

Laboratory and semi-field efficacy evaluation of permethrin-piperonyl butoxide treated blankets against pyrethroid-resistant malaria vectors

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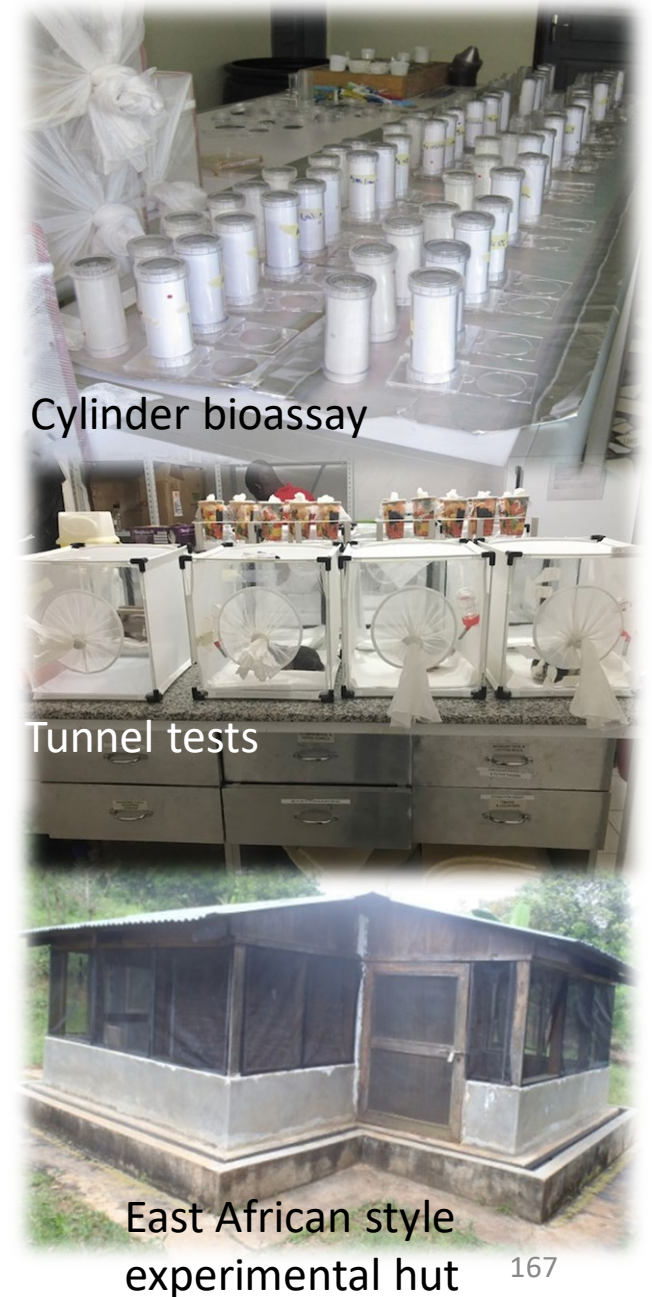
Introduction

- Countries affected by wars or natural disasters are disproportionately affected by malaria, intensified by displacement of highly vulnerable non-immune populations to malaria endemic areas.
- In such situations, the vulnerable populations are housed in temporary shelters (not always suitable for LLINs, IRS).
- With widespread insecticide resistance in malaria vectors, there is need for alternative control tools that are not only suitable for temporary settings but also effective against insecticide resistant malaria vectors.
- Therefore in this study the efficacy of pyrethroid-PBO blanket was evaluated in experimental huts against pyrethroid resistant *Anopheles gambiae* s.s.

