

TRIAL OF SPATIAL REPELLENCY OF METOFLUTHRIN-IMPREGNATED PAPER STRIP AGAINST *ANOPHELES* AND *CULEX* IN SHELTERS WITHOUT WALLS IN LOMBOK, INDONESIA

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ABSTRACT. Trials of metofluthrin-impregnated multilayer paper strips against mosquitoes in shelters with no walls were carried out at 3 sites in Lombok, Indonesia. Major reductions in human biting by *Culex quinquefasciatus*, *Anopheles balabacensis*, and *An. sundaicus* were achieved. The device is a very practical measure of preventing outdoor mosquito biting, with no need for electricity or heating to evaporate its active ingredient.

KEY WORDS Metofluthrin, spatial repellency, *Anopheles balabacensis*, *Culex quinquefasciatus*, *Anopheles sundaicus*

INTRODUCTION

We reported in a previous paper that a newly synthesized pyrethroid metofluthrin (2,3,5,6-tetrafluoro-4-methoxymethylbenzyl (*E,Z*)(1*R*,3*R*)-2,2-dimethyl-3-(prop-2-enyl) cyclopropanecarboxylate; S-1264), impregnated into a multilayer paper strip, showed a promising spatial repellent effect against mosquitoes in the laboratory and under field conditions (Kawada et al. 2004, Ujihara et al. 2004). The laboratory test proved that mosquitoes were affected by airborne metofluthrin vapor without need for direct contact with the strip, and with a 4 wk persistence under field conditions.

The preliminary investigation was carried out in Meninting County, Lombok Island, including the test areas of the present study. *Anopheles sundaicus* (Rodenwaldt) and *Anopheles balabacensis* Baisas, which are thought to be important malaria vectors, are exophagic and most of their biting takes place in the evening when most people are still active outside (Maekawa et al., unpublished data). The people in Lombok Island use huts made of palm leaves called “beruga” (Fig. 1) for resting, praying, and evening conversations with neighbors. There is a high risk of malaria transmission on these occasions. A beruga has no walls or may have simple screens on 1 or 2 sides. The use of mosquito coils or vaporizing mats for prevention of mosquito bites is not customary in such communities because of lack of electricity and their cost. Moreover, their effectiveness is limited in the semioutdoor conditions of a beruga. Multilayer paper strips impregnated with metofluthrin may be more appropriate because of their ease in handling and long-lasting efficacy at low cost. In this paper, we report a test of this concept.

MATERIALS AND METHODS

Formulation of metofluthrin-impregnated paper strips: Metofluthrin and multilayer paper strips were supplied by Sumitomo Chemical Co., Ltd. (Hyogo, Japan). Two-hundred milligrams of metofluthrin diluted with acetone was uniformly applied to the paper strips, which are multilayered and foldable (Fig. 2), and the acetone was allowed to evaporate. When folded, the strip was compact (9 × 7 cm, ca. 3 mm in thickness) and when unfolded the surface area of the paper was ca. 2,000 cm².

Cage test with *An. balabacensis*: Knock-down activity of the metofluthrin-impregnated paper strips was evaluated against caged mosquitoes in a beruga. Field-collected larvae of *An. balabacensis* were reared in the laboratory and emerged adults were used for the test. Ten females (3–7 days after emergence) were released in a stainless steel cage (210 × 170 × 150 mm, 11 mesh). Three cages were hung at the center and in each corner of the beruga at a height of 70 cm from the floor. A multilayer paper strip was hung at the center of the ceiling with the bottom of the strip 130 cm from the floor. One cage was hung at a distance of ca. 5 m from the paper strip as an untreated control. Knock-down of mosquitoes was observed for 6 h (1800–2400 h) and mortality was recorded at 24 h. Air temperature was 25–27°C during the test.

