The Republic of Uganda

10th ANNIVERSARY malaria consortium disease control, better health

a decade in communicable disease control and child health

UKaid from the British people

Vector resistance studies in Uganda in relation to insecticide use in public health and agriculture

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Malaria Consortium

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PREVENTION | DIAGNOSIS | TREATMENT | RESEARCH

Pyrethroid Resistance Management Project Objectives

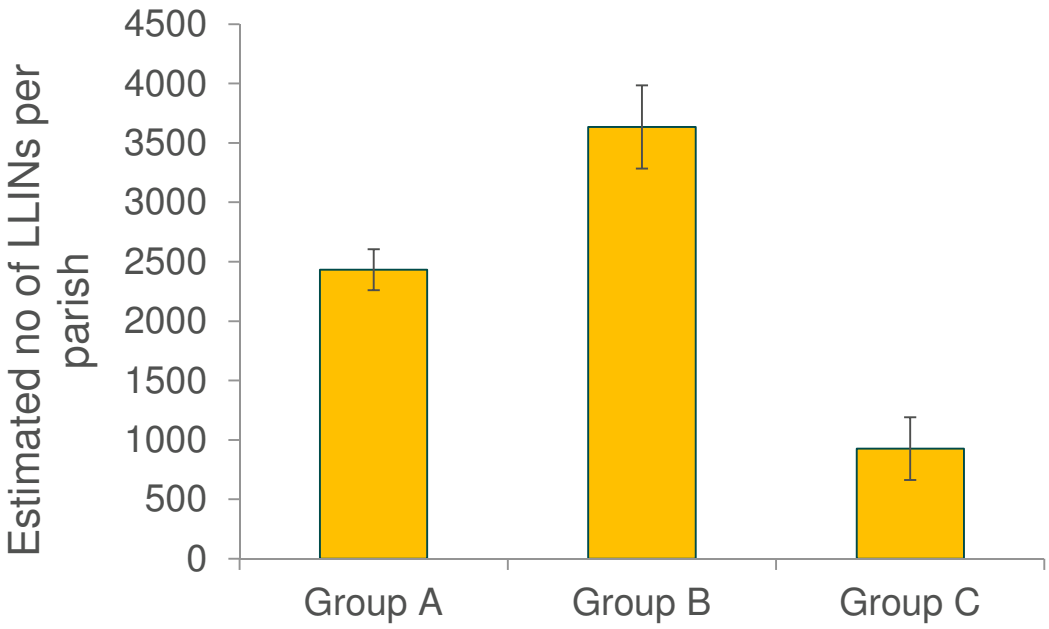
- To evaluate the role of IRS using carbamates or organophosphates in pyrethroid resistance management to prolong the usefulness of LLINs
- To understand the role of insecticides used in public health and agriculture in the spread of vector resistance
- To understand the impact of resistance on effectiveness of interventions
- To support MOH to develop resistance management strategies to maintain coverage of effective malaria interventions

IRS target districts

Year	Implementer	No Districts targeted IRS	Insecticide used
2006	PMI (RTI)	1 District South	Lambda-cyhalothrin
2007	PMI (RTI)	2 Districts South, 3 Districts North	Lambda-cyhalothrin
2008	PMI (RTI) NMCP	5 Districts North 1 District East	DDT Alpha-cypermethrin
2009	PMI (RTI/Abt)	5 Districts North	Alpha-cypermethrin
2010	PMI (Abt)	10 Districts* North	Alpha-cypermethrin Bendiocarb
2011	PMI (Abt)	10 Districts* North	Bendiocarb
2012	PMI (Abt) NMCP	10 Districts* North 1 District East	Bendiocarb

* In 2010, large districts underwent district subdivision

Historical distribution of LLINs per site (2001-2011)



Study site selection

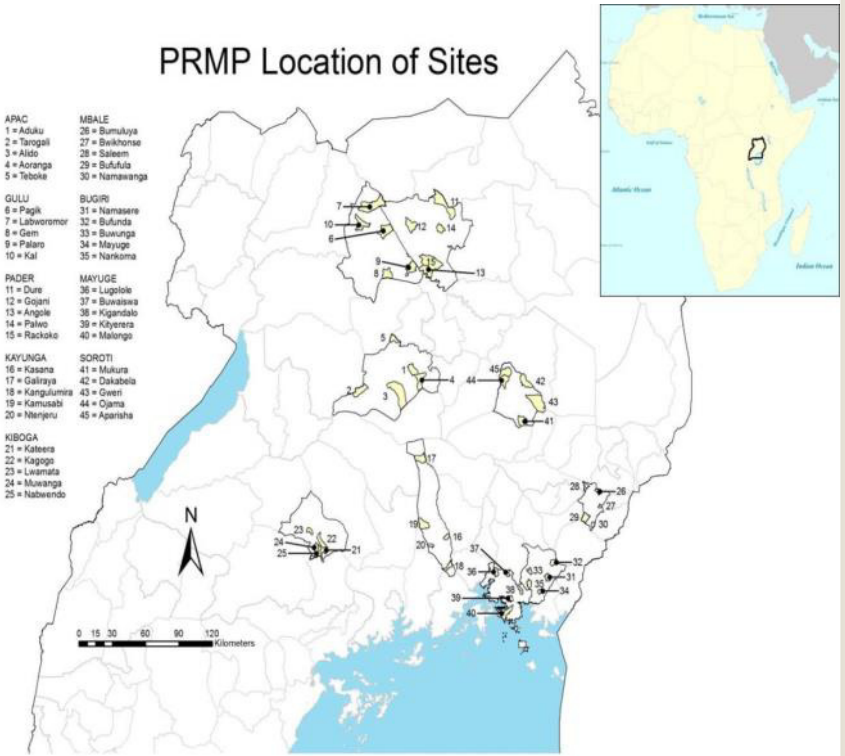
45 sites in 3 groups of districts:

Group A Districts that had undergone several rounds of IRS and received LLINs (Apac, Gulu, Pader)

Group B Districts where LLINs had been distributed but no IRS had taken place (Kayunga, Kiboga, Mbale)

Group C Districts that had not received IRS or LLINs as part of a large campaign (Bugiri, Mayuge, Soroti)

During our survey in September of 2012, LLINs were distributed in Mayuge and Bugiri districts as part of a LLIN mass distribution campaign. In Soroti, nets were distributed a couple of months before the survey.



