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EVALUATION OF THE EFFICACY OF PERMETHRIN - IMPREGNATED INTACT AND
PERFORATED MOSQUITO NETS AGAINST VECTORS OF MALARIA¹

by

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1. INTRODUCTION

The use of fabrics impregnated with insecticide for the control of insect vectors has long been considered, especially for tsetse flies (Rupp, 1952).

This procedure has actually come into operational use in West Africa for the control of river-bank tsetse flies (*Glossina tachinoides*, *G. palpalis gambiensis*), with the aid of biconical traps impregnated with deltamethrin (Laveissière et al., 1980a,b,c; 1981a,b) or screens impregnated with deltamethrin (Laveissière & Couret, 1981) or with dieldrin (Laveissière & Couret, 1983).

Moreover, trials are currently in progress in Cameroon to control blackflies by the same technique (Traoré & Lamizana, personal communication).

It seemed appropriate to test this method in the control of anopheline mosquitos, not by house spraying but by impregnating mosquito nets in rural communities.

The study was carried out at the Soumousso experimental station, a centre collaborating with WHO in Stage II evaluation of insecticide efficacy.

2. MATERIALS AND METHODS

2.1 Description of the experimental village

The Soumousso experimental station was set up in 1968 and consists of 20 one-room dwellings built in the traditional local style and designed as "hut traps".

It consists of 10 "Mossi"-type dwellings with circular walls of brick or laterite covered with dried mud (banco), and topped by a conical straw roof, and 10 "Bobo"-type dwellings, box-shaped with walls of earth bricks plastered with dried mud and a flat roof consisting of heavy branches covered with a layer of dried mud.

The special arrangements for catching mosquitos are (a) controlled openings: slits fitted with baffles in Bobo huts (window traps for incoming mosquitos), interstices between walls and ceilings provided with Textiglass baffles in Mossi huts, and (b) a veranda trap: a metal frame, across which Textiglass lined with tulle is stretched and which is attached to the eastern side of each hut to cover a wide opening (equivalent to an exit door for the mosquitos).

The trials with impregnated mosquito nets made it necessary to construct four additional control huts (two Bobo and two Mossi huts).

¹ This study received financial support from the World Health Organization.

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There is a small meteorological unit at the station for measuring local rainfall. The rainfall was substantially lower in 1983 (700 mm) than in 1982 (1100 mm).

2.2 Insecticide used

The mosquito nets were impregnated with permethrin in the form of an emulsifiable concentrate (EC) containing 20% active ingredient. This insecticide was received on 5 April 1983.

2.3 Mosquito nets

2.3.1 Models

Two types of mosquito nets were tested: an individual model and a "group" model with total surface areas of 10 and 13.5 m² respectively.

These mosquito nets are made of cotton tulle (from Black Bros. and Boden, Nottingham, England) and cotton percale purchased on the market at Bobo-Dioulasso, Burkina Faso.

It is well known that the mosquito nets used in rural areas are generally damaged, and Port & Boreham (1982) showed a relationship between the size of the holes and the percentage of mosquitos able to take blood meals. A series of square holes, 100 cm² in area, were made deliberately in one half of the mosquito nets (18 of 36). (Fifty holes in an individual mosquito net and 70 holes in a collective net.) All the holes in these perforated nets initially represented 5% of the surface area of the net.

2.3.2 Method of impregnation

The mosquito nets were impregnated during the week of 20-25 June 1983. The amount of water absorbed by each type of mosquito net had been calculated beforehand so that during the drying process there would be no insecticide lost through run-off. The individual mosquito nets absorbed 900 ml of water, the group nets 1200 ml.

A single application of 0.08 g/m² to tulle and percale was selected in the light of previous studies. The calculation for the impregnation concentration is given in an annex.

The impregnated mosquito nets were dried (by laying them flat for 90 min.) and packed in kraft paper until they were placed in the houses. The personnel responsible for preparing the solutions and for impregnating and setting up the mosquito nets displayed no symptoms of intoxication or skin irritation.

The staff handling the insecticide took the customary protective measures when impregnating the nets.

2.3.3 Experimental methods

The distribution of the huts was as follows:

- 2 Bobo huts and 2 Mossi huts: individual mosquito nets, intact and treated
- 2 Bobo huts and 2 Mossi huts: individual mosquito nets, with holes, treated
- 2 Bobo huts and 2 Mossi huts: group mosquito nets, intact, treated
- 2 Bobo huts and 2 Mossi huts: group mosquito nets, with holes, treated
- 1 Bobo hut and 1 Mossi hut: individual mosquito nets, intact, untreated
- 1 Bobo hut and 1 Mossi hut: individual mosquito nets, with holes, untreated
- 1 Bobo hut and 1 Mossi hut: group mosquito nets, intact, untreated
- 1 Bobo hut and 1 Mossi hut: group mosquito nets, with holes, untreated.

