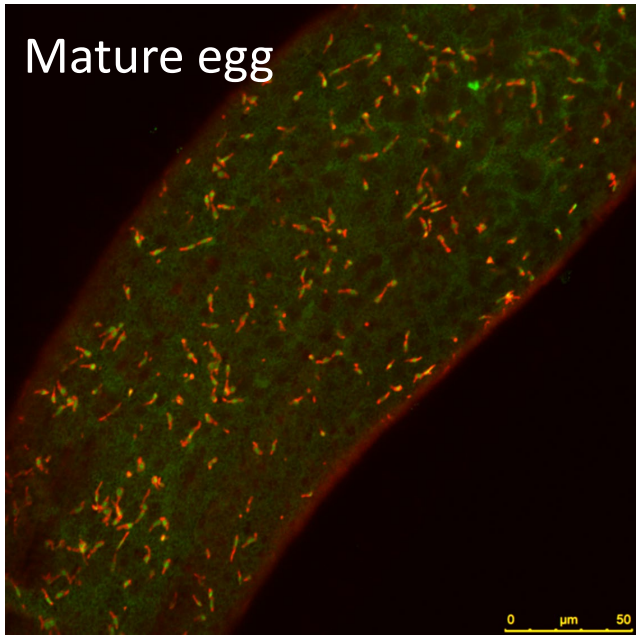




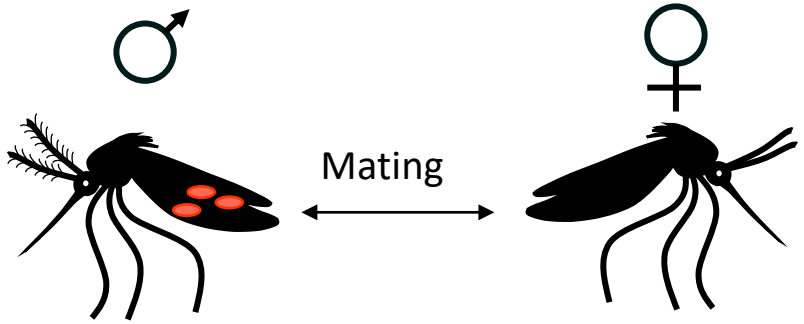


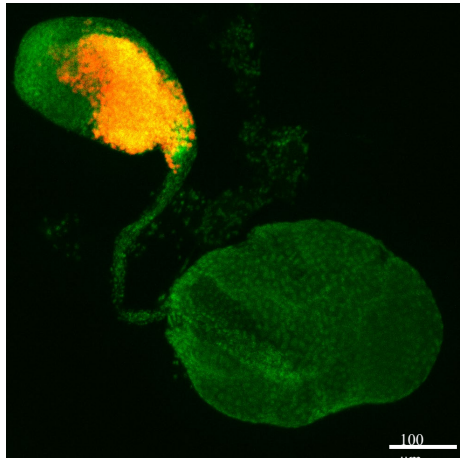
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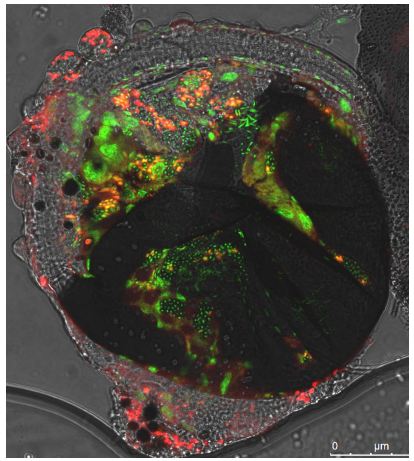


Microsporidia MB spreads naturally through mating (Horizontal transmission)





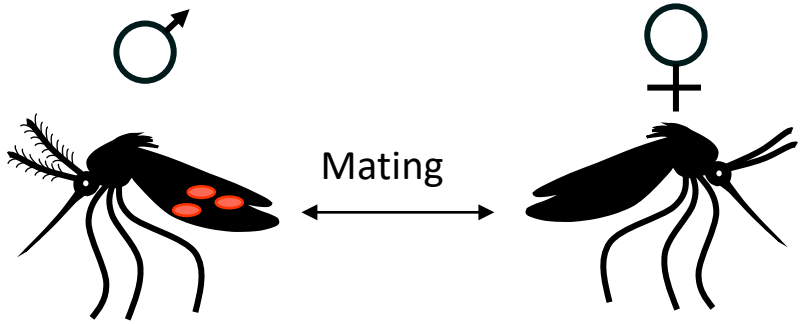
Microsporidia MB in **male testis**

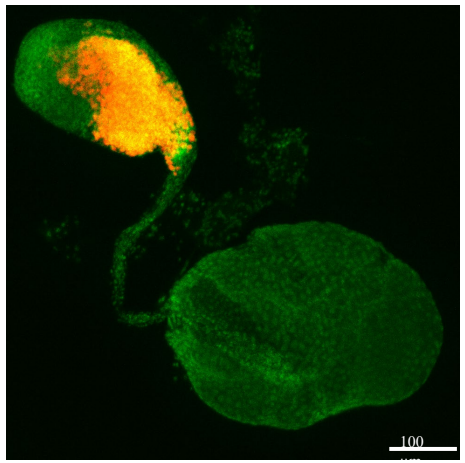


Microsporidia MB in Spermathecae with **sperms**

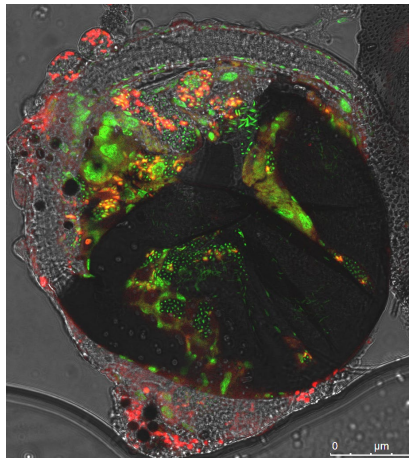
Microsporidia MB transferred to female spreads to the ovary to infect developing eggs

Microsporidia MB spreads naturally through mating (Horizontal transmission)

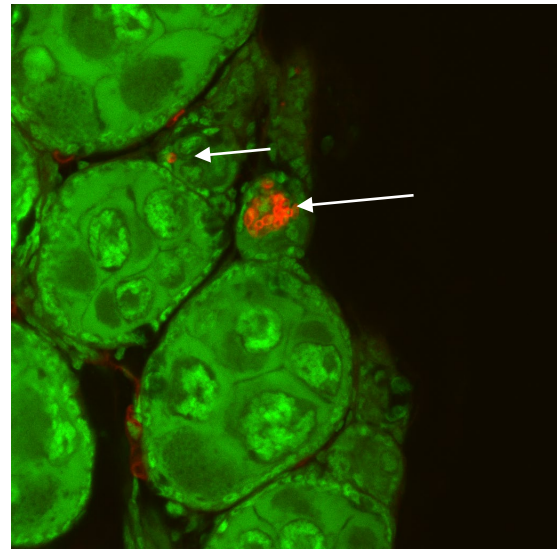




Microsporidia MB in **male testis**



Microsporidia MB in Spermathecae with **sperms**



Microsporidia MB transferred to female spreads to the ovary to infect developing eggs

Acknowledgement



Gates Foundation

Coefficient Giving

wellcome

CIFF CHILDREN'S INVESTMENT FUND FOUNDATION

SYMBIO VECTOR

Thank you

www.icipe.org

RBM Partnership
To End Malaria

4 March 2026

Lightning talk: Mapping the potential use cases and impact of Wolbachia for malaria control in WHO African region

Preethi Lakshminarayanan, London School of Hygiene and Tropical Medicine

Mapping the potential use cases and impact of *Wolbachia* for malaria control in WHO African region

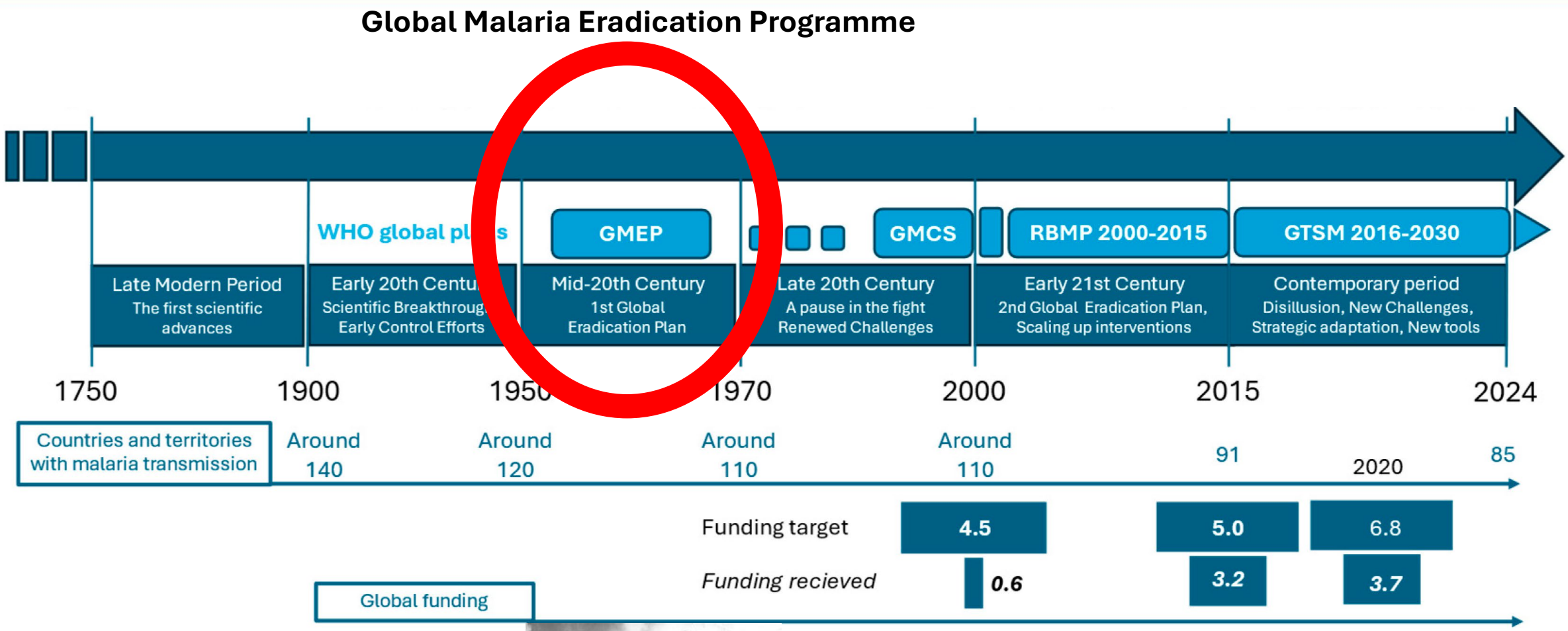
Preethi Lakshminarayanan
PhD candidate at LSHTM

Supervised by Prof Oliver Brady and Prof Thomas Walker

VCWG workshop, Nairobi
3-5th March 2026

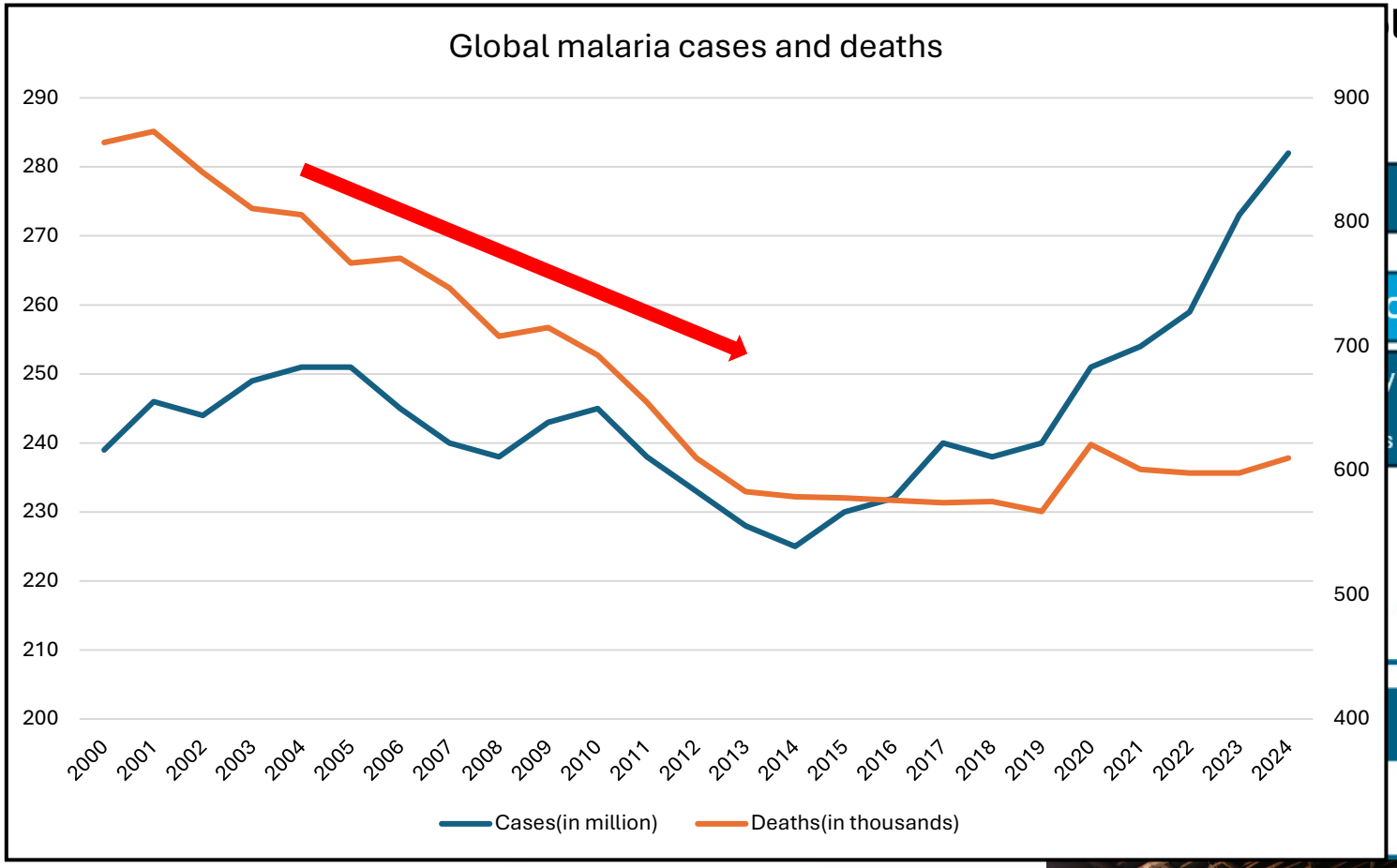
LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

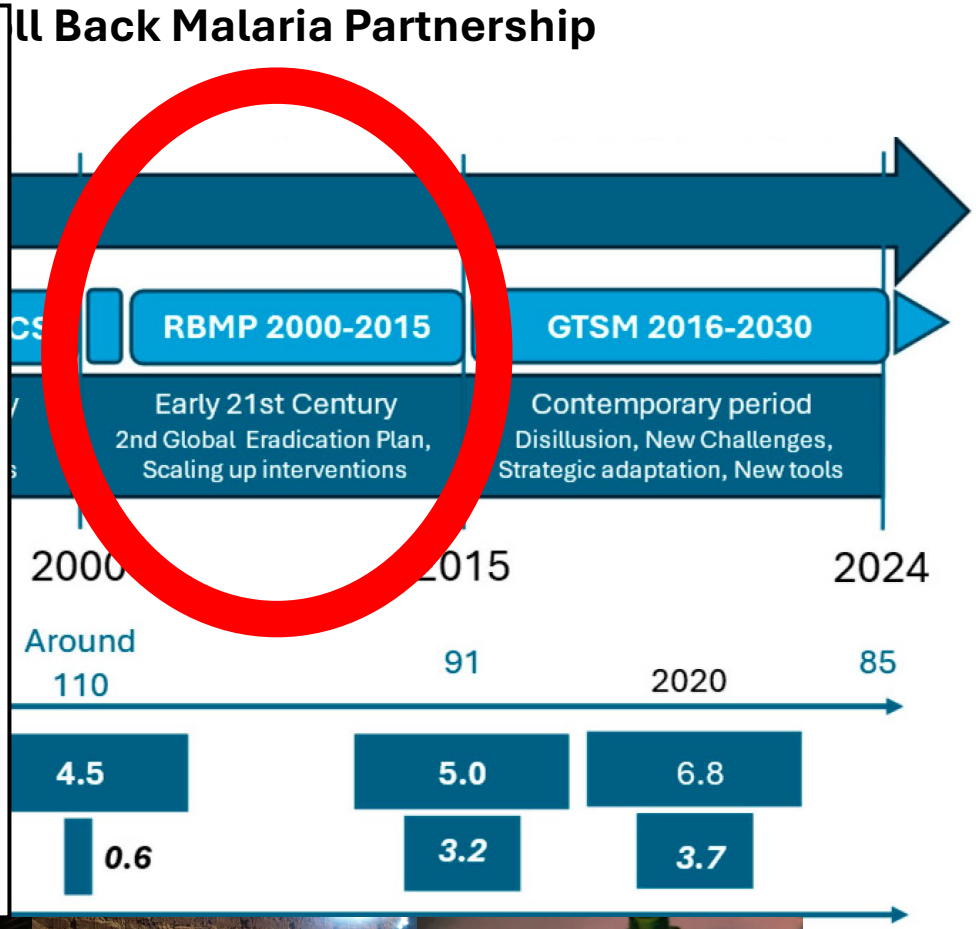
How has malaria control evolved over time?



(Thellier et al., 2024)

How has malaria control evolved over time?





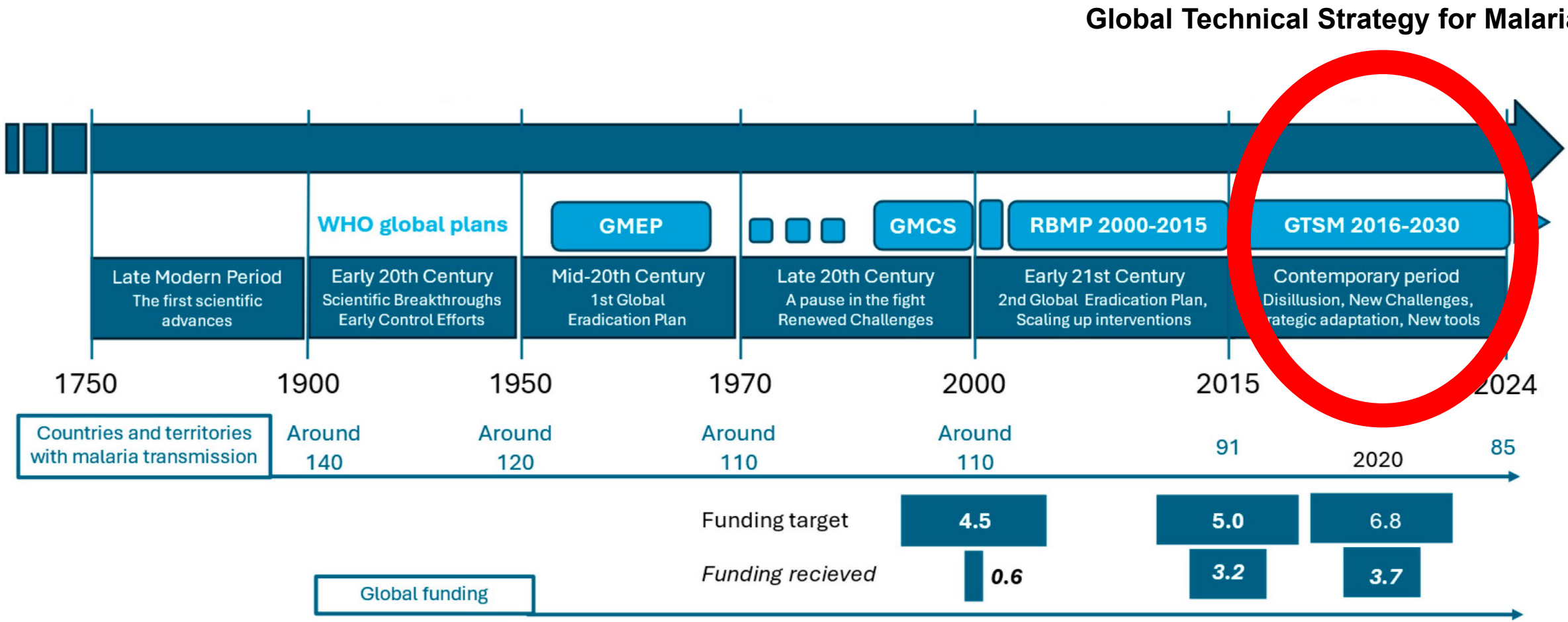






(Thellier et al., 2024)

How has malaria control evolved over time?



(Thellier et al., 2024)

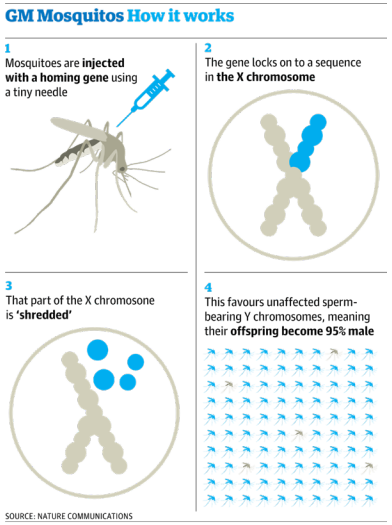
What new tools have come in this period?