Study components

Entomological surveys

Household and malariometric surveys

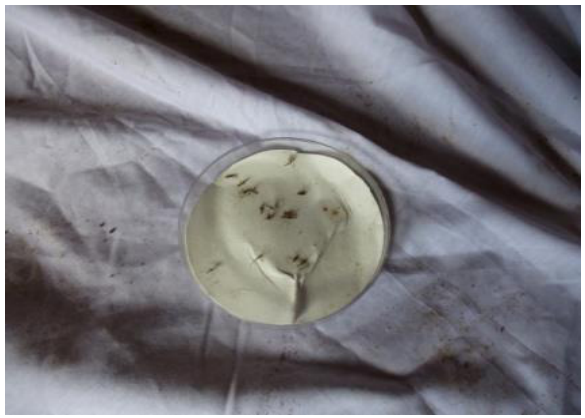
Health facility-based morbidity studies

Intensity of insecticide use in public health

Intensity of insecticide use in agriculture

Entomology survey

- WHO susceptibility tests
- Pyrethrum Spray Catches (PSC)
  - 12 houses in each site x 2 rounds
- Molecular analysis:
  - Species
  - Sporozoite rates
  - Molecular markers of resistance



Household and malariometric surveys

- Household interviews
  - Ownership of ITNs
  - Use of ITNs by household members
  - Spray status of houses
  - Socio-economic status
- Malaria infection rates
  - Infection rates linked with use of interventions by households and household members

Health facility-based morbidity studies

- Trends in morbidity from a geographically defined area (health centre data) over about 10 years:
  - How is the trend associated with the intensity of use of interventions?
  - Is the trend of malaria in any way related to variation in resistance levels?

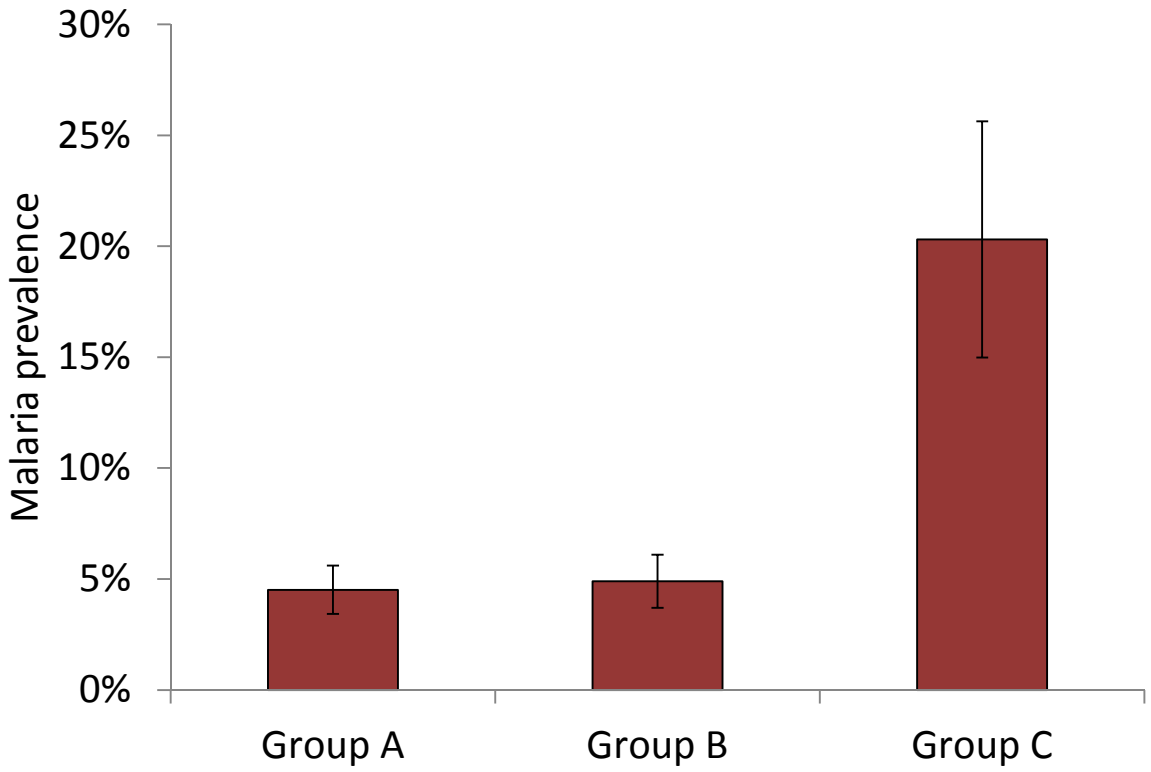
Intensity of insecticide use: public health

- Use of IRS over the years
- ITNs distributed over the years
- Current use of IRS
- Current use of LLINs