Each hut contained either two individual nets or one group net; altogether 36 nets were tested.

During the night one person slept from 20h00 to 06h00 under each individual net and three people slept under each group net.

The control nets were placed in the central huts, and the impregnated nets were distributed symmetrically among the other huts.

The nets were placed in the houses on 27 June 1983 and removed on 27 November 1983. The first insect collection took place on 4 July, i.e. one week after the mosquito nets were fitted and two weeks after they were impregnated.

The staff handling the mosquito nets when they were fitted felt no irritant effect, even though this was done without any special precautions. A nursing auxiliary was present on the site for the whole duration of the trial, while an entomologist visited the site three times a week. No complaints were received from the volunteers who slept under the treated nets and no symptoms of irritation were observed. Moreover, the nets were not found to emit any distinctive smell.

2.4 Evaluation methods

Evaluation was carried out in accordance with two protocols:

2.4.1 Daily collections in the hut traps

The mosquitos were collected regularly six days a week (Monday to Saturday) by hand or tube, three times every morning, in accordance with the following timetable:

05h00: This collection took place before the sleepers emerged. It comprised the collection of the dead and live females in the mosquito net and in the veranda trap and the dead mosquitos in the hut. The sleepers did not leave the huts until the 05h00 collection was completed.

08h00: Collection of dead and live mosquitos in the mosquito net, the veranda trap and the hut.

10h00: Collection of dead and live mosquitos in the mosquito net, the veranda trap and the hut.

The mosquitos were collected, identified and sorted (dead and live). The live mosquitos were labelled according to the time and place of collection (mosquito net, hut or veranda trap) and placed under observation for 24 hours in cardboard cups containing a wad of cotton-wool soaked in glucose solution. The dead mosquitos were then counted. Total mortality was obtained by adding the immediate and deferred mortality figures.

2.4.2 Biological tests

The purpose of the biological tests (equivalent to tests of residual effect) was to check how the efficacy of the insecticide developed over time.

The tests consisted of studying the mortality of freshly engorged bred females (Aedes aegypti, Kari* strain) by placing them in plastic cones that were kept in contact for one hour with both the fabrics used in the construction of the mosquito net.

The cones were fixed to the mosquito net with an elastic band in such a way that the fabric under study covered the entire open surface of the cone.

After one hour of contact with the treated surfaces, the dead mosquitos were counted and the survivors were kept under observation for 24 hours in order to assess total mortality.

* Name of the village in Burkina Faso from which this strain was obtained.

In order to keep the number of cones per hut to four, they were arranged in different ways according to the type of mosquito net. For the group nets four cones were used, of which two were placed on tulle and two on percale; for the individual nets, of which there were two in each hut, two cones were placed on each mosquito net, one on the tulle and the other on the percale.

The residual effect was assessed once a week throughout the campaign on each of the two materials, cotton tulle and cotton percale.

3. RESULTS AND OBSERVATIONS

3.1 General mosquito collections

During the 21 weeks of the trial, 4682 female mosquitos were collected, comprising:

<u>Anopheles gambiae</u>	1058
<u>An. funestus</u>	3079
<u>An. nili</u>	228
<u>An. flavicosta</u>	4
<u>An. rufipes</u>	6
<u>Mansonia africana</u>	174
<u>Ma. uniformis</u>	133

The fortnightly figures for the major species are given in Table 1.

It is noted that An. gambiae was more frequent than An. funestus at the start of the rainy season. From September onward An. funestus was more frequent than An. gambiae, the density of which remained virtually constant throughout the rainy season. The difference in the density of these two species was particularly marked at the start of the dry season. This alternation of vectors in the region has long been known (Choumara et al., 1959).

The results of the daily insect collections need to be analysed in the light of the modifications in the behaviour of the Culicidae brought about by the insecticide treatment of the mosquito nets.

3.2 Influence of insecticide-impregnated mosquito nets on the density of anopheline mosquitos in the huts

The numbers of An. gambiae and An. funestus caught in the Bobo and Mossi huts provided with mosquito nets, whether or not impregnated with permethrin, are indicated in Table 2.

Comparison of these figures with the number found in trial huts (Table 2, line 16) shows that on average the presence of impregnated mosquito nets reduced An. gambiae by 69% (from 81.6 to 25.3 females per hut) and An. funestus by 73% (from 249.7 to 67.6 females per hut).

This influence of the impregnated mosquito net on the reduction of the numbers of anopheline mosquitos caught in the houses varied according to the type of hut and type of mosquito net.

