Proceedings of the Fifth International Conference on Urban Pests
Chow-Yang Lee and William H. Robinson (editors), 2005.
Printed by Perniagaan Ph'ng @ P&Y Design Network, Malaysia.

EFFICACY AND SUBLETHAL EFFECTS OF MOSQUITO MATS ON *AEDES AEGYPTI* AND *CULEX QUINQUEFASCIATUS* (DIPTERA: CULICIDAE)

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Abstract Mosquito mats with active ingredient d-allethrin (36 mg/mat) and prallethrin (15 mg/mat) were tested in the laboratory against *Aedes aegypti* (L.) and *Culex quinquefasciatus* (Say) using test method of the Standard and Industrial Research Institute of Malaysia. Results indicated that KT_{50} values for d-allethrin against *Ae. aegypti* and *Cx. quinquefasciatus* were 1.38 min and 8.36 min, respectively. There were significant differences between *Ae. aegypti* and *Cx. quinquefasciatus* (t test, 95%, $p<0.05$) which were tested with d-allethrin and prallethrin. *Ae. aegypti* that were tested with d-allethrin and prallethrin showed that percentage mortality were 63.33% and 90.00%, respectively. Longevity of *Ae. aegypti* and *Cx. quinquefasciatus* species decreased more than 80% and 45%, respectively, after exposure to mosquito mats containing either d-allethrin or prallethrin. The percentage of blood-engorgement activity for *Ae. aegypti* and *Cx. quinquefasciatus* was reduced to less than 70% and 25% respectively after a 20 min exposure to mat containing either one of active ingredients. The number of eggs oviposited by the treated females, egg hatchability, pupation rate and adult emergence rate were not affected if the mosquitoes were still able to blood-engorge.
Key Words D-allethrin, prallethin, mosquito control

INTRODUCTION

Household insecticide products are a common and popular mode of personal protection against household insect pests in all parts of the world. These products include aerosols, mosquito coils, fumigation mats, liquid vaporizers and baits. A range of products are available to combat household insect pests. In temperate climates, the most important household pests are cockroaches, ants, fleas and, in the summer months, flies, mosquitoes and wasps. In tropical climates, mosquitoes are the most important household insect pest, in addition to houseflies, cockroaches, ants, sandflies, bedbugs and in part of Latin America, tritomine bugs. The active ingredient used in household insecticide products should be cheap and effective with low mammalian toxicity.

Electric vaporizing mat have become increasingly popular since the early 1980s and consist of a mat heater and vaporizing mat. The mat is made from fiberboard impregnated with insecticides, stabilizers, slow-releasing agents, perfumes and coloring agent. The heater is plugged into an ordinary household electric socket and heats up to an optimum temperature between 110° C, depending on the type of the heater and accompanying mats. When the mat is heated, insecticide vapour is released to provide a low aerial concentration of insecticide. This induces behaviour changes in flying insects through a sequence of sub-lethal effects including deterring them from entering the room, bite inhibition and knock down. Continued exposure results in death of the insect. The size of the mat is compatible with the associated brand of heater for easy insertion and removal. The advantage of using mats over coils is that with the former, there is no unpleasant smoke. The disadvantages are that electricity is required and replacement mats, are generally more expensive than coils.

MATERIALS AND METHODS

Mosquito Mat Formulations

All mosquitoes mats used in this study are from the market shelves with the following formulations: mat containing d-allethrin (d 1–3-allyl-2-methyl-4-oxo-2-cyclopentenyl d-cis trans chrysanthemate) (36 mg/mat) and mat containing prallethrin ((S)-2-methyl-4-oxo-3-(2-propinyl) cyclopent-2-enyl(IR)-cis, trans-chrysanthemate) (15 mg/mat).

Mosquitoes

Two species of mosquitoes used in this study were *Ae. aegypti* and *Cx. quinquefasciatus*. Both species, originating from Penang, Malaysia, have been reared in our laboratory since 1980s. The techniques for rearing these two species follow those of Chong et al. (1995). All the adult female mosquitoes used in this study were sucrose fed and aged 3-5 days old.

