MACEPA PATH
Malaria Control and Elimination Partnership in Africa

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Government of the Republic of Zambia

Outdoor biting behaviour and insecticide resistance in malaria vectors might challenge malaria elimination in Southern Province, Zambia

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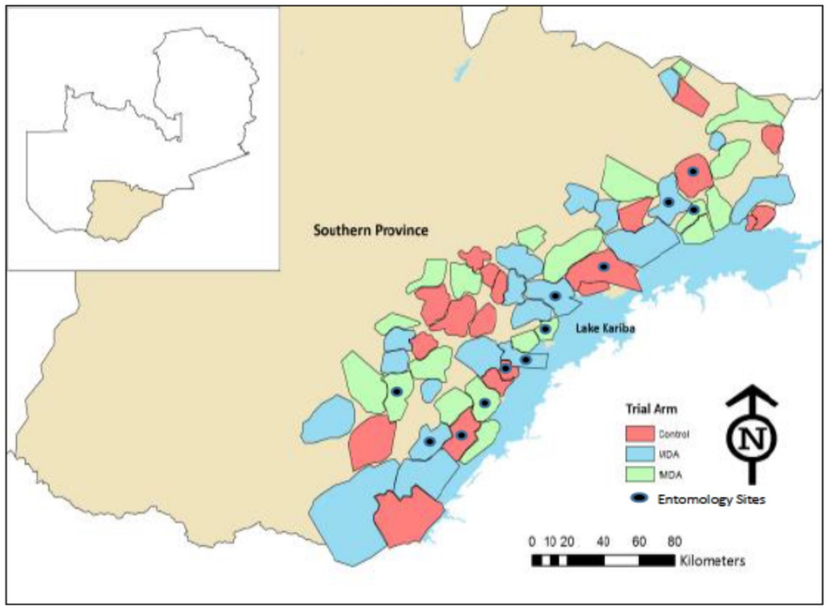
Background

- In the last decade, malaria has been reduced in Africa by 33% as a result of the rapid roll-out of malaria control interventions (WHO, 2011).
- In Zambia, long-lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS) are the main malaria vector control interventions.
- The use of these interventions depends on high coverage, vector susceptibility status to insecticides, and the indoor biting and resting behaviour of malaria vectors.
- However, there is limited information on the behaviour of malaria vectors and their susceptibility to insecticides used for vector control in Zambia's Southern Province.
- This study aimed to monitor vector behaviour, species vector composition, and vector susceptibility to insecticides used for malaria vector control in Southern Province to guide the malaria elimination agenda.

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



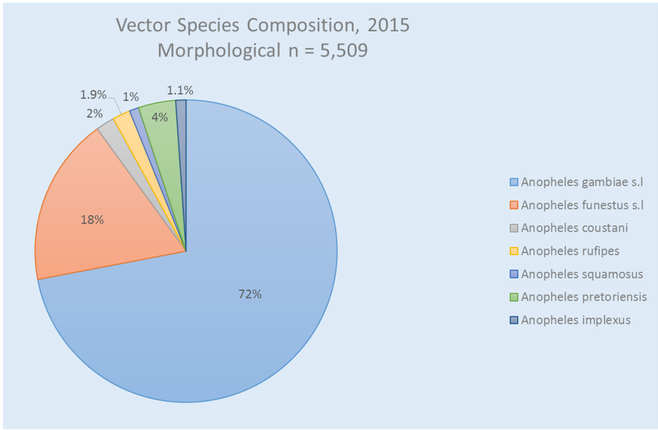
Methods

- Indoor, host-seeking mosquitoes were collected from 36 randomly selected houses from April to May 2015 and from November to December 2015 using Human Landing Catches, a method used to collect live mosquitoes attempting to bite human baits both inside and outside a house.
- Three pairs of human landing collectors were recruited and trained in 12 study areas on how to collect mosquitoes. Mosquito collection was conducted on an hourly basis starting from 18:00 and ending at 06:00 for 15 consecutive days. Individual mosquito collectors were given one tablet of deltaprim™ once a week as a prophylactic drug.
- Insecticide susceptibility tests were conducted on 0.05% deltamethrin, 0.1% bendiocarb, 4% DDT, and 0.25% pirimiphos-methyl following the WHO standard protocol. Metabolic resistance was determined in populations of *An. gambiae* s.l and *An. funestus* by using a synergist piperonyl butoxide (PBO).
- Multiplex Polymerase Chain Reaction (PCR) was used to determine sibling species of *An.gambiae* s.l and *Anopheles funestus*.