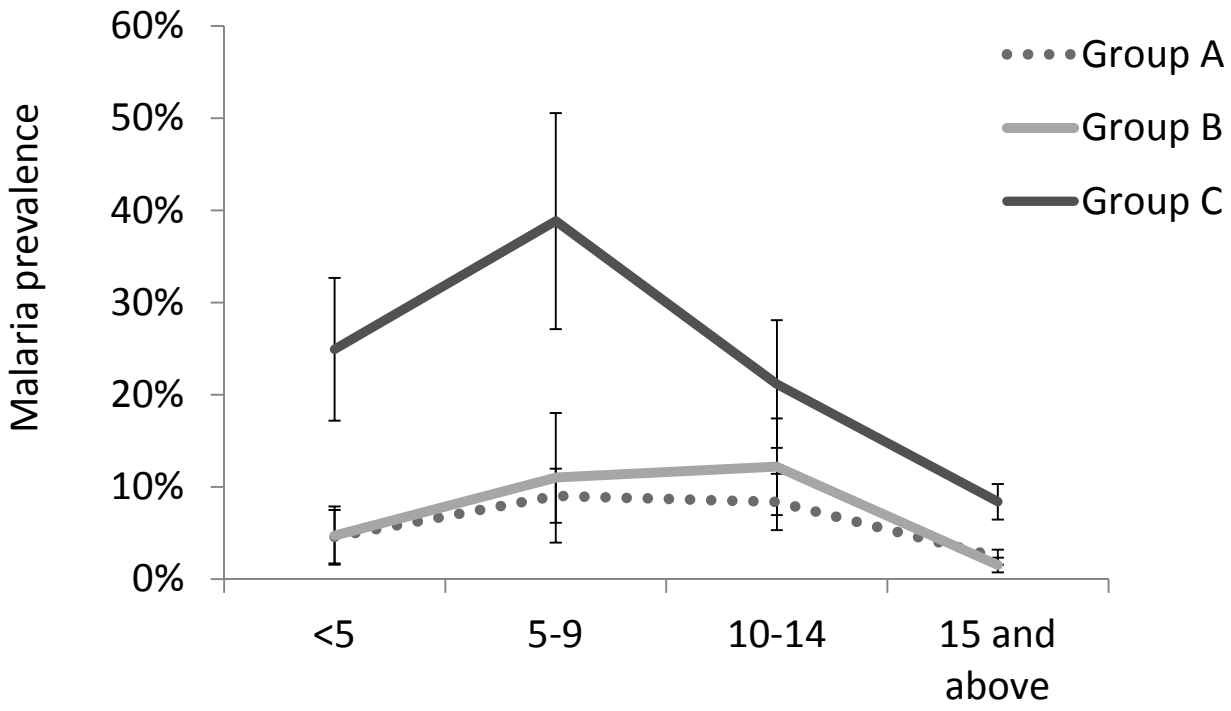
Intensity of insecticide use: agriculture

- Agricultural chemicals supplied at district and sub-district levels
- Agricultural offices
- Pesticide suppliers/shops (Agro-dealers)
- Use of agricultural pesticides by farmers (household surveys)

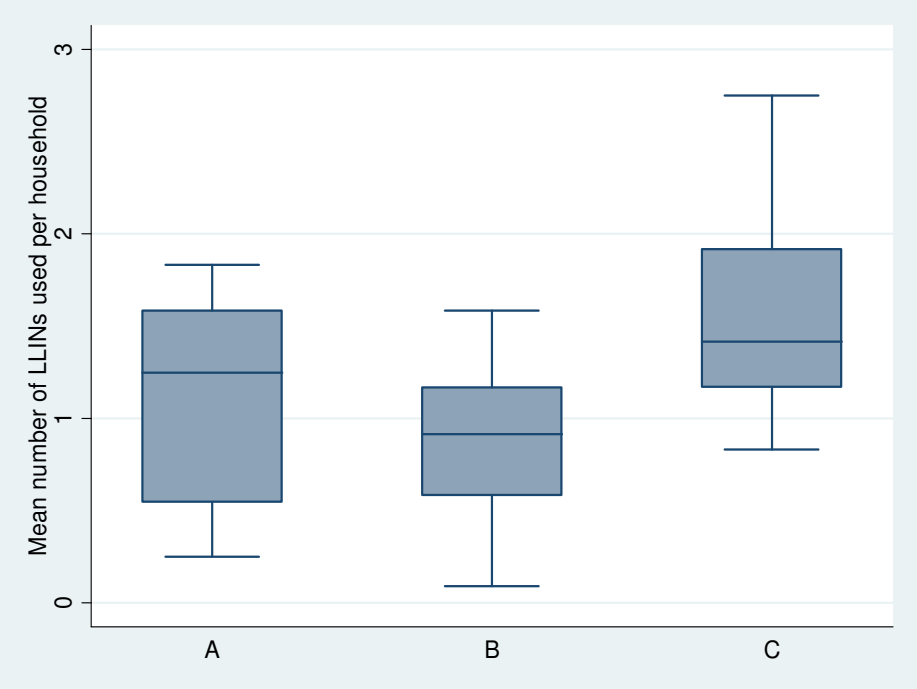
Malaria prevalence (Sep 2012)