Vaccines



Attractive toxic sugar baits



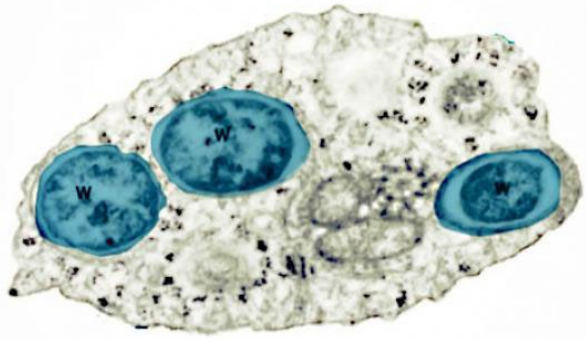
Genetic Modification strategies



Endectocides

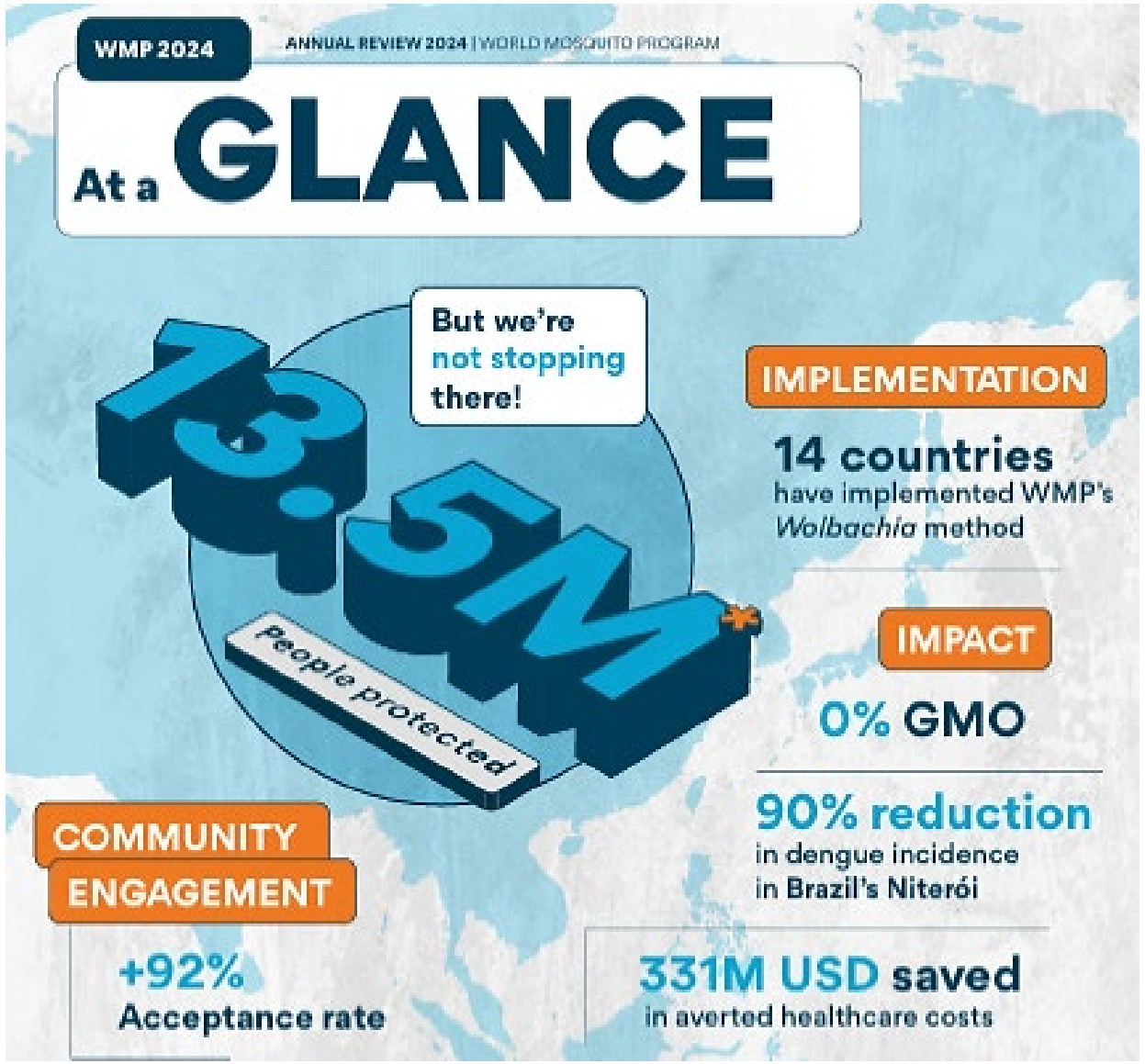


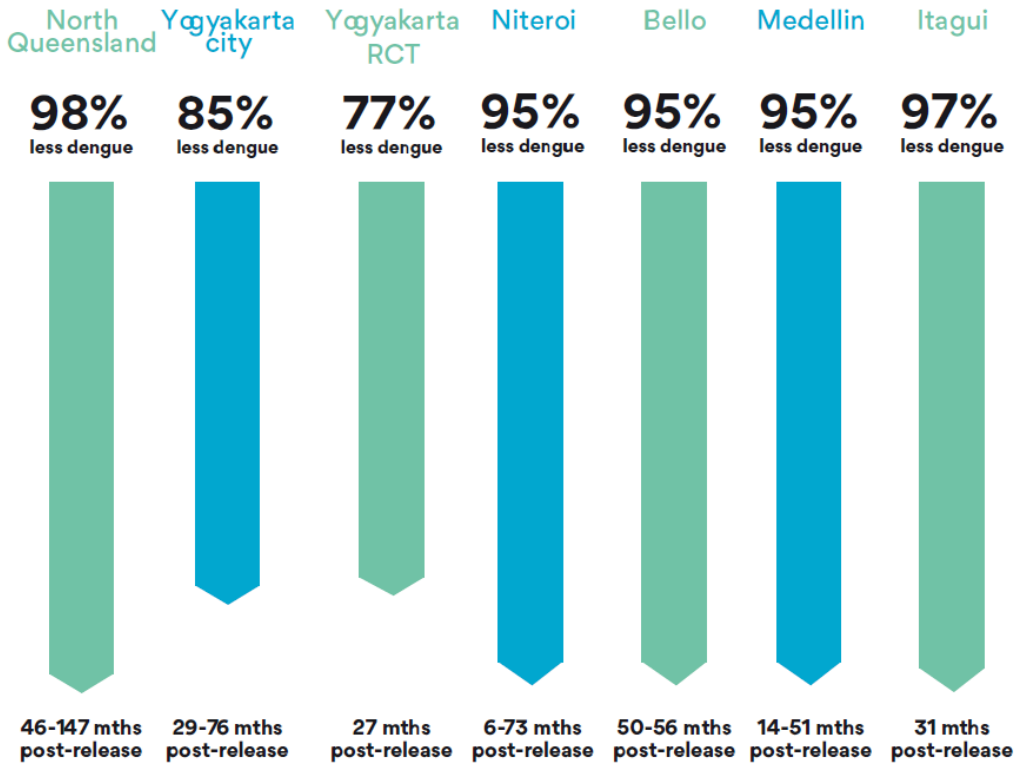
Eave tube



Wolbachia

World Mosquito Program: Real-World Impact of *Wolbachia*









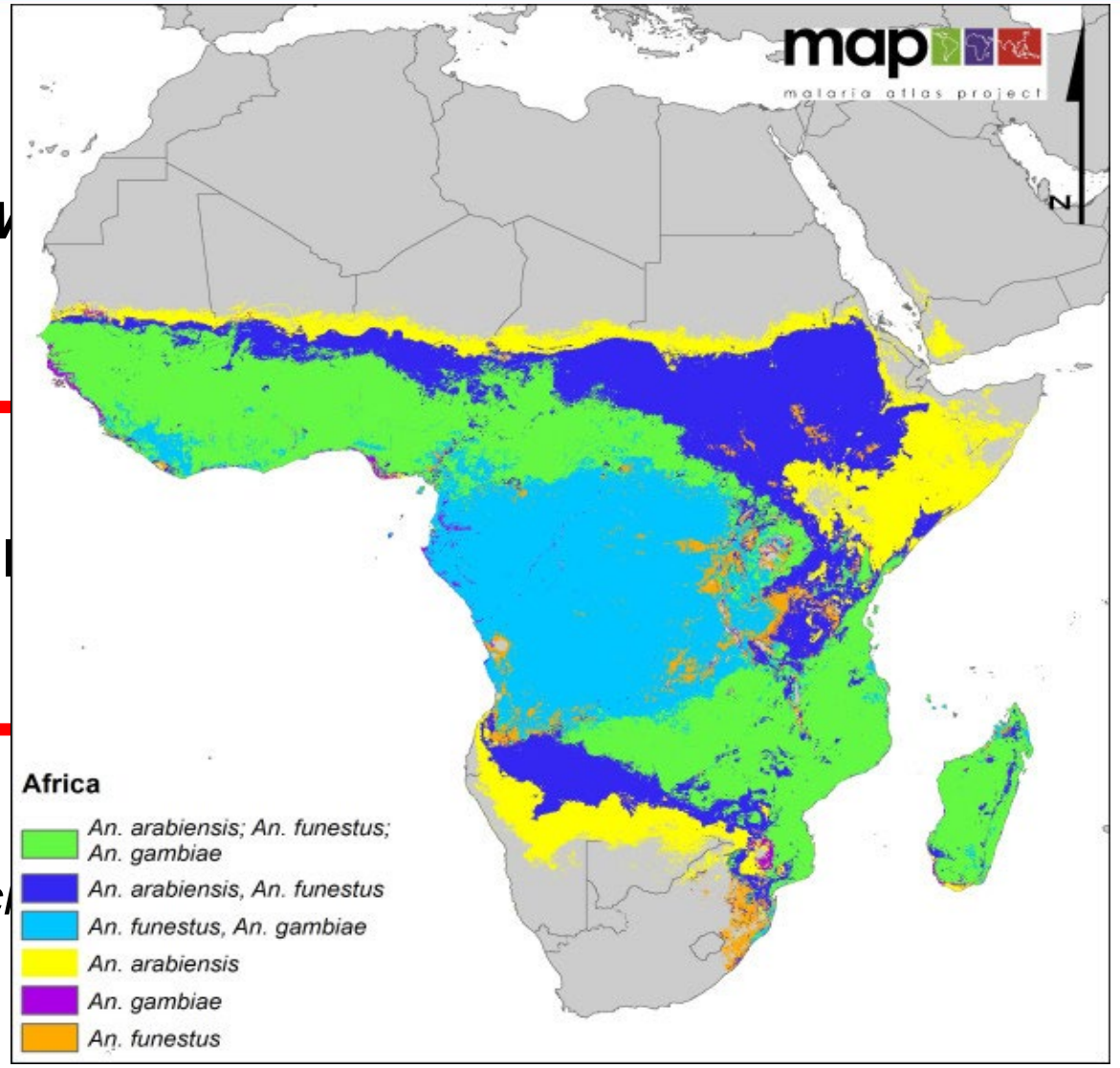
(*Annual Review 2024*, n.d.)

What is needed?

Learn from **existing framework for use of *W***

Identify **where** and **with which species** coul

Model the **feasibility and impact** of *Wolbac*



Methods

Geospatial modelling



Where?

Question	Use case	PfPR	ITN use rate	Vector dominance
Can it establish?	**Entomological demonstration**	Low	Low	High
Does it reduce transmission	**Epidemiological demonstration**	High	Low	High
Can it provide additional impact along with other interventions	**Routine implementation**	High	High	High
Can it accelerate progress towards malaria elimination	**Elimination support**	Very low	High	High

Which species to invest in?



An. arabiensis

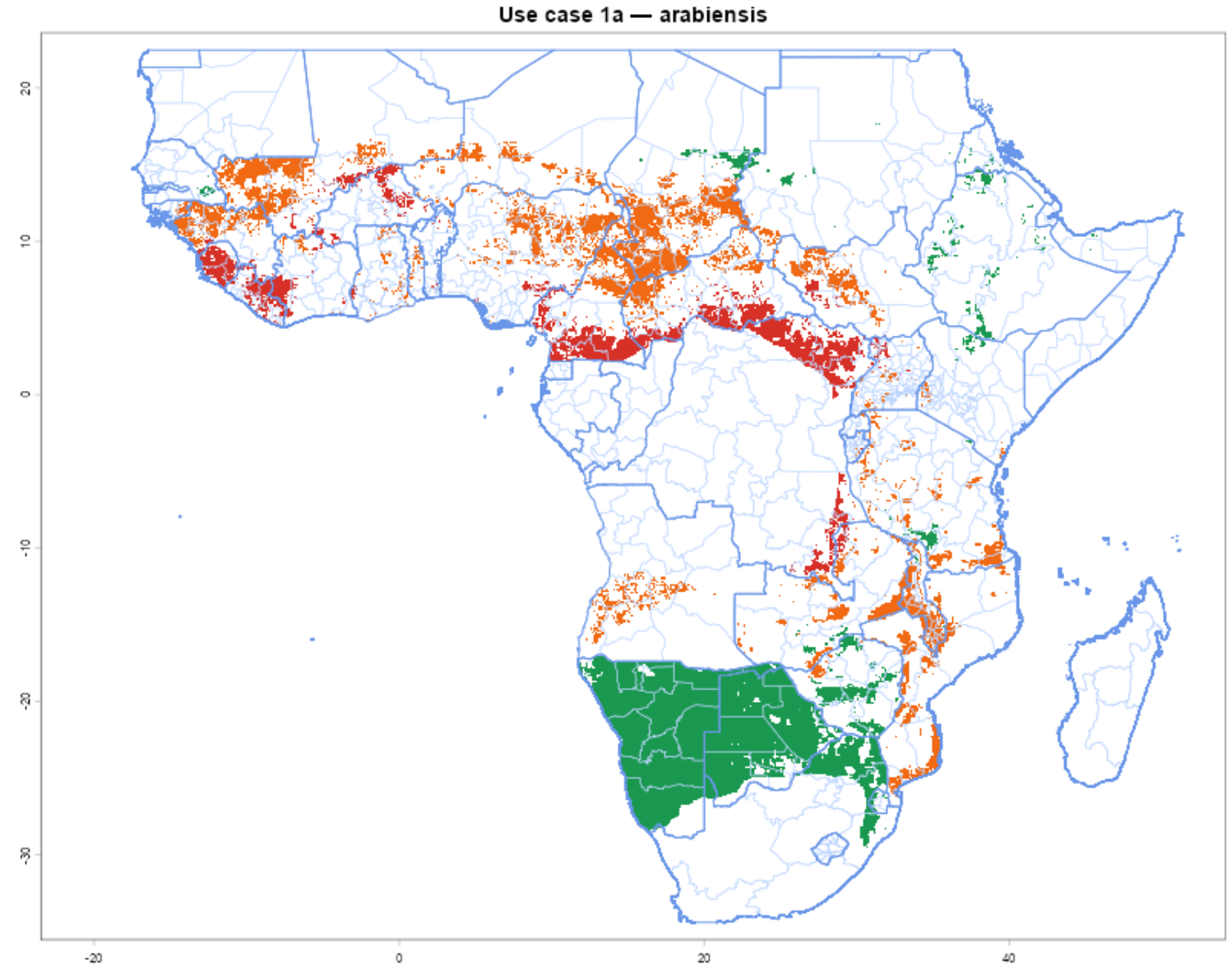


An. coluzzii



An. moucheti

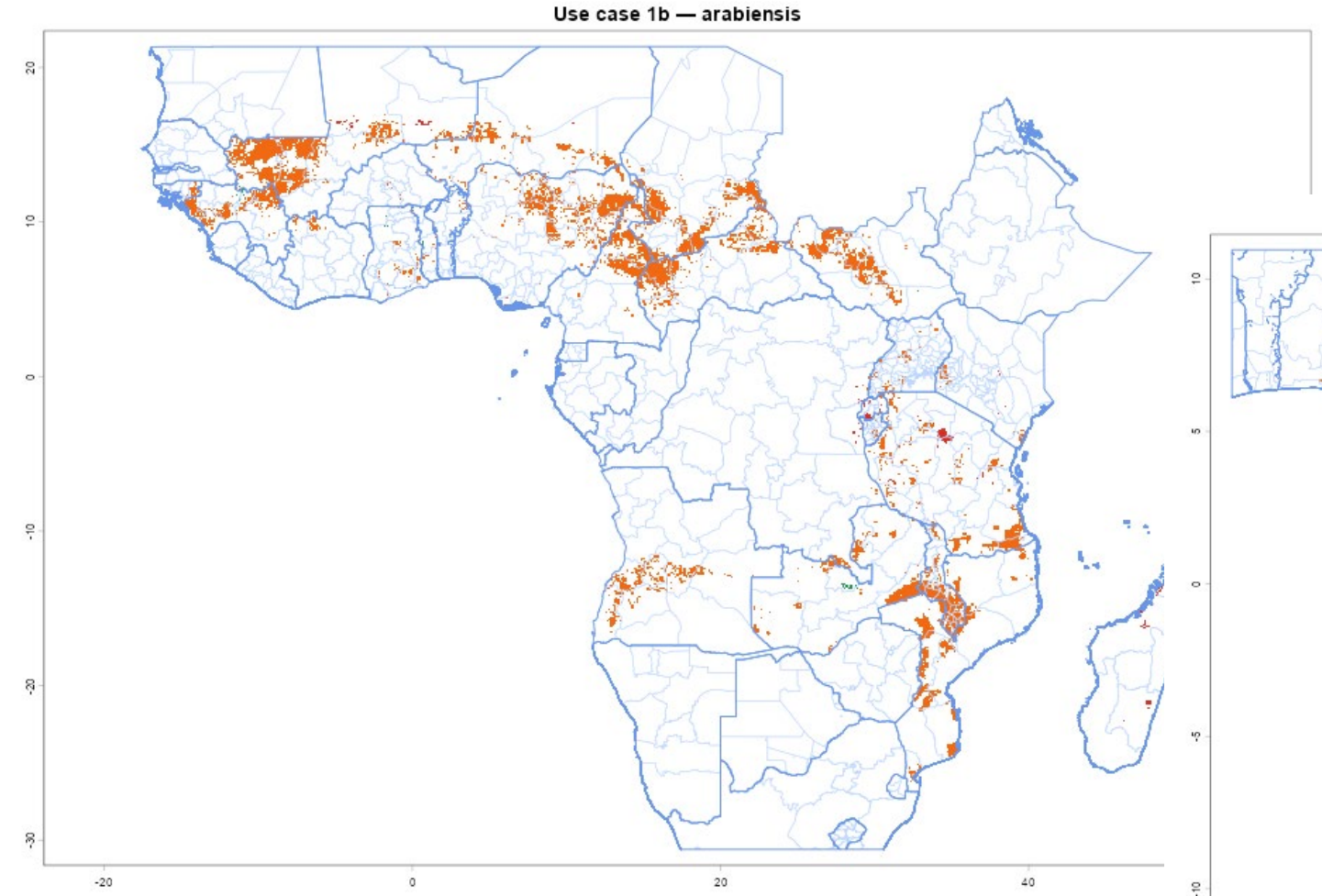
Use case 1a: Entomological demonstration



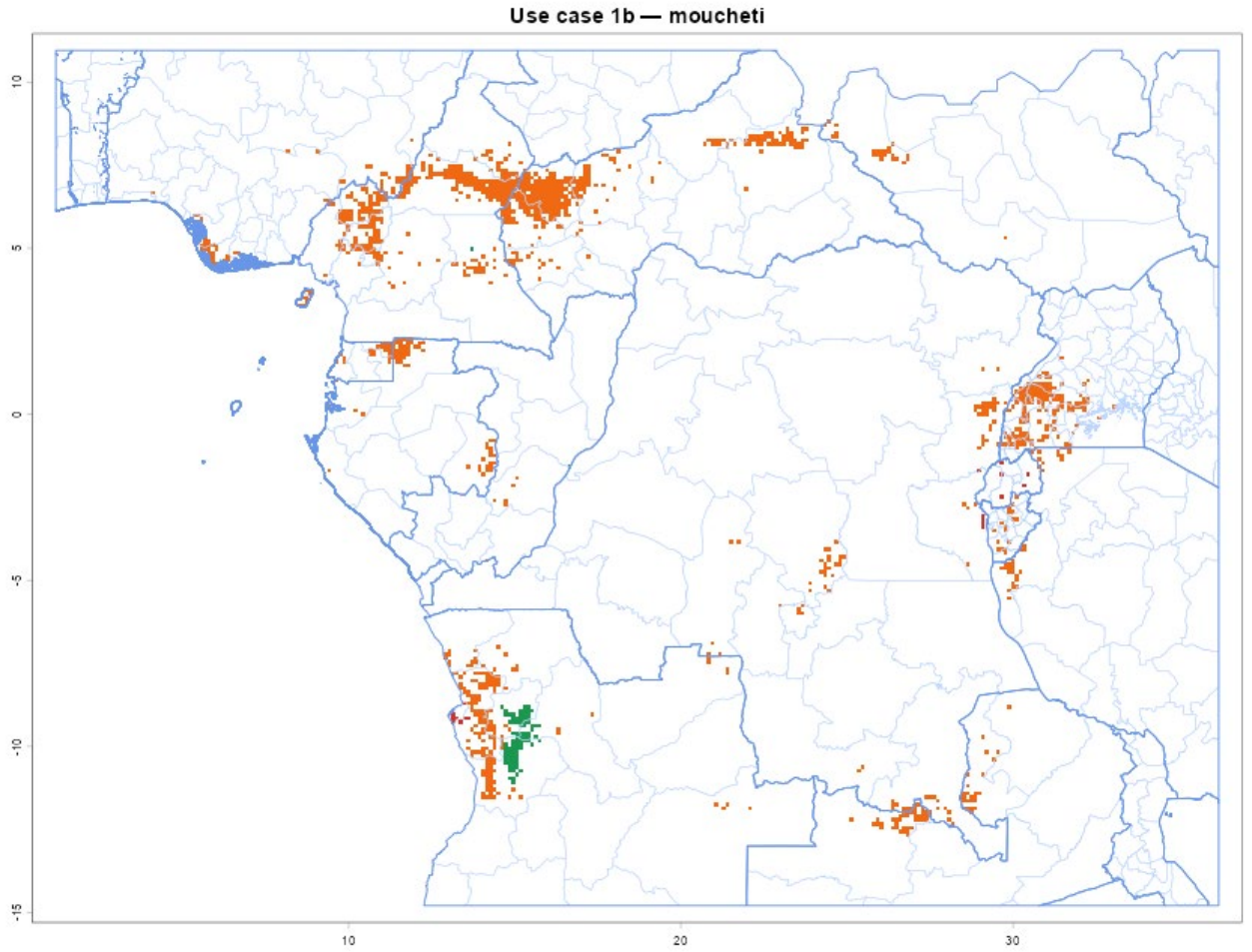
- Tier 1 (High eligibility)
- Tier 2 (Moderate)
- Tier 3 (Low)

- *An. arabiensis* showed the widest geographic reach, with eligible areas identified in **42 WHO African countries (3.69 million km^2).**
- Tier 1 coverage in areas across **18 countries**.

