

## FIELD EVALUATION OF SPATIAL REPELLENCY OF METOFLUTHRIN IMPREGNATED PLASTIC STRIPS AGAINST MOSQUITOES IN HAI PHONG CITY, VIETNAM

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**Abstract.** Spatial repellency of metofluthrin-impregnated polyethylene plastic strips against mosquitoes, *Aedes aegypti* and *Culex quinquefasciatus*, were studied in a residential area in Hai Phong city, Vietnam. Thirty houses were selected as trial sites; half of these were assigned as untreated control and the other half were assigned for treatment. Primarily, irrespective of the room size, one room was treated with one strip. The dominant species in the trial sites were *Culex quinquefasciatus* and *Aedes aegypti*. A rapid decrease in the mosquito index was observed immediately after the treatment with metofluthrin strips, and treatment was effective for at least 6 weeks.

### INTRODUCTION

Metofluthrin (2,3,5,6-tetrafluoro-4-methoxymethylbenzyl (*E, Z*)(1*R, 3R*)-2,2-dimethyl-3-(prop-1-enyl)cyclopropanecarboxylate) (S-1264) is a newly synthesized pyrethroid, produced by Sumitomo Chemical Co. Ltd. (Osaka, Japan).<sup>1</sup> Metofluthrin belongs to the highly safe category of pyrethroids<sup>2</sup> and has already been registered in several Asian countries such as Singapore, Indonesia, Myanmar, and Vietnam. The vapor pressure of metofluthrin is greater than 2-fold and 100-fold that of *d*-allethrin and permethrin, respectively, and it vaporizes at normal temperature without heating, whereas the other conventional pyrethroids require heating for evaporation. The high vapor pressure and insecticidal activity of metofluthrin may lead to the development of new mosquito controlling devices, which require no external energy for vaporization, are low cost, and provide long-term efficacy. Metofluthrin-impregnated multilayer paper strips have shown a promising spatial repellent effect against mosquitoes in the laboratory and in field conditions.<sup>3,4</sup> Mosquitoes were repelled by airborne metofluthrin vapor for 4 weeks in simulated outdoor conditions.<sup>3</sup> The field tests also suggest that metofluthrin may be useful for prevention of mosquito bites in shelters without walls (*beruga*), which people in Lombok Island, Indonesia, use for resting, praying, and evening conversations with neighbors, and in which there is a high risk of malaria transmission.<sup>4</sup>

The above preliminary investigations were conducted using the prototype paper devices, which were experimentally prepared in the laboratory. During another preliminary trial in Lombok, Indonesia, we observed that in outdoor conditions, the effective duration of the paper strips was shorter than what we had expected. To achieve a longer effectiveness, we manufactured the slow-release plastic formulation that was impregnated with 1,000 mg of metofluthrin. Using this formulation, we could achieve more than 14 weeks of activity in outdoor conditions in Lombok.<sup>5</sup> In this study, we report the indoor residual spatial repellency of this new plastic formulation against mosquitoes in Hai Phong city, Vietnam.

### MATERIALS AND METHODS

**Metofluthrin-impregnated plastic strips.** Plastic strips (same devices as reported by Kawada and others<sup>5</sup>) were supplied by Sumitomo Chemical Co. Ltd. (Hyogo, Japan). The plastic material had a folded cylinder-shaped network structure (11.5 cm wide, 3–4 mesh) made of polyethylene impregnated with 5% (w/w) metofluthrin. The plastic material was cut into a piece of 20 g (11.5 cm × 37 cm) to make a strip (Figure 1).

**Location of the field study.** The field study was conducted at Do Son town, Hai Phong city, Vietnam (20°40'–20°45'N, 106°46'–106°49'E). Do Son town is located in a coastal area that includes mountains and plains and is recognized as a famous tourist landscape; the three sides of the town face toward the eastern seacoast. The total area of Do Son is 4 sq. km with a population of 31,000, and it is divided into four wards and one commune. The three main occupations of the residents are fishing, tourism, and agriculture. This area obviously reflects typical tropical climate with four seasons, while it is colder in winter and cooler in summer. During the period from 1976 to 1978, outbreaks of dengue posed major health problems (Annual Report on Infectious Diseases, Hai Phong Preventive Medicine Center, Hai Phong, Vietnam). Thus far, dengue cases have rarely been reported in this location. From January to October 2004, only three clinical diagnosed dengue cases were reported at commune health stations. People residing in the coastal area usually use traditional mosquito-killing measures such as burning dry leaves to repel mosquitoes, implementing environmental sanitation program, spraying insecticides, and impregnating bed nets.