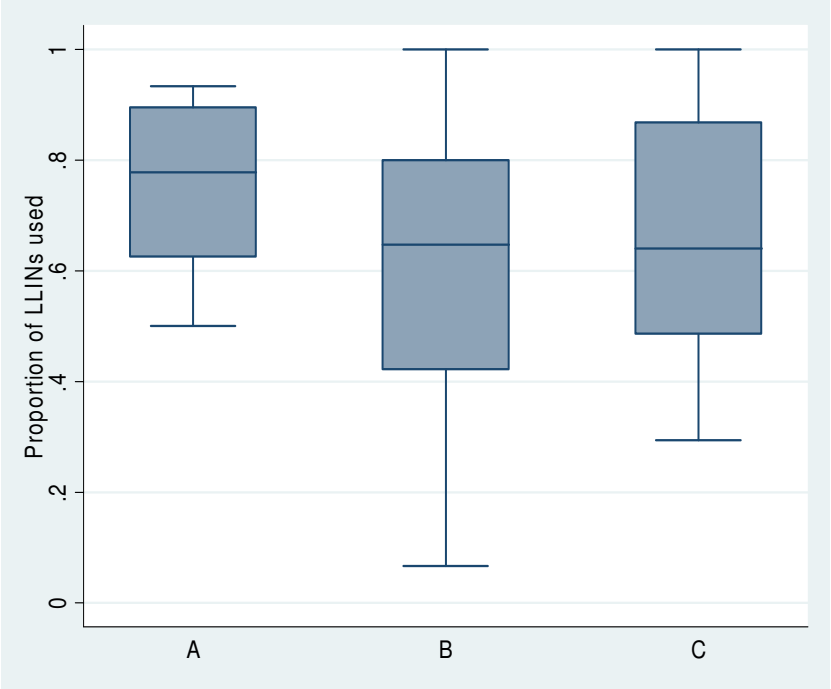


Malaria prevalence by age

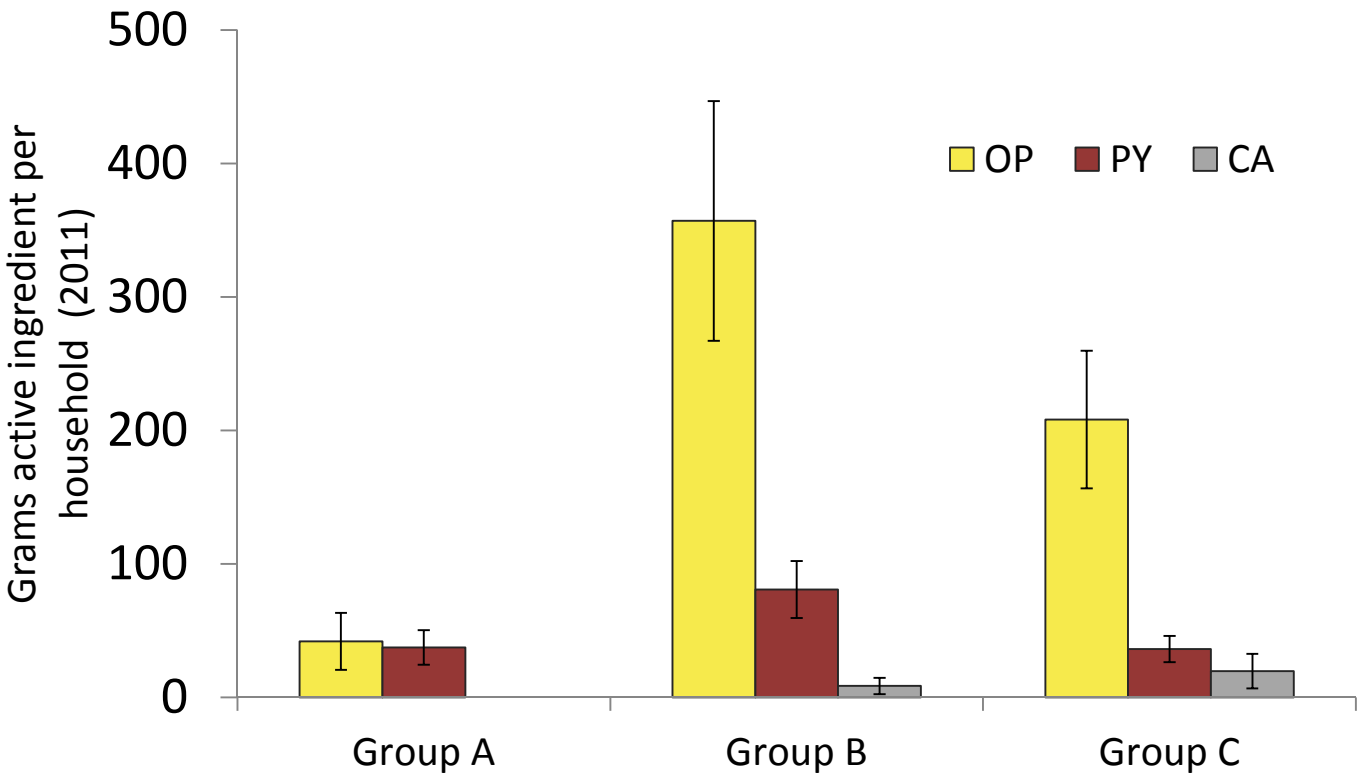


LLIN use during survey



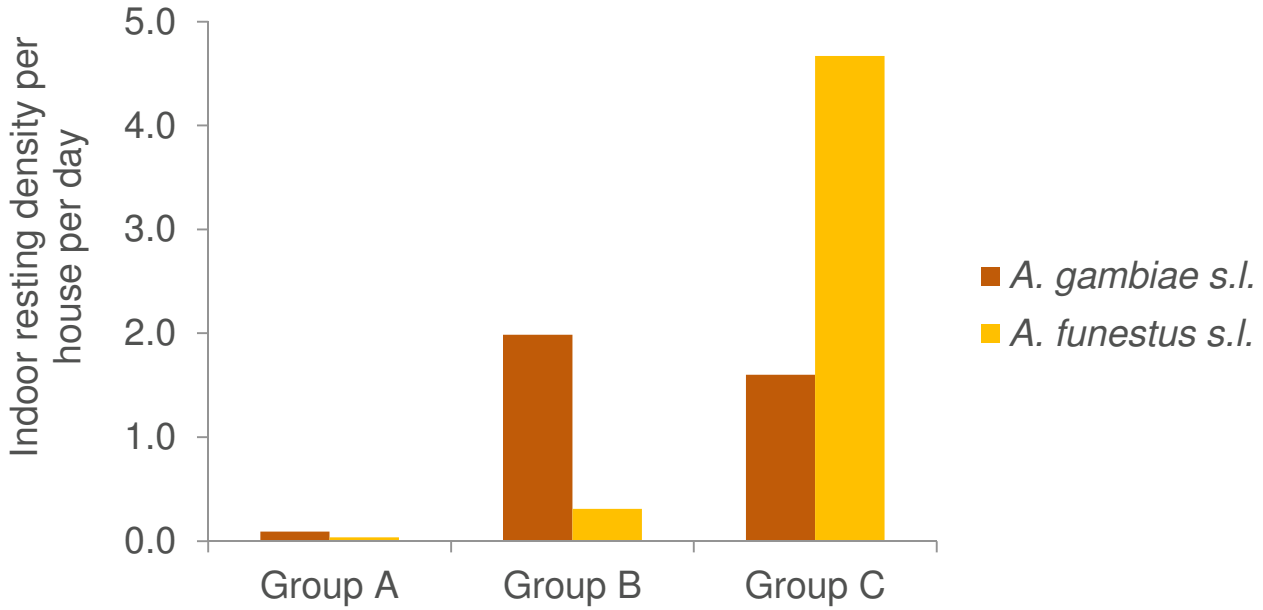


Agricultural use of pesticides (2011)



Entomology Results

Indoor resting densities of *A. gambiae* s.l. and *A. funestus* s.l.