3.2.1 Influence of the type of hut

Species	Females per Bobo hut		Females per Mossi hut		Chi-squared
	Impregnated net	Control net	Impregnated net	Control net	
<u>An. gambiae</u>	25.4	58	25.3	105.2	
	difference =	-56%	difference =	-76%	3.46
<u>An. funestus</u>	58.6	247.5	76.5	252.0	
	difference =	-76%	difference =	-70%	1.62

Although not statistically significant ($X^2 = 3.46$ for 1 df) the reduction is greater for An. gambiae in the Mossi huts (-76%) than in the Bobo huts (-56%).

For An. funestus the reduction in the entry rate due to the presence of impregnated mosquito nets is of the same order of magnitude (approximately 70%) in the two types of dwellings. It may well be that the Mossi huts, which are less well-sealed and better ventilated than the Bobo huts, permit the better spread of volatile substances that are irritant to An. gambiae, and the "repellent" effect of the hut may be felt even some distance away from it.

3.2.2 Influence of the type of mosquito net (individual or group net)

The number of anopheline mosquitos per hut was consistently higher in the huts provided with group mosquito nets (three people per hut) than in those provided with individual nets (two people per hut). This difference was visible whether or not the net had been impregnated with insecticide.

Mosquito nets	Species	No. of females per hut		Difference
		Impregnated nets	Non-impregnated nets	
Individual (intact + damaged)	<u>An. gambiae</u>	19.4	21.0	-8%
	<u>An. funestus</u>	45.5	107.2	-58%
Group (intact + damaged)	<u>An. gambiae</u>	31.2	142.2	-78%
	<u>An. funestus</u>	89.6	392.2	-77%

In the huts provided with impregnated mosquito nets, the number of mosquitos caught was 60% higher for An. gambiae and 97% higher for An. funestus in huts with one group net than in those with two individual nets.

In the control huts there were 6.8 times more An. gambiae and 3.7 times more An. funestus in the huts with group mosquito nets than in those with individual nets.

Moreover, impregnation of the net substantially reduced the numbers collected. In the huts provided with group nets, the reduction was of the order of 80% for both An. gambiae and An. funestus. The reduction was less pronounced for individual nets, but was still 58 for An. funestus and 8% for An. gambiae.

Species		Impregnated mosquito nets	Non-impregnated mosquito nets	Difference
<u>An. gambiae</u> :	Intact nets	27.7	41.0	-32%
	Damaged nets	22.9	122.2	-81%
<u>An. funestus</u> :	Intact nets	77	143.2	-46%
	Damaged nets	58.1	356.2	-84%

For An. gambiae impregnation of the mosquito nets reduced the numbers by 32% when the nets were initially intact and by 81% when the nets were initially damaged.

For An. funestus, the reductions were 46% for intact nets and 84% for damaged nets.

These unexpected results may be attributed to the very special attractiveness of the control huts with damaged group nets (Table 2).

3.3 Influence of impregnated mosquito nets on the exit rate of anopheline mosquitos

The numbers of An. gambiae and An. funestus caught in the huts, under the mosquito nets and in the veranda traps, in each experimental situation, are shown in Tables 3A and 3B respectively.

In the huts with non-impregnated nets, 33% of An. gambiae and 27% of An. funestus were caught in the morning in the veranda traps; 10-15% of the anopheline mosquitos were caught under the mosquito nets and 50-60% in the hut (on the walls or under the roof).

The situation was entirely different in the huts with mosquito nets impregnated with permethrin (see Figure). Under these circumstances, 97% of the mosquitos caught in the morning were found in the veranda trap, an exit rate three times that normally recorded for An. gambiae and An. funestus. About 2% of the specimens were caught in the hut. There were virtually no mosquitos inside the impregnated nets (five An. gambiae females and one An. funestus female in five months of collections).

This spectacular increase in the exit rate perfectly reflects the well-known "irritant" effect of permethrin.

3.4 Influence of impregnated mosquito nets on the blood meals of anopheline mosquitos

In order to assess the influence of the presence of mosquito nets impregnated with insecticide on the man-biting habits of An. gambiae and An. funestus at night inside the huts, we detailed the physiological status of the females caught in the houses in the morning and also the number (and percentage) of engorged females (Tables 4A and 4B). The ratio between the number of engorged females and the number of females caught is known as the "engorgement rate".

Mosquito nets		Engorgement rate			
		<u>An. gambiae</u>		<u>An. funestus</u>	
		%	Mean	%	Mean
Impregnated	intact	75.2	78.0%	90.7	87.6%
	with holes	80.9		84.5	
Non-impregnated	intact	94.5	96.7%	95.5	96.6%
	with holes	99.0		97.8	

It would seem that the presence of insecticide-impregnated mosquito nets, with or without holes, reduced the engorgement rate of An. gambiae by about 20% and that of An. funestus by almost 10%.