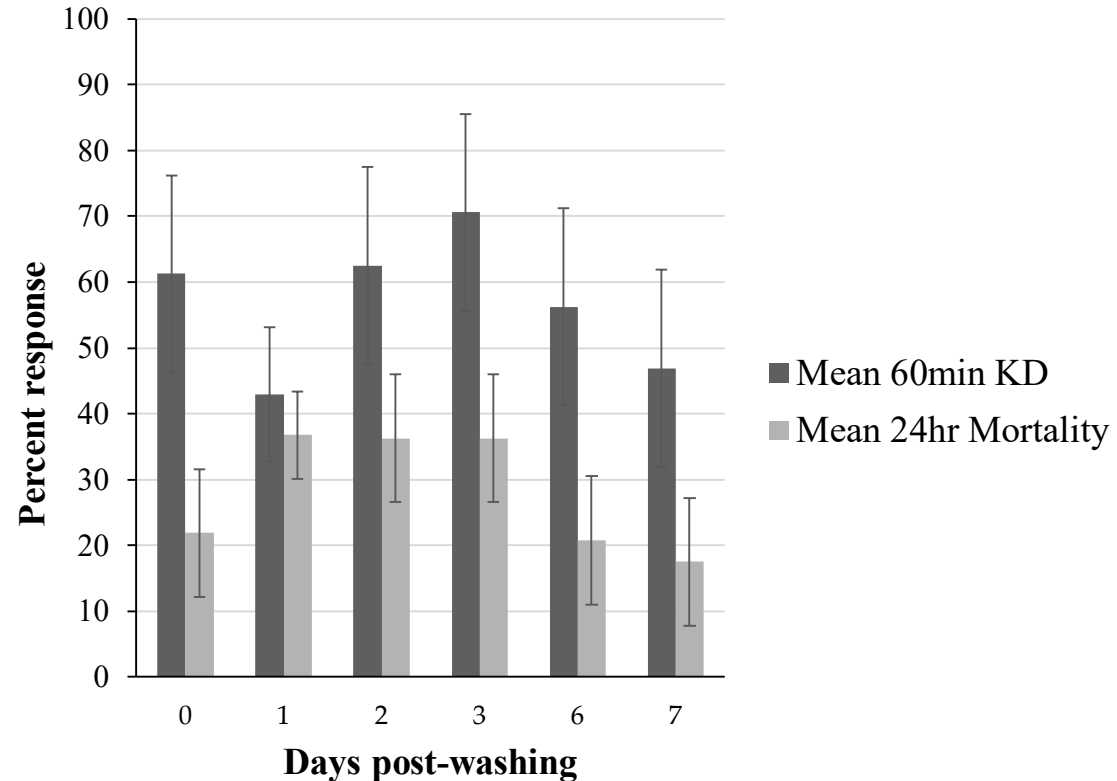


Methods

- Study site.
 - The laboratory experiments were conducted at the KCMUCo-PAMVERC Insecticide Test Facility in Moshi Tanzania; while experimental hut study was carried out at the facility's field site in Lower Moshi.
- Test systems
 - Non-blood fed 2–5-day old females of pyrethroid susceptible (Kisumu) and resistant (Muleba-kis) laboratory-reared *An. gambiae* s.s
- Laboratory bioassays
 - WHO cylinder and tunnel test to assess the regeneration time and wash resistance.
- Experimental hut trial
 - A 6 × 6 Latin square design : untreated blankets (washed 10 times), Olyset LLIN (washed 20 times), Treated Blanket & Olyset LLIN roof-treated IG2 (10 times and 20 times washed respectively), Olyset Plus LLIN (washed 20 times), treated blanket (10 times washed) and unwashed treated
 - In each hut, 20 blood-unfed, 2-5 days old female pyrethroid resistant *An. gambiae* s.s were released inside the hut and collected in the morning.
- Main outcome measures: **blood feeding inhibition, knockdown (KD) and mortality.**



Laboratory study results: Regeneration time (RT)



- KD had the longest RT and follows the expected dynamic of insecticide bioavailability in the treated fabrics.
- The RT for the PBO–permethrin blanket was confirmed to be 2 days.

Figure 1. Regeneration time for PBO-permethrin treated blankets against *An. gambiae* Kisumu

