# The Repellent Efficiency of a Mosquito Coil with Emphasis on Coverage Area in Laboratory Conditions

**Narumon Komalamisra, Sampas Nicharat, Somjai Leemingsawat, Supatra Thongrungkiat, Raweewan Srisawat**

*Insecticide Research Unit, Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, 420/6 Rajvithi Road, Bangkok 10400, Thailand*

## Abstract

The efficiency of a mosquito coil formulation containing d-allethrin 0.3% w/w was examined in order to find the protective coverage area from *Aedes aegypti* in closed room conditions. Eight volunteers sat at positions 1 m, 2 m, 4 m and 7 m away from the coil. When the mosquito coil was ignited, the mosquito-landing number was counted and recorded at 2, 4, 6, 8, 10, 15, 20, 25, 30, 45 and 60 min. It revealed that the percentage reduction in mosquitoes landing at every distance increased corresponding to the increase in burning time. At 10 min, more than 60% mosquito landing reduction was found at 1 m and 2 m from the coil, while the same percentage reduction for 4 m and 7 m was observed at 15 min. When the coil had been alight for 60 min, 98% landing reduction could be achieved at every radial distance of the experiment.

**Keywords:** mosquito coil, protective coverage area

## Introduction

Insect-borne diseases are still a problem in many tropical and sub-tropical countries. These diseases, such as malaria, filariasis, dengue hemorrhagic fever etc, can impede national economic and social development. Nowadays, chemical control is still considered the most important element in controlling insect vectors, especially during epidemic of a disease. However, alternative control measures, such as environmental management, source reduction of breeding sites, and personal protection, are promoted worldwide [1].

The mosquito coil is one of household insecticide products. Smoke and mosquito coils were the first methods used by man for protection against mosquito bites. They are widely used all over the world, predominantly in Asia, Africa and the Western Pacific.

The efficacy of the mosquito coil is evaluated based on the percentage of repellency and the observed knockdown times of a sample of introduced mosquitoes, from which the $KT_{50}$ (time for 50% knockdown) is calculated by probit analysis. Usually, evaluation was conducted at a constant 1 meter from the coil or with a constant weight of coil in a certain volume of test chamber [2]. Users of mosquito coils desire high percentage repellency and rapid knockdown, however, the coverage area protected is also a consideration. In this study, the experimental procedure was designed to determine the coverage area radius of protection and the repellency of the coil.

## Materials and methods

Five to seven days old, unfed female *Aedes aegypti* were used for the study. A single strand of a mosquito coil formulation containing d-allethrin 0.3% w/w was used in the experiment.

**Experimental procedure:**

1. The test was conducted in a closed room, with a volume of 92.8 $m^3$ (W x L x H = 5.3 m x 7.0 m x 2.5 m) in the Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University.

2. The human volunteers sat at 1 m, 2 m, 4 m, and 7 m from the mosquito coil (Fig 1).

3. The mosquito coil was put in the middle of one side of the room (at 5.3 m side).

4. For control, 50 female unfed, 5 days old mosquitoes were released in the center of the room. Then the number of landing mosquitoes on the bare legs of the human volunteers were counted for a period of 2 min.

5. For testing, the mosquito coil was ignited, then counting of the number of landing mosquitoes on the bare legs of the human volunteers began and was recorded at 2, 4, 6, 8, 10, 15, 20, 25, 30, 45, and 60 min.

6. Three replications were done by changing the positions of the human volunteers, and then repeating the procedure the next day.