Field collection of mosquitoes: Weekly collections of adult mosquitoes were carried out at 3 different villages in Kerandangan, Presak, and Kedongdon Atas, Lombok Island. Presak is located in the coastal area ca. 7.5 km northwest of Mataram. Kedongdon Atas is located at ca. 300 m altitude, ca. 10 km northeast of Mataram. A house was used for indoor human-baited collections. Two humans lay inside a bed-net and mosquitoes were collected outside the net. Outdoor human-baited collections were carried out by using a double net. Collection of mosquitoes was made between the outer and inner nets, which were 3 × 3 × 2 m and 1 × 1 × 2 m, respectively, with 2 humans inside the inner net. Collections were made with aspirators for 45 min in each hour from 1800 h to 2400 h weekly from

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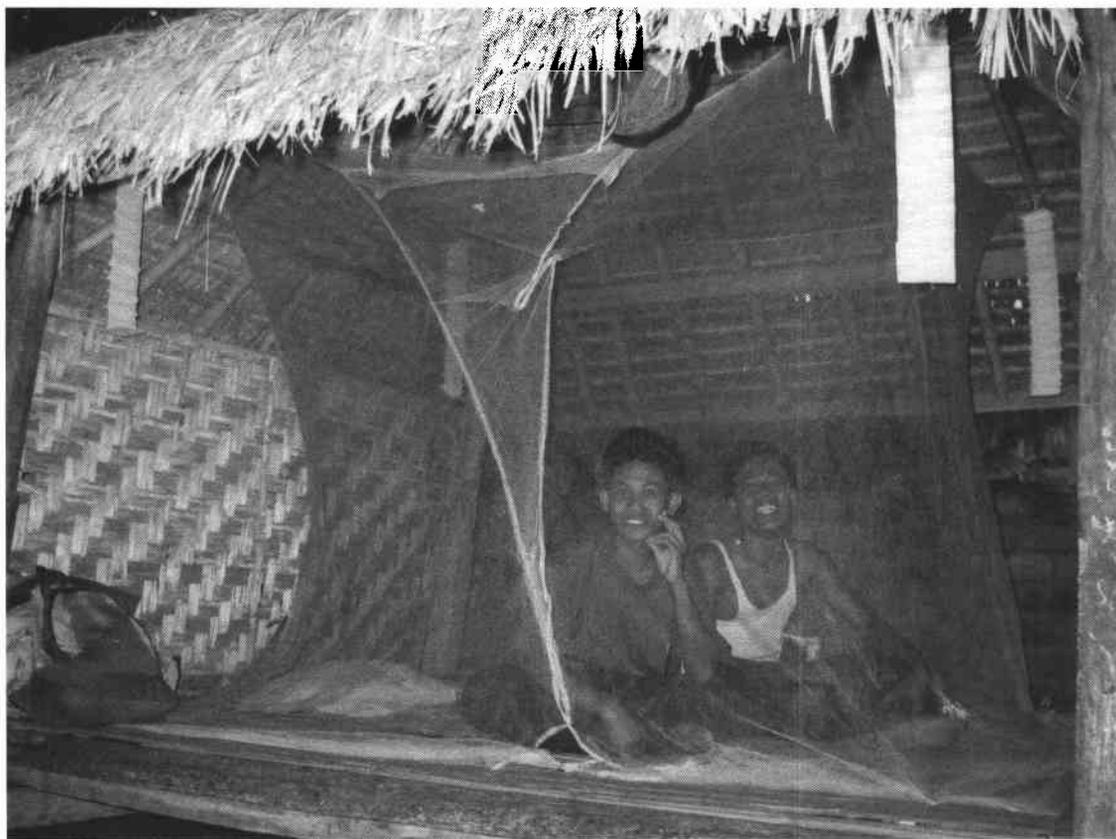


Fig. 1. Field test with 4 strips in a beruga.

April to September 2003. Numbers of each species collected were recorded.

