MACEPA PATH
Malaria Control and Elimination Partnership in Africa

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Government of the Republic of Zambia

Monitoring population and transmission dynamics of malaria vectors along Lake Kariba in southern Zambia: Implications for the malaria control and elimination programme

Kochelani Saili[1], Javan Chanda[1], Chadwick Sikaala[2], Adam Bennett[3], Thomas P. Eisele[4], Richard W. Steketee[1], Joseph Keating[4], John M. Miller[1]
[1]Malaria Control and Elimination Partnership in Africa (MACEPA), a program at PATH; [2]Zambia National Malaria Elimination Centre, Ministry of Health; [3]University of California, San Francisco;
[4]Center for Applied Malaria Research and Evaluation, Tulane University School of Public Health and Tropical Medicine

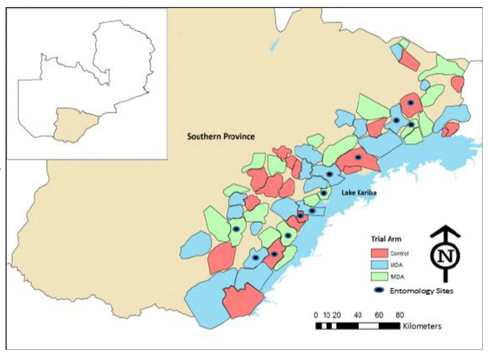
Background

- Malaria continues to be a serious mosquito-borne disease in Zambia where it affects one in every five children, accounting for more than 5 million cases and 2,500 deaths annually.
- The Zambian Ministry of Health (MOH), in collaboration with its partners through the National Malaria Elimination Centre, have an ambitious goal of eliminating malaria by 2021. In order to achieve this, indoor residual spraying (IRS) and long-lasting insecticide-treated nets (LLINs) remain the pillars for malaria vector control. The success of both methods depends on robust entomological surveillance to identify and understand the malaria vectors and their specific ecology, population dynamics, and role in malaria transmission.
- This study reports on the impact of pirimiphos methyl (Actellic™ 300 CS) IRS on malaria vector populations and transmission in areas targeted for malaria elimination in southern Zambia.

Methods

- This study was conducted along the banks of Lake Kariba in Southern Province, Zambia. Since 2014, the province has been subject to key malaria interventions, namely IRS with pirimiphos methyl (Actellic™ 300 CS), mass distribution of LLINs, robust case management at facility and community levels (Ministry of Health, 2015), and research and programmatic mass drug administration (MDA) using dihydroartemisinin-piperaquine (Eisele *et al.* 2016).

Figure 1. Map of Zambia showing the study sites in Southern Province



- This entomological study was conducted parallel to the MDA activities with four sentinel sites being selected from each of the three study arms of the MDA (i.e., community-wide MDA [MDA], focalized MDA [fMDA], and control [i.e., no MDA]).
- Indoor host-seeking and resting *Anopheline* mosquitoes were sampled using CDC Light Traps and Pyrethrum Spray Catches, respectively. Ten randomly selected houses (n=10) were used for each collection method. These and other households in the study areas were also targeted for IRS with Actellic-CS during the trial.
- A baseline study, which included community sensitization and mapping of the study sites, was conducted in September 2014. Initial entomological collections were conducted using CDC Light Traps placed in the ten randomly selected houses for a period of three days each. Thereafter, collections were performed by trained community health volunteers for the period of December 2014 to December 2016.
- Sibling species of *An. gambiae* s.l. and *An. funestus* group were identified by Polymerase Chain Reaction (PCR) whilst sporozoite infection rates of malaria vectors were determined by Enzyme Linked Immunosorbent Assay (ELISA).

Results

- A total of 11,768 adult female *Anopheles* mosquitoes were collected from the 240 houses from August, 2015, to December, 2016.
- A sample of 678 *An. gambiae* s.l. was considered for PCR species identification. PCR results confirmed the presence of *An. arabiensis* (98.4%, n=667) and *An. quadriannulatus* (1.62%, n=9).
- Comparing 2014 (Figure 2) and 2015 data, the proportion of *An. arabiensis* increased from 2.4% (n=154) to 61.5% (n=1,948) and the densities (Table 1) increased from 0.79 to 16.23. In contrast, the proportion of *An. funestus* declined from 95.4% (n=6,011) in 2014 to 25.6% (n=809) in 2015 while densities decreased from 31.63 in 2014 to 6.74 in 2015 in the study areas.