It is noted that for both species the rates are similar in the two types of huts, Bobo and Mossi, and that the lowest engorgement rate for An. gambiae (57%) was recorded in the Bobo huts provided with intact impregnated group mosquito nets (Table 4A). On the whole, however, the engorgement rate of the major vectors An. gambiae and An. funestus did not undergo any marked change, whether or not the mosquito net was initially intact.

This can readily be explained by the fact that the mosquito nets which were intact to start with were soon damaged by the users and that the mosquitoes take advantage of the tiniest hole to get inside the net.

3.5 Influence of impregnated mosquito nets on the mortality rate of anopheline mosquitos

There were practically no deaths among the female mosquitos caught in the control huts (one out of 653 for An. gambiae and 0 out of 1998 for An. funestus). It is therefore justifiable to analyse the mortality figures in the huts with treated mosquito nets without any adjustment.

3.5.1 Overall mortality

Overall mortality was comparable for An. gambiae and for An. funestus, i.e. 17.8% and 16.4% respectively. The overall mortality does not vary for these two species, whether the impregnated mosquito nets were intact or not:

Impregnated nets		No. of females caught	No. of females dead	Mortality (%)
Intact	<u>An. gambiae</u>	222	43	19.4
	<u>An. funestus</u>	616	99	16.1
With holes	<u>An. gambiae</u>	183	29	15.8
	<u>An. funestus</u>	465	78	16.8

On the other hand, there are some variations in the overall mortality rate depending on the types of mosquito net placed in the huts:

Impregnated mosquito nets (intact & with holes)						
	Individual			Group		
	No. of females caught	No. of females dead	Overall mortality	No. of females caught	No. of females dead	Overall mortality
<u>An. gambiae</u>	155	31	20%	250	41	16.4%
<u>An. funestus</u>	364	74	20.3%	717	103	14.4%
Total	519	105	20.2%	967	144	14.9%

The significant reduction ($\chi^2 = 6.90$ for 1 df) in the mortality recorded in these two experimental situations might be attributed to the difference in the amount of permethrin introduced into the huts. A hut with two intact individual nets received a total of 1.6 g of permethrin, whereas a hut with only one group mosquito net received a total of 1.08 g.

Thus an additional 0.52 g of permethrin in a hut may considerably increase mortality, but an experiment specifically designed to solve this aspect of the problem is needed before any definite conclusions can be drawn.

It can already be stated that a group mosquito net with holes, impregnated with about 1 g of permethrin, produces mean mortality of 12% in An. gambiae and An. funestus females caught in the huts.

3.5.2 Immediate and deferred mortality

One-third of the overall mortality is immediate mortality observed at each collection within the houses, while two-thirds is observed after 24 hours of observation under good survival conditions. Immediate and deferred mortality differs for the two species, An. gambiae and An. funestus.

Impregnated mosquito nets			
	No. of dead mosquitos	Immediate mortality	Deferred mortality
<u>An. gambiae</u>	72	31 (43.1%)	41 (56.9%)
<u>An. funestus</u>	177	49 (27.7%)	128 (72.3%)
Total	249	80 (32.1%)	169 (67.9%)

This information shows that under experimental conditions permethrin did not have a particularly significant knock-down effect. This could account for the relatively high engorgement rates (78% for An. gambiae and 87.6% for An. funestus) of the mosquitos found in the morning in the huts containing nets impregnated with insecticide. The mosquito is only inconvenienced by the irritant effect and has sufficient time to take a blood meal before receiving a possibly lethal dose.

It is also noted that all the mosquitos found dead in the morning in the experimental huts were found in the veranda traps.

3.6 Tests of residual effect

Tests of residual effect were carried out weekly for 21 consecutive weeks.

It seems that when permethrin (20% EC) is applied in a concentration of 0.08 g/m² to tulle and cotton percale it displays an excellent residual effect in respect to Ae. aegypti (Kari strain) after one hour of contact.

Four months after the mosquito nets were put in place the tests showed a mortality rate of 90% and over. The mortality rate was still over 70% on percale five months after the introduction of the mosquito nets. At this point the mortality rate on the tulle mosquito nets was around 40-50%.

The position of the cones on the tulle and the percale was varied each week, and the fluctuations in mortality during the 21 weeks of the experiment might be attributable to the inevitable variations in insecticide impregnation.

In the 14th week the mortality rates on tulle were 57.1% in the Bobo huts and 56.6% in the Mossi huts. The cones had been sited at the bottom of the net, an area frequently in contact with the ground and handled by the sleepers when they get in or out of the net. This indicates the loss of insecticide caused by handling of the net.

