RESIDUAL EFFECTS OF MOSSMANN 100 (PERMETHRIN 10% EC) IMPREGNATED BED NETS AND ITS IMPACT ON MALARIA VECTORS AND INCIDENCE OF MALARIA

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Abstract. The objective of this field trial was to assess the residual effectiveness of permethrin 10% treated mosquito nets on malaria control compared with untreated nets. The study was carried out between July and December 2007 in the Pong Nam Ron District of Chantaburi Province, Thailand. Mosquito population densities were assessed using the landing catch method. Mosquitoes were collected between 6:00 PM and 12:00 PM. Residual effectiveness of the treated nets was assessed using standard WHO bioassay tests carried out monthly using *Anopheles dirus* mosquitoes reared in the insectary of the Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, Thailand. The results showed the population densities of *Anopheles* spp, including the malaria vector *Anopheles minimus*, were unaffected in the study area where mosquito nets treated with Mossmann 100 (permethrin 10% EC) at 300 mg/m^2 were used. WHO bioassay tests showed the nets treated with Mossmann 100 remained biologically effective against *An. dirus* for up to six months. Indigenous cases of malaria were reduced by 27.7% at the site where the nets treated with Mossman 100 (permethrin 10% EC) were used but no changes in malaria cases at the control site were seen.

INTRODUCTION

Malaria is a serious problem in many tropical and subtropical countries. Indoor residual sprays are used in endemic areas to control disease vectors but effective alternatives are essential for successful management of malaria. Darriet *et al* (1984) reported the successful use of pyrethroid-treated mosquito nets for malaria control and Curtis and Lines (1985) compared the efficacy of different insecticides available for this purpose. Mosquito nets treated with pyrethroid insecticides have been shown to protect users from malaria (Cheng *et al*, 1995; Jana-Kara *et al*, 1995; Nevill *et al*, 1996; Curtis *et al*, 1998). The widespread distribution of insecticide-impregnated bed nets is a major component of the WHO global strategy for malaria control, especially in sub-Sahara Africa where more than 90% of malaria cases are reported annually.

In Thailand DDT applied as an indoor residual spray was the original major measure for malaria vector control programs. Introduced in 1949 DDT was replaced after

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four decades by organophosphate and pyrethroid insecticides. Additional control measures using insecticide treated nets were introduced and pyrethroid treated nets have now been used in malaria control programs since 1992. The present study was carried out to assess the residual effectiveness for malaria control using mosquito nets treated with Mossmann 100 (permethrin 10% EC) compared to untreated nets.

MATERIALS AND METHODS

Study area

Two malaria endemic areas in Pong Nam Ron District, Chantaburi Province, Thailand were selected for the study. Mu5, Ban Dong Jig village has 299 houses and a population of 1,097. It was used as the treated area. One hundred fifty nets freshly treated with permethrin were provided to the selected houses. Mu3, Ban Pang Ngon village has 288 houses and a population of 1,170. It was used as the control area. One hundred fifty untreated nets were provided to the selected houses.

Preparation of insecticide treated nets

Nets were white polyester with a fiber denier of 100 and a mesh of 190 holes/inch^2; the net size was 180 x 190 x 150 cm. The insecticide used was permethrin 10% w/v emulsifiable concentrate (trade name Mossmann 100 supplied by WellTech HealthCare, Thailand). To treat nets a 40-ml sachet of insecticide was mixed with 360 ml of water in a large plastic bag, a new net was put into the bag thoroughly soaked for 2-3 minutes and then dried in the shade. The target concentration of insecticide on the net was 300 mg/m^2.

Entomological study

The entomological study was performed from July to December 2007. Field mosquitoes were collected between 6:00 PM and 12:00 PM for 2 consecutive nights using a standard landing catch method. One house in each area was selected and used as a catching station. Mosquitoes were collected both indoors and outdoors by two collectors. All collected mosquitoes were identified by species. The test mosquitoes were female, 3 to 5 day old lab-bred *Anopheles dirus* mosquitoes fed with 10% sucrose solution and later used for the bioassay. These were reared in the insectary of the Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, Thailand.