Figure 2. Vector species composition in southern Zambia, 2014 (pre-intervention)

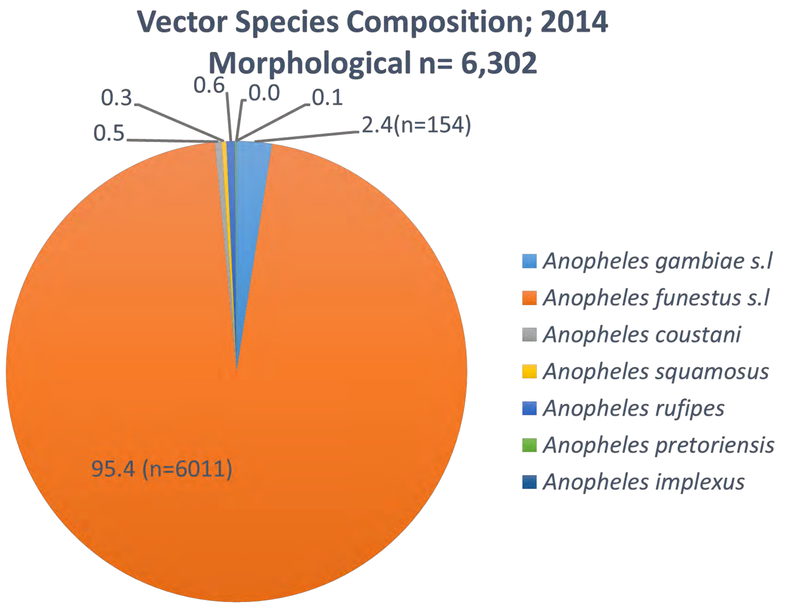
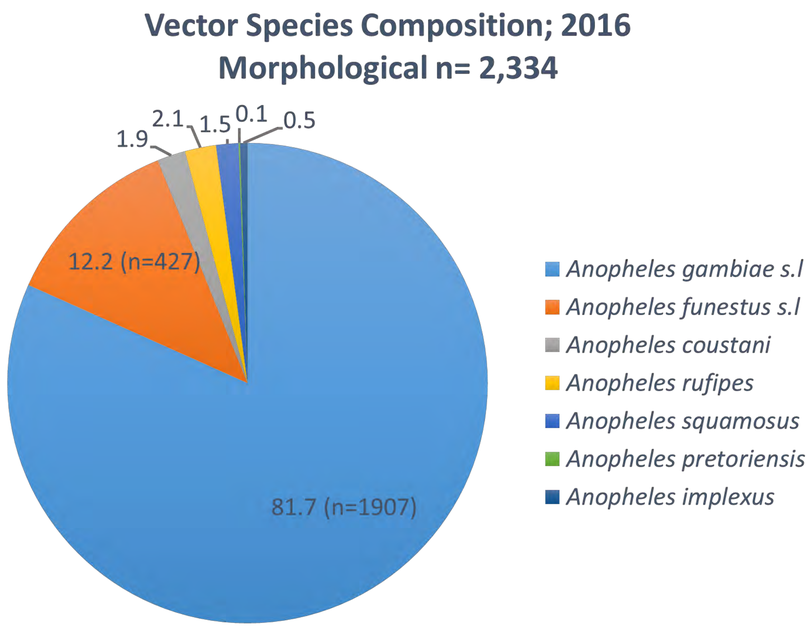


Figure 3. Vector species composition in southern Zambia, 2016 (post intervention)



Results continued

- Following two rounds of pirimiphos methyl IRS in 2015 and 2016 (Figure 3), the proportion of *An. funestus* s.l. reduced from 25.6% (n=809) to 12.2% (n=430) and densities decreased significantly from 6.74 in 2015 to 3.58 in 2016 per house in the study areas. In contrast, the proportion of *An. arabiensis* increased from 61.5% (n=1,948) to 81.7% (n=1,743) while the densities slightly decreased from 16.23 to 14.52 in 2016 as summarized in Table 1.

Table 1. Mosquito density in southern Zambia

Vector species	Number and density	Pre-spray 2014	Post-spray I 2015	Post-spray II 2016
Anopheles gambiae s.l	Total collected	154	1,948	1,743
	Mean density	[0.79]	[16.23]	[14.52]
Anopheles funestus s.l	Total collected	6,011	809	430
	Mean density	[31.63]	[6.74]	[3.58]
Anopheles coustani	Total collected	30	65	18
	Mean density	[0.16]	[0.54]	[0.15]
Anopheles squamosus	Total collected	20	75	84
	Mean density	[0.11]	[0.63]	[0.70]
Anopheles rufipes	Total collected	38	152	16
	Mean density	[0.20]	[1.27]	[0.13]
Anopheles pretoriensis	Total collected	9	82	19
	Mean density	[0.05]	[0.68]	[0.16]
Anopheles implexus	Total collected	43	6	0
	Mean density	[0.23]	[0.05]	[0.00]

- The sporozoite rates of *Plasmodium falciparum* (*Pf*) in *An. funestus* s.s. decreased from 1.75% (n= 600) in 2014 to 0.25% (n=600) in 2016 while only one positive out of the 530 tested was detected in populations of *An. arabiensis* in 2014 in the study areas.

Conclusions

- The introduction of IRS into these study areas corresponded with a decline in mosquito abundance and densities. This decline was most noticeable among *An. funestus.* This decline in abundance and densities was more pronounced among endophilic than exophilic vectors. Further analysis is needed to understand the association with the reductions in vector populations and the level of IRS coverage achieved across the study areas.
- The reduction in *An. funestus* populations and sporozoite infection rates in study areas further suggests the additive impact of malaria interventions (IRS and MDA) on malaria parasite clearance in the study areas.
- To adequately control populations of *An. arabiensis* in the study areas, additional outdoor interventions are required in Southern Province, Zambia.