Susceptibility tests

- Insecticide-susceptibility tests were performed following WHO guidelines
- Deltamethrin, permethrin and bendiocarb
- *A. gambiae* s.l. and *A. funestus* s.l.
- The main challenge was low mosquito densities


EXICO

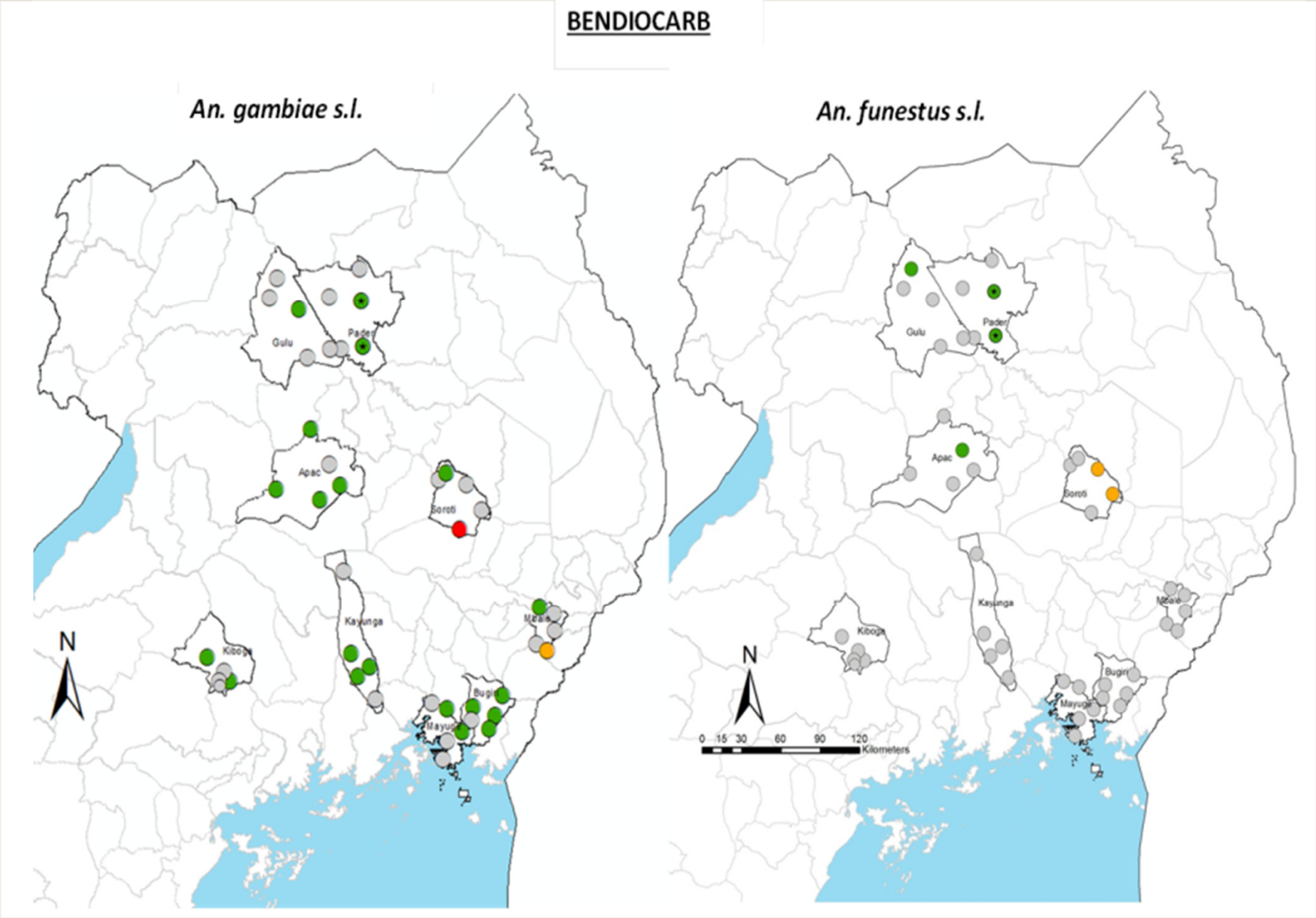
Susceptibility tests

- Resistance status determined according to current WHO guidelines:

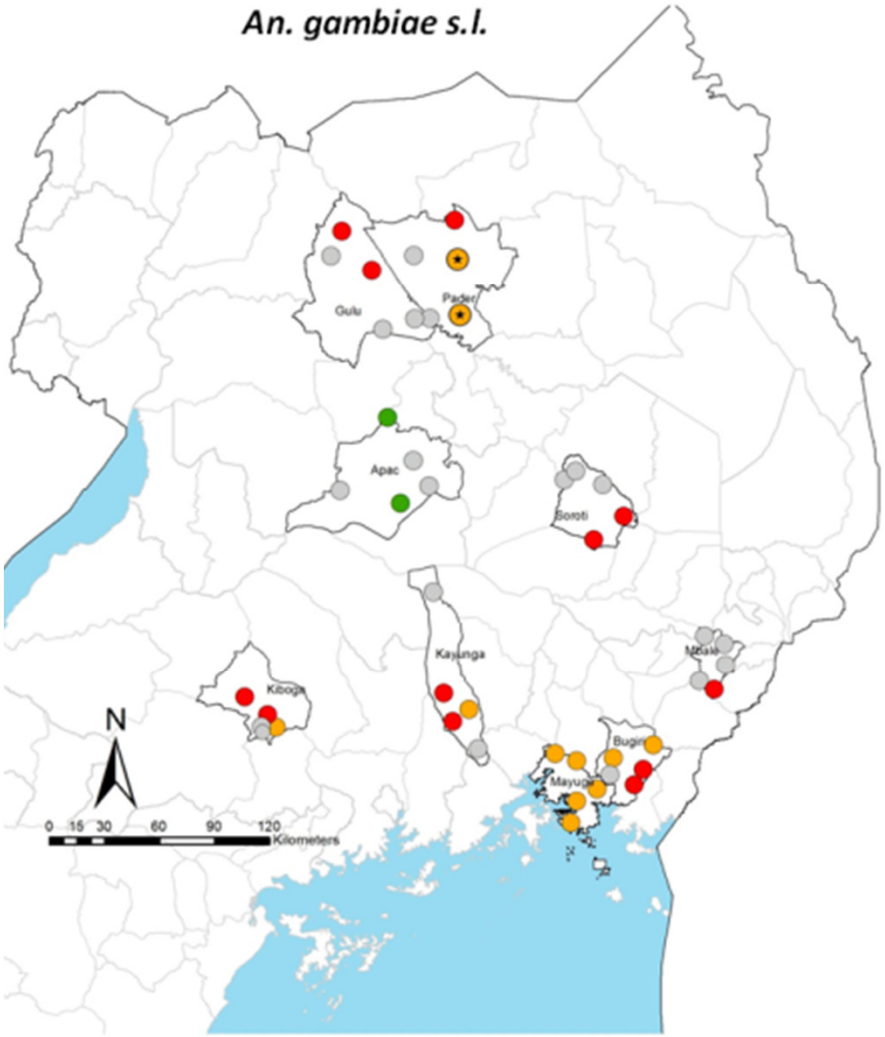
S: susceptible populations
(>=98% mortality: GREEN)

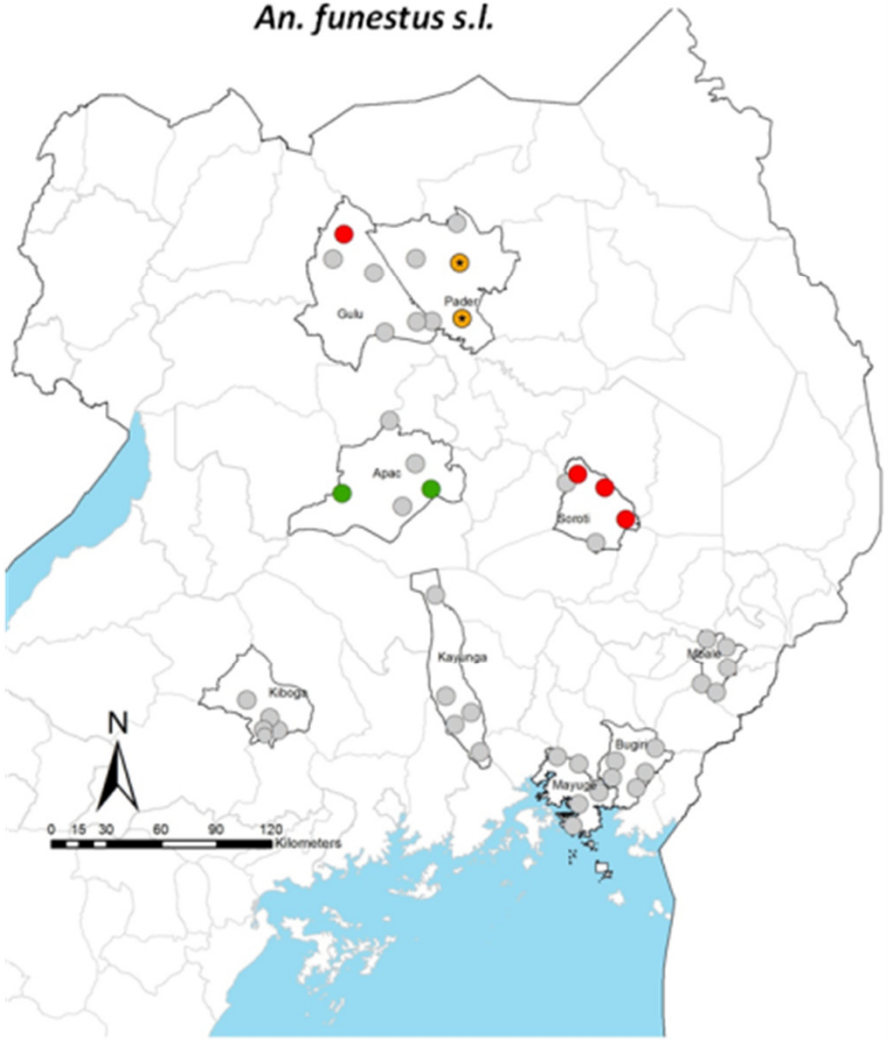
SR: suspected resistant populations
(90-<98%: ORANGE)