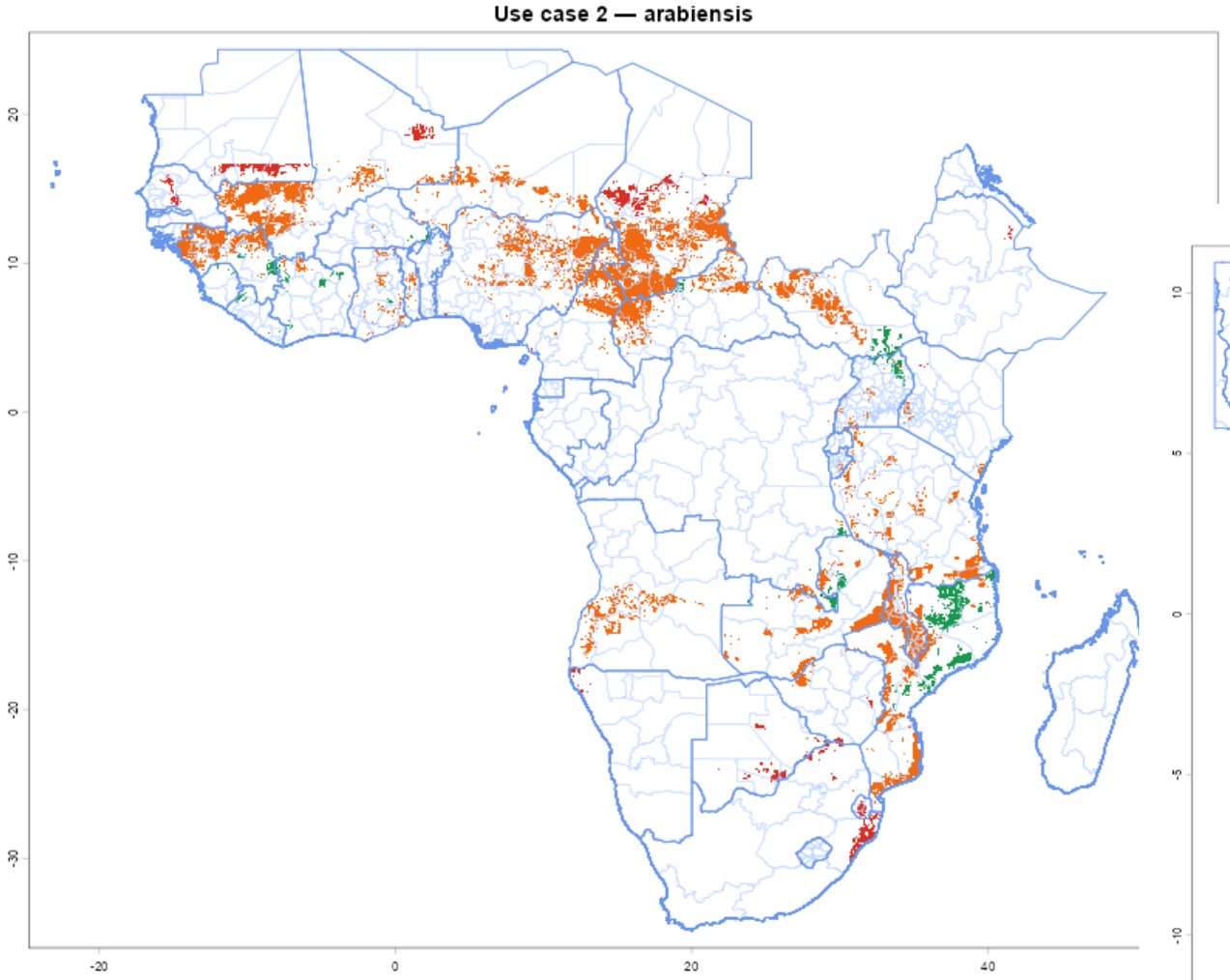
Use case 1b: Epidemiological demonstration



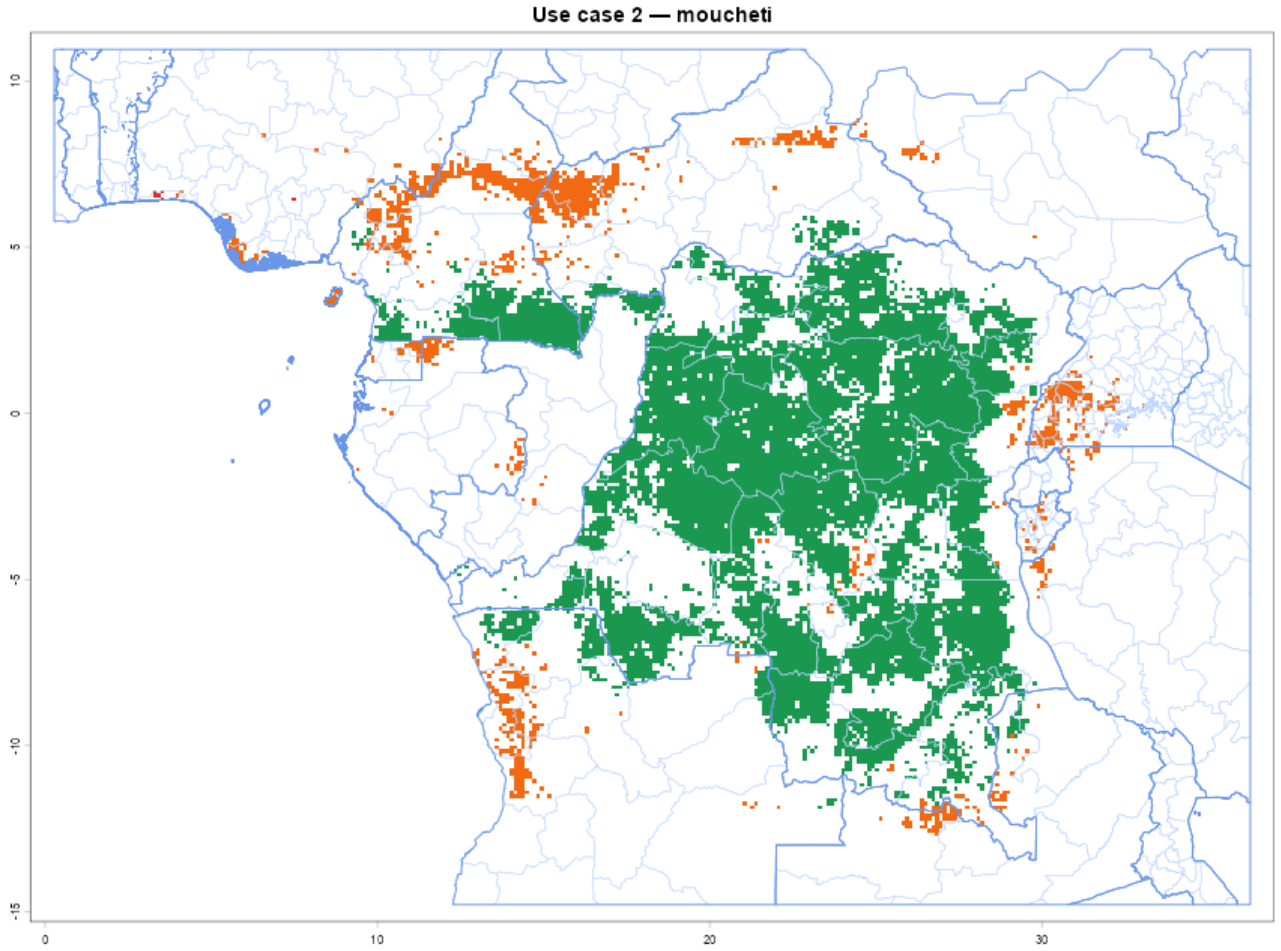
An. arabiensis retained greater geographic reach than ***An. moucheti*,** with eligible areas identified in **32 versus 15 countries**

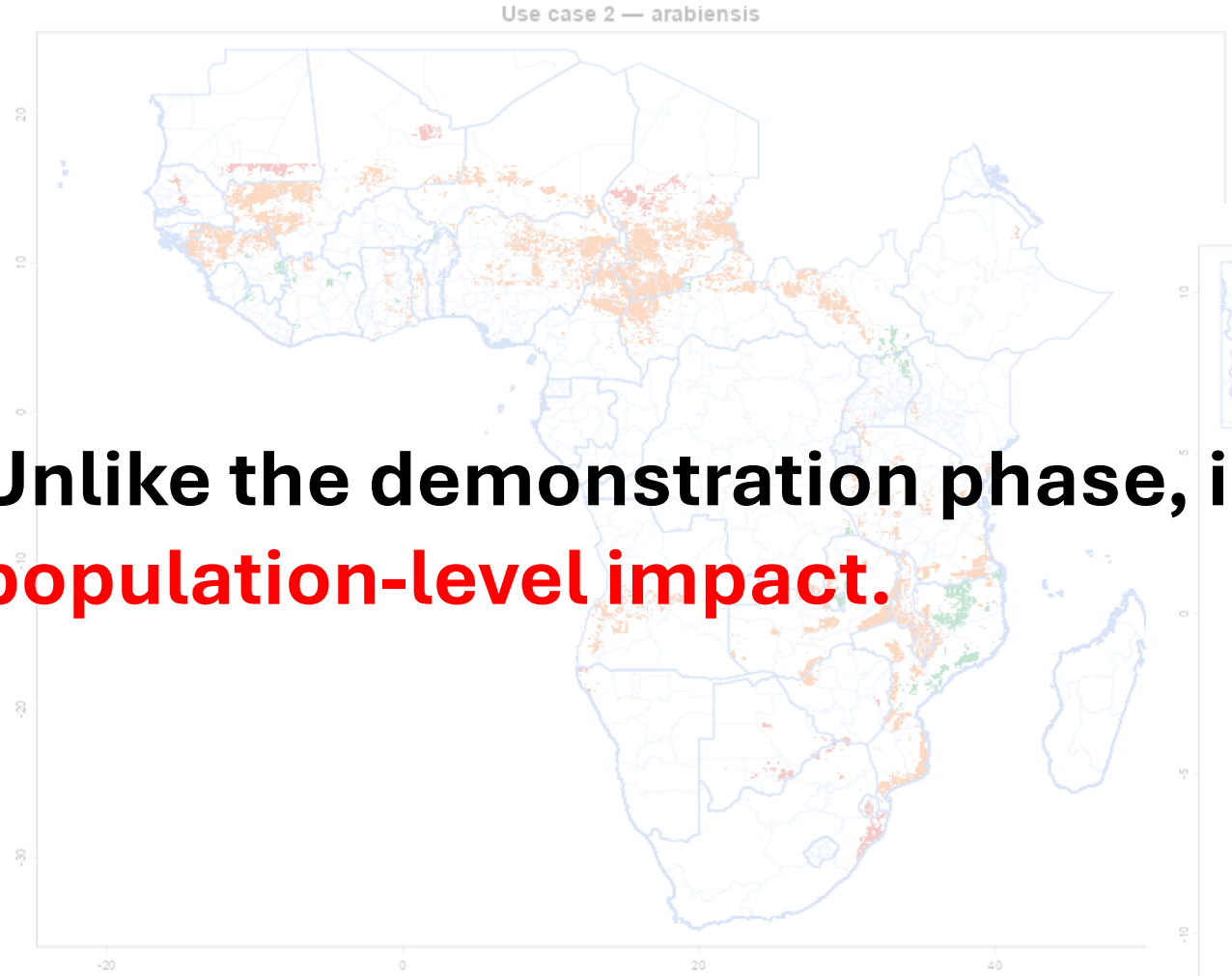


Use case 2: Routine implementation

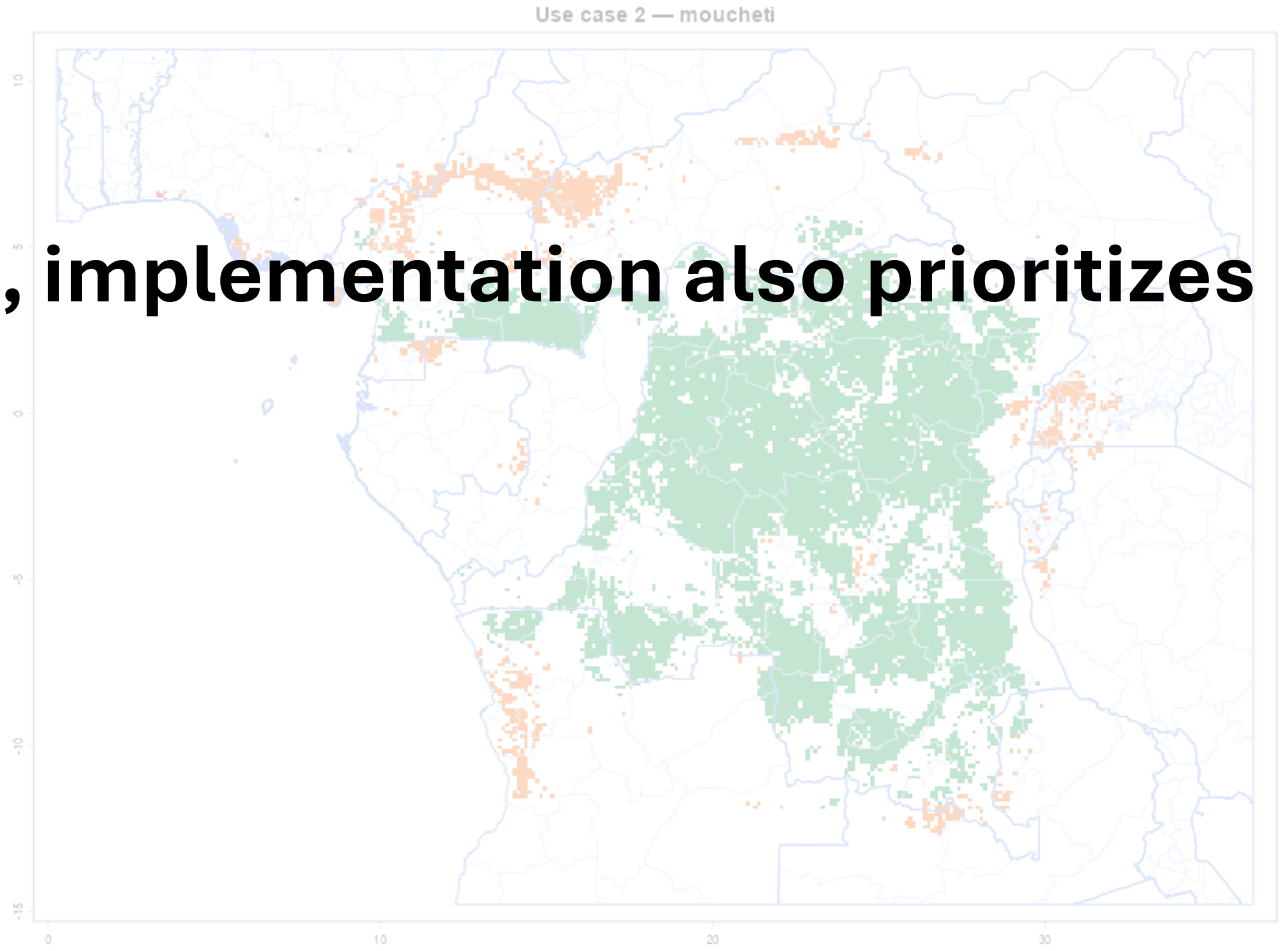


Eligible area was comparable **(~1.7million km^2),** but *An. arabiensis* extended across **39 countries** versus **15** for *An. moucheti*.

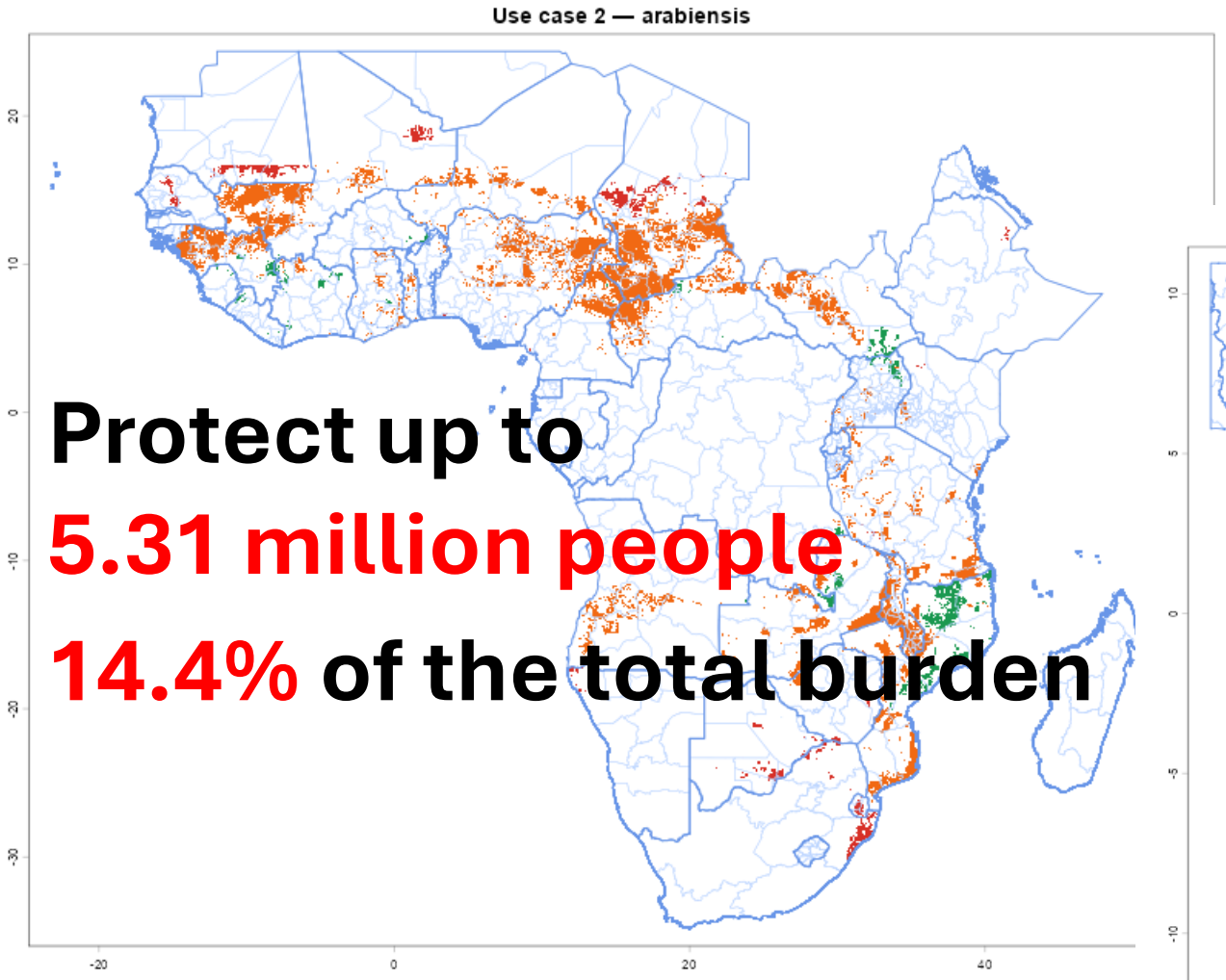




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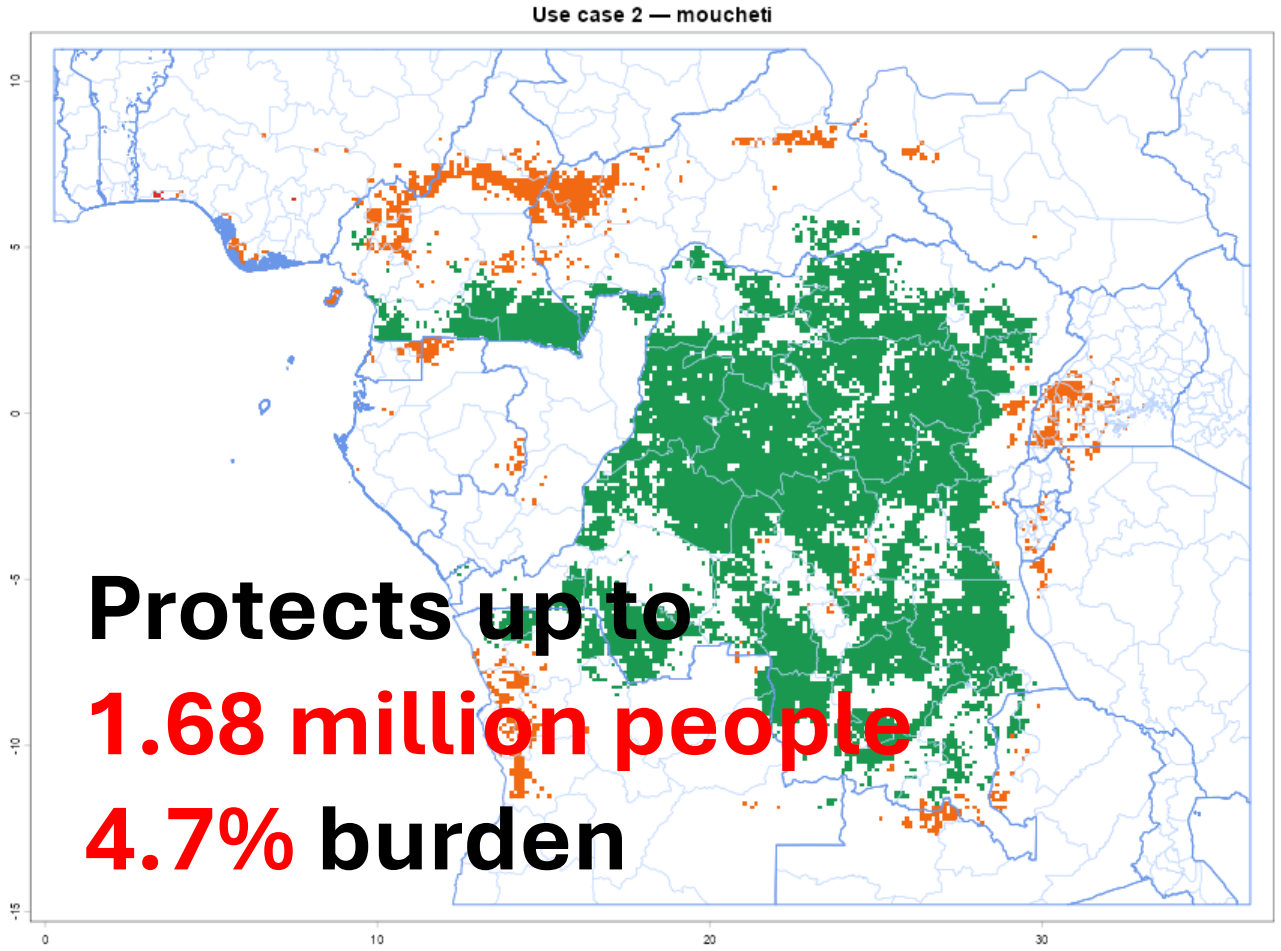
Unlike the demonstration phase, implementation also prioritizes population-level impact.