Bioassay test

Evaluation of the residual efficacy of treated nets in the field was conducted for 6 months using the WHO cone bioassay method (WHO, 1998). The tests were carried out each month. Three treated nets were randomly selected and five cones attached to each net. Ten mosquitoes in each cone were exposed to the treated net for 3 minutes. The mosquitoes were transferred to a clean paper cup which was sealed with a mesh screen onto which was put a cotton pad soaked with 10% sugar solution. The number of dead mosquitoes was counted after 24 hours and the percent mortality was calculated.

Detection of malaria cases

The number of malaria cases was assessed by both active and passive detection during the study period by the staff of the Vector Borne Diseases Control Center 3.5, Chantaburi Province.

Acceptance of new insecticide treated nets

A survey to determine the acceptability of the Mossmann 100 treated nets was conducted among 30% of the people to whom these had been distributed. A questionnaire was completed one to three months after the nets had been supplied.

RESULTS

Table 1 shows the mosquito density and

Table 1
The number of *Anopheles* mosquitoes collected during July to December in treated and control areas.

Anopheles species	Mu5, Ban Dong Jig village (treated area)		Mu3, Ban Pang-Ngon village (control area)	
	No. anophelines/man/hr (Total no.)		No. anophelines /man/hr (Total no.)	
	Indoors	Outdoors	Indoors	Outdoors
An.minimus	1.89 (136)	1.67 (120)	1.57 (113)	2.76 (199)
An.barbirostris gr	1.65 (119)	1.83 (132)	0.64 (46)	0.96 (69)
An.vagus	0.04 (3)	0.21 (15)	0.01 (1)	0.06 (4)
An.philippinensis	0.01 (1)	0.03 (2)	0 (0)	0.03 (2)
Total	3.60 (259)	3.74 (269)	2.22 (160)	3.80 (274)

Table 2
Bioefficacy of Mossmann 100 (permethrin 10%EC) treated nets against *Anopheles dirus.*

After use of treated net (month)	Total tested	Number dead	% Mortality±SD
1	150	110	73 ± 11.5
2	150	128	85 ± 7.6
3	150	129	86 ± 10.7
4	150	105	70 ± 6.0
5	150	98	65 ± 16.0
6	150	96	64 ± 1.0

total number of anopheline mosquitoes caught by landing catches indoors and outdoors in both the treated and control areas. A total of 259 *Anopheles* specimens, or 61.8% of all the indoor-collected *Anopheles* specimens, were collected from the treated area. *Anopheles minimus*, the principal malaria vector, was the prominent species collected at 1.89 and 1.57 mosquitoes/man/hr in the treated and control areas, respectively. There was no statistically significant difference in the number of *Anopheles minimus* mosquito counts indoors and outdoors (t = 0.309, p >0.05 and t = 0.833, p >0.05) for both study areas nor in *Anopheles* densities in either study area (t = 1.308, p >0.5).

Results of bioassay tests for residual efficacy of insecticide treated nets used in the field (Table 2) showed that Mossmann 100 treated nets caused about 70% mortality in *Anopheles* mosquitoes by 6 months. It caused 86±10.7% to 70±6.0% mortality in *Anopheles dirus* by 4 months and 60% mortality by 6 months.

Table 3 shows the number of malaria cases in 2007 decreased by 27.3% compared to the same period (July-December) in 2006 in the treated area. In contrast, the malaria cases in the control area were the same as the previous year. However, there was no statistically significant difference in the number of malaria cases in the control area and

Table 3
Comparison of malaria cases during July-December 2006 and 2007 in treated and control areas.

Study areas	No. malaria cases during July-December 2006	No. malaria cases during July-December 2007	% Change
Mu5, Ban Dong Jig village(treated area)	22	16	-27.3
Mu3, Ban Pang Ngon village(control area)	13	13	0

Table 4
Demography of the interviewed sampling group in the study area.