In the 15th week, the test cones were again placed at random on the mosquito net, on areas still well impregnated with permethrin, and mortality was once again above 80%.

4. DISCUSSION AND CONCLUSION

At the experimental station at Soumouso, Burkina Faso, the 20% emulsifiable concentrate of permethrin used for impregnating individual and group mosquito nets of cotton, with or without holes, in a concentration of 0.08 g/m², reduced the number of An. gambiae and An. funestus mosquitos entering the experimental huts by 70%.

This reduction in the entry rate of female anopheline mosquitos which normally bite man at night proves the irritant effect of this insecticide, which is seen even outside the huts provided with impregnated mosquito nets. This effect is clearly felt inside the huts, because the exit rate changes from 25% in the control huts to over 97% in the huts provided with impregnated nets.

By comparison with the control huts, impregnation of the mosquito nets reduces the engorgement rate by 20% for An. gambiae and by 10% for An. funestus.

These three parameters - reduction in entry rate, increase in exit rate, reduction in engorgement rate - are attributable to the repellent and irritant effect of permethrin.

The anopheline vectors entering the huts with impregnated mosquito nets display an overall mortality of 17%, which is directly attributable to the insecticide and varies according to the amount of permethrin used for impregnation. One-third of this mortality is immediate and two-thirds is deferred.

The residual effect observed under these conditions of normal use is of the order of at least five months.

The use of permethrin 20% EC for impregnating mosquito nets does not completely isolate man from the anopheline vectors, but substantially reduces man/vector contact to such a degree that the insecticide-impregnated mosquito net, even damaged, could become an effective method of malaria prevention for populations normally at risk of this disease.

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SUMMARY

At Soumouosso, a centre collaborating with WHO in the Pesticides Evaluation Scheme, a study was conducted from June to November 1983 to evaluate the efficacy of permethrin-impregnated mosquito nets in reducing man/vector contact. Thirty-six cotton mosquito nets were placed inside Bobo-type and Mossi-type experimental huts. These nets were either "individual" (for one person) or "group" (for three persons), and, in order to reproduce the usual conditions, 50% of the nets had holes in them. The nets were impregnated with permethrin (20% EC) in a concentration of 0.08 g/m².

Under these experimental conditions, it was observed that in huts with impregnated mosquito nets:

- (1) the entry rate of An. gambiae and An. funestus was reduced by about 70%;
- (2) the exit rate of these two species increased from 25-30% in control huts to 97% in huts with impregnated nets;
- (3) the biting rate of these two vectors was reduced by about 10-20%;
- (4) about 20% of anophelines entering the hut died; one-third of these died immediately, two-thirds within 24 hours.

The results indicate that insecticide-impregnated mosquito nets, whether damaged or not, very significantly reduce man/vector contact and could thus be considered as an individual means of controlling vectors in villages.

FIGURE

PERCENTAGES OF An. gambiae AND An. funestus CAUGHT IN THE MORNING
IN THE HUTS, UNDER THE MOSQUITO NETS AND IN THE VERANDA TRAPS,
ACCORDING TO WHETHER THE NETS WERE IMPREGNATED (▨) OR NOT
IMPREGNATED (□) WITH INSECTICIDE