Protect up to

5.31 million people

14.4% of the total burden

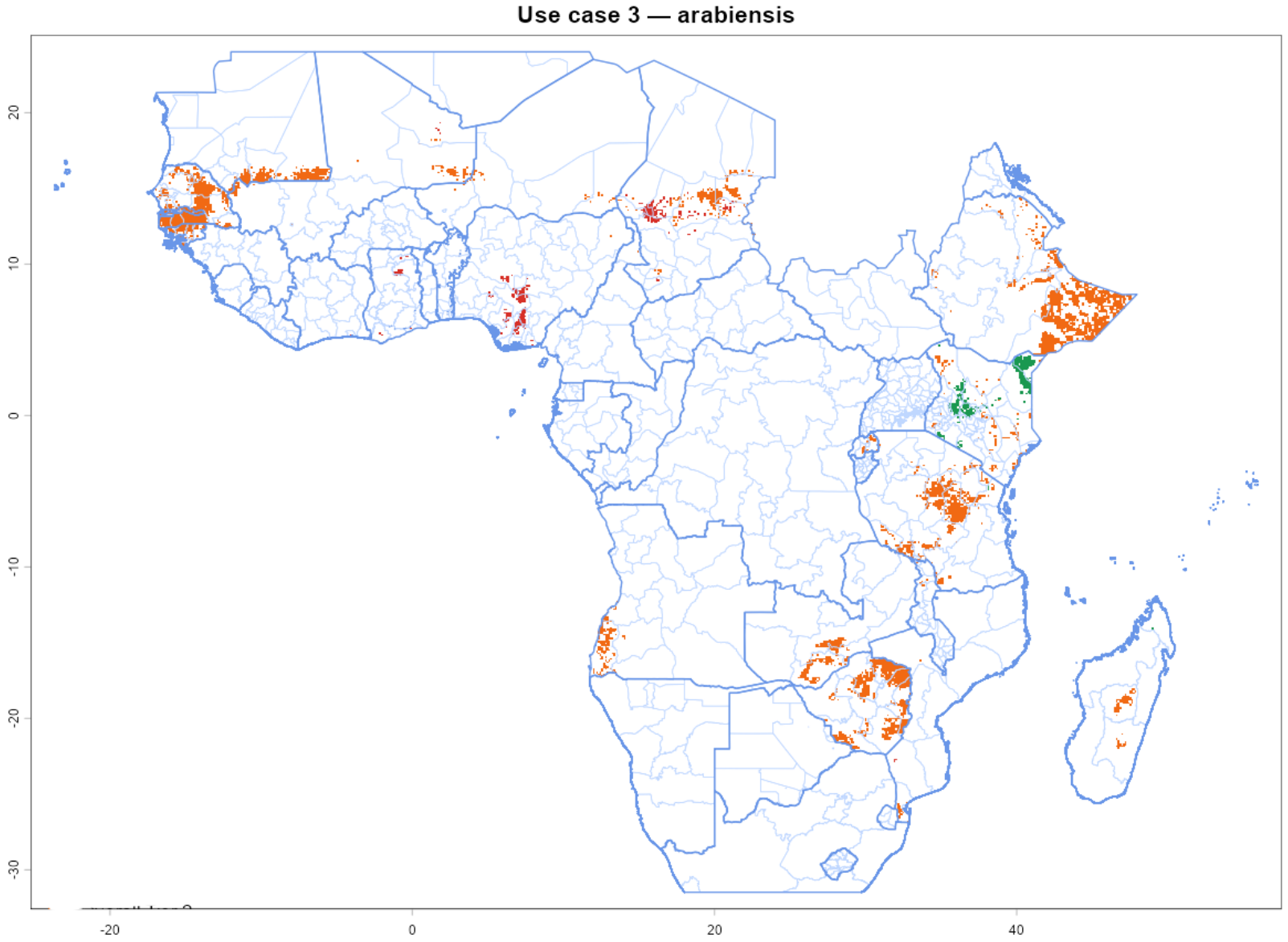


Protects up to

1.68 million people

4.7% burden

Use case 3: Elimination support



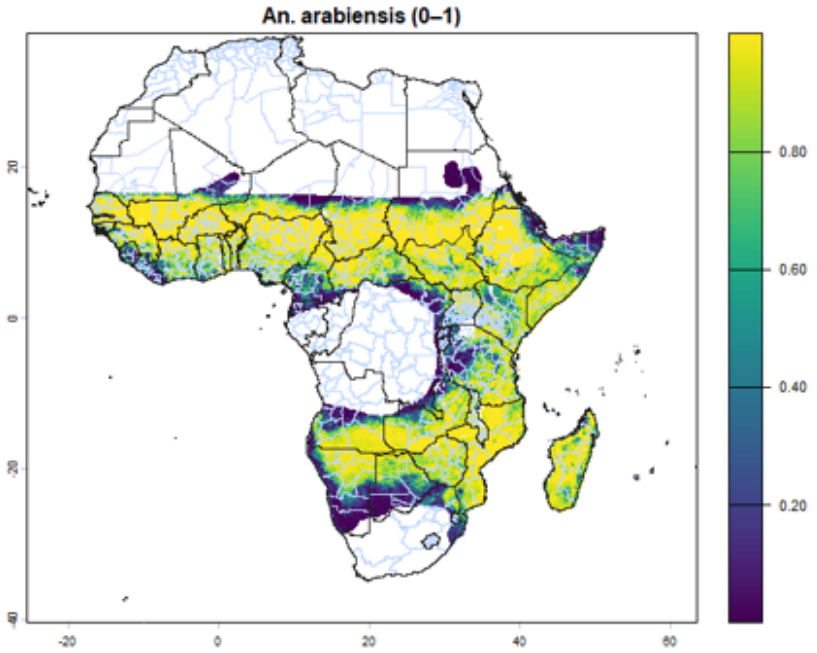
- Eligibility across **33 WHO AFRO countries**
- Best case in **8 countries**
- Could potentially **protect up to 3 million people**
- Capturing **5.26%** of the total WHO AFRO burden

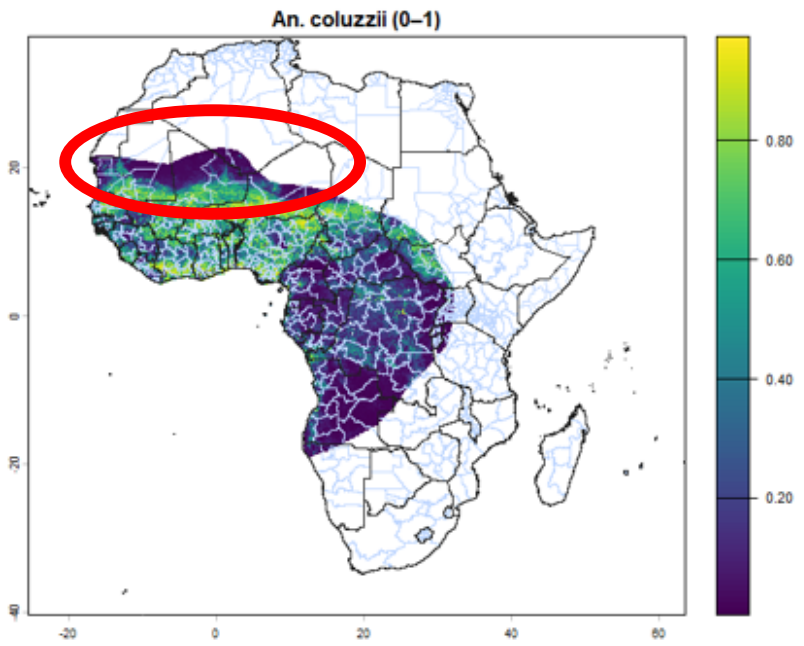
Conclusion

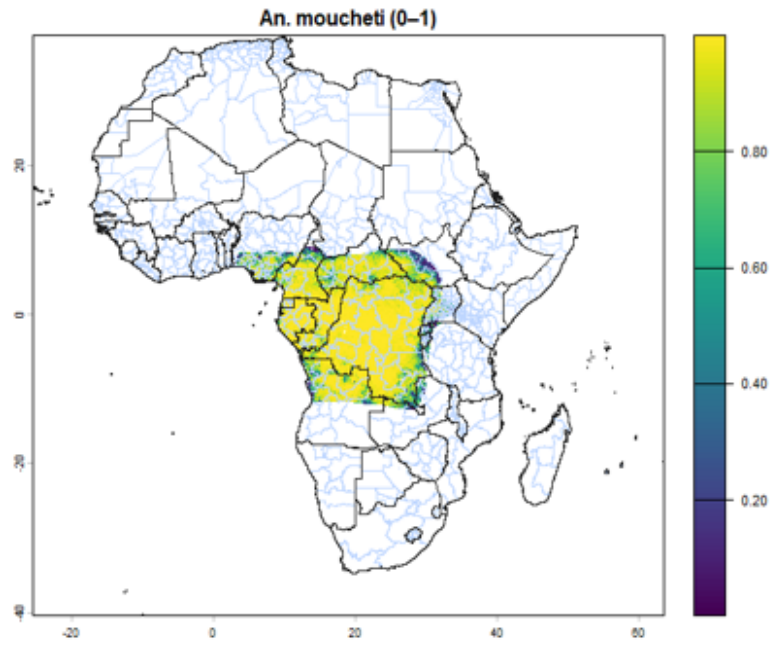
- Geospatial analysis can guide product development by anticipating where emerging interventions can be trialed, scaled, and impactful.
- No single species uniformly dominates across all objectives, instead, suitability is use-case dependent.
- **Entomological demonstration (1a):** *An. arabiensis* offers the broadest and most practical pathway.
- **Epidemiological demonstration (1b):** *An. arabiensis* retains the largest geographic opportunity, while *An. moucheti* may provide more tightly defined Tier-1 settings for clearer impact attribution.
- **Routine implementation (Use Case 2):** Start with *An. moucheti* settings (efficiency), then expand into *An. arabiensis* regions (scale).
- **Near-elimination settings (Use Case 3):** Opportunity narrows substantially and is largely confined to *An. arabiensis* mid-priority areas.

Conclusion

- *An. coluzzii* shows limited programmatic advantage across scenarios, likely due to spatial overlap and lower population relevance.



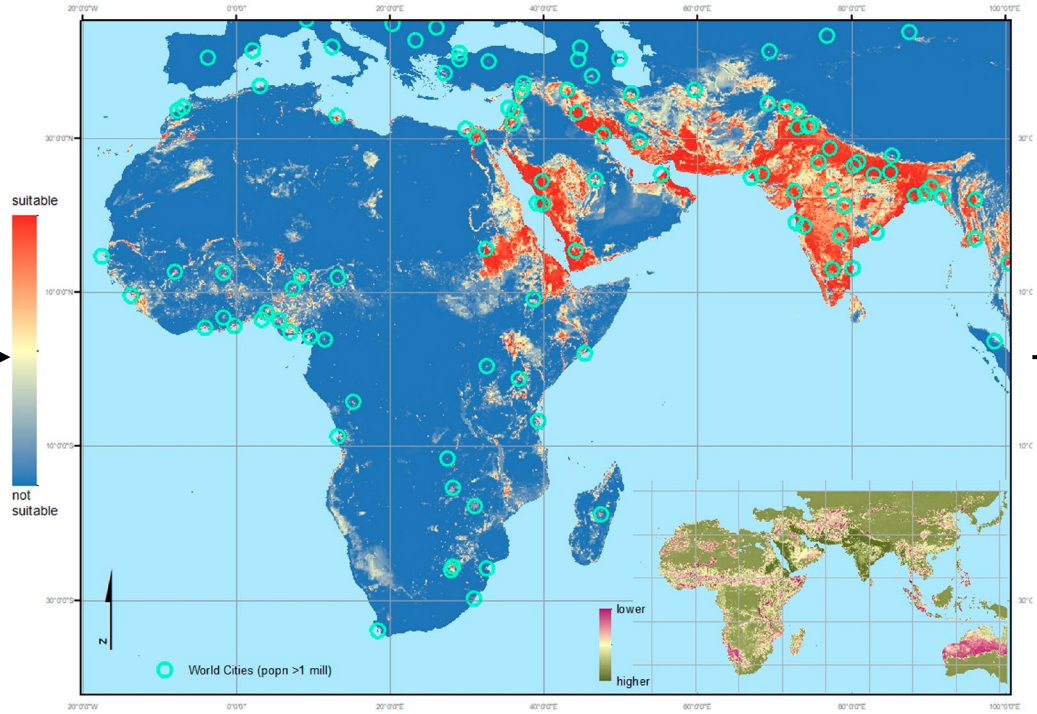




Next steps



An. stephensi





?

Nick Golding's work on *An.stephensi* spread

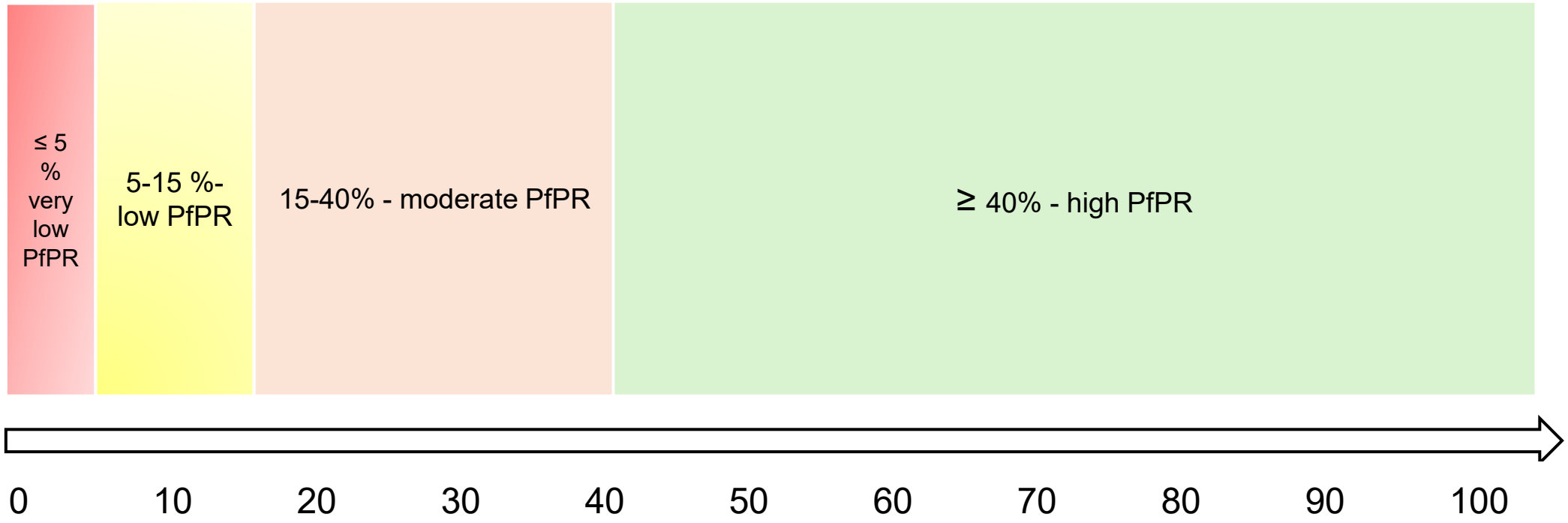
Thanks to

Oliver Brady and Thomas Walker

Supplementary slides

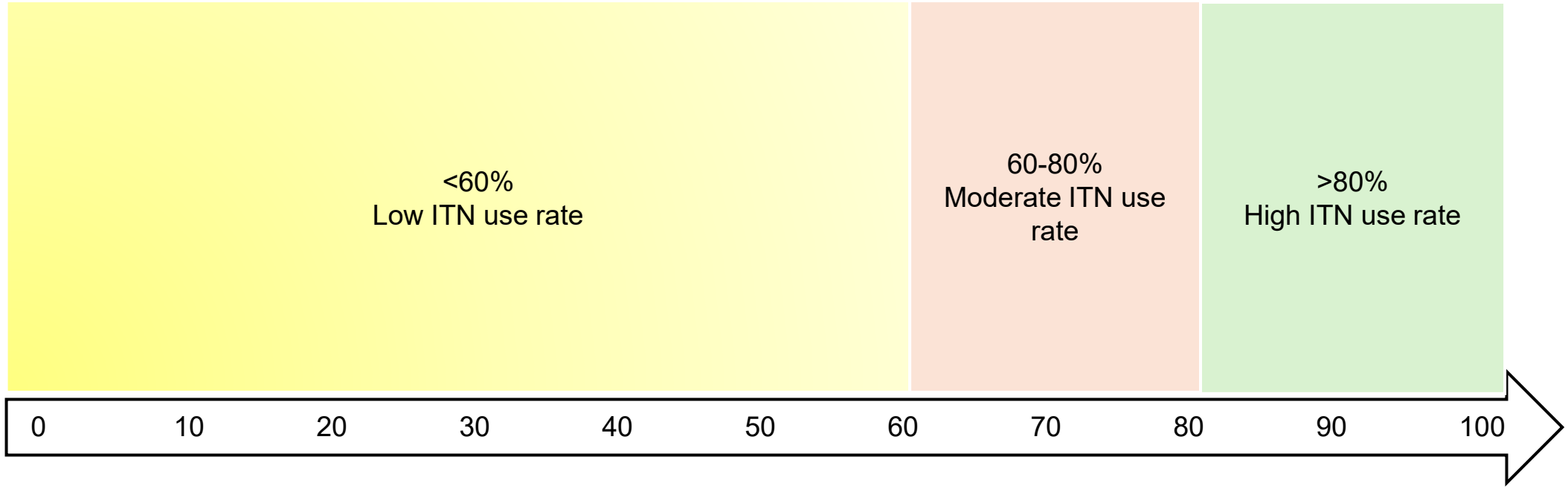
Data thresholds

P.falciparum Parasite Rate (PfPR) threshold:

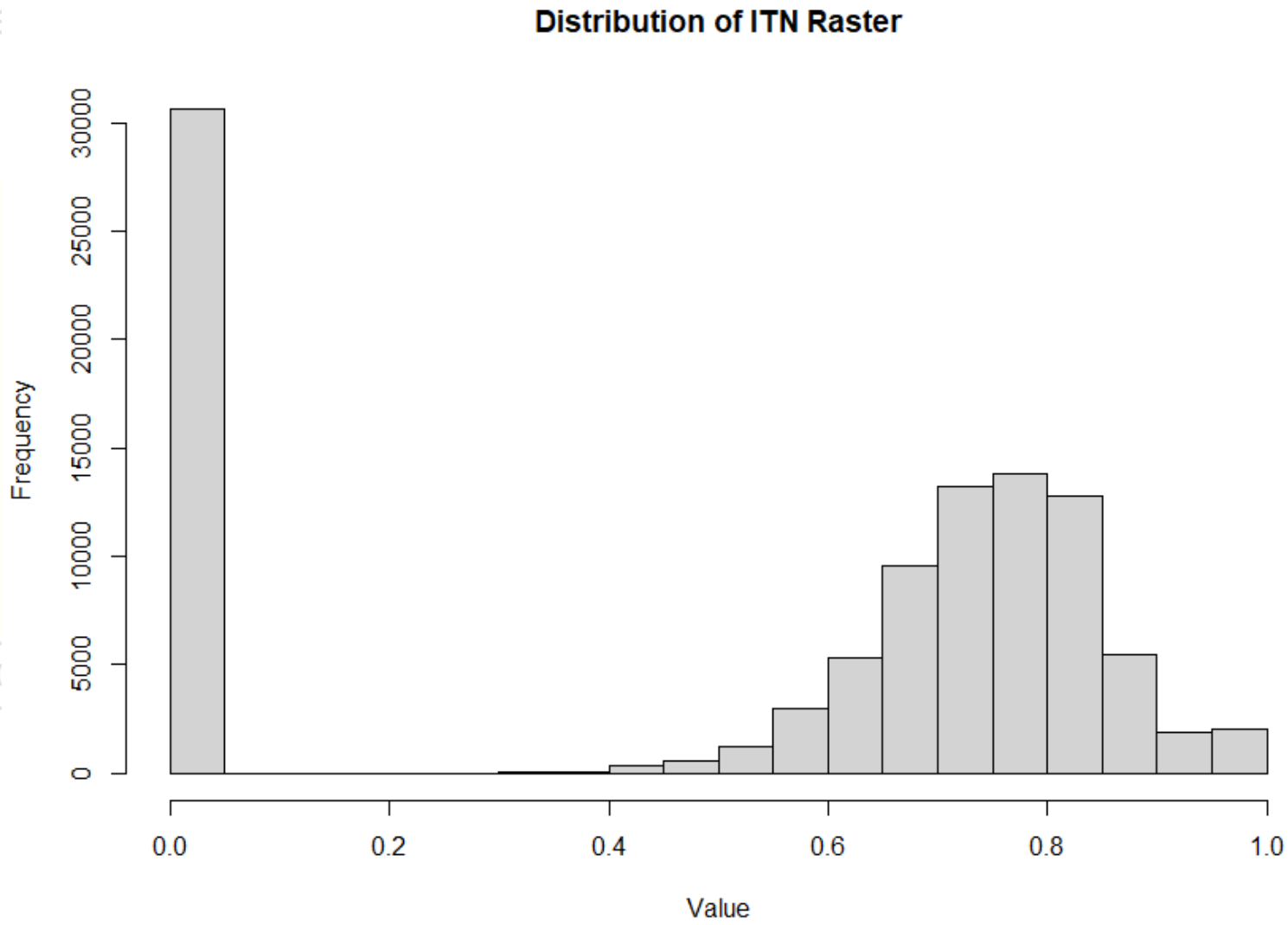


Data thresholds

ITN use rate threshold



Data thresholds



Scenario construction

Use Case	Endpoint	Use case description	Tier thresholds (%)
1a. Entomological Demonstration	Demonstrate fixation of *Wolbachia* in natural mosquito population	• Mostly single species.	T1: ≥70 T2: 40-70 T3: <40
		• Low interventions pressure	T1: <60 T2: 60-80 T3: ≥ 80
		• Relatively low PfPR	T1: <15 T2: 15-40 T3: ≥ 40
1b. Epidemiological demonstration	Estimate the epidemiological effectiveness of *Wolbachia* replacement.	• Mostly single species.	T1: ≥ 70 T2: 40-70 T3: <40
		• Low intervention pressure	T1: <60 T2: 60-80 T3: ≥ 80
		• High PfPR	T1: ≥ 40 T2: 15-40 T3: <15

Scenario construction

Use Case	Endpoint	Use case description	Tier thresholds (%)
2. Routine implementation	Further reduce transmission after coverage with other interventions has been maximised	• Dominant species	T1: ≥70 T2: 40-70 T3: <40
		• High ITN use rate	T1: ≥ 80 T2: 60-80 T3: <60
		• High transmission	T1: ≥40 T2: 15-40 T3: <15
3. Elimination support	Achieve and sustain malaria elimination in areas where it is not currently possible with existing interventions	• Dominant species	T1: ≥70 T2: 40-70 T3: <40
		• High ITN use rate	T1: ≥80 T2: 60-80 T3: <60
		• Very low transmission (approaching elimination)	T1: <5 T2: 5-15 T3: 15-40

RBM Partnership
To End Malaria

Panel discussion and Q&A:

Moderated by VCWG Task Team lead Rinki Deb

A discussion on practical challenges in the development and implementation of genetic and biological vector control tools in Africa.

Panel:
George Christophides (Transmission Zero), Tullu Bhakari (ICIPE),
Jonathan Kayondo (Target Malaria Uganda), Preethi Lakshminarayanan (LSHTM),
Kibor Keitany (Kenya NMCP), Helen Jamet (Gates Foundation)

Panel discussion: Practical challenges in the development and implementation of genetic and biological vector control tools in Africa

RBM Partnership
To End Malaria

4 March 2026

Task Team 3: Innovations in vector surveillance

Task Team 3 - Innovations in Vector Surveillance



- **TT3 Leads:** Yang Hu & Evelyn Olanga
  - Goal for This Year: Sharing a comprehensive inventory of novel vector surveillance tools and approaches.
- **TT3 Mandate:**
  - *Our mandate is to maintain a living inventory of novel surveillance tools and to identify the critical gaps where new development is most needed; spanning molecular techniques, species identification, smart traps, remote sensing, citizen science, and predictive modelling.*
  - *But inventory alone isn't enough; can innovations can actually be absorbed by programmes operating under real budget pressure?*



The Malaria Vector Genome Observatory – data and tools to support genomic surveillance and vector control of *Anopheles* mosquitoes	Anastasia Hernandez Koutoucheva, Liverpool School of Tropical Medicine
The Entomology for Impact Initiative: Reimagining vector surveillance in the context of reduced financing	Evelyn Olanga, Clinton Health Access Initiative
Lightning talk: Operationalizing environmental DNA (e DNA) detection of major malaria vector species	Louisa Messenger, University of Nevada, Las Vegas
Lightning talk: Predicting Mosquito Age and Species with Mid-Infrared Spectroscopy and AI: A Cost-effective Alternative Method for Enhanced Malaria Surveillance	Amos Okot, Kampala Capital City Authority
Panel discussion: Maintaining the quality of entomological surveillance in a resource constrained environment	Panel members: Raymond Tabue Cameroon NMCP, Edith Ramaita, Kenya NMCP, Otubea Ansah Ghana NMCP, Charles Fanaka Zambia NMCP

RBM Partnership
To End Malaria

4 March 2026

Presentation: The Malaria Vector Genome Observatory – data and tools to support genomic surveillance and vector control of *Anopheles* mosquitoes.

Anastasia Hernandez Koutoucheva, Liverpool School of Tropical Medicine

The Malaria Vector Genome Observatory – data and tools to support genomic surveillance and vector control of *Anopheles* mosquitoes

Anastasia Hernandez-Koutoucheva

VCWG-21, 3-5th March 2026

MalariaGEN
GENOMIC EPIDEMIOLOGY NETWORK

LSTM
LIVERPOOL SCHOOL OF TROPICAL MEDICINE

Accessing and using genomic surveillance data for research, monitoring and control remains challenging

- Timely access is critical
  - Quick turn-around
  - Up-to-date results





- Standardised, integrated, maintained

- … and, ready for immediate public health use



MalariaGEN
GENOMIC EPIDEMIOLOGY NETWORK

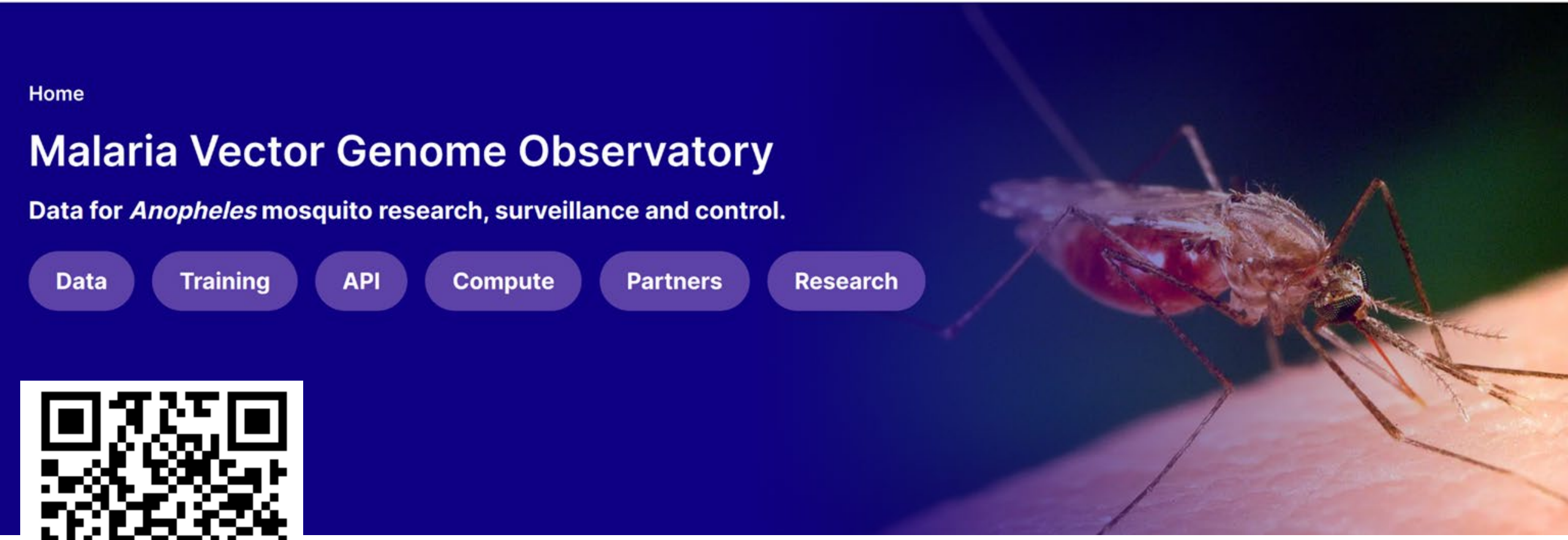
About Get involved Data Tools & Resources Impact

Home

Malaria Vector Genome Observatory

Data for *Anopheles* mosquito research, surveillance and control.

Data Training API Compute Partners Research



https://www.malariagen.net/vobs/

Gates Foundation

Our approach to data generation, access and sharing

- Genomics allow us to monitor vector populations (species composition, insecticide resistance, geographic spread) – providing crucial data for vector control

- The Vector Observatory supports the access and integration of individual mosquito whole-genome sequence data:

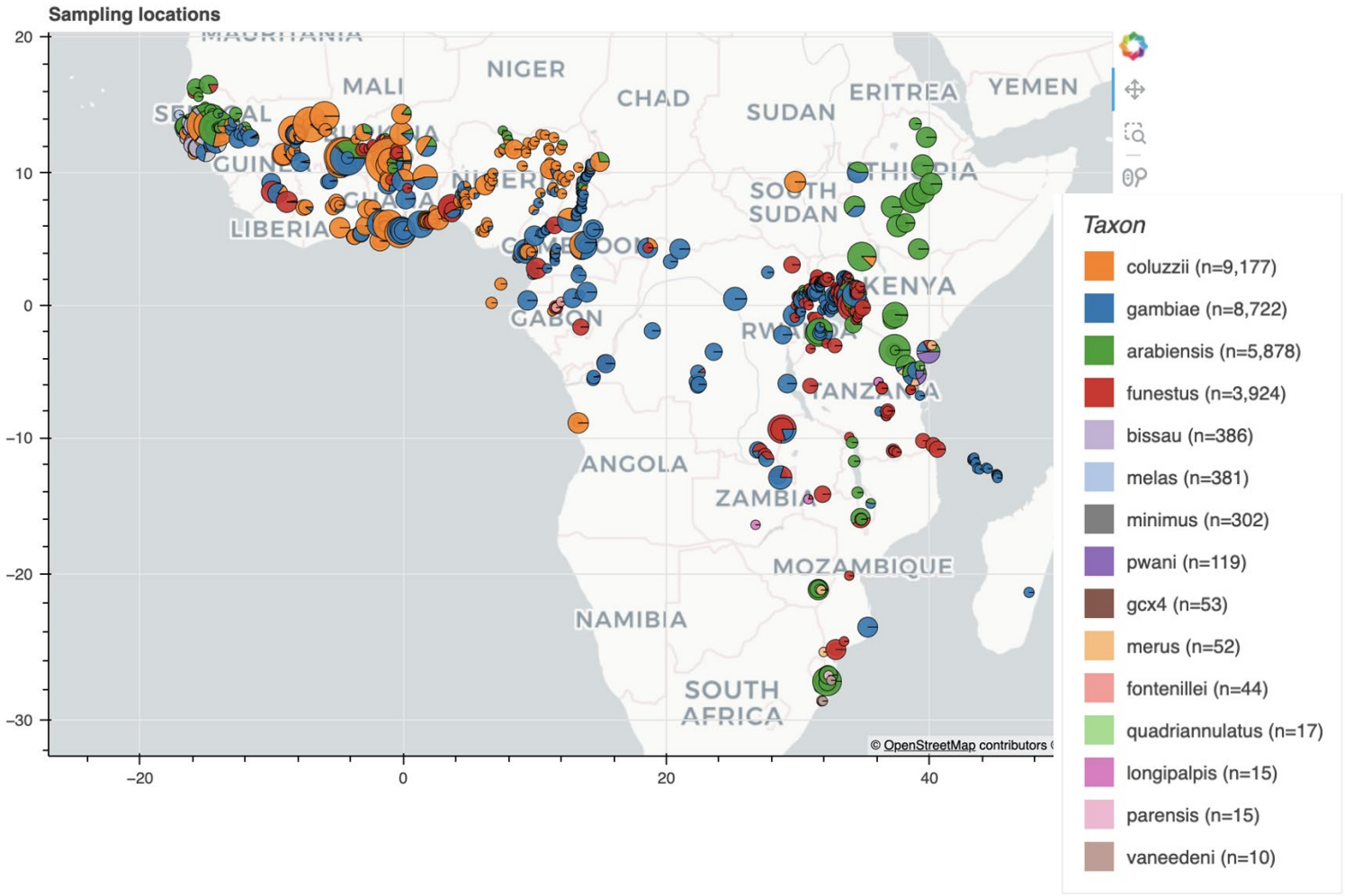
  - Partners sample *Anopheles* mosquitoes from natural populations as part of different independent studies, each addressing different scientific primary questions

  - Data is produced, curated and made accessible in the public cloud

Our approach to data generation, access and sharing

- **Standardised** analysis-ready data
- **Integrated** across studies
- **Publicly available** for public health and training purposes
  - Data are made accessible immediately after curation, with a two-year publication embargo – preserves the right of lead investigators to make the first publication of results

Vector Observatory (VObs) - a community-built resource



- **>30,000** WGS of wild-caught *Anopheles* mosquitoes and laboratory crosses
- Spatio-temporal and ecological resolution
  - Across 67 partner studies

Analytical software

- **malariagen_data** Python software package
  - Cloud-native
  - No dedicated compute resources are required

- Development focused on easing data **usability**, allowing for analysis **scalability**, and new **functionality**

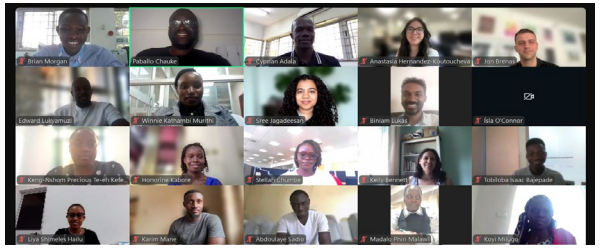


https://malariagen.github.io/malariagen-data-python/latest/

Building capacity for data analysis for malaria vectors

- Self-directed/guided **entry-level** training for genomic surveillance of malaria vectors
- New self-directed **advanced** data analysis training modules
- **Train-the-trainer** Bioinformatics fellowships:
  - 2 year end-to-end bioinformatics and data science for malaria vector genomic surveillance in partnership with PAMCA, Tree of Life Programme at Wellcome Sanger Institute, and IRSS.
  - Currently, 4 trainees - collaboration with AVECGEN (CRID))

Self directed openly available training programmes



Guided training



Jane Mwangi, Edward Lukyamuzi



Sonia Barasa, Ibra Lujumba



Mahamadi Kientega and Honorine Kabore

How do we build on this ecosystem to **accelerate** the **generation**, **utilisation** and **sharing** of genomic insights to detect and characterise e**merging evolutionary threats** to malaria vector control in Africa?

MalariaGEN
GENOMIC EPIDEMIOLOGY NETWORK

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Data: Integrating new key vector species to lower the entry barrier for acces & analysis

Adir1.0 (Vector Observatory - Asia Project *Anopheles dirus* Phase 1 Data Release)

The **Adir1.0**: ***Anopheles dirus* data resource** contains single nucleotide polymorphism (SNP) calls from whole-genome sequencing of 540 mosquitoes. These data were generated as part of the MalariaGEN Vector Observatory Asian Vector Genomic Surveillance Project.

Vector Observatory - Asia connects research groups that are investigating the population structure and diversity of malaria vectors in Asia. This centres on multiple vectors from the Greater Mekong Subregion in Southeast Asia, where drug-resistant malaria parasites are emerging and spreading. This research is expanding the range of mosquito species that are represented in our whole genome data.

More information about this release can be found in the data resource website.

https://malariagen.github.io/vector-data/adir1/adir1.0.html

The origin, invasion history and resistance architecture of *Anopheles stephensi* in Africa

Tristan PW Dennis [1,*], Jihad Eltaher Sulieman [2,3], Mujahid Abdin [4], Temesgen Ashine [5,6], Yehenew Asmamaw [6], Adane Eyasu [7], Eba A Simma [8], Endalew Zemene [9], Nigatu Negash [6], Abena Kochora [6], Muluken Assefa [6], Hamza Sami Elzack [10], Alemayehu Dagne [7], Biniam Lukas [7], Mikiyas Gebremichael Bulto [6], Ahmadali Enayati [11], Fatemeh Nikpoor [12], Ashwaq M Al-Nazawi [13,14], Mohammed H Al-Zahrani [15], Bouh Abdi Khaireh [16,17], Samatar Kayed [18], Abdoul-Ilah Ahmed Abdi [19,20], Richard Allan [21], Faisal Ashraf [1], Patricia Pignatelli [1], Marion Morris [1], Sanjay C Nagi [1], Eric R Lucas [1], Anastasia Hernandez-Koutoucheva [22,1], Patricia Doumbe-Belisse [1], Adrienne Epstein [1], Rebecca Brown [1], Anne L Wilson [1], Alison M Reynolds [1], Ellie Sherrard-Smith [1], Delenasaw Yewhalaw [7,9], Endalamaw Gadisa [6], Elfatih Malik [4], Hmooda Toto Kafy [4,23], Martin J Donnelly [1,*], David Weetman [1,*]

bioRxiv [Preprint]. 2025 Mar 15:2025.03.13.643102. [Version 1] doi: 10.1101/2025.03.13.643102

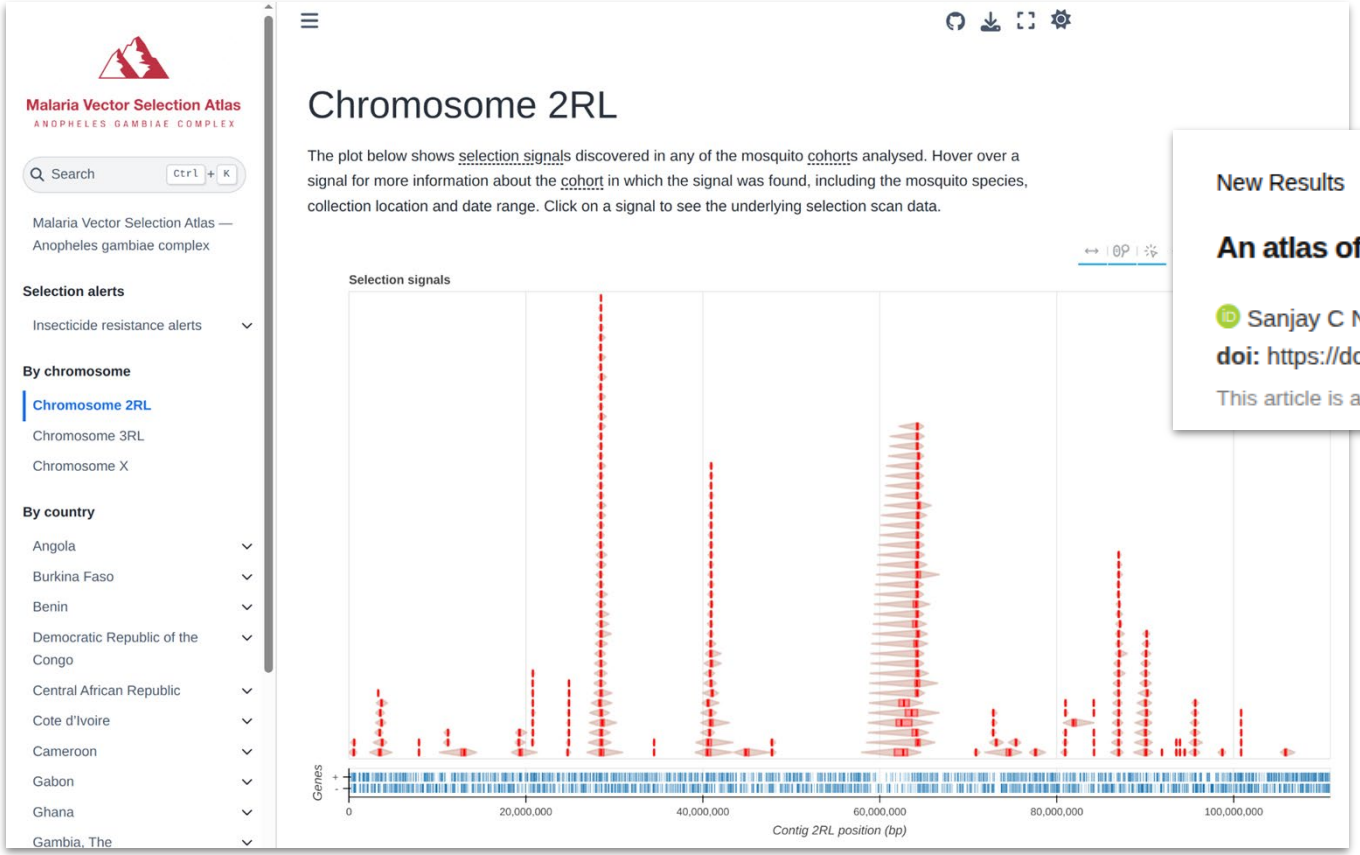
Population genomics of *Anopheles darlingi*, the principal South American malaria vector mosquito

Jacob A Tennessen [1,2,*], Raphael Brosula [2], Estelle Chabanol [3], Sara Bickersmith [4], Angela M Early [2], Margaret Laws [1,2], Katrina A Kelley [1,2], Maria Eugenia Grillet [5], Dionicia Gamboa [6], Eric R Lucas [7], Jean-Bernard Duchemin [3], Martha L Quiñones [8], Maria Anice Mureb Sallum [9], Eduardo S Bergo [10], Jorge E Moreno [11], Sanjay Nagi [7], Nicholas J Arisco [1], Mohini Sooklall [12], Reza Niles-Robin [12], Marcia C Castro [1], Horace Cox [12], Mathilde Gendrin [3], Jan E Conn [4,13], Daniel E Neafsey [1,2]

Author information · Copyright and License information

PMCID: PMC11952511 PMID: 40161849

Tools: Building in partnership with independent studies to discover new resistance mechanisms





- Provides web reports on recent positive selection in populations of *An. gambiae* complex and *An. funestus* species group mosquitoes.

https://anopheles-genomic-surveillance.github.io/selection-atlas/

Community: Collaborating in discovery science to identify emerging threats



Dr El Hadji Amadou Niang

- National distribution of dual AI nets in Senegambia
  - Ecological and environmental heterogeneity

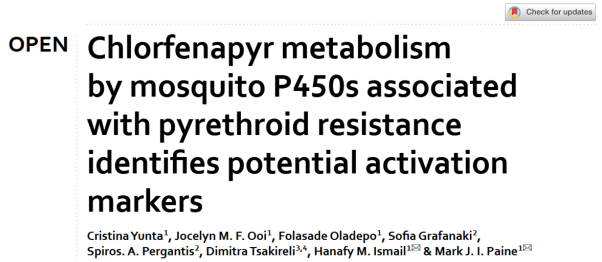
Community: Collaborating in discovery science to identify emerging threats



Dr El Hadji Amadou Niang

- National distribution of dual AI nets in Senegambia
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- Investigate strategies to block adaptation in *Anopheles* populations
  - CYP6P3, CYP9J5, CYP9K1 have all found to metabolise both pyrethroids and chlorfenapyr.
  - Competition was found between α-cypermethrin and chlorfenapyr metabolism by CYP6P3 and CYP6K1.