**Strip treatment and mosquito collection.** Thirty houses were selected in the trial sites; half of these were assigned as untreated control and the other half were assigned for treatment. The treatment of the metofluthrin-impregnated plastic strips was conducted from May 25 to 27, 2004. Irrespective of the room size, one room was treated with one strip, as shown in Figure 2. A total of 60 strips were used for treating 15 houses. A preliminary survey for mosquito density was conducted for two consecutive weeks prior to the treatment. Mosquito collection in the houses was conducted 1 day, 1 week, and 2 weeks after the treatment. The same procedure was repeated at intervals of 2 weeks until 18 weeks after the treatment.

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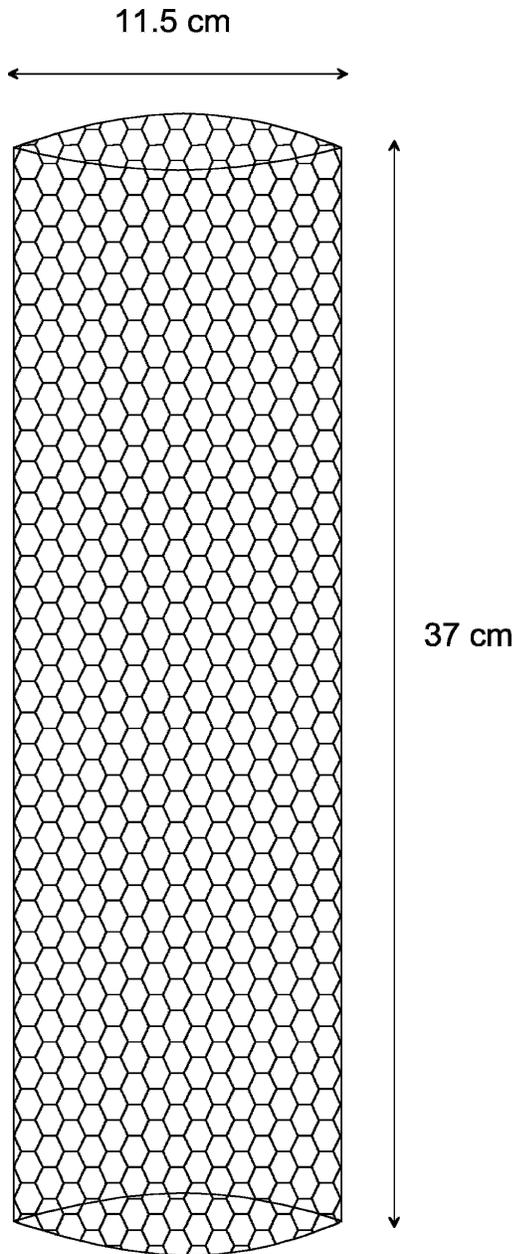


FIGURE 1. Metofluthrin-impregnated polyethylene plastic strip used in the study.

Mosquito collection was conducted by the conventional method, that is, using glass test tubes (20 cm in length, 1.5 cm in diameter) to catch mosquitoes resting on the walls, under the furniture, on clothes, and so forth. Mosquitoes were collected during 7 AM–11 AM. The total collection time in each house was 30 minutes; that is, 10 minutes by each of the three staffs. After collection, the mosquitoes were identified, the number of mosquitoes per house was recorded, and the mosquito density index was calculated as general (based on the total number of mosquitoes) and species specific.

**Data analysis.** The density index was calculated as the mean number of mosquitoes in a house. The density indices in treated and untreated houses were compared using repeated measure ANOVA.



FIGURE 2. Treatment with a metofluthrin-impregnated plastic strip in a room, Do Son.

## RESULTS AND DISCUSSION

Changes in the number of mosquitoes collected in the metofluthrin-treated and untreated houses are shown in Figure 3. The dominant species in the trial sites was *Culex quinquefasciatus* Say, followed by *Aedes aegypti* (L.). A small number of *Culex tritaeniorhynchus* Giles, *Armigeres* spp., and *Anopheles* spp. were also collected. The ambient temperature during the study ranged from 27°C to 39°C.

General density indices—based on the total number of mosquitoes collected—of both the treated and untreated sites were 3.7 and 3.3, respectively, at 2 weeks prior to treatment and 4.5 and 4.8, respectively, at 1 week prior to treatment. The index decreased rapidly in the treated houses 1 day after the treatment with metofluthrin strips, and it was maintained at significantly lower values than those in the untreated houses (Figure 3A; repeated measure ANOVA,  $F = 21.1$ , 1 df,  $P = 0.00018$ ). Based on these observations, the effective duration of metofluthrin was shown to be less than 8 weeks.