Laboratory study results: Wash resistance cylinder assays

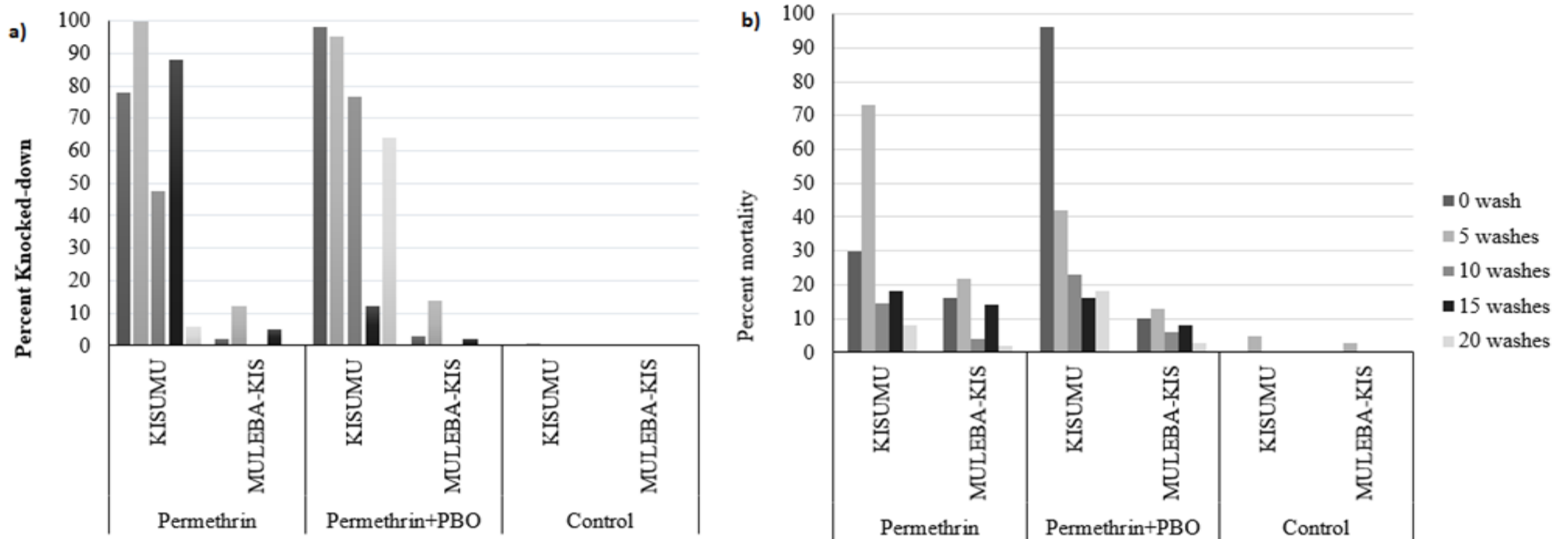


Figure 2. The efficacy of PBO-permethrin in terms of a) KD and b) mortality against susceptible Kisumu and resistant Muleba-Kis *An. gambiae* strains