## Results

The mosquito coil was burnt for 60 min and the burning weight was 1.3 gram. At the two-minute interval with the control, there was no difference in the mosquito landing numbers per person at distances of 1 m, 2 m and 4 m, but a high number of landing mosquitoes at 7 m. The mosquito landing number per person at different time intervals (2, 5 and 15 min) for a period of 60 min is shown in Table 1. One landing was observed at 1 m; 2 m and 4 m; and 7 m, when the coil was ignited for 25 min, 30 min and 60 min, respectively. However, when the landing rate was calculated, it revealed 1 landing mosquito/person/min at 1 m and 2 m at 10 min, and 4 m and 7 m at 20 min (Table 2). Beside the repellency effect, the mosquito coil did have a knock-down effect, due to the pyrethroid insecticide in the coil. Knocked-down mosquitoes could be observed at less than 10 min of coil exposure. The percentage reductions in the landing rate at 10 min, 15 min, 30 min and 60 min are shown in Table 3. The percentage

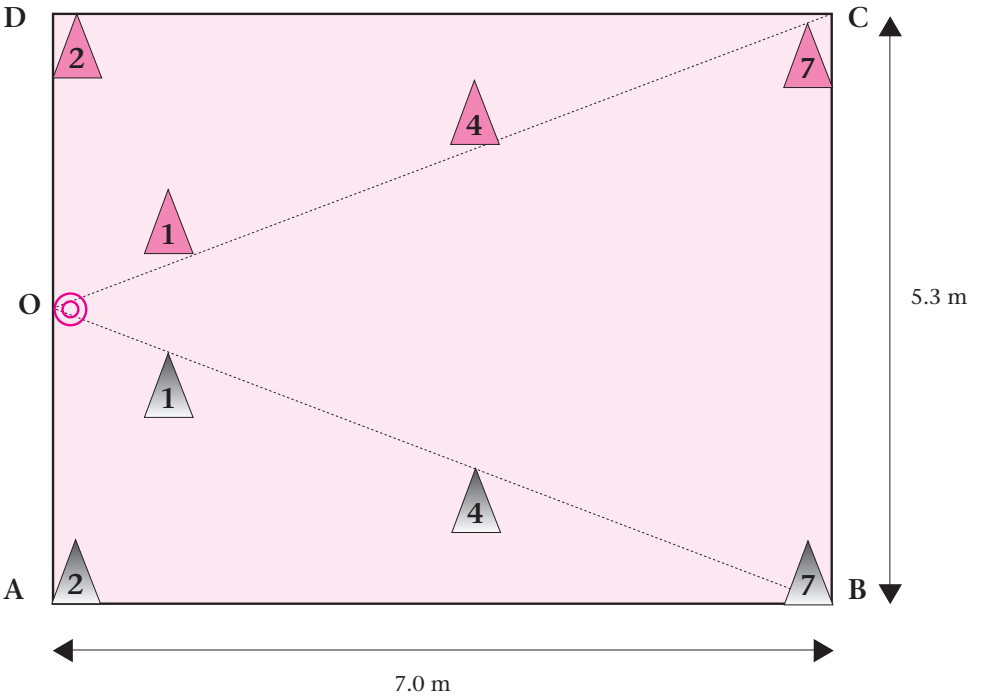


**Fig 1 Diagram of the seating position. ABCD is a room 7.0 m in length and 5.3 m in width. O is the position of the coil. The number in the triangle indicates the seating position in relation to the coil.**

reduction at every distance increased corresponding to the increase in burning time. At 10 min, more than 60% mosquito landing reduction was found at 1 m and 2 m from the coil, while at the other two distances, landing reduction was less than 20%. Marked increases in the landing reduction percentage were observed at 4 m and 7 m at 15 min. At 30 min, there was no difference in the reduction percentage at 2 m and 4 m. When the coil was ignited for 60 min, 98% landing reduction was achieved at every radial distance in the experiment.

## Discussion

The active ingredients, commonly in the class of pyrethroids, improve the limited effect of the simple smoke particles and lead to a significant improvement in the biological effect of coils, which mainly consist of repellents, and after prolonged exposure, have a potential knockdown or killing effect on mosquitoes and other flying insects. Mosquito coils using synthetic pyrethroids had better efficacy when compared with natural pyrethrins and other groups of organic insecticides [3-4]. The active ingredient 0.3% w/w d-allethrin was the most commonly used in mosquito coils worldwide [5]. Mosquito biting rates can be reduced by up to 80% in the presence of a burning coil, depending on the size of the room in which it is used and the active ingredient in the coil [6]. To achieve the desired repellency effect, one coil is recommended for a room of approximately 20 $m^3$ [7]. This experiment was conducted in a closed room with a volume of 92.8 $m^3$, which was similar to a rather large living room. The mosquito coil, weighing 1.3 gram, was burnt within 60 min. The concentration of active ingredients in the smoke was more diluted than the same amount of coil ignited in the room size recommended by the WHO [7]. However, the knockdown effect was observed within 10 min at a radius of 1 m from the coil. This is