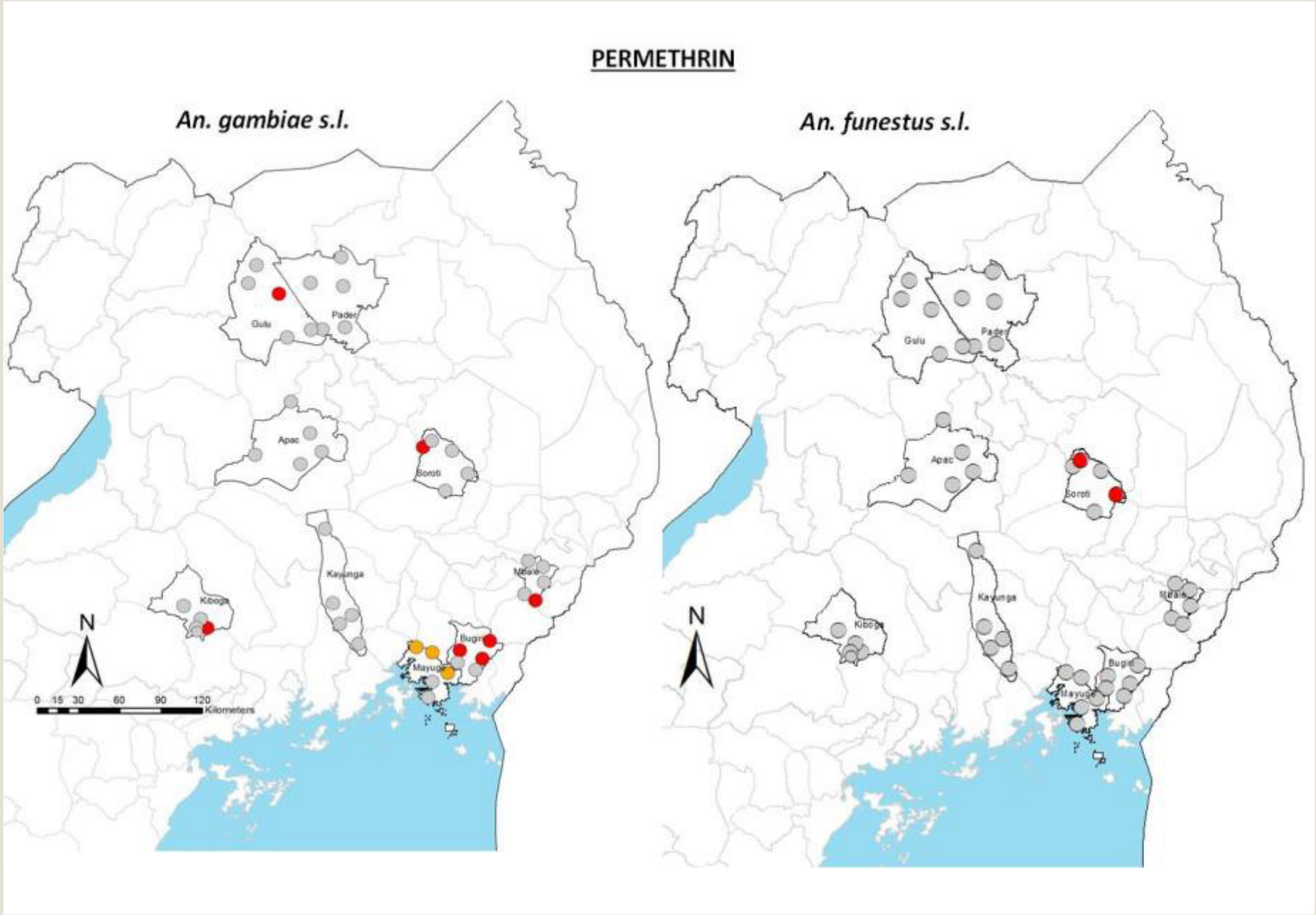
R: resistant populations
(<90% mortality: RED)


BENDIOCARB
An. gambiae s.l.
An. funestus s.l.
Gulu
Pader
Apac
Soroti
Kayunga
Kiboga
Mayuge
Bugiri
N
0 15 30 60 90 120
Kilometers