Bioefficacy Test

The bioefficacy test used in this study follows exactly those of SIRIM (1986). It was conducted in a glass chamber with aluminum frames (70 x 70 x 70 cm) under conditions of 26 ± 2˚ C and 65 ± 10% Relative Humidity. A small window (18 x 20 cm) with a sliding closure at the mid bottom of the chamber door was used for the introduction of the mat and mosquitoes

Sublethal Effects

On the second day after the bioefficacy test, the survivors of each mat were collected and kept separately in cages (30 x 30 x 30 cm). On the third day, a white mouse restrained within a piece of wire-netting was placed in each cage for 12 hours for blood engorgement. Due to the different biting behavior, the mouse was provided to *Ae. aegypti* during the day, while the animal was placed in the *Cx. quinquefasciatus* cages at night. The number of mosquitoes which were blood-engorged was recorded at the fourth day. Twenty female blood-engorged mosquitoes were then transferred into individual polyethylene cups (height 8.9 cm x diameter 4.5 cm) and provided with 10% sucrose solution. Each individual was allowed to lay eggs up to seventh day. For *Ae. aegypti*, a wet cotton bung lined with filter paper was provided as the oviposition site, while 40 ml of distilled water was introduced into each polyethylene cup for *Cx. quinquefasciatus*. The egg production of each mosquito was recorded daily.

The survival of the adult mosquitoes was monitored by recording the numbers of mosquitoes that died daily. The longevity of the mosquitoes was calculated according to a modified formula of Flether et al. (1990): longevity = Ó (number of dead mosquitoes x number of days mosquitoes survived)/total number of mosquitoes.

The larvae that hatch from the eggs produced by treated individuals were counted at the third and fourth day for *Ae. aegypti* and at the fourth and fifth day for *Cx. quinquefasciatus*. A total of 500 larvae from each experiment were taken at random for further study on the pupation rate and adult emergence rate. The adult mosquitoes were also segregated into males and females and counted. All experiments were replicated three times.

Data Analysis

The bioefficacy data were subject to probit analysis using a computer program develop by Daum (1970) to determine the KT_{50} values. Data from experiment on sublethal effects were analyzed with student t-test analysis. All statistical analysis was performed using a statistical analysis computer program, SPSS.

RESULTS AND DISCUSSION

Bioefficacy Test

Results indicated that KT_{50} values for d-allethrin against *Ae. aegypti* and *Cx. quinquefasciatus* were 1.38 min and 8.36 minutes respectively whereas KT_{50} values for prallethrin against *Ae. aegypti* and *Cx. quinquefasciatus* were 1.13 min and 12.68 minutes, respectively (Table 1). Results showed that *Ae. aegypti* was more susceptible than *Cx. quinquefasciatus* to both mat formulations containing an active ingredient. This finding corresponded well with earlier finding by Chadwick (1975) and Yap and Chung (1987) on mosquitoes coil formulations. McIver (1964) suggested that the larger body size of *Cx. quinquefasciatus* when compared to *Ae. aegypti* probably contributes to its increase tolerance.

Table 1. Efficacy of mosquito mats against *Aedes aegypti* and *Culex quiquefasciatus*

Active Ingredient	*Aedes aegypti*		*Culex quinquefasciatus*	
	KT_{50} ± SE	% Mortality ± SE	KT_{50} ± SE	% Mortality ± SE
d-allethrins (36 mg/mat)	1.38 ± 0.24a (a)	63.33 ± 1.67	8.36 ± 0.39a (b)	26.67 ± 3.33
Prallethrin (15 mg/mat)	1.13 ± 0.12a(a)	90.00 ± 0.00	12.68 ± 0.12a(b)	18.33 ± 1.67
Control		13.33 ± 1.67		11.67 ± 0.05

All mosquitoes used in this study are sucrose fed and 3-5 days old.
For each active ingredient, mean values follow by same letter within the same column are not significantly different. Mean values in ( ) follow by the same letter within the row are not significantly different (t test, 95%, $p > 0.05$)

Table 2. Effect of mosquito mats exposure on blood feeding activity in *Aedes aegypti* and *Culex quinquefasciatus*

Species	Mean % blood feeding ± S.E.		
	d-allethrins (36 mg/mat)	Prallethrin (15 mg/mat)	Control
Ae. aegypti	30.98 ± 1.17a	27.66 ± 0.12a	93.25 ± 4.39b
Cx. quinquefasciatus	72.86 ± 1.67a	76.01 ± 0.14a	96.58 ± 1.71b

All mosquitoes used in this study are sucrose fed and 3-5 days old.
For each species, mean values follow by same letter within the same row are not significantly different (t test, 95%, $p > 0.05$).