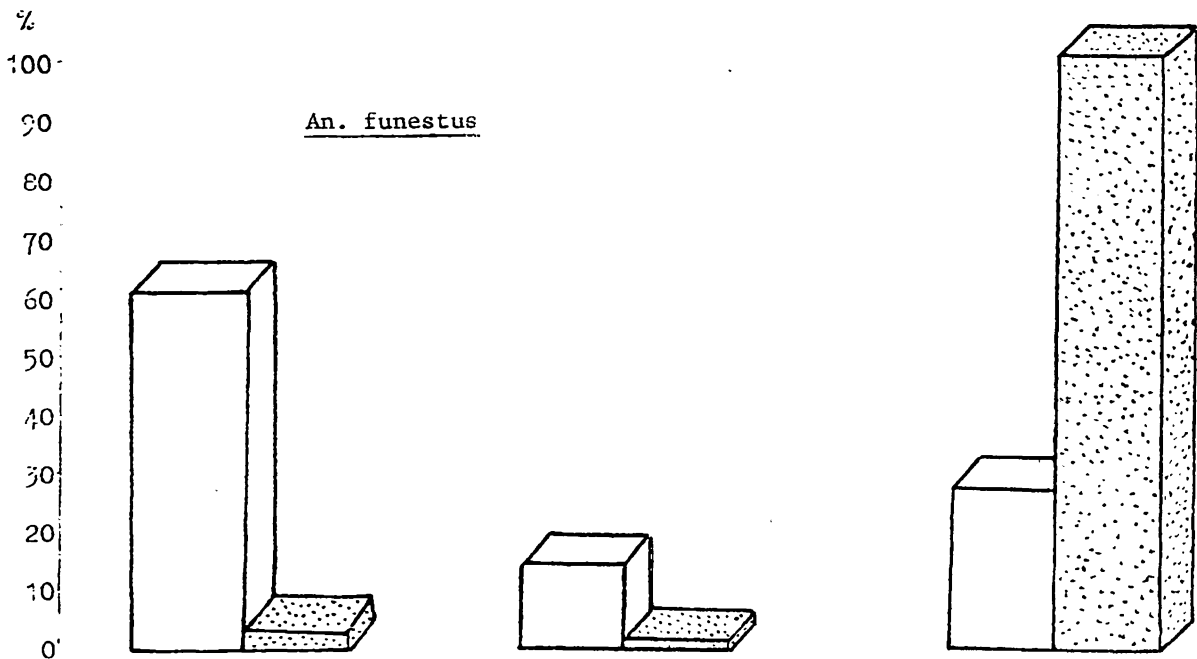
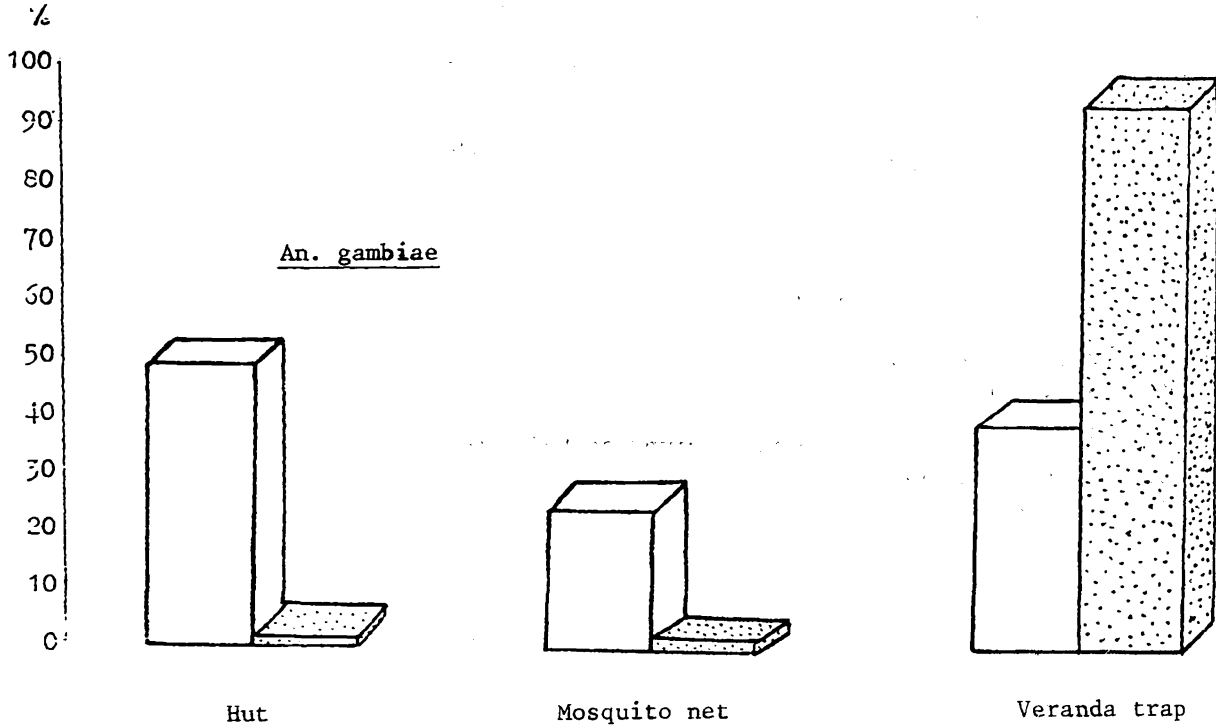