Education	%	Occupation	%	Age (Years)	%	Income per month (Baht)	%
Primary school	83.2	Farming	26.6	15 - 24	4.0	0 - 1,000	7.1
		Worker	27.8	25 - 34	28.7	1,000 - 3,000	1.0
High school	13.8	Orchard	38.1	35 - 44	19.8	3,000 - 5,000	84.8
Certificate	1.0	Commerce	0.6	45 - 54	17.8	5,000 - 10,000	7.1
Higher	2.0	Other	6.9	> 54	29.7	> 10,000	0

the treated area (t = 0.389, p >0.05 and t = 0.282, p >0.05). Most of the malaria patients (14 out of 16) in the treated area were age 15 years or older, which is the group considered at high risk for contracting malaria infection.

Most people in the treated area (83.2%) had only a primary school level education. The major occupation in the study area was agriculture or orchard plantation worker. The group age 25-54 years old was the main constituent (66.3%) of the population considered at high risk for malaria infection. The average income was 3,000-5,000 THB per month (Table 4). Data from the questionnaire showed a high acceptance of the new chemical treated net. There were no complaints of irritation, smell or feeling unsafe from the people responding to the questionnaire (Table 5).

DISCUSSION

The use of insecticide treated bed nets is an established technique in malaria control. The present study was designed to evaluate the efficacy of a new formulation Mossmann 100 (permethrin 10%EC) as a bed net application. According to the WHO, nets freshly treated with recommend doses of pyrethroids should give 80-100% mortality in bioassays. The percent mortality is observed to decline markedly after several months of use and especially after washing. Re-treatment of the nets is recommended in areas where malaria is a perennial problem and when mortality in bioassays drop to about 50%. This is likely 6 months after treatment with permethrin, but may not no be for 12 months or more with the alpha-cyano-pyrethroids (WHO, 1997). In this present

Table 5
Summary of questionnaire regarding acceptance of treated nets.

Acceptance of treated net	Low (%)	Medium (%)	High (%)
1. They have a bed net in the house	0	0	100
2. The net has been treated with new chemicals	0	0	100
3. The owner accepts the new chemical treated net	1	0	99
4. The new treated net does not smell	5.9	0	94.1
5. The owner thinks that the new treated net			
5.1 can kill mosquitoes	0	67.3	0
5.2 is better than the old one	0	0	99
6.Side effect of the new chemical treated net			
6.1 No eye irritation	0	0	100
6.2 No skin irritation	0	0	100
6.3 No nausea	0	0	100
7. You think the treated net is safe	0	0	100

study the efficacy of Mossmann 100 treated nets at the recommend dose (permethrin 300 mg/m^2) was acceptable. By 4 months, 70-86% tested mosquito mortality was achieved and 60% by 6 months. Limrat *et al* (2005) and Jawara *et al* (2001) reported similar results for permethrin efficacy with malaria vector control with a high acceptance of the people using them. The numbers of *An. minimus* biting indoors and outdoors was not significantly different. This may be due to the properties of the permethrin which is less effect at repellency than mortality (Limrat *et al*, 2005). Different concentrations of permethrin can cause different effects on mosquitoes. Mosquitoes are repelled from entering houses at higher concentrations while at lower concentrations, mosquitoes are likely to enter houses and contact a lethal dose of insecticide (Lindsay *et al*, 1991).

In Thailand insecticide treated nets have been widely introduced as an alternative malaria control measure to prevent malaria infection, especially in low endemic areas. While this study was carried out in a low transmission area and for 6 months, the impact on malaria vectors showed no statistically significant difference between the treated and control area. The permethrin impregnated bed nets had no impact on malaria transmission, however, the number of malaria cases was reduced in the treated area. This was due to incomplete coverage with insecticide treated nets in the study area. About 50% of the houses were provided with nets (treated and untreated). The low vector population density in the study areas resulted in an ambiguous effect on the vector population in contrast to some studies in highly endemic areas in Africa (Gimnig *et al*, 2003). In low endemic areas, the annual parasite incidence (API) is generally so low that the sample size needed to detect a statistically significant reduction (implying low transmission) may be impractically large. Therefore, in this study the use of Mossmann 100 impregnated nets showed some degree of protecting the inhabitants from malaria infection and which did not reach statistical significance and mosquitocidal activity lasted for about 6 months in field conditions.

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