The changes in the number of *Ae. aegypti* are shown in Figure 3B. Mosquito indices of both treated and untreated sites were 0.9 and 0.8, respectively, at 2 weeks prior to treatment and 0.6 and 0.4, respectively, at 1 week prior to treatment. After the treatment with metofluthrin strips, the values remained significantly lower than those in the untreated houses (repeated measure ANOVA,  $F = 9.9$ , 1 df,  $P = 0.0050$ ). The effective duration of metofluthrin against *Ae. aegypti* was shown to be the same (less than 8 weeks) as that evaluated by the general index.

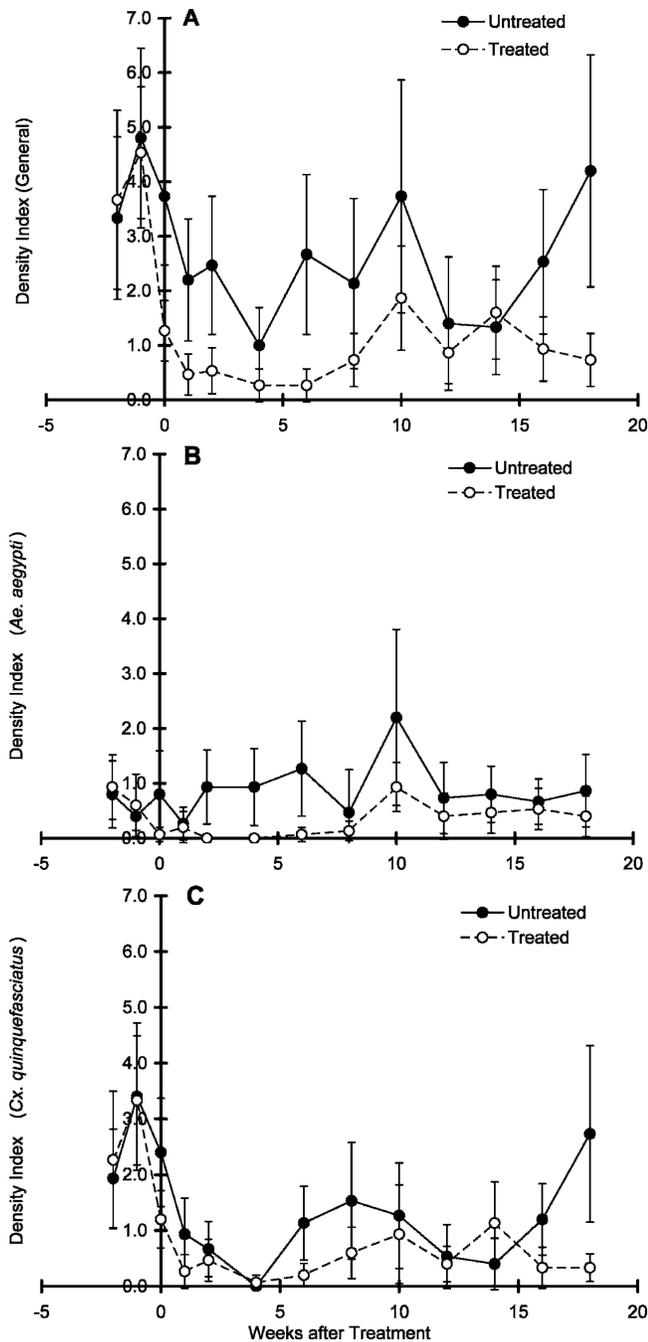


FIGURE 3. Changes in the number of mosquitoes collected in metofluthrin-treated and untreated houses. **A**, General density index based on the total number of mosquitoes collected. **B**, *Ae. aegypti* index. **C**, *Cx. quinquefasciatus* index. Bars indicate 95% confidence limits.

The difference in the density index between metofluthrin-treated and untreated houses was also significant (repeated measure ANOVA,  $F = 5.2$ , 1 df,  $P = 0.034$ ) in *Cx. quinquefasciatus* (Figure 3C). However, the repellent activity of metofluthrin appeared to be lower for this mosquito species as compared with the other species, particularly during the first 5 weeks after treatment. This might indicate that *Cx. quinquefasciatus* has a lower susceptibility as compared with *Ae. aegypti*. The difference in the susceptibility between the

two species, however, should not be merely attributed to insecticide resistance. Arugueta and others<sup>6</sup> reported that  $LD_{50}$ s of *d*-allethrin topically applied to several Asian strains of *Cx. quinquefasciatus* ranged from 0.013 to 0.063  $\mu\text{g}$  per female, while  $LD_{50}$ s of the same pyrethroid for *Ae. aegypti* were 0.0055  $\mu\text{g}$  per female<sup>7</sup> and 0.004  $\mu\text{g}$  per female,<sup>8</sup> indicating that *Cx. quinquefasciatus* appears to be less susceptible to pyrethroids than *Ae. aegypti*. Further investigation will be required for evaluating the difference in the susceptibility in both the mosquito species.

