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Field bioefficacy of deltamethrin residual spraying against dengue vectors

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Abstract. Field bioefficacy of residual-sprayed deltamethrin against *Aedes* vectors was evaluated in an urban residential area in Kuala Lumpur. The trial area consisted of single storey wood-brick houses and a block of flat. The houses were treated with outdoor residual spraying while the flat was used as an untreated control. Initial pre-survey using ovitrap surveillance indicated high *Aedes* population in the area. Deltamethrin WG was sprayed at a dosage of 25mg/m^2 using a compression sprayer. The effectiveness of deltamethrin was determined by wall bioassay and ovitrap surveillance. The residual activity of 25mg/m^2 deltamethrin was still effective for 6 weeks after treatment, based on biweekly bioassay results. Bioassay also indicated that both *Aedes aegypti* and *Aedes albopictus* were more susceptible on the wooden surfaces than on brick. *Aedes aegypti* was more susceptible than *Ae. albopictus* against deltamethrin. Residual spraying of deltamethrin was not very effective against *Aedes* in this study since the *Aedes* population in the study area did not reduce as indicated by the total number of larvae collected using the ovitrap (Wilcoxon Sign Test, p> 0.05). Further studies are required to improve the effectiveness of residual spraying against *Aedes* vectors.

INTRODUCTION

Indoor and outdoor residual insecticide spraying is a commonly used technique for obtaining a reduction of vector-man contact (Laura *et al*., 1998). House-spraying is still an important malaria control method in tropical countries.

In Malaysia, the first experiment of *Aedes aegypti* control by residual spraying was carried out in Port Swetthenham in 1952 (Cheong, 1986). After a preliminary survey by Reid (1954), residual spraying with DDT was carried out. However, the result was not very encouraging. Another experiment was done in Jeram village, Selangor and found to give almost complete control of *Ae. aegypti* for a year or more (Macdonald, 1957). In 1955 the Port Swettenham program was revised, dieldrin was substituted for DDT and after eight months, the *Aedes* index was still below 1 percent (Macdonal, 1957). According to Cheong (1986), the spray method, however, was never used subsequently due to the safety considerations of the chemicals.

With the development of safer pyrethroid insecticides, residual spraying with pyrethroids is constantly used in malaria control.The residual effect of a pyrethroid, deltamethrin up to 20 weeks on thatched surfaces has been reported against *Culex quinquefasciatus*, *Anopheles stephensi* and *Aedes aegypti* at 50mg/m^2 (Das & Kaylanasundram, 1984). However in the study by Ansari *et al.* (1997), it was revealed that deltamethrin sprayed at the rate of 20mg/m^2 on various surfaces can produce effective control with 100% mortality of *Anopheles culicifacies* for 9 to 12 weeks. In Malaysia, Rohani & Lee (per. comm.) reported that *Ae.aegypti* adults exposed to bamboo wall sprayed with 20mg/m^2 or 25mg/m^2 of deltamethrin in aboriginal villages in Pahang exhibited 3 times faster knockdown at 25mg/m^2 than at 20mg/m^2. After several decades, there

are still no trials done to evaluate the efficacy of pyrethroid residual spray against dengue vectors in Malaysia. Because of increase of dengue cases in Malaysia, it is important to control the vector population, as effective vaccines and anti-viral drugs against dengue are still unavailable. Residual spraying may offer effective control in specific areas such as the slum. The objectives of this study were to determine the distribution and frequency of dengue vectors in a selected area in Kuala Lumpur, to evaluate the field bioefficacy of deltamethrin residual spraying against *Aedes* vectors, and to evaluate the residual effect of deltamethrin over time.

MATERIAL AND METHODS

Study sites

The location chosen was Institute for Medical Research staff quarters in Jalan Fletcher, Kuala Lumpur with an area of about 2.5 ha. Previous ovitrap survey showed that this area had a high *Aedes* population. The areas consisted of ten single storey wooden-brick houses and a block of flat. The houses were treated, while the flat was used as an untreated control.

Population surveillance and treatment

The *Aedes* populations in the treatment and control areas were monitored using ovitraps for 6 weeks pre-treatment and post-treatment. Deltamethrin WG was sprayed at 25mg/m^2 using a Hudson compression sprayer. Only the outer surfaces of all premises were treated. Besides spraying the walls, outdoor bushes, trees and other plants within the immediately proximity of the houses were also sprayed with deltamethrin (barrier spraying) to control *Aedes* resting on plants.