Laboratory study results: blood feeding and mortality in tunnel tests

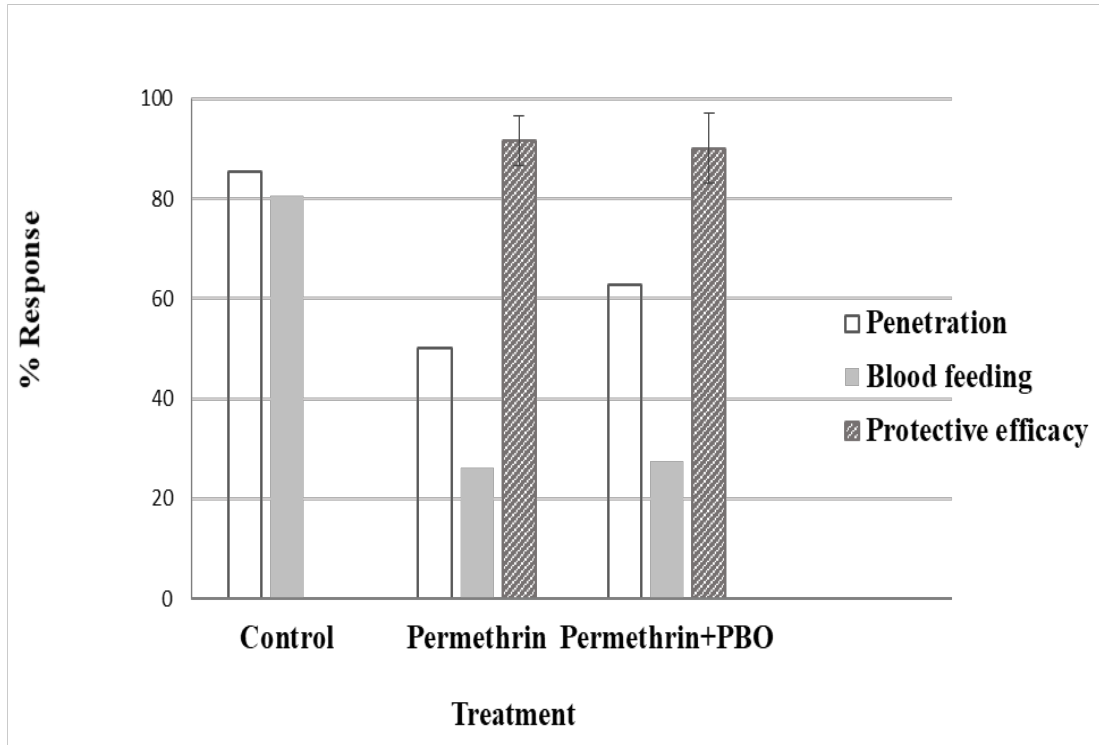


Figure 3. Penetration, blood-feeding and protective efficacy from different blanket treatments in tunnel tests against *An. gambiae* Kisumu. Error bars are equivalent to 95% confidence intervals.

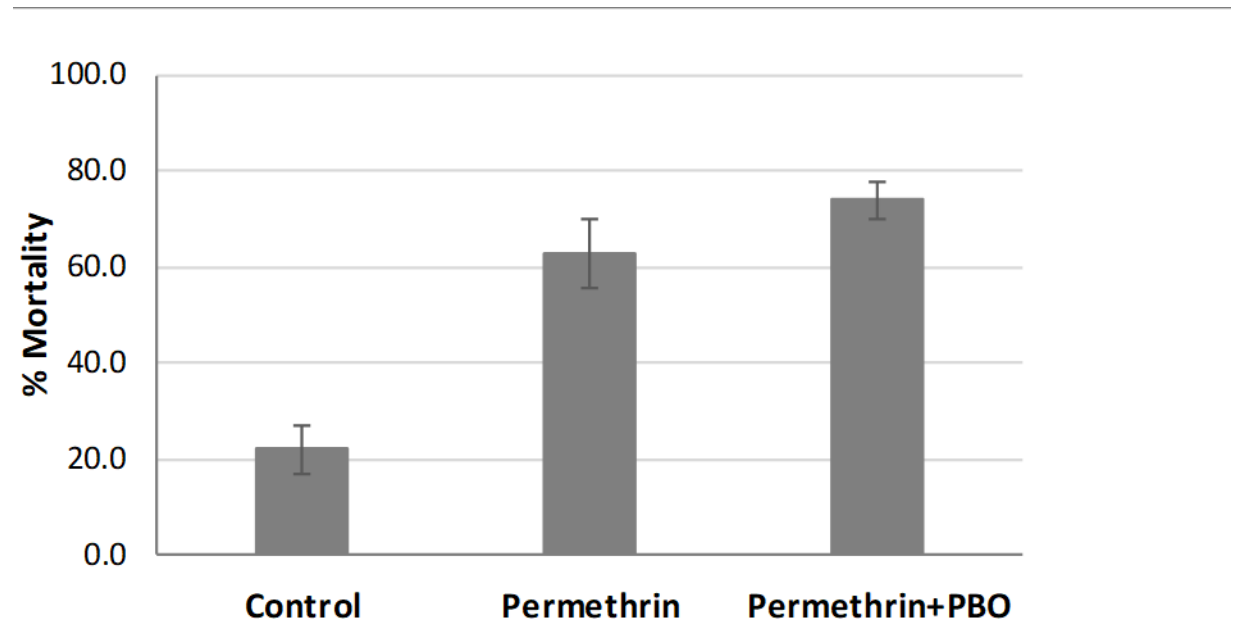


Figure 4. Mortality rates of resistant *Anopheles gambiae* Muleba-Kis after exposure from different blanket treatments in tunnel tests. Error bars are equivalent to 95% confidence intervals.