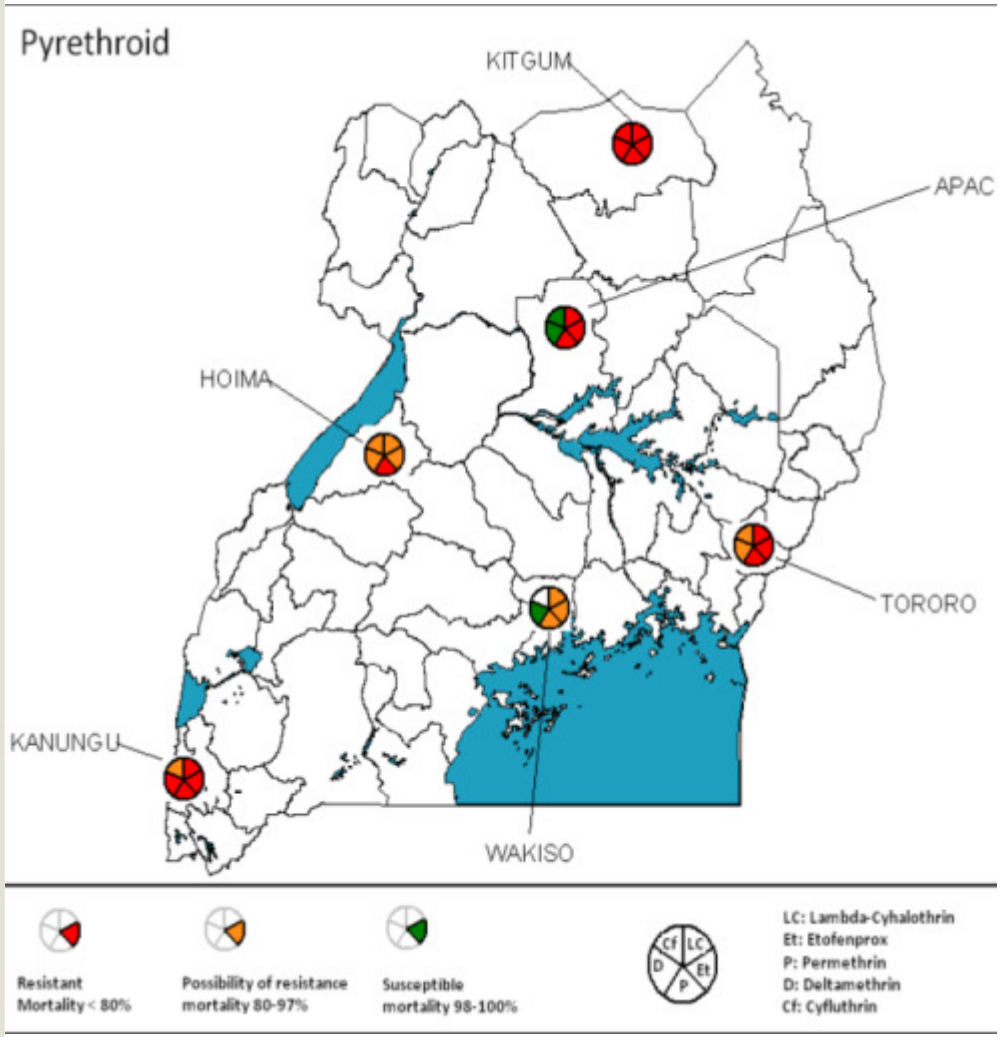
DELTAMETHRIN



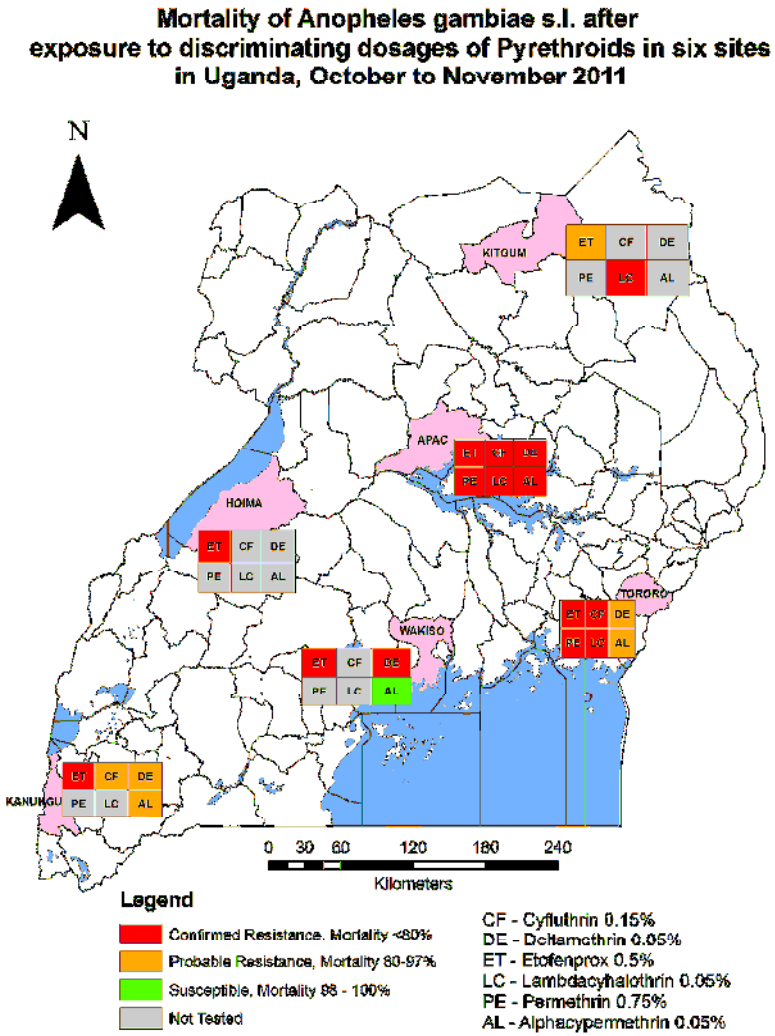



PERMETHRIN
An. gambiae s.l.
An. funestus s.l.
Gulu
Pader
Apac
Soroti
Kayunga
Mbale
Kiboga
Bugiri
Mayuge
N
0 15 30 60 90 120
Kilometers

2009


Pyrethroid
KITGUM
APAC
HOIMA
TORORO
KANUNGU
WAKISO
Resistant
Mortality < 80%
Possibility of resistance
mortality 80-97%
Susceptible
mortality 98-100%
CF
LC
D
Et
P
LC: Lambda-Cyhalothrin
Et: Etofenprox
P: Permethrin
D: Deltamethrin
Cf: Cyfluthrin

2011


Mortality of Anopheles gambiae s.l. after
exposure to discriminating dosages of Pyrethroids in six sites
in Uganda, October to November 2011
N
KITGUM
APAC
HOIMA
TORORO
WAKISO
KANUNGU
ET CF DE
PE LC AL
0 30 60 120 180 240
Kilometers
Legend
Confirmed Resistance, Mortality <80%
Probable Resistance, Mortality 80-97%
Susceptible, Mortality 98 - 100%
Not Tested
CF - Cyfluthrin 0.15%
DE - Deltamethrin 0.05%
ET - Etofenprox 0.5%
LC - Lambdacyhalothrin 0.05%
PE - Permethrin 0.75%
AL - Alphacypermethrin 0.05%

Resistance mechanisms Uganda

- Metabolic resistance *An. funestus* (Morgan et al 2010)
- L1014S *kdr* mutation observed in *An. gambiae s.s.*, less common in *An. arabiensis* (Verhaegen et al 2010, Ramphula et al 2009, Mawejji et al 2012)
- Ace-1R mutation absent *An. gambiae* s.s. (Ramphula et al 2009)
- Metabolic and target site resistance testing ongoing by ABT/PMI/CDC

Tentative conclusions

- Resistance to pyrethroids is widespread in Uganda
- Bendiocarb resistance was not detected in any of the IRS districts
- The apparent reversion of pyrethroid resistance in Apac requires confirmation
- Apart from Apac, in the other bendiocarb-sprayed districts, pyrethroid resistance does not seem to have reverted
- In the districts with less historical coverage of nets, malaria prevalence is relatively higher compared to areas with high ITN coverage – this indicates that nets seem to be providing protection despite widespread resistance
- Next steps: molecular analysis and further data analysis

Acknowledgements

- Study participants
- Vector Control Officers and field staff
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- Malaria Consortium staff
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www.malariaconsortium.org

Thank you

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