U.S. President's Malaria Initiative

Malaria Vectorial System and Insecticide Resistance in Ethiopia

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Background

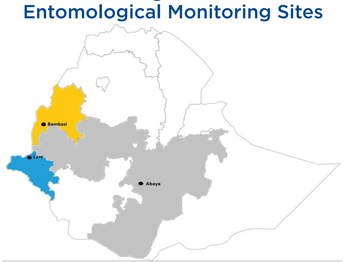
- Routine entomological and insecticide resistance monitoring provide essential information useful for the selection as well as evaluation of malaria vector control interventions.
- The U.S. President's Malaria Initiative (PMI) VectorLink Project in Ethiopia is engaged in indoor residual spraying operations in 44 districts in three regions.
- In addition, the project in collaboration with universities conducts entomological surveillance and insecticide susceptibility tests in selected sentinel sites.

Materials and Methods

Longitudinal Monitoring

- Monthly entomological surveillance was carried out from May 2018 to April 2019 in three districts: Abaya (Oromia – grey region), Lare (Gambela – blue region) and Bambasi (Benshangul-Gumuz – orange region) [Figure 1].
- Anopheline surveillance was conducted using pyrethrum spray sheet collections, human landing collections and CDC light trap collections.

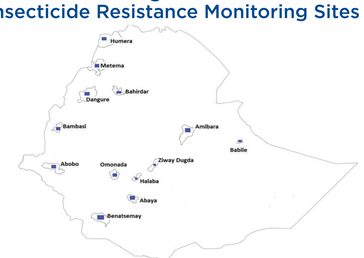
Figure 1.
Entomological Monitoring Sites



Insecticide Resistance Tests

- Susceptibility tests of *An. gambiae* s.l. (presumably *An. arabiensis*) to deltamethrin, permethrin, alphacypermethrin, bendiocarb, propoxur, pirimiphos-methyl, clothianidin and chlorfenapyr were conducted in 4-13 sentinel sites using the WHO tube test for all insecticides with the exception of chlorfenapyr, which were tested using the CDC bottle bioassay.
- Resistance intensity and PBO synergist tests were also conducted.

Figure 2.
Insecticide Resistance Monitoring Sites

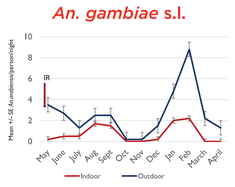


Results

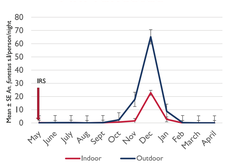
- In Lare, malaria transmission was perennial and it might be due to the occurrence of *Anopheles arabiensis*, *An. funestus* group and *An. pharoensis* at different times throughout the year, but with seasonal shifts particularly between the first two vectors (Figure.3).
- *Anopheles arabiensis* prevailed from May to September and December to April.
- *Anopheles funestus* appeared from October to January.

Figure 3.
Biting Densities of Malaria Vectors in Lare, 2018

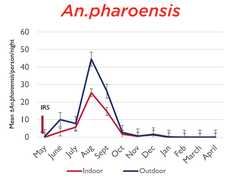
An. gambiae s.l.



An. funestus

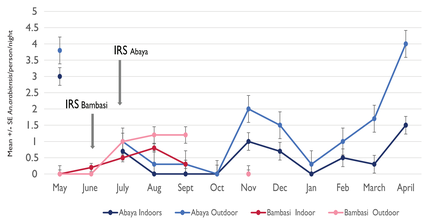


An.pharoensis



- Malaria in Abaya was vectored by *An. arabiensis* and *An. pharoensis* while transmission in Bambasi was accounted to *An. arabiensis*, *An. funestus* s.s and probably also to *An. rivolurum*. *An.arabiensis* in Abaya prevailed through out the year (Figure 4).

Figure 4.
Biting density of *An. arabiensis* in Abaya and Bambasi, 2018



- More expohagy than endophagy of all vectors was prevalent in the sites (Table 1).