TABLE 1. NUMBERS OF MOSQUITOS* CAUGHT IN THE HUT TRAPS (CONTROL AND TREATED) FROM 5 JULY TO 26 NOVEMBER 1983

Date	An. gambiae			An. fumestus			An. nili			Ma. africana			Ma. uniformis								
	WAT	B	M	Tot	%	B	M	Tot	%	B	M	Tot	%	B	M	Tot	%				
5 Jul	1	28	32	60	1.4	1	4	5	0.1	0	1	1	0.02	1	1	2	0.6	0	0	0	0
16 Jul	2	52	98	150	3.4	7	10	17	0.4	1	1	2	0.04	2	5	7	2.3	6	2	8	2.6
18 Jul	3	32	85	117	2.7	10	35	45	1.0	7	8	15	0.3	10	7	17	5.5	9	5	14	4.6
30 Jul	4	86	102	188	4.3	72	67	139	3.2	8	7	15	0.3	5	4	9	2.9	10	5	15	4.9
1 Aug	5	62	95	157	3.6	166	193	359	8.2	29	20	49	1.1	8	7	15	4.9	15	8	23	7.5
13 Aug	6	98	113	211	4.8	393	314	707	16.2	39	32	71	1.6	10	12	22	7.2	10	7	17	5.5
15 Aug	7	62	77	139	3.2	488	580	1068	24.5	28	43	71	1.6	15	16	31	10.1	20	8	28	9.1
27 Aug	8	9	17	26	0.6	152	262	414	9.5	3	1	4	0.09	14	9	23	7.5	8	4	12	3.9
29 Aug	9	3	4	7	0.2	143	131	274	6.3	0	0	0	0	9	13	22	7.2	3	8	11	3.6
10 Oct	10	3	0	3	0.07	21	21	48	1.0	0	0	0	0	10	10	20	6.5	4	1	5	1.6
22 Oct	11	0	0	0	0	6	3	9	0.2	0	0	0	0	4	2	6	2	0	0	0	0
24 Oct	12	435	623	1058	24.2	1459	1620	3079	70.5	115	113	228	5.2	88	86	174	56.7	85	48	133	43.3
5 Nov	13																				
7 Nov	14																				
19 Nov	15																				
21 Nov	16																				
26 Nov	17																				
Total																					

*Four An. flavicosta females and six An. rufipes females were also caught, but are not shown in this table.
 WAT: No. of weeks after treatment
 B: No. of mosquitos caught in Bobo huts
 M: No. of mosquitos caught in Mossi huts
 Tot.: Total no. of mosquitos caught
 %: Total as percentage of grand total for the genus

TABLE 2. NUMBERS OF An. gambiae AND An. funestus CAUGHT IN BOBO AND MOSSI HUTS WITH EXPERIMENTAL IMPREGNATED MOSQUITO NETS (16 HUTS) AND CONTROL NETS (8 HUTS)

Test conditions	<u>An. gambiae</u>		<u>An. funestus</u>	
	Impregnated	Control	Impregnated	Control
INI: Bobo	62	11	131	51
Mossi	21	32	43	58
Total	83	43	174	109
INH: Bobo	54	26	127	230
Mossi	18	15	63	90
Total	72	41	190	320
GNI: Bobo	40	59	76	288
Mossi	99	62	366	176
Total	139	121	442	464
GNH: Bobo	47	136	135	421
Mossi	64	312	140	684
Total	111	448	275	1 105
Grand total	405	653	1 081	1 998
Mean	25.31 females per hut	81.63 females per hut	67.56 females per hut	249.7 females per hut
Impregnated nets/ control nets	\triangle = - 69%		\triangle = - 73%	

INI: Individual nets, intact
 INH: Individual nets, with holes
 GNI: Group nets, intact
 GNH: Group nets, with holes

TABLE 3A. TOTAL NUMBERS (AND PERCENTAGES) OF An. gambiae CAUGHT IN EACH TEST SITUATION

Net type	Hut type	In hut	Under net	In veranda trap	Total
INI*	Mossi	0	0	21	21
	Bobo	0	0	62	62
INH*	Mossi	0	0	18	18
	Bobo	0	0	54	54
GNI*	Mossi	3	3	93	99
	Bobo	2	0	38	40
GNH*	Mossi	3	1	60	64
	Bobo	1	1	45	47
Total and % N*	Mossi	6(2.97)	4(1.98)	192(95.01)	202
	Bobo	3(1.5)	1(0.5)	199(98.0)	203
Grand total	No.	9	5	391	405
	%	2.22%	1.23%	96.5%	
INI	Mossi	17	10	5	32
	Bobo	4	2	5	11
INH	Mossi	7	5	3	15
	Bobo	6	10	10	26
GNI	Mossi	36	9	17	62
	Bobo	18	2	39	59
GNH	Mossi	179	42	91	312
	Bobo	64	28	44	136
Total and % N	Mossi	239(56.8)	66(15.7)	116(27.6)	421
	Bobo	92(39.7)	42(18.1)	98(42.2)	232
Grand total	No.	331	108	214	653
	%	50.7%	16.5%	32.8%	

