



# EFFICACY OF A COMBINATION LONG LASTING INSECTICIDAL NET (PERMANET® 3.0) AGAINST PYRETHROID RESISTANT ANOPHELES GAMBIAE S.S AND CULEX QUINQUEFASCIATUS: AN EXPERIMENTAL HUT TRIAL IN NIGERIA



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## BACKGROUND:

Insecticide resistance in the African malaria mosquitoes presents a major challenge facing malaria control. Newer methods of preserving the efficacy of available public health insecticides need to be put in place. PermaNet® 3.0, a new long lasting insecticidal net (LLIN), was designed to give increased efficacy against pyrethroid-resistant malaria vectors. This mosaic LLIN combines deltamethrin coated polyester side panels and deltamethrin with piperonyl butoxide (PBO) incorporated polyethylene roof. There are currently no guidelines for evaluating products that have an effect on insecticide resistant vectors. A practical approach is to compare the efficacy of PermaNet 3.0 with LLINs that received full WHOPES recommendation. At present, only PermaNet 2.0 and Olyset® nets have met these criteria (1-2), with Yorkool® nets given a full recommendation but based only on equivalence with PermaNet 2.0 (2) Aside from a parallel study in Benin (3), previous field evaluations of PermaNet 3.0 were made in comparison with PermaNet 2.0, a product from the same manufacturer but relying on deltamethrin alone (4-5). Here we compared the performance of PermaNet 3.0 with permethrin-impregnated Olyset nets in experimental hut in north-central Nigeria.

## MATERIAL AND METHODS

The study was conducted in experimental huts (Figure 1) situated at the Nigerian Institute of Medical Research field station at New Bussa (9° 53'N; 4° 31' E). The malaria mosquito *Anopheles gambiae* s.s. in the area exhibit a high level of pyrethroid resistance associated with both knock down resistance (*kdr*) and metabolic-based resistance with mixed function oxidases (MFOs). Six experimental huts were built on concrete floor following the pattern of huts used in West Africa. The style of the huts simulates domestic habitations and is purposely built with the front side facing perennial mosquito breeding sites. Prior to the field test, a subset of net samples were washed using standard WHO washing protocols and bio-efficacy evaluations were conducted with resistant strains of *A. gambiae* s.s and *Culex quinquefasciatus*. Incubation of Olyset samples was adapted from the previous phase 1 study (6). Nets were purposely holed, with 6 holes of 4 x 4 cm cut in each net. A polyester net treated with deltamethrin and washed until just before exhaustion was used as the positive control. Six nets were used per treatment arm and the treatment arms were rotated each week among the huts, with rotation of adult male volunteers who slept under the nets each night. The 12 weeks Latin Square design was adapted from WHO guidelines for phase 2 field trial (7). Field efficacy was expressed in terms of mosquito deterrence in hut entry, blood-feeding inhibition, induced exophily and mortality.



Fig. 1. Experimental huts at the Nigerian Institute of Medical Research field station in north-central Nigeria

## RESULTS AND DISCUSSION:

Laboratory cone bioassays using resistant *A. gambiae* s.s. prior to and after experimental hut evaluations showed high mortality (>75%) in PermaNet 3.0 and was consistent with the field data. Increased bioefficacy likely due to the synergist effect of PBO and deltamethrin was obvious from *in situ* bioassays, with significant mortality of resistant *A. gambiae* s.s. recorded following exposure to the roof panel. This property was however lost with *C. quinquefasciatus* after 20 washes. Sufficient time was given between washing and bioassay of Olyset net samples but a decline was observed in the bioefficacy of Olyset nets after 20 washes which was consistent with data from our previous study on wash resistance of Olyset nets (6).

Analysis of the 12 weeks experiment hut data showed that PermaNet 3.0 induced a level of deterrence against *A. gambiae* and *C. quinquefasciatus* similar to that of the Olyset net. Both nets still deterred hut entry after 20 successive washes (Fig. 2). The similarity in deterrence of both nets could explain the negligible difference in the overall number of mosquito collected in the different treatment arms.

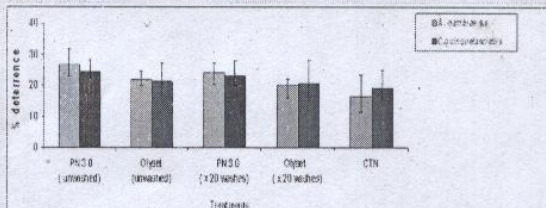


Fig. 2. Deterrence of *Anopheles gambiae* s.s. and *Culex quinquefasciatus* in huts with PermaNet® 3.0, Olyset net and a conventionally treated net washed until before exhaustion (CTN).

The excito-repellency property of both net types was also similar, but the feeding rate of *A. gambiae* s.s. in huts with PermaNet 3.0 was highly minimized compared to the Olyset net and the protective effect was not lost after 20 washes (Fig. 3). The overall proportion of *A. gambiae* s.s. that successfully blood fed in the Olyset net was triple that for PermaNet 3.0. A similar trend with significant higher blood feeding rate was recorded for *C. quinquefasciatus*.

Mortality of *A. gambiae* and *C. quinquefasciatus* in the untreated net was negligible compared to the insecticide treatment arms thereby making a correct deduction of the overall insecticide effect on the mosquito more reliable. Despite the presence of both *kdr* and MFOs resistant mechanisms, the proportion of *C. quinquefasciatus* and *A. gambiae* s.s. killed by the unwashed PermaNet 3.0 was significantly higher than the Olyset net ( $P < 0.01$ ; Fig. 4) confirming the increased bioefficacy (PermaNet 3.0.) However, after 20 washes of PermaNet 3.0, there was a marked reduction in mortality of *C. quinquefasciatus* compared to unwashed PermaNet 3.0 (Fig. 4).

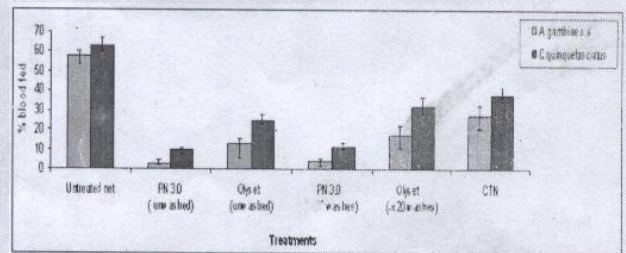


Fig. 3. Proportion of blood fed *Anopheles gambiae* s.s. and *Culex quinquefasciatus* in experimental huts with PermaNet® 3.0, Olyset net and CTN.

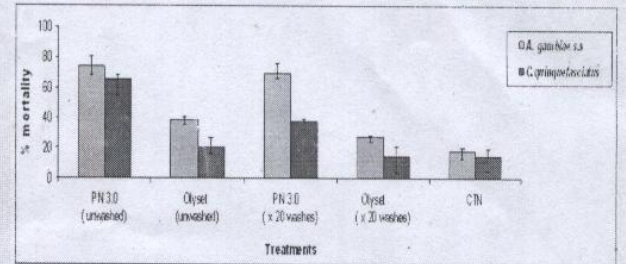


Fig. 4. Mortality rate of *Anopheles gambiae* s.s. and *Culex quinquefasciatus* in experimental huts with PermaNet® 3.0, Olyset net and CTN.

## CONCLUSION:

This study showed that PermaNet 3.0 could provide additional protection in term of reduction in blood feeding and increases in mosquito mortality but has no obvious comparative advantage over the Olyset net in term of deterrence in hut entry and induced exophily.

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