Species	Lare			Abaya		
	Indoor	Outdoor	Ratio Out/indoor	Indoor	Outdoor	Ratio Out/indoor
An. arabiensis	52	189	3.6:1	46	96	2.1:1
An. funestus s.l.	179	569	3.2:1	-	-	-
An. pharoensis	316	561	1.8:1	29	72	2.5:1

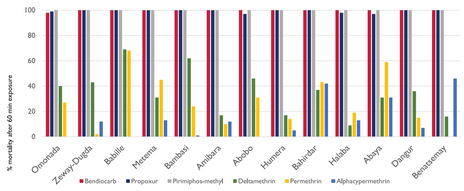
- **Sprozoite infections:** ELISA detected circumsporozoite proteins of *Plasmodium falciparum* and/or *P. vivax* in all vectors with variable rates (Table 2).

Table 2. Sprozoite Infection Rates

Site	Species	No. tested	# Positive Pf (%)	# Positive Pv (%)
Lare	*An. arabiensis*	308	2 (0.65)	
	An. funestus s.l.	964	1 (0.1)	1 (0.1)
	An. pharoensis	999	1 (0.1)	
Bambasi	*An. arabiensis*	121	1 (0.83)	
	An. funestus s.l.	376		1 (0.27)
Abaya	*An. gambiae* s.l.	157	1 (0.64)	

- **Insecticide susceptibility test results:** Populations of *An. arabiensis* were susceptible to Bendiocarb and PM in all 13 sites and to propoxurhin 11/13 sites; high resistance to all pyrethroids was observed in all sites (Figure 5).

Figure 5.
Insecticide Susceptibility Test Results



Resistance intensity and PBO tests: deltamethrin and permethrin

- *Anopheles arabiensis* in Ziway-Dugda and Halaba exhibited low resistance intensity to deltamethrin (>98% mortality at 5X the diagnostic dose). Moderate resistance to deltamethrin was found in Metema, Bambasi, and Amibara (>98% mortality at 10X), while in Abaya, there was high deltamethrin resistance intensity (97% mortality at 10X).
- Low permethrin intensity was recorded in Abaya, moderate intensity in Amibara. Permethrin at the 10X diagnostic dose killed less than 98% of *An. gambiae* s.l. in Zeway-Dugda, Metema, Bambasi, and Halaba, implying high resistance intensity.
- Pre-exposure to PBO restored susceptibility of *An. gambiae* s.l. to deltamethrin in Ziway-Dugda (98.7% mortality), Metema (100% mortality), Amibara (100% mortality), and Halaba (100% mortality) and to permethrin in Metema (98.7% mortality), Amibara (100% mortality), and Halaba (98.7% mortality).
- Pre-exposure to PBO partially restored susceptibility to deltamethrin in Bambasi (97.3% mortality) and Abaya (94.7% mortality) and to permethrin in Ziway-Dugda (45.3% mortality), Bambasi (66.7% mortality), and Halaba (93.3% mortality).

Conclusions

- *Anopheles arabiensis* (species PCR confirmed) is the major malaria vector in Ethiopia. It was found in all the entomological monitoring sites at variable proportions.
- *Anopheles funestus* s.l. in Lare and Bambasi as well as *An. pharoensis* might play an important role as secondary vectors.
- All three vector species were more exophagic than endophagic; the proportion of the outdoor human biting density was two to three times higher than the indoor human biting density.
- Cirumsporozoite ELISA detected *P. falciparum* infections in the three species.
- Populations of *An. arabiensis* were susceptible to bendiocarb, propoxur, and pirimiphos-methyl but resistant to deltamethrin, permethrin, and alpha-cypermethrin.
- Resistance intensity assays indicated low to high resistance to deltamethrin and permethrin.
- PBO synergist either partially or fully restored susceptibility of *An. arabiensis* to pyrethroids indicating the involvement of P450s as resistance mechanism.