Experimental hut study results: Mortality and blood feeding

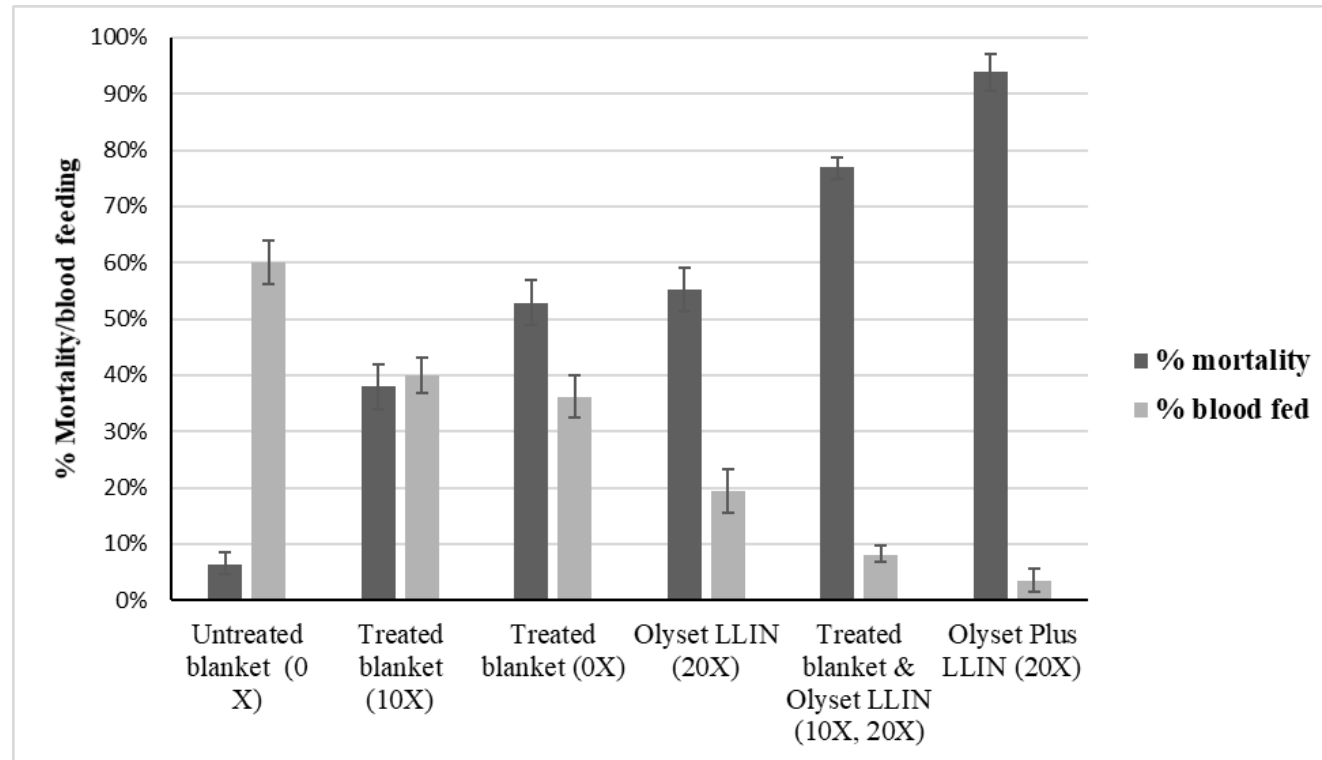


Figure 5. Mortality and blood feeding rates from different treatment arms. Error bars are equivalent to 95% confidence intervals

- All treatments killed significantly more mosquitoes (31.7%–87.3%) than the untreated blanket ($p < 0.05$).
- In the order: Olyset® Plus (94.0%), PBO-permethrin blanket with Olyset® net (77.9%), washed Olyset® net (56.3%), unwashed treated PBO-permethrin blanket (53.7%), and lastly washed PBO-permethrin blanket (38.4%).
- Significant **blood feeding inhibition** was detected with all treatments compared to the negative control ($p < 0.05$), in the order: Olyset Plus (94.0%): PBO-permethrin blanket + Olyset Net (86.5%), Olyset Net (67.5%), (0X) PBO-permethrin blanket (40.3%), (10X) PBO-permethrin blanket (35.1%).

Conclusion

- Treated blankets significantly induced mortality against mosquitoes both at laboratory and semi-field trials relative to untreated blankets.
- Noticeably, in the experimental hut trial, mortality in the new permethrin-PBO blankets trial arm was comparable to standard Olyset LLIN arm.
- The results indicate potential benefits of the PBO blankets **if widely used**, and calls for further **technological adjustment** to improve wash fastness and validation by a **large-scale field trial to assess the epidemiological impact** of the intervention, durability and acceptability of this new vector control strategy for malaria vector control.

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