OPEN

Chlorfenapyr metabolism by mosquito P450s associated with pyrethroid resistance identifies potential activation markers

Cristina Yunta[1], Jocelyn M. F. Ooi[1], Folasade Oladepo[1], Sofia Grafanaki[2], Spiros. A. Pergantis[2], Dimitra Tsakireli[3,4], Hanafy M. Ismail[1✉] & Mark J. I. Paine[1✉]

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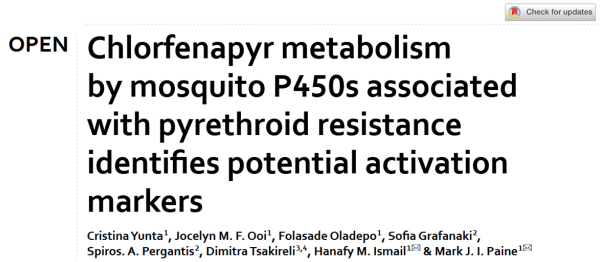


Dr El Hadji Amadou Niang

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  - Competition was found between α-cypermethrin and chlorfenapyr metabolism by CYP6P3 and CYP6K1.

- Observe the evolution of natural anopheline populations in response to the mass distribution of dual AI ITNs.
  - Detect novel resistance variants
  - Measure changes in resistance allele frequencies

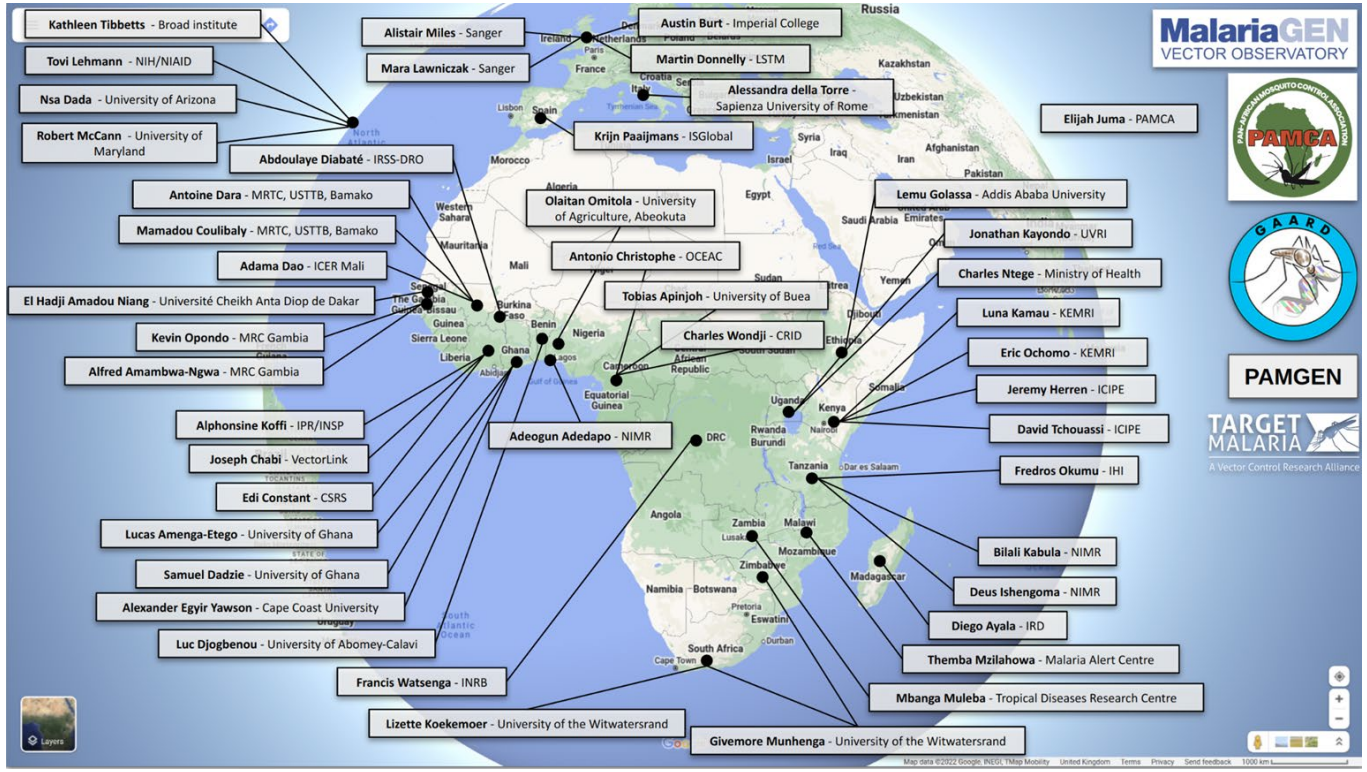


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Acknowledgements



MalariaGEN UK @ LSTM:

- Chris Clarkson
- Vikki Simpson





Gates Foundation

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To End Malaria

4 March 2026

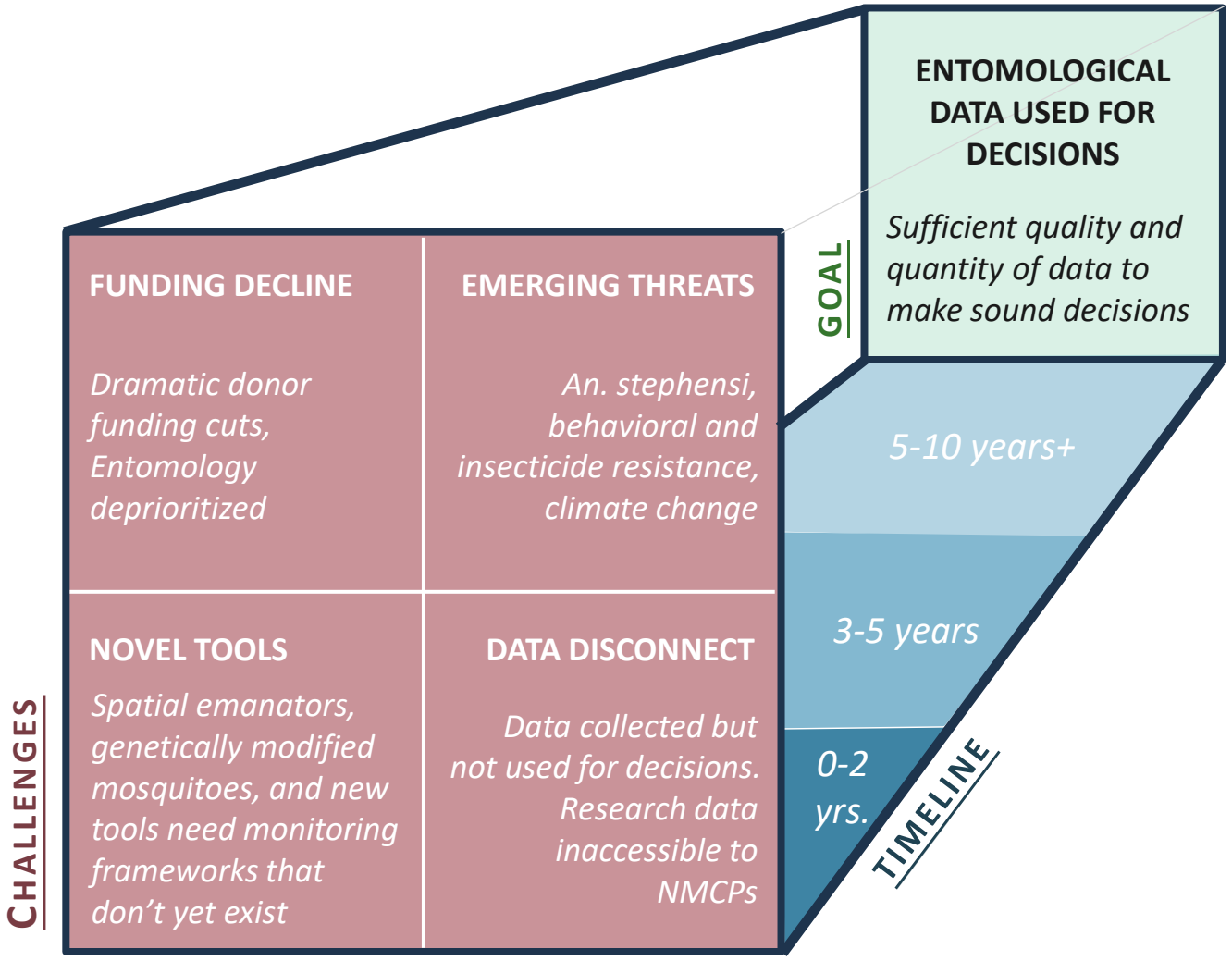
Presentation: The Entomology for Impact Initiative: Reimagining vector surveillance in the context of reduced financing

Evelyn Olanga, CHAI

The Entomology for Impact Initiative (EII): Reimaging Vector Surveillance in the context of reduced funding

4th March 2026

Given present funding constraints and rapidly changing vector and disease dynamics, we need to adapt by fundamentally redesigning programmatic entomology



- Currently use static surveillance methods (for example fixed sentinel sites)
- Facing an abrupt reduction in funding
- Dealing with a more dynamic disease

- More technology and knowledge than before
- Geospatial tools, genomic data, climatic data, and modeling

- Adapt to the funding constraints and programmatic needs of the current era while preparing ourselves for developments in the future

To help to address this question, CHAI, UCSF-MEI, and Jen Armistead (with the Gates Foundation) met with global, regional, and country experts to brainstorm “blue sky” ideas

Over the last 6 months, we have held:

SENSITIZATION MEETINGS

12+

STRUCTURED INTERVIEWS

12+

EXPERTS ENGAGED

20+

INITIATIVE GOAL

Preserve entomological surveillance, make it inexpensive enough so that countries and partners can afford it, while collecting data that’s meaningful to make VC decisions



ACADEMIA

Uni of Glasgow, Uni of Basel, IHI, CRID, OCEAC, KEMRI, Nat Uni of Colombia, Uni of Honduras

COUNTRY PROGRAMS

NMCPs in Zimbabwe, Cameroon, Uganda

GLOBAL PARTNERS

Abt / PMI Evolve, WHO, Global Fund, IVCC

EII PARTNERSHIP

CHAI

Initiative lead, Project coordination

UCSF-MEI

Technical guidance, Country support integration

Jen Armistead (Gates Foundation consultant)

Gene drive landscape, future tools planning

We’re not starting from scratch; we have existing principles that work well

2018 MANUAL

Activity-Based Surveillance

- Define surveillance objectives broadly
- List all entomological activities
- Collect comprehensive indicator sets
- Monitor interventions separately
- Single unified surveillance framework
- Heavy emphasis on methodology details
- "Receptivity" as core planning concept

2025 MANUAL

Decision-Driven Surveillance

- Data collection designed for decisions
- "Question-based" surveillance approach
- Essential vs useful indicators differentiated
- Entomological + vector control monitoring unified
- Priorities tailored by transmission setting
- New technology & enabling factors foregrounded
- Integration with other vector-borne diseases

Summarized from 2018 and *2025 WHO Surveillance Manual*

Successfully held workshops with NMCPs, academia and partners to identify and discuss blue-sky surveillance approaches/ creative ideas that countries may consider

The goal is to preserve entomological surveillance by making it inexpensive enough that countries and partners can afford it, while collecting data that's meaningful to make key VC decisions

Identify New Surveillance Approaches

Generate and assess approaches for cost-effectiveness, feasibility, data quality and implications for VC decisions

- Consider which VC decisions are relevant for different time frames (short-, medium-, and longer-term)

Improve Global Fund Cycle 8 Readiness

Produce concrete approaches that NMCPs could consider for concept notes in 2026

*** NOT one-size-fits-all**
*** Approaches are context-specific**
*** Ideas shared NOT guidelines**
*** Approaches can be layered**

To save costs, interviews to date have flagged a need to optimize between quantity and quality of entomological data

High volume of moderate quality data



Low volume of high-quality data

At present, it is not possible to generate high volumes of high-quality data for low cost. Instead, we combine both approaches, balancing breadth and depth, to get the full picture

Expert conversations to date raised a number of cost-effective approaches that could be part of an entomological surveillance “redesign”

SITE SELECTION & SAMPLING STRATEGY

The architecture of the surveillance system; where and how often data is collected is a primary operational layer for cost reduction



- ***Rotating sentinel sites***
- ***Reduced collection frequency***
- ***Optimizing focal | routine collection***

INTEGRATION ACROSS PROGRAMS, SECTORS & BORDERS

Integration reduces duplication and spreads costs across health needs, making ento more sustainable and the investment case stronger



- *Integrated mosquito control programs*
- *Regional integration hubs*

COLLECTION METHODS

The choice of collection method affects cost per data point, with implications on the quality and quantity of data collected



- *Larval sampling*

WORKFORCE / DATA COLLECTORS

Expanding the pool of people who collect surveillance data, and embedding collection into existing activities, is essential for sustainability



- ***Community collection***
- ***Central / district collection***

LABORATORY AND ANALYTICAL METHODS

Innovations in lab and analytical methods reduce per-sample costs of high-quality species identification, resistance, and infectivity data



- *MALDI-TOF-MS*

TECHNOLOGY & INNOVATION

Emerging tech can amplify the value of data collected, reduce dependence on scarce expertise, and enable proactive decision-making



- ***VectorCam***
- ***AI- or model-generated predictions of sentinel site results, geographic gaps, etc.***

Theme 1: Site Selection and Sampling Strategy

Roving / Rotational Sites

- **Rotate entomological teams across locations on a scheduled basis**
- **Increases spatial coverage with the same workforce**

Roving Options

All sites in a district/province/ region are classified as roving

Some sites are designated as fixed, while others are assigned as roving

Cost Considerations

Moderate and uses existing workforce; requires travel/logistics for site rotation

Data Considerations

Spatial coverage is good; temporal resolution is low at any given site

Reduced Frequency

Define minimum effective frequency for each indicator, considering:

- **Not every indicator requires monthly monitoring**
- **Biannual assessment of insecticide resistance may be sufficient in stable areas**
- **Not all sites need to be collected from each year**

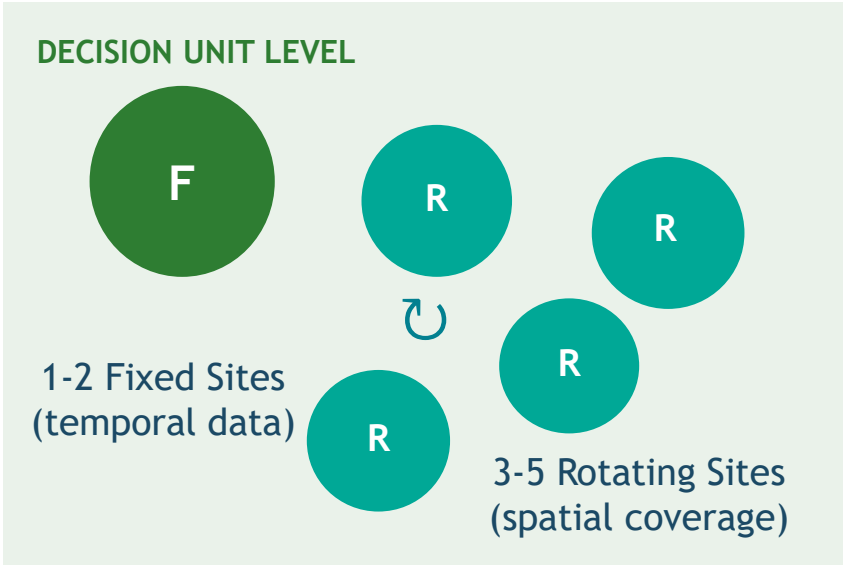
Cost Considerations

Reducing collections can significantly save costs

VC Implications

Align frequency with procurement cycles / decisions to be made

Roving Site Model Structure



VC Implications

Characterize vector behaviors and resistance across wider area, enabling more geographically nuanced decisions

Decisions Supported

- *Where* to prioritize *which* VC interventions; based on broader geographical data
- *Timing* of interventions

Theme 4: Incorporating community-based data collection expands the workforce, increasing data quantity for trend monitoring and complementing higher quality, expert-led data collections

Community-Based Surveillance

The scarcity of trained entomologists is a binding constraint. Expanding the pool of people who contribute to surveillance (e.g. CHWs, village-based volunteers) is essential for sustainability.

VC Implications

Trend monitoring (vector densities), species presence/absence, breeding site mapping for LSM

Cost Considerations

Low costs per collection point (e.g. Zambia's community-based trapping estimated at $2–5 per trap-night vs. $15-30).