Field evaluation of metofluthrin-impregnated paper strips against mosquitoes in berugas: The evaluation was carried out at the 3 villages mentioned above. Four beruga at Kerandangan (floor areas 5.3–5.7 m²), 4 at Presak (floor areas 4.4–6.2 m²), and 3 at Kedongdon Atas (floor areas 3.4–5.2 m²) were chosen as the test sites. At Kerandangan and Presak, 4 treatment regimes were rotated between the beruga: 1-strip, 2-strip, and 4-strip treatments and an untreated control. Figure 1 shows the 4-strip treatment site. At Kedongdon Atas, only 2 and 4 strips were tested, with an untreated control. Two humans lay in a bed-net hung in each beruga during the test as human bait. Test strips were set before the test started (1800 h). Strips were hung below the ceiling of the beruga outside the bed-net as shown in Fig. 1. Test strips were folded and kept in aluminum laminated bags after each test and were preserved in a refrigerator until the next test. Collections of mosquitoes were carried out from 1800 h to 2400 h as described above. The tests were carried out from June 30 to July 3 at Kerandangan, from July 7 to 10 at Presak, and from September 1 to 3 at Kedongdon Atas. Average tem-

perature during the tests ranged from 22.7 to 25.3°C.

RESULTS AND DISCUSSION

Knock-down activity of metofluthrin-impregnated paper strips against *An. balabacensis* in a beruga

Knock-down was fastest when the cage was placed immediately under the paper strip, with all mosquitoes being knocked down within 3 h, and mortality at 24 h was 100%. Knock-down in the cages ca. 1.5 m from the paper strip was slower, with more than 50% of mosquitoes being left alive 6 h after treatment, whereas their mortality was ca. 70% at 24 h. No knock-down or death was observed in the control cage at a distance of ca. 5 m from the paper strip.

Population density and species composition of adult mosquitoes during the test period

Species composition at each test site from April 10 to September 25, 2003, is shown in Table 1. At Kerandangan and Presak, indoor and outdoor col-

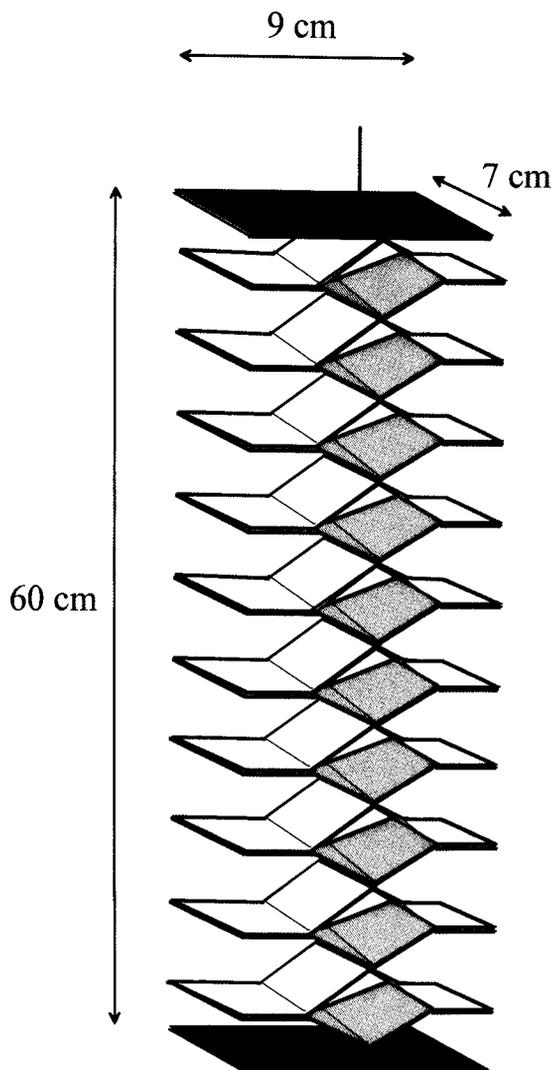


Fig. 2. Metofluthrin-impregnated multilayer paper strips.

lections yielded many *Culex* spp., among which *Cx. quinquefasciatus* Say was dominant (>90%). The dominant anopheline indoors was *An. sundaicus*, whereas *An. vagus* Doenitz, *An. indefinitus* (Ludlow), and *An. subpictus* Grassi of the Pyretophorus series were found to be the predominant exophagic mosquitoes.