Results

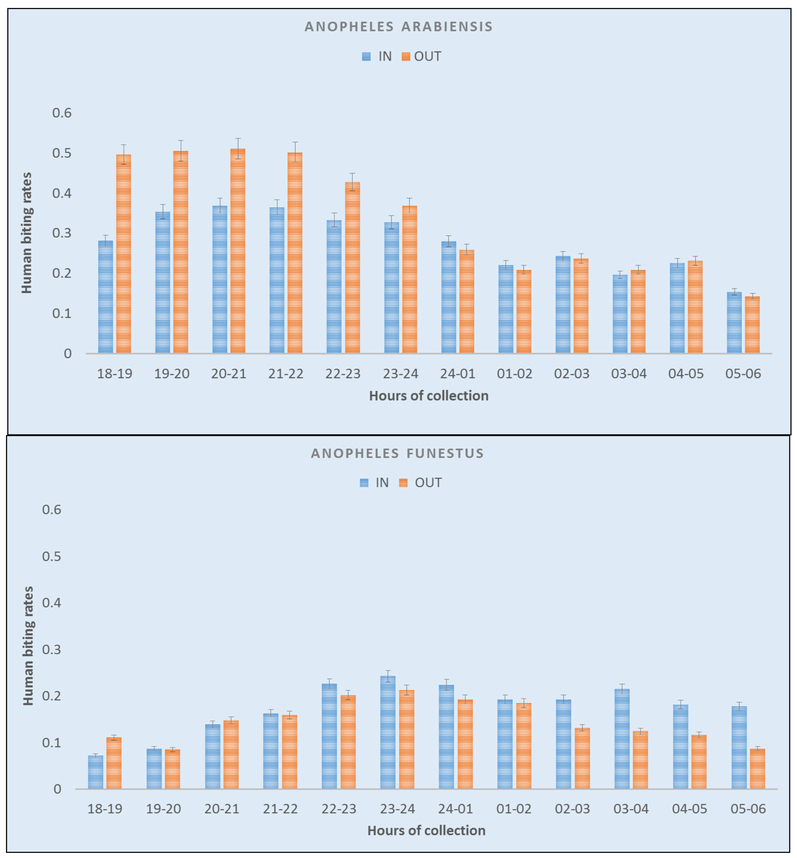
- A total of 5,509 adult *Anopheles* mosquitoes were collected from Apr–May 2015 and Nov–December 2015.
- 72 % (n= 3966) constituted *An. gambiae* s.l, 18% (n= 991) constituted *An. funestus*, and 2% (n = 113) were other anopheline mosquitoes (summarized in Figure 2).
- PCR confirmed the presence of *An. arabiensis, An. quadriannulatus*, and *An. funestus* s.s in the study sites.

Figure 2. Vector species composition in the study areas of Southern Province



- *An. arabiensis* mainly bit humans outdoors (0.55) rather than indoors (0.45), (ANOVA: F=7.1294, df=11, *P*= 0.0217). In contrast, *An. funestus* mainly bit humans indoors (0.55) rather than outdoors (0.45), ANOVA: F=6.55, *P*=0.03.

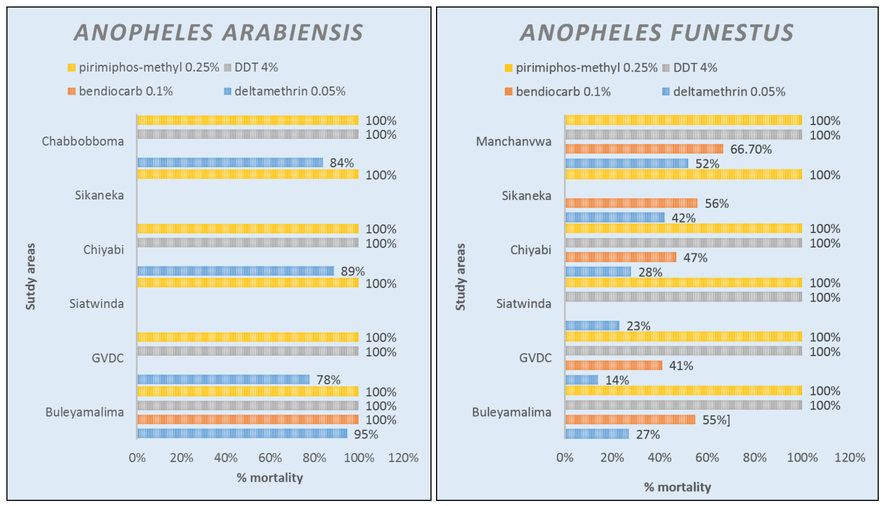
Figure 3. Biting behaviour of *Anopheles arabiensis* and *funestus* in the study areas of Southern Province



Results continued

- Standard WHO bioassays indicate that populations of *An. arabiensis* are resistant to deltamethrin; mortality rates ranged from 78% to 95% (Figure 4).
- In *An. funestus*, high resistance was detected to deltamethrin (mortality rates ranged from 14% to 42%) and bendiocarb (mortality rates ranged from 41% to 56%).
- In all the study sites, *An. arabiensis* and *An. funestus* recorded 100% susceptibility to DDT and pirimiphos-methyl.
- Pre-exposure of *An. arabiensis* and *An. funestus* to piperonyl butoxide nullified both pyrethroid and carbamate resistance.

Figure 4. WHO bioassays of malaria vectors in the study areas of Southern Province



Conclusions

- The outdoor, early-biting behaviour of malaria vectors in the study areas can reduce the effectiveness of LLINs and IRS for malaria control and elimination in Southern Province.
- The high pyrethroid and carbamate resistance in populations of *An. arabiensis* and *An. funestus* may threaten the effectiveness of chemical-based malaria vector control interventions (LLINs and IRS) in the study areas.
- Persistent outdoor biting behaviour of *An. arabiensis* coupled with high pyrethroid resistance in *An. funestus* is likely to undermine malaria elimination efforts by extending residual transmission of malaria in the study areas.
- To adequately suppress malaria transmission and attain malaria elimination in the study areas, additional interventions that target outdoor-biting mosquitoes and sustainable insecticide resistance management strategies are likely to be required in Southern Province, Zambia.