- Small stipends needed for motivation
- Solar panels for trap charging provide sustainable power

Focal Investigations and Routine Surveillance

Detailed, expert-led investigations and surveillance according to data collection site strategy (fixed/rotating) and foci

Identify local transmission drivers, guiding appropriate response (which tool/intervention to put where and when)

Cost Considerations

- Relying on skilled entomology data collectors costs more
- In elimination settings, focal investigations may be the primary surveillance expenditure

Cross-Cutting Considerations

Data Considerations

Community members likely collect lower quality data than professional teams, but due to high volume, data may be adequate for trend detection. This should be validated and complemented with expert-led collections

Challenges

- Retention, motivation, and incentives
- Technology and infrastructure barriers

Theme 6: Technology and innovation can amplify the value of data collected, reduce dependence on scarce expertise, and enable proactive rather than reactive decision-making

Modeling / AI

Models and/or AI using climate, land use, historical data, and intervention coverage can predict vector dynamics and resistance trends between data collection points or areas

Machine Learning

Apps like VectorCam use automated image recognition for morphological ID, reducing dependence on scarce expertise. Pairs well with community collection

Remote Sensing

Freely available satellite imagery combined with climate data to model vector habitat suitability and guide where to deploy limited entomological resources

Cross-Cutting Considerations

- Lack of standardization and universally accepted SOPs
- Funding for surveillance innovation competes with ITN campaigns, IRS rounds, case management
- Have limited field validation across ecological settings (Sahel vs. coast)
- Fear of de-skilling entomologists
- Limited IT support as NMCPs rarely have software engineers
- Digital tools require stable power supply that may lack in different areas

Acknowledgements

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RBM Partnership
To End Malaria

4 March 2026

Lightning talks 1: Operationalizing environmental DNA (eDNA) detection of major malaria vector species

Louisa Messenger, University of Nevada, Las Vegas



Operationalizing environmental DNA (eDNA) detection of major malaria vector species

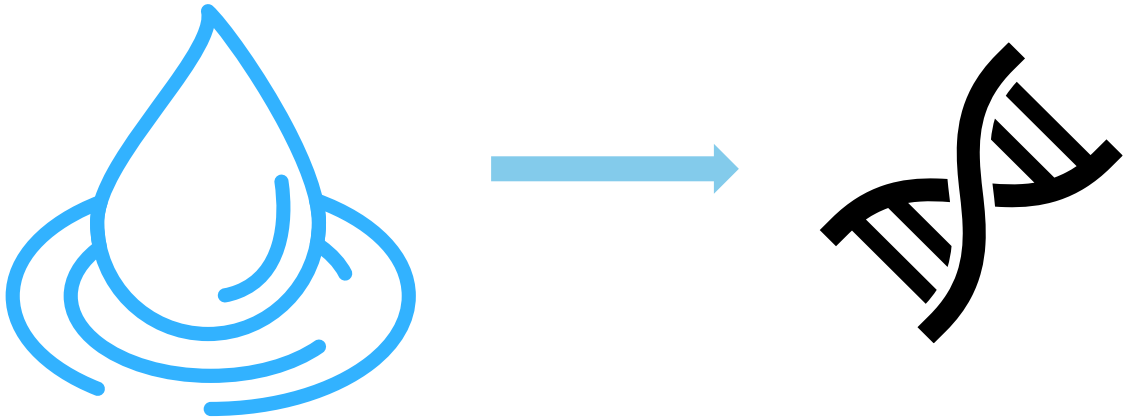
Dr. Louisa Messenger

21st Annual RBM Vector Control Working Group

Wednesday 4th March 2026

UNLV
SCHOOL OF PUBLIC HEALTH

Environmental DNA (eDNA) Surveillance







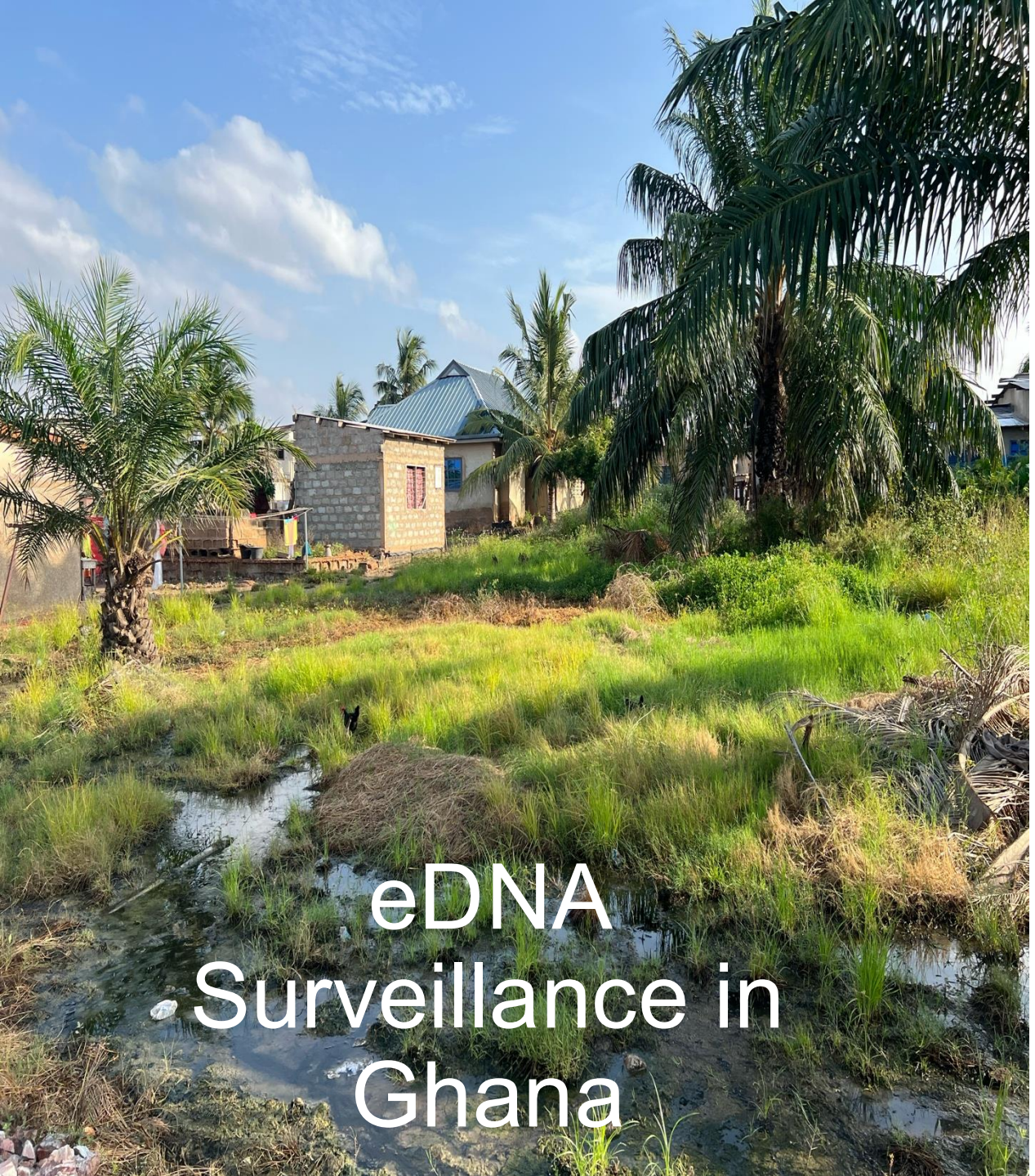


eDNA IS GENETIC MATERIAL THAT ORGANISMS SHED IN THEIR ENVIRONMENT

NON-INVASIVE, HIGHLY SENSITIVE SURVEILLANCE OF ENVIRONMENTAL SAMPLES (WATER / AIR / SOIL)

DETECTION OF eDNA IS AN INDICATOR OF RECENT PRESENCE OF THE (INVASIVE) SPECIES OF INTEREST

CAN BE LEVERAGED FOR CITIZEN SCIENCE SAMPLING



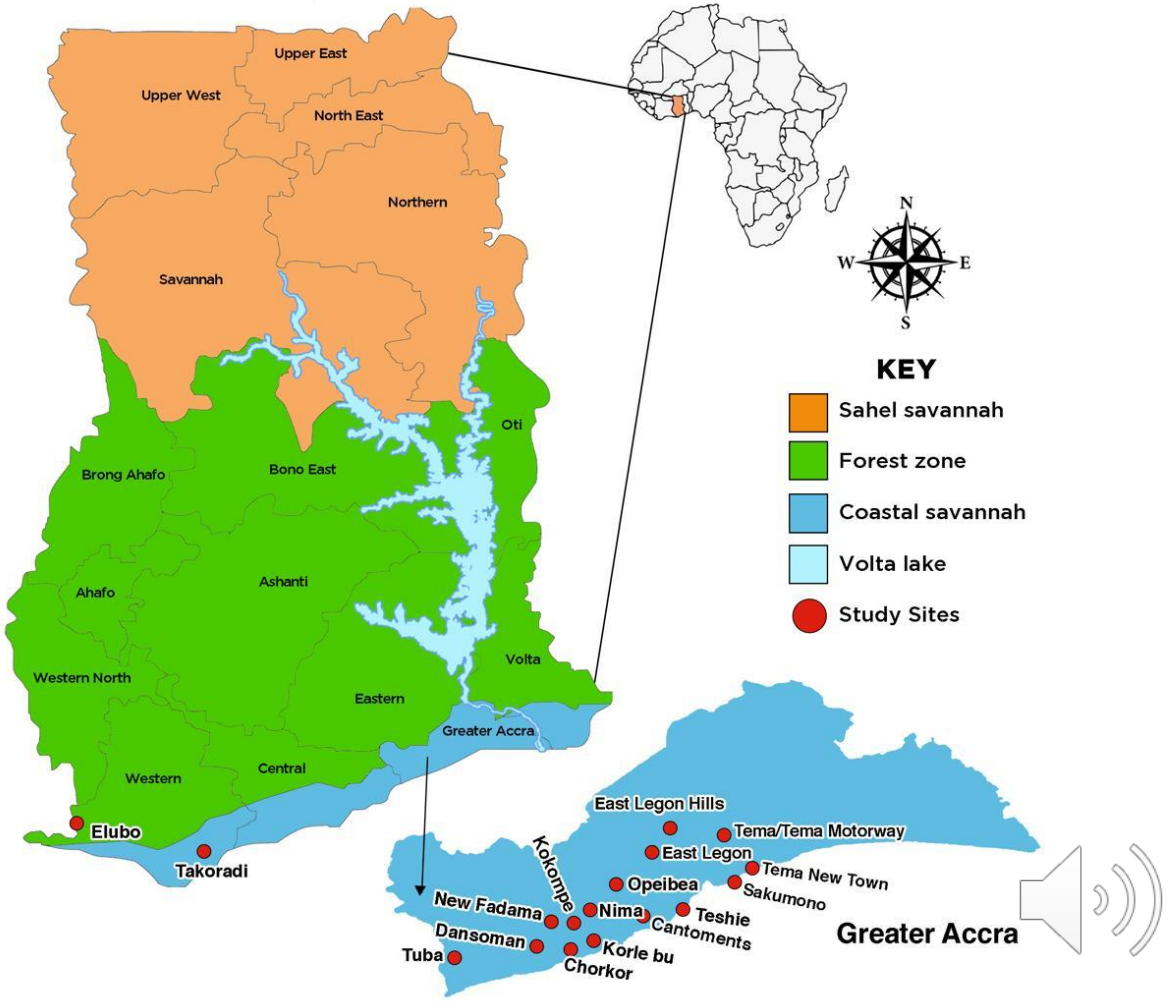
eDNA Surveillance in Ghana

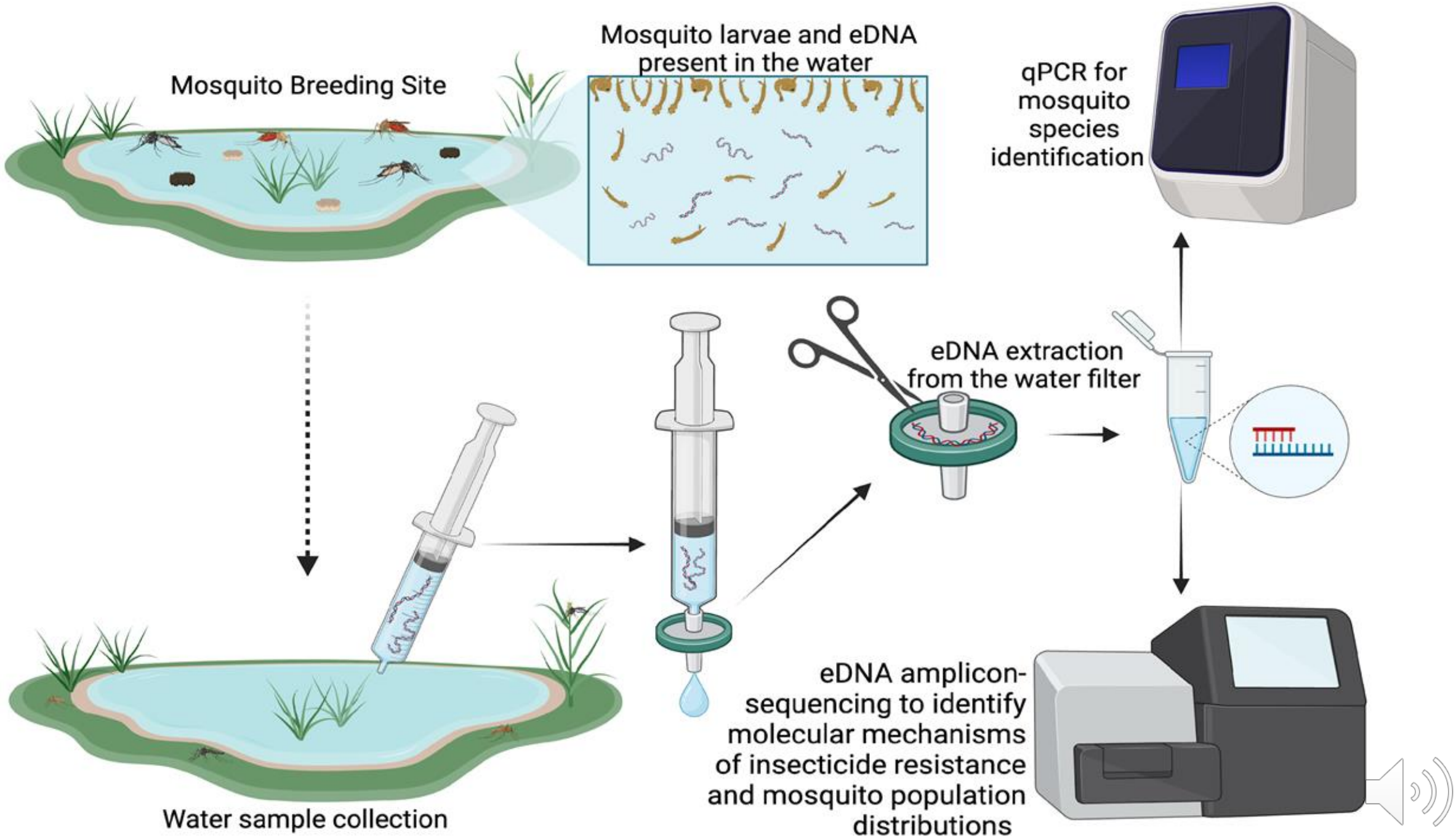
scientific reports

OPEN

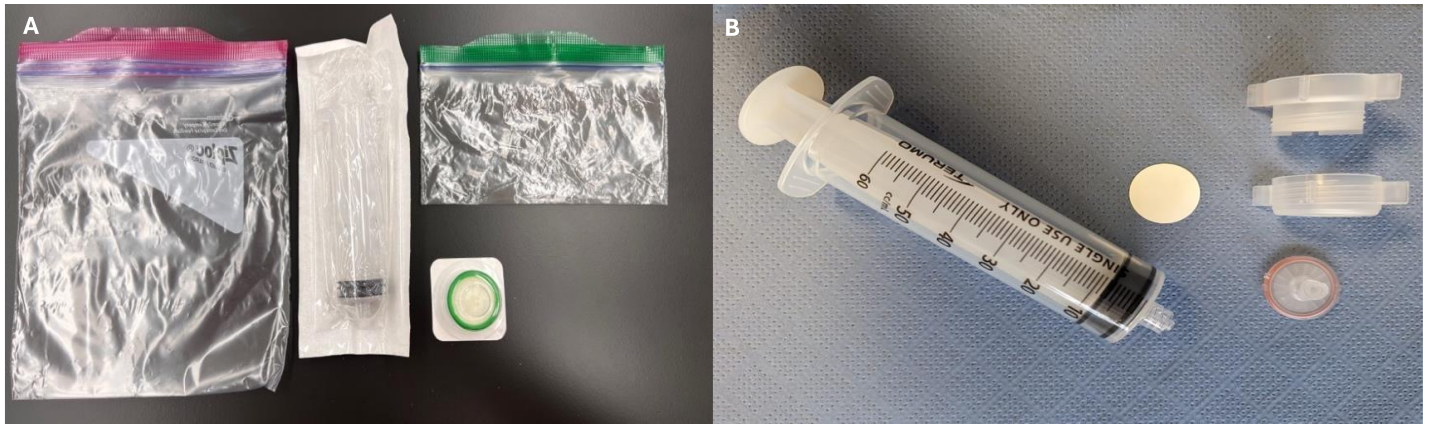
Towards environmental detection, quantification, and molecular characterization of *Anopheles stephensi* and *Aedes aegypti* from experimental larval breeding sites

Mojca Kristan[1✉], Holly Acford-Palmer[1], Monica Oliveira Campos[1], Emma L. Collins[1], Jody Phelan[1], Natalie M. Portwood[1], Bethanie Pelloquin[1], Sian Clarke[1], Jo Lines[1], Taane G. Clark[1], Thomas Walker[1,2], Susana Campino[1] & Louisa A. Messenger[1,3✉]




Mosquito Breeding Site
Mosquito larvae and eDNA present in the water
qPCR for mosquito species identification
eDNA extraction from the water filter
Water sample collection
eDNA amplicon-sequencing to identify molecular mechanisms of insecticide resistance and mosquito population distributions


A
B
C
D
E
F
G
H
I


A
B

Study Findings & Conclusions

- 183 eDNA samples (55 re-usable filters and 128 fixed filters) collected from 116 breeding sites across 19 sites in Greater Accra Region, of which immature *Anopheles* spp. were observed in 93.4%
- PCR data generated for 91.2% of eDNA samples with observable breeding, of which *Anopheles* eDNA was detected in 76.3%; predominant species was *An. coluzzii* (56.4%)
- By filter type, positivity rates were similar (65.4% *vs*. 70.3% for re-usable *vs*. fixed, respectively)
- Next-generation sequencing of eDNA PCR amplicons, covering 8 insecticide resistance mutations, was feasible
- First to report *gste2*-F102L – a novel resistance associated mutation, detected by sequencing eDNA

CHR	POS	REF	ALT	Amplicon	ALT Alleles	# Samples with Coverage	FREQ	Known SNP
2L	2422652	A	T	VGSC1_D2	32	32	0.500	L995F
2L	2429617	T	C	VGSC1_D3	1	26	0.019	I1527T
2L	2429623	T	G	VGSC1_D3	1	26	0.019	F1529C
2L	2430424	G	T	VGSC1_D4	3	7	0.214	A1746S
2L	25429236	C	G	RDL	31	28	0.554	A296G
2R	3492074	G	A	ACE1	5	16	0.156	G280S
3R	28598057	G	T	GSTE2	3	24	0.063	F120L
3R	28598062	G	C	GSTE2	5	24	0.104	L119V

- **eDNA represents a highly feasible, sensitive, community-led vector surveillance tool, which requires minimal training or technical infrastructure**
- **Can be used to augment entomological monitoring capacity, including to detect early shifts in vector epidemiology and tracking of invasive species dispersal**

Funded by: RAFT
RESILIENCE AGAINST FUTURE THREATS

With thanks to the entire study team:
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Karen Figueroa Chilito (UNLV)
Jo Lines (LSHTM)
Sian Clarke (LSHTM)
Taane Clark (LSHTM)
Susana Campino (LSHTM)

Questions?

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UNLV PARAVEC

RBM Partnership
To End Malaria

4 March 2026

Lightning talks 2:

Predicting Mosquito Age and Species with Mid-Infrared Spectroscopy and AI: A Cost-Effective Alternative Method for Enhanced Malaria Surveillance.

Amos Okot, Kampala Capital City Authority

Predicting Mosquito Age and Species with Mid-Infrared Spectroscopy and AI: A Cost-Effective Alternative Method for Enhanced Malaria Surveillance, Ifakara Health Institute, Tanzania: 2024

Okot Amos

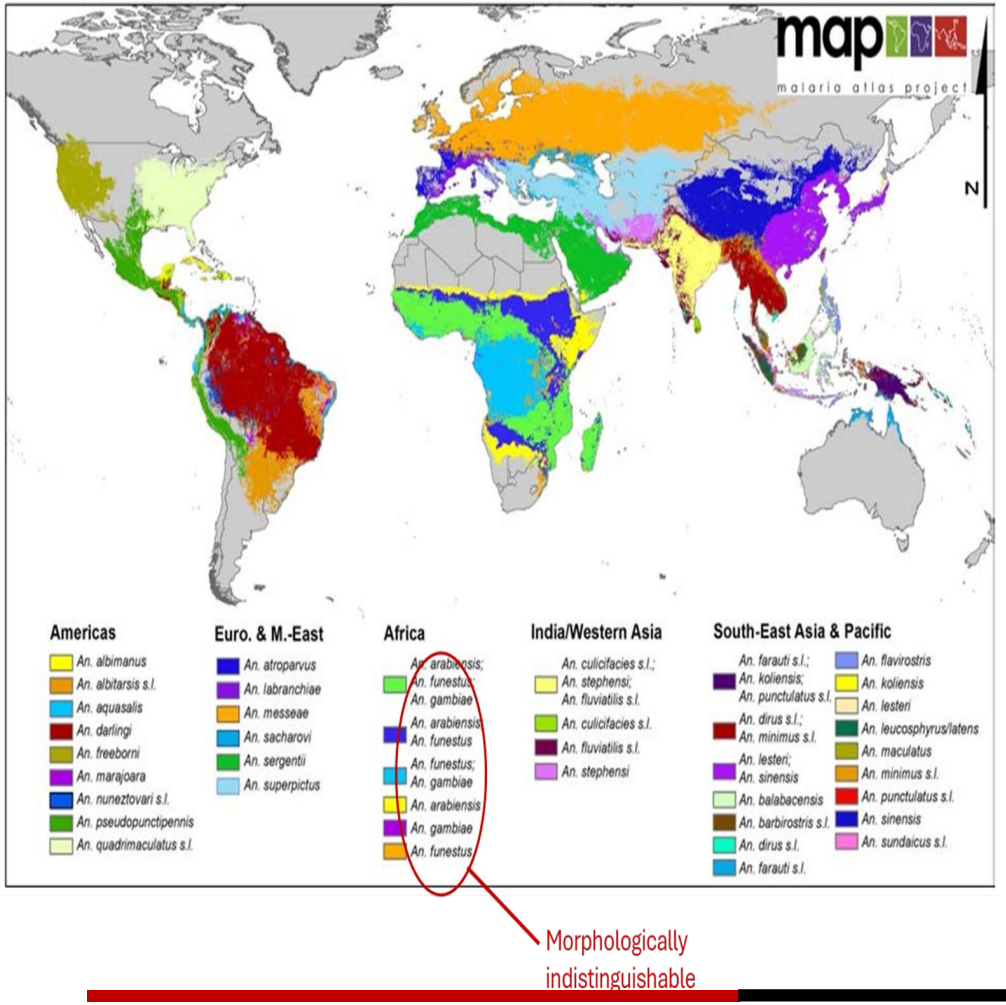
LABORATORY SCIENTIST

Directorate of public health and environment, Kampala Capital City Authority

amokot2007@gmail.com

Background

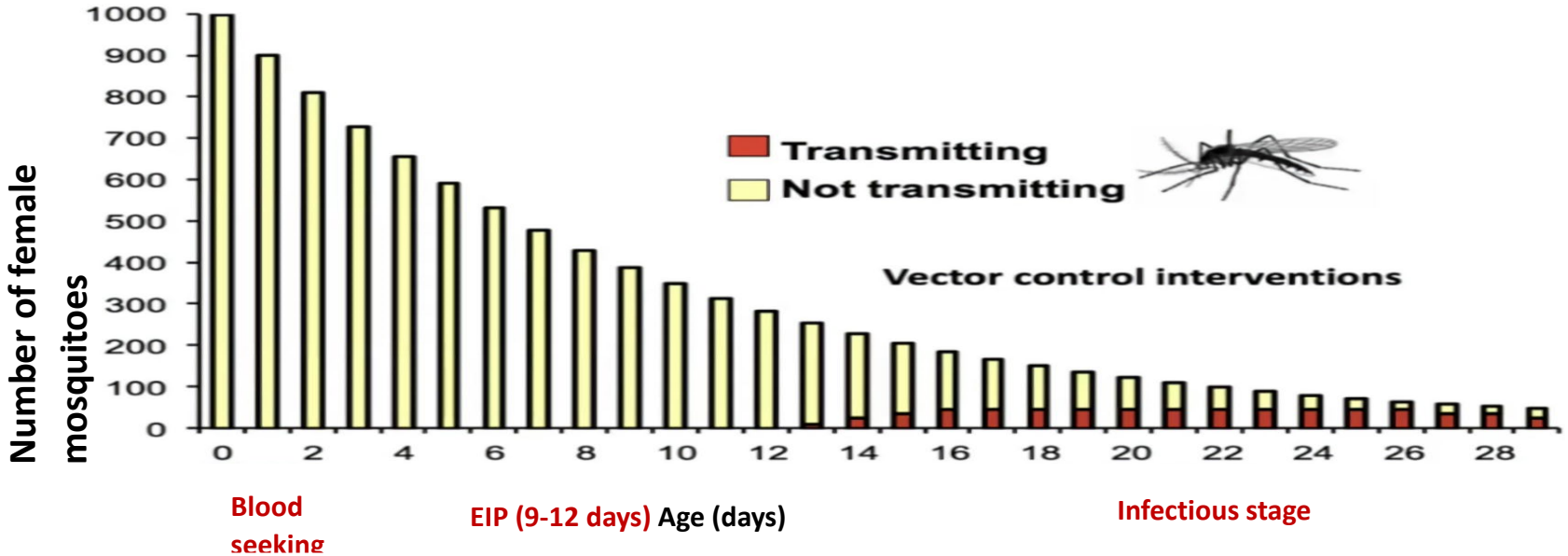
Entomological surveillance: vector species