Kawada and others<sup>3,4</sup> reported that mosquitoes were affected by airborne metofluthrin vapors and not by direct contact with the chemical, thereby resulting in the spatial repellency. The spatial repellency is considered to occur through two main modes of pyrethroid action; that is, knockdown activity and biting inhibition or disruption of orientation toward the host. Among these, the latter may be categorized as a sublethal effect that results from neural excitement, which appears to occur at an earlier stage of toxication or with a dosage that is lower than that required for knockdown or death.<sup>9</sup> Winney<sup>10</sup> reported that female *Ae. aegypti* exposed for a few minutes to the smoke of a pyrethroid-based mosquito coil did not bite. MacIver<sup>8</sup> defined the "repellency" associated with pyrethroids as a reaction of mosquitoes at the threshold level when the neural activation and knockdown occur resulting in the loss of power to orient toward their hosts. Similarly, the spatial repellency of metofluthrin-impregnated paper strips is considered to be caused by the disruption of the orientation activity of mosquitoes. Using metofluthrin-impregnated plastic strips in indoor conditions, we could confirm the long-lasting spatial repellent efficacy of metofluthrin against mosquitoes. However, the effective duration (6 weeks) observed in the current result is considered to be insufficient for the practical application of the devices with regard to treatment cost. Long-term effectiveness might be achieved by further formulation studies, such as investigation for the optimum density of plastic polymer, to optimize the release rate of the active ingredient. Further improvements in methods for manufacturing plastic will enable the formulation of a more optimum recipe that results in a longer effective duration.

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## REFERENCES

1. Ujihara K, Mori T, Iwasaki T, Sugano M, Shono Y, Matsuo N, 2004. Metofluthrin: a potent new synthetic pyrethroid with high vapor activity against mosquitoes. *Biosci Biotechnol Biochem* 68: 170–174.
2. Shono Y, Kubota S, Sugano M, Yap HH, Tsushima K, 2004. Field evaluation of papers strip and mosquito coil formulation impregnated metofluthrin for mosquito control in Malaysia. *The Abstract Book, 70th Annual Meeting of American Mosquito Control Association*, 2004 February 21–26; Savannah, GA. Eatontown, NJ: American Mosquito Control Association. P40.
3. Kawada H, Maekawa Y, Tsuda Y, Takagi M, 2004. Laboratory and field evaluation of spatial repellency with metofluthrin-impregnated paper strip against mosquitoes in Lombok Island, Indonesia. *J Am Mosq Control Assoc* 20: 292–298.
4. Kawada H, Maekawa Y, Tsuda Y, Takagi M, 2004. Trial of spatial repellency of metofluthrin-impregnated paper strip against *Anopheles* and *Culex* in shelters without walls in Lombok, Indonesia. *J Am Mosq Control Assoc* 20: 434–437.
5. Kawada H, Maekawa Y, Takagi M, 2005. Field trial of the spatial repellency of metofluthrin-impregnated plastic strip against mosquitoes in shelters without walls (*Beruga*) in Lombok, Indonesia. *J Vector Ecol*.
6. Arugueta TBO, Kawada H, Sugano M, Kubota S, Shono Y, Tsushima K, Takagi M, 2004. Comparative insecticidal efficacy of a new pyrethroid, metofluthrin, against colonies of Asian *Culex quinquefasciatus* and *Culex pipiens pallens*. *Med Entomol Zool* 55: 289–294.
7. Shinjo G, Yamaguchi T, Tsuda S, Yoshida K, Okuno Y, 1981. A study on the insecticidal activity of *d*-tetramethrin. *Jpn J Sanit Zool* 32: 221–228.
8. MacIver DR, 1964. Mosquito coils Part II. Studies on the action of mosquito coil smoke on mosquitoes. *Pyrethrum Post* 7: 7–14.
9. Birley MH, Mutero CM, Turner IF, Chadwick PR, 1987. The effectiveness of mosquito coils containing esbiothrin under laboratory and field conditions. *Ann Trop Med Parasito*. 81: 163–171.
10. Winney R, 1975. Pyrethrins and pyrethroids in coils—a review. *Pyrethrum Post* 13: 17–22.