In Kedongdon Atas, indoor collection was not carried out, because we had found in the preliminary study in 2002 that the mosquito density in this area were very low and most of them were collected outdoors. The dominant species collected by human bait in this area was *An. balabacensis*.

Spatial repellency of metofluthrin-impregnated paper strips against mosquitoes at beruga

The data are shown in Table 2. There was evidence that the pyrethroid vapor from the strips was effective against the malaria vectors *An. sundaicus* and *An. balabacensis*, although only 8 of each species were caught in the untreated control beruga. The total number of *Cx. quinquefasciatus* caught declined as the number of strips was increased, although a few of the mosquitoes were caught even with 4 strips. Biting inhibition of mosquitoes has been well known as a sublethal effect of pyrethroids (Birley et al. 1987). MacIver (1964) defined the "repellency" of mosquitoes associated with pyrethroids as a reaction of insects at the threshold when the neural activation and knock-down occur resulting in the loss of power to orient to their hosts. Similarly, the spatial repellency of metofluthrin-impregnated paper strips is thought to be caused by disruption of orientation activity of mosquitoes, and the effective area for a single strip is estimated to be more than 5 m².

We previously reported promising spatial repellency of metofluthrin and its impregnated multilayer paper strips in rather artificial conditions in Lombok Island (Kawada et al. 2004). The conditions in the present trial were more realistic. Therefore, the promising results in the present study gave us in-

Table 1. Species composition of mosquitoes in 3 test sites in April–September 2003.

Mosquito species	Species composition (%)					
	Kerandangan		Presak		Kedongdon Atas	
	In ¹	Out ²	In ¹	Out ²	In ¹	Out ²
<i>Anopheles vagus</i> + <i>An. indefinitus</i> + <i>An. subpictus</i>	9.8	46.5	3.4	15.8	—	4.5
<i>An. tessellatus</i> + <i>An. barbirostris</i> + <i>An. maculatus</i>	0	1.3	0	1.2	—	0
<i>An. balabacensis</i>	0	0	0	0	—	37.4
<i>An. sundaicus</i>	52.9	10.2	0	0	—	0
<i>Aedes</i> spp. + <i>Armigeres</i> spp. + <i>Mansonia</i> spp.	2.0	6.5	1.0	6.2	—	20.7
<i>Culex</i> spp. ³	35.3	35.5	95.6	76.8	—	37.4
Total	100	100	100	100	—	100
Mean no. mosquitoes per man per night	6.4	80.8	102	333	—	9.9

¹ Indoor human-baited collection.

² Outdoor human-baited collection.

³ >90% was *Cx. quinquefasciatus*.

Table 2. Number of mosquitoes collected at the beruga treated with metofluthrin-impregnated strips by half-night human-baited collection at 3 sites.¹

No. strips	Mean no. mosquitoes collected per man per night					
	Kerandangan		Presak		Kedongdon Atas	
	An. <i>sundaicus</i> ²	Cx. <i>quinquefasciatus</i> ²	An. <i>sundaicus</i>	Cx. <i>quinquefasciatus</i>	An. <i>balabacensis</i>	Cx. <i>quinquefasciatus</i>
0	2.0 a	11 a	0	84 a	2.0 a	0
1	0 b	2.5 b	0	29 b	—	—
2	0 b	0.25 b	0	11 b	0 b	0
4	0 b	0.25 b	0	1.5 b	0 b	0

¹ Values followed by the same letters are not significantly different ($P > 0.05$; Tukey's honestly significant difference test).

² An., *Anopheles*; Cx., *Culex*.

centive to continue the research. The multilayer paper strip examined in the present study was just a prototype that requires further improvement. Details, such as quality of the material and the structure of strip; the amount of active ingredient in a strip; chemical protective measures to prevent the active ingredient from degradation by oxidation, light, and other causes; the dosage for the strips for indoor and outdoor use; and long-term toxicity studies, will be the next subjects to be investigated.

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