- **Malaria Control Success:** LLINs and IRS prevented 537 million cases.
- malaria still caused **610,000 deaths in 2024, upward trend prior to previous y**
- **Resistance Challenge:** Insecticide resistance threatens effectiveness
- need for **vector/parasite surveillance**
  - Transmission hotspots
  - Species present and their abundance
  - Infection rates
  - Survival (age)
  - Insecticide resistance
  - Assess change in mosquito behavior

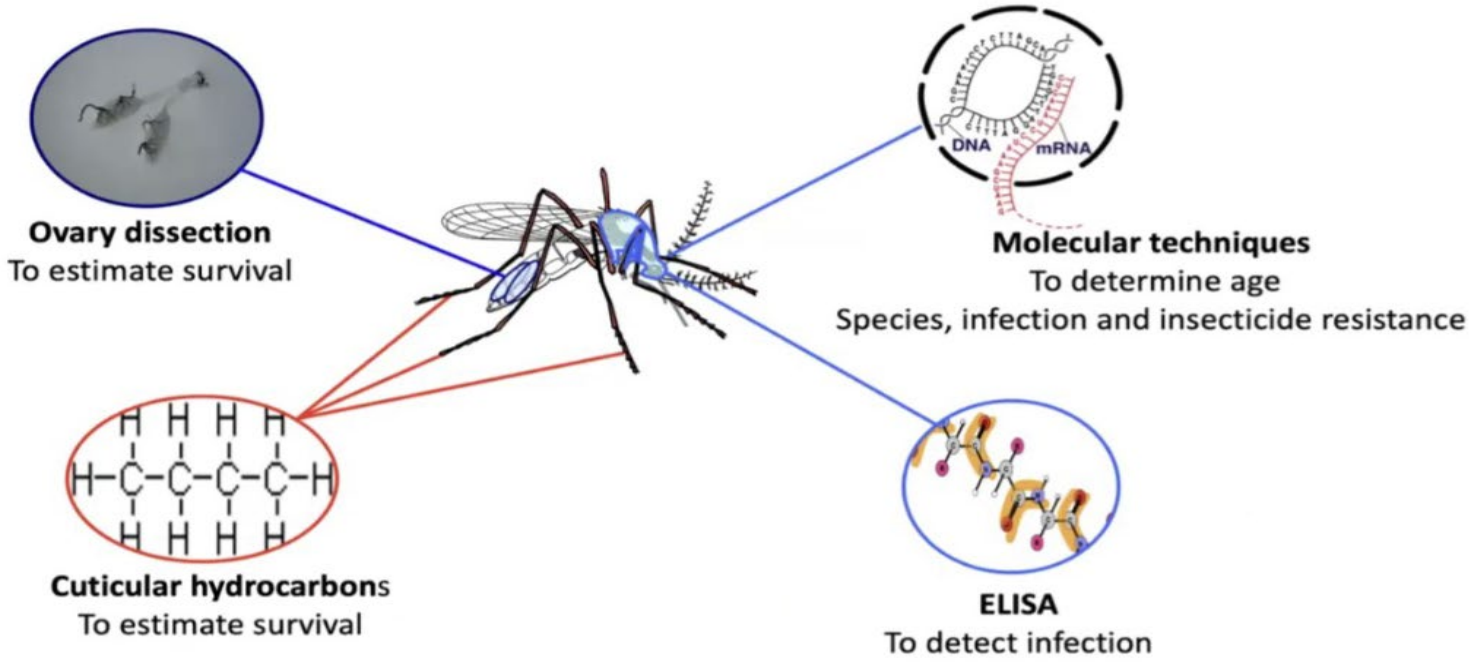
Vector surveillance

- Vector surveillance is the routine monitoring of mosquito populations to assess the impact of vector control interventions



Modified from Brownstein et al. 2003. J. Invertebr. Pathol. 84: 24-29

Traditional mosquito surveillance tools



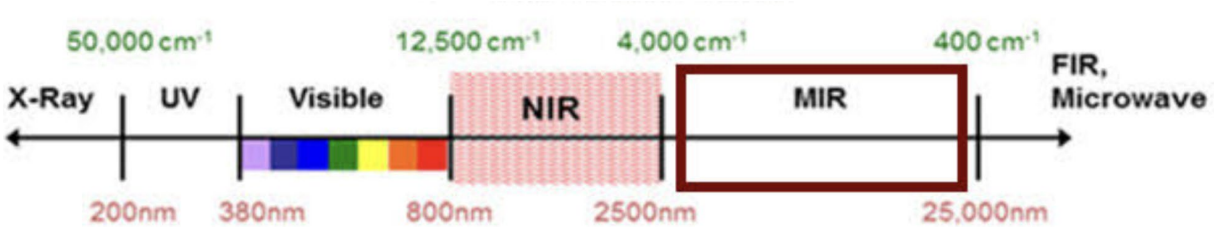
WHO Malaria elimination framework 2016-2030

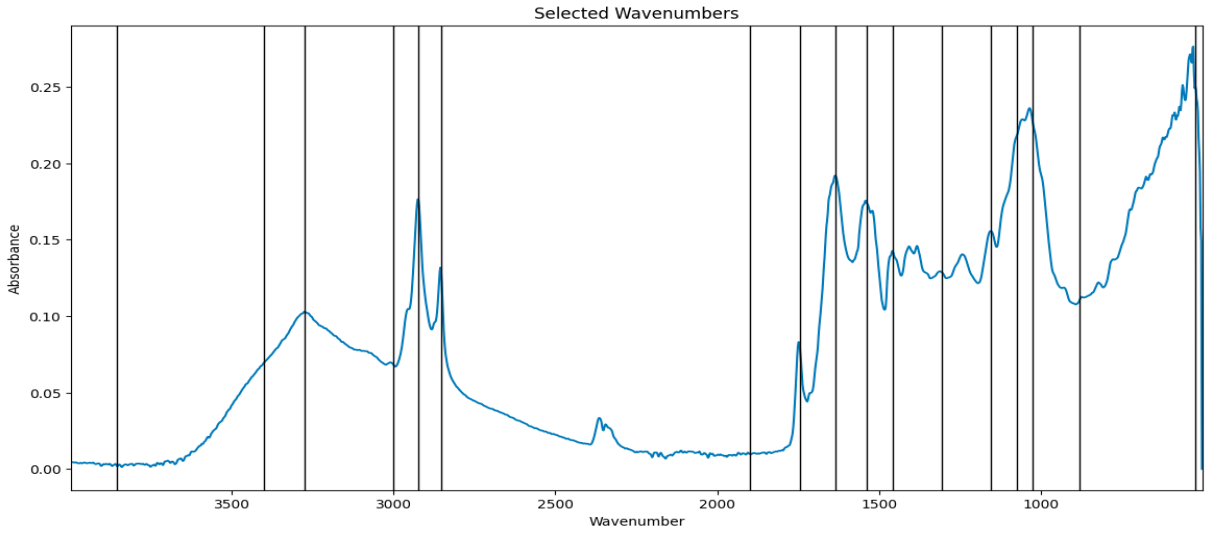
1. Strengthen vector surveillance
2. Transform malaria surveillance into a core intervention
   - Test all individuals with suspected malaria
   - Quality and timelines for case reporting
   - Community case detection
3. Universal access to malaria prevention, diagnosis and treatment
4. Understand the intensity of malaria transmission
5. Enhance and optimize vector control

Methods Overview

- **Mid-Infrared Spectroscopy (MIR):** Measures the chemical composition of mosquito cuticles.









Experimental Setup

Species

- **AA** : 19130
- **AG** : 15790
- **AC** : 6448

Age grading

- **11-17** : 17171
- **5-10** : 13417
- **1-4** : 4392

KEY RESULTS: AGE 94% accuracy (Random Forest best).

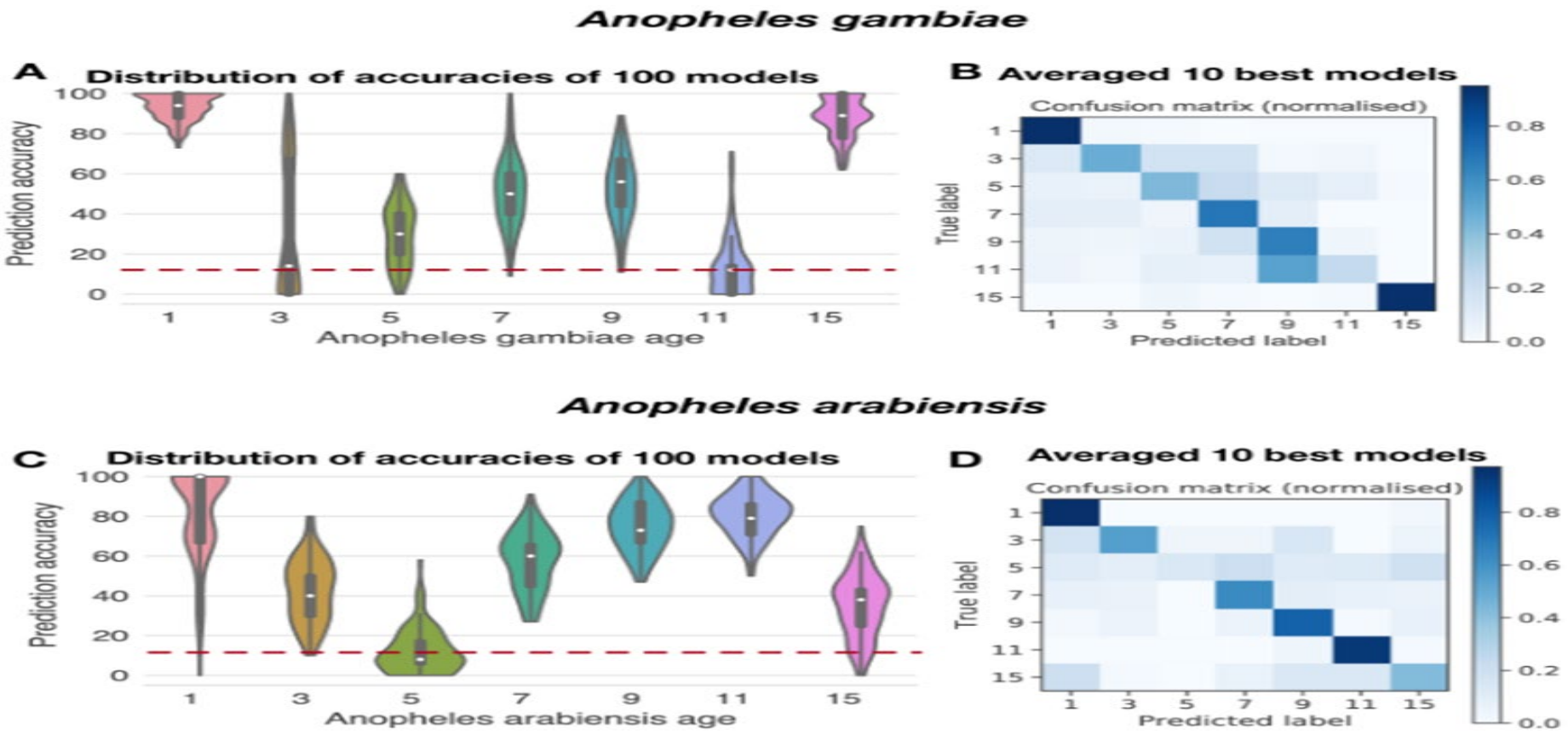


Figure 14. Prediction of *An. gambiae* (**A**–**B**) and *An. arabiensis* (**C**–**D**) age class using mid-infrared spectra. (**A**, **C**) Violin plots of the distribution of per age class prediction accuracies of 100 optimised models. (**B**, **D**) Confusion matrices showing the proportion of accurate (diagonal) classification of mosquitoes as either 1, 3, 5, 7, 9, 11, or 15 days old using the 10 best logistic regression models trained on repeated stratified random subsets using 70% of all mosquitoes sampled, and tested on the remaining 30% (n = 681 for *An. gambiae* and n = 737 for *An. arabiensis*).

KEY RESULTS: SPECIES 43% accuracy

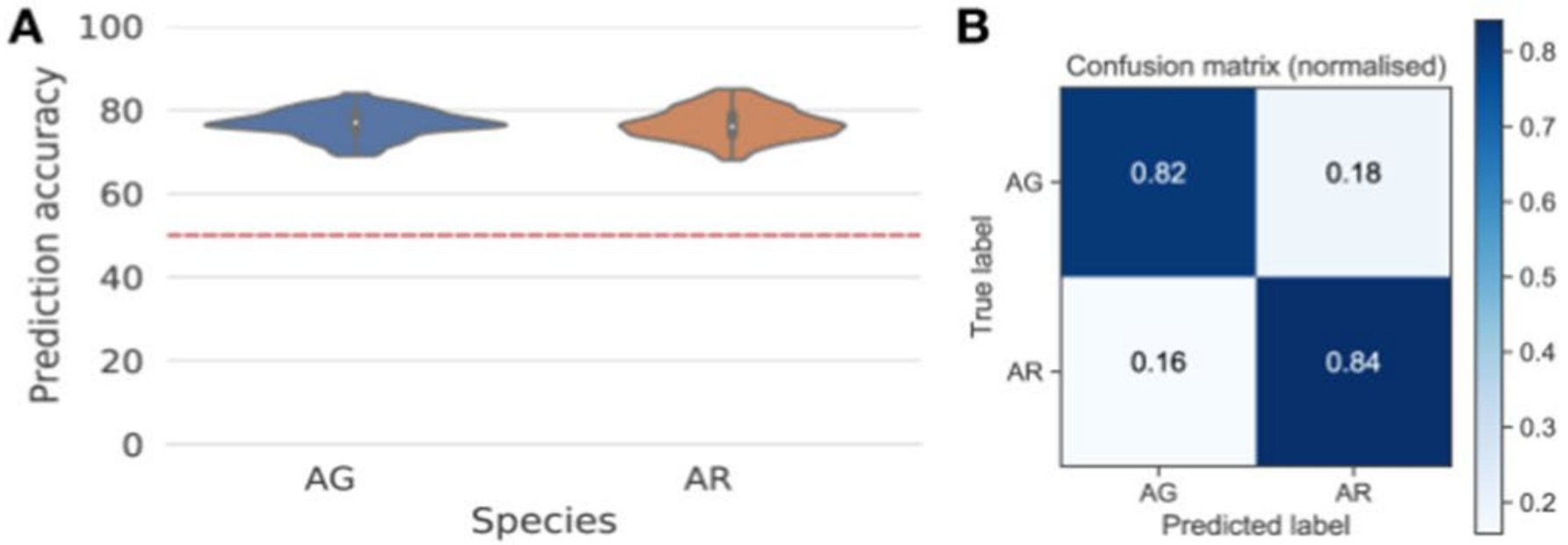
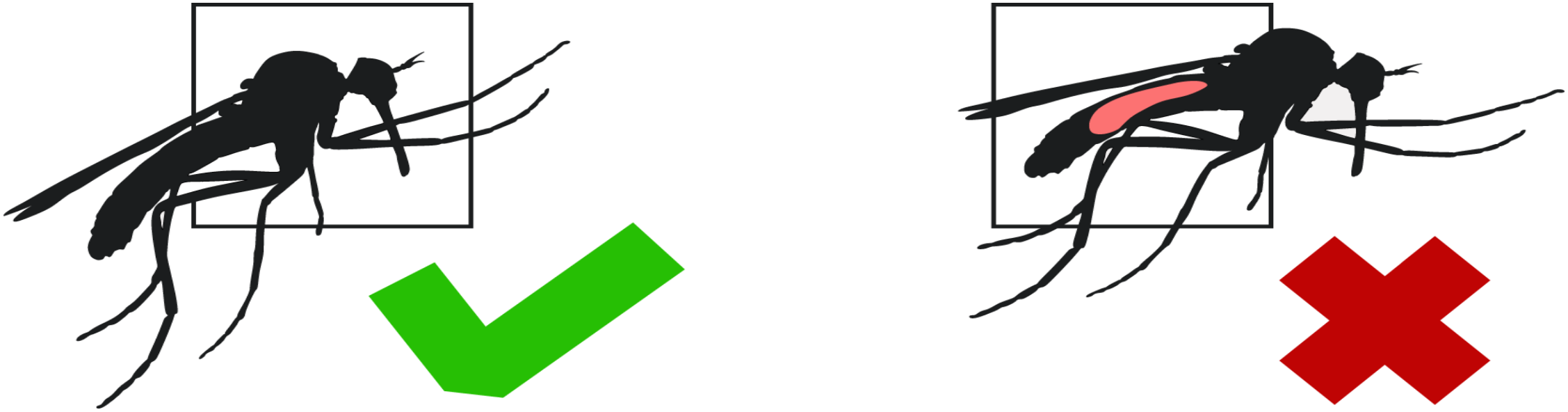


Figure 13. Prediction of mosquito species using mid-infrared spectra. (**A**) Violin plots of the distribution of per species prediction accuracies of 100 models trained on different random stratified subsets (70/30 splits) of the data. The red line shows model prediction accuracy under chance alone (i.e. in the absence of learning). (**B**) Confusion matrix showing the proportion of accurate (diagonal) classification of mosquitoes as either *An. gambiae* (AG) or *An. arabiensis* (AR) using the 10 best logistic regression models (n = 2,536).

Applications in Malaria Control

- Faster/accurate age grading alternatives
- More affordable species differentiation methods
- Faster and affordable infection detection techniques
- Faster detection tools for insecticide resistance



Best position of the mosquito on the ATR crystal. The correct way to place a mosquito on the ATR crystal (left)

Future Work



Expand dataset with field-collected mosquitoes.



Further refine machine learning models for better accuracy.



Explore MIR for detecting insecticide resistance

Conclusion

- MIR spectroscopy coupled with machine learning offers a novel, cost-effective method for mosquito species and age classification.
- The approach has significant potential for enhancing malaria vector surveillance and control.

Acknowledgments









Thank you

RBM Partnership
To End Malaria

4 March 2026

Panel Discussion: Maintaining the quality of entomological surveillance in a resource constrained environment

Panel members: Raymond Tabue (Cameroon NMCP), Edith Ramaita (Kenya NMCP), Otubea Ansah (Ghana NMCP), Charles Fanaka (Zambia NMCP)

WS2 TT3 Panel

Raymond (Cameroon):

Has your programme ever made a successful case to the Ministry of finance or a domestic budget line for entomological surveillance funding, separate from donor support? Tell us what happened.

WS2 TT3 Panel

Edith Ramaita (Kenya):

How do changes in malaria funding (i.e. reductions from PMI/USAID and the Global Fund) affect your surveillance activities? What adaptations have you made or plan to make?

WS2 TT3 Panel

Otubea Akrofi (Ghana):

What is the single most important piece of entomological data your programme needs but currently struggles to collect, and what is the barrier?

WS2 TT3 Panel

Charles Fanaka (Zambia):

How do you balance the demand for nationally representative data with the reality that you can only monitor a limited number of sentinel sites?

RBM Partnership
To End Malaria

4 March 2026

Buffet lunch
Networking
E-Poster Viewing (Group C & D)

RBM Partnership
To End Malaria

3 March 2026

E-Poster Group C & D

See the list