Table 3. Effect of mosquito mats exposure on the adult longevity of *Aedes aegypti* and *Culex quinquefasciatus*

Species	Mean Longevity ± S.E.		
	d-allethrins (36 mg/mat)	Prallethrin (15 mg/mat)	Control
Ae. aegypti	4.60 ± 0.38a	4.40 ± 0.27a	26.33 ± 1.36b
Cx. quinquefasciatus	13.63 ± 1.97a	10.90 ± 0.99a	22.32 ± 1.45b

All mosquitoes used in this study are sucrose fed and 3-5 days old.
For each species, mean values follow by same letter within the same row are not significantly different (t test, 95%, $p > 0.05$).

Table 4. Effects of mosquito mats exposure on the egg production, egg hatchability and pupation rate of *Ae. aegypti* and *Cx. quinquefasciatus*

Species	Mean ± SE		
	d-allethrins (36 mg/mat)	Prallethrin (15 mg/mat)	Control
Ae. aegypti			
No. of eggs produced	102.47 ± 9.28a	117.50 ± 7.76a	117.35 ± 065a
Egg hatchability	68.06 ± 1.45a	71.64 ± 1.12a	73.43 ± 8.34a
Pupation	97.29 ± 1.47a	99.09 ± 0.47a	99.51 ± 0.27a
Cx quinquefasciatus			
No. of eggs produced	209.94 ± 5.62a	209.94 ± 5.62a	223.22 ± 6.38a
Egg hatchability	76.37 ± 4.04a	78.09 ± 0.66a	82.45 ± 2.93a
Pupation	96.21± 0.27a	95.65 ± 1.49a	97.73 ± 0.31a

All mosquitoes used in this study are sucrose fed and age 3-5 days old.
For each parameter, mean values followed by the same letters within the same row are not significantly different (t test, 95%, $p > 0.05$).

Sublethal Effects

The blood-engorgement activity of *Ae. aegypti* decreased to less than 70% after exposure to mosquito mat with active ingredients. In *Cx. quinquefasciatus*, the reduction of blood-engorgement activity was less than 25% (Table 2). An earlier study by Liu et al. (1986) showed that the blood engorgement activity of *Ae. aegypti* decreased after being subjected to pyrethroid treatment at high dosage.

The longevity of treated mosquitoes (subject to mat formulations containing either d-allethrin or prallethrin) was reduced by at least 80% and 45% in *Ae. aegypti* and *Cx. quinquefasciatus* respectively (Table 3). Yap et al. (1996) also found the same results when they study the longevity of *Ae. aegypti* and *Cx. quinquefasciatus* against mosquitoes coil formulations. Decrease in longevity of insects treated with insecticides has been reported previously, such as in *Ae. aegypti* (Duncan, 1963) and German cockroaches (Abd-Elghafar and Appel, 1992; Lee, 1995).

The numbers of eggs produced by treated mosquitoes (both mat formulations) that engorge blood were not significantly different from the control. Generally, *Cx. quinquefasciatus* produced more eggs (average 220 eggs /female) as compared to *Ae. aegypti* (117 eggs /female) (Table 4). The numbers of eggs produced decreased with increase in age for both species of mosquitoes (Yap et al., 1996). The older mosquitoes only manage to achieve partial engorgement (half-full abdomen) (unpublished data). No significant difference was observed in egg hatchability rate when compared with untreated ones. No significant difference in terms of pupation rate, adult emergence and adult female:male sex ratio were observed for the progenies of treated mosquitoes when compared with control (untreated).

Significant sublethal effects of mat formulations against *Ae. aegypti* and *Cx. quinquefasciatus* showed in this study include shorter longevity and reduced blood-engorgement activity. With its proven efficacy and consumer friendly properties, the mosquito mats can be incorporated into overall vector control strategies for major mosquito-borne diseases, especially in the endemic tropical areas.

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