**Table 1 Mean landing number of *Aedes aegypti* at different time intervals and different distances from the burning mosquito coil.**

| Distance (m) | Mean of mosquito-landing numbers/person (at 2-60 min) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | 2 | 4 | 6 | 8 | 10 | 15 | 20 | 25 | 30 | 45 | 60 | NB |
| 1 | 7.5 | 9.8 | 5.1 | 4.2 | 3.6 | 2.9 | 3.0 | 1.8 | 1.0 | 0.5 | 2.5 | 0.5 | KD at 6 min |
| 2 | 6.5 | 6.5 | 4.2 | 2.8 | 2.1 | 1.9 | 4.6 | 3.6 | 3.0 | 1.1 | 2.6 | 1.2 | KD at 15 min |
| 4 | 8.0 | 6.6 | 8.8 | 7.9 | 6.4 | 6.4 | 7.8 | 4.6 | 2.4 | 0.9 | 1.1 | 0.4 | KD at 8 min |
| 7 | 19.2 | 18.9 | 19.2 | 16.1 | 17.5 | 15.8 | 18.2 | 6.9 | 4.1 | 4.6 | 2.0 | 1.2 | KD at 20 min |

KD = knockdown

**Table 2 Mean landing number of *Aedes aegypti* per person per minute at different times and distances from the burning mosquito coil.**

| Distance (m) | Mean of mosquito-landing numbers/person/min (at 2-60 min) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | 2 | 4 | 6 | 8 | 10 | 15 | 20 | 25 | 30 | 45 | 60 |
| 1 | 3.8 | 4.9 | 2.5 | 2.1 | 1.8 | 1.4 | 0.6 | 0.4 | 0.2 | 0.1 | 0.2 | 0.0 |
| 2 | 3.2 | 3.2 | 2.1 | 1.4 | 1.0 | 1.0 | 0.9 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 |
| 4 | 4.0 | 3.3 | 4.4 | 4.0 | 3.2 | 3.2 | 1.6 | 0.9 | 0.5 | 0.2 | 0.1 | 0.0 |
| 7 | 9.6 | 9.4 | 9.6 | 8.0 | 8.8 | 7.9 | 3.6 | 1.4 | 0.8 | 0.9 | 0.1 | 0.1 |

**Table 3 Percentage reduction in landing rate at different times and distances.**

| Distance (m) | % reduction in landing rate | | | |
|---|---|---|---|---|
| | 10 min | 15 min | 30 min | 60 min |
| 1 | 62.7 | 84.0 | 97.3 | 99.2 |
| 2 | 70.8 | 71.7 | 93.2 | 97.5 |
| 4 | 20.0 | 61.0 | 95.5 | 99.2 |
| 7 | 17.7 | 62.1 | 90.4 | 99.2 |

because of the d-allethrin in the coil, which possesses rapid knockdown and killing activity against mosquitoes. From Table 1 it was noted that the landing number of mosquitoes at the 7 m position was greater than the other positions in the room. This may be attributable to the darker corners when compared to other positions in the room due to less light exposure from the window, and the mosquitoes' behavior of aggregating in dark places. In closed room conditions, within the first 10 min of coil ignition, significant differences were noted in mosquitoes' landing 2 m from the coil. The mosquitoes were repelled from landing at 4 m and 7 m from the coil; the coil should be ignited for 30 min and 60 min, respectively. However, these times may be shorter when the coil is ignited in an open, ventilated room. Nevertheless, this experiment showed that the continuous ignition of a certain weight of coil had a repellent effect that could prevent mosquito bites at a coverage radius of 7 m from the coil.

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