N*: Impregnated nets
 N: Non-impregnated nets
 INI*: Individual nets, intact
 INH*: Individual nets, with holes
 GNI*: Group nets, intact
 GNH*: Group nets, with holes

TABLE 3B. TOTAL NUMBERS (AND PERCENTAGES) OF An. funestus
 CAUGHT IN EACH TEST SITUATION

Net type	Hut type	In hut	Under net	In veranda trap	Total
INI*	Mossi	1	0	42	43
	Bobo	2	0	129	131
INH*	Mossi	3	0	60	63
	Bobo	3	0	124	127
GNI*	Mossi	9	1	356	366
	Bobo	4	0	72	76
GNH*	Mossi	1	0	139	140
	Bobo	4	0	131	135
Total and % N*	Mossi	14(2.3)	1(0.2)	597(97.5)	612
	Bobo	13(2.8)	0(-)	456(97.2)	469
Grand total	No.	27	1	1 053	1 081
	%	2.5%	0.09%	97.4%	
INI	Mossi	43	2	13	58
	Bobo	31	3	17	51
INH	Mossi	61	12	17	90
	Bobo	126	57	47	230
GNI	Mossi	138	8	30	176
	Bobo	193	5	90	288
GNH	Mossi	467	64	153	684
	Bobo	171	85	165	421
Total and % N	Mossi	709(70.3)	86(8.5)	231(21.1)	1 008
	Bobo	521(52.6)	150(15.2)	319(32.2)	990
Grand total	No.	1 230	236	532	1 998
	%	61.6%	11.8%	26.6%	

TABLE 4A. PHYSIOLOGICAL STATUS OF *An. gambiae* FEMALES CAUGHT BY HAND IN THE MORNING IN HUTS WITH INSECTICIDE-IMPREGNATED (N*) OR NON-IMPREGNATED (N) MOSQUITO NETS

Net type	Hut type	No. of females caught	No. with blood meal	% with blood meal
INI*	Mossi	21	17	80.9
	Bobo	62	47	75.8
INH*	Mossi	18	11	61.1
	Bobo	54	41	75.9
GNI*	Mossi	99	80	80.8
	Bobo	40	23	57.5
GNH*	Mossi	64	51	79.7
	Bobo	47	45	95.7
Total N*	Mossi	202	159	78.7%
	Bobo	203	156	76.8%
Grand total		405	315	77.8%
INI	Mossi	32	29	90.6
	Bobo	11	10	90.9
INH	Mossi	15	15	100
	Bobo	26	26	100
GNI	Mossi	62	60	96.8
	Bobo	59	56	94.9
GNH	Mossi	312	309	99.0
	Bobo	136	134	98.5
Total N	Mossi	421	413	98.1%
	Bobo	232	226	97.4%
Grand total		653	639	97.9%

INI*: Individual nets, intact
 INH*: Individual nets, with holes
 GNI*: Group nets, intact
 GNH*: Group nets, with holes

TABLE 4B. PHYSIOLOGICAL STATUS OF *An. funestus* FEMALES CAUGHT BY HAND
 IN THE MORNING IN HUTS WITH INSECTICIDE-IMPREGNATED (N*)
 OR NON-IMPREGNATED (N) MOSQUITO NETS

Net type	Hut type	No. of females caught	No. with blood meal	% with blood meal
INI*	Mossi	43	33	76.7
	Bobo	131	116	88.5
INH*	Mossi	63	49	77.8
	Bobo	127	100	78.7
GNI*	Mossi	366	354	96.7
	Bobo	76	56	73.7
GNH*	Mossi	140	116	82.9
	Bobo	135	128	94.8
Total N*	Mossi	612	552	90.2%
	Bobo	469	400	85.3%
Grand total		1 081	952	88.1%
INI	Mossi	58	54	93.1
	Bobo	51	48	94.1
INH	Mossi	90	87	96.7
	Bobo	230	223	96.9
GNI	Mossi	176	171	97.2
	Bobo	288	274	95.1
GNH	Mossi	684	673	98.4
	Bobo	421	410	97.4
Total N	Mossi	1 008	985	97.7%
	Bobo	990	955	96.5%
Grand total		1 998	1 940	97.1%

ANNEX

Calculation of concentrations for impregnating mosquito nets with permethrin (20% EC)

1 ml of formulation: 0.2 g of active ingredient

Treatment concentration: 0.08 g of active ingredient/m²

I. Individual net

Absorption capacity: 900 ml

Surface area: 10 m²

Insecticide needed: 0.80 g per net, i.e. 4 ml of formulation in 900 ml of water

II. Group net

Absorption capacity: 1200 ml

Surface area: 13.5 m²

Insecticide needed: 1.08 g per net, i.e. 5.4 ml of formulation in 1200 ml of water.

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