Evaluation of wall residual activity

The residual activity of deltamethrin was evaluated by following the standard WHO technique of assessing insecticidal deposits on wall (WHO, 1975). Once in every two weeks the bioassay was carried out on the treated wall surfaces (cement and wooden surfaces) of 3 houses, by fixing standard transparent plastic cones (internal diameter 8.5cm and internal height 5.5cm) onto the surfaces vertically positioned. Each house was tested with 2 cones each for *Ae. aegypti* and *Ae. albopictus*, respectively. A total of 15 sucrose-fed, 2 to 5 days old laboratory-bred *Ae. aegypti* or *Ae. albopictus* were introduced gently into the cone using an aspirator. The entrance hole of the cone was plugged with a cotton ball. The knock down time was observed for 30 minutes with 1 minute intervals or until 90% knock down. After the exposure, the mosquitoes were aspirated out and transferred into clean paper cups. The mosquitoes were allowed to feed on cotton pads soaked with 10% sugar solution and vitamin B complex up to 24 hours at 28±2°C and 80% R.H. The final mortality was recorded after 24 hours holding period.

Data analysis

Wilcoxon Rank Test was used to test the abundance of *Aedes* population between pre-treatment and post-treatment of deltamethrin residual spray. Log time probit mortality regression and the knockdown time (KT) values for *Ae. aegypti* and *Ae. albopictus* for each treated wall surface (brick and wooden surfaces) were analyzed using a probit analysis software. The ovitrap index and mean number of *Aedes* larvae was also determined to monitor changes of the population pre-treatment and post-treatment.

RESULTS AND DISCUSSIONS

Bioassay

Table 1 and table 2 showed the knockdown time values for *Ae. aegypti* and *Ae. albopictus* for six weeks of bioassay conducted.

Table 1(a). Knockdown time values (minutes) of deltamethrin on the wooden surfaces against *Aedes aegypti*

Week	KT_{50} (min) (95% C.L)	KT_{95} (min) (95% C.L)	Regression slope ± SE
0	1.43 (1.16–1.69)	4.48 (3.79–5.58)	3.53 ± 0.32
2	1.53 (1.26–1.79)	5.64 (4.90–6.66)	2.76 ± 0.22
4	5.10 (4.71–5.48)	13.75 (12.66–15.11)	3.82 ± 0.20
6	10.63 (9.87–11.37)	16.84 (15.40–19.08)	8.24 ± 0.44

Table 1(b). Knockdown time values (minutes) of deltamethrin on the brick surfaces against *Aedes aegypti*

Week	KT_{50} (min) (95% C.L)	KT_{95} (min) (95% C.L)	Regression slope ± SE
0	3.17 (2.96–3.39)	5.05 (2.59–10.12)	7.26 ± 0.68
2	8.15 (3.27–20.59)	16.88 (3.85–13.31)	5.20 ± 0.24
4	8.93 (8.33–9.52)	17.33 (16.70–18.12)	12.57 ± 0.78
6	12.82 (12.50–13.14)	22.77 (20.90–25.20)	4.05 ± 0.19

Table 2(a). Knockdown time values (minutes) of deltamethrin on the wooden surfaces against *Aedes albopictus*

Week	KT_{50} (min) (95% C.L)	KT_{95} (min) (95% C.L)	Regression slope ± SE
0	4.79 (4.25–5.31)	18.09 (16.13–20.17)	2.85 ± 0.14
2	5.56 (4.19–6.87)	181.87 (108.34–401.03)	1.09 ± 0.10
4	6.57 (3.97–9.06)	23.10 (15.77–50.48)	3.01 ± 0.13
6	13.61 (12.46 – 14.75)	35.74 (31.00–43.29)	3.92 ± 0.19

Table 2(b). Knockdown time values (minutes) of deltamethrin on the brick surfaces against *Aedes albopictus*

Week	KT_{50} (min) (95% C.L)	KT_{95} (min) (95% C.L)	Regression slope ± SE
0	4.79 (4.25–5.31)	18.09 (16.13–20.17)	2.85 ± 0.14
2	5.56 (4.19–6.87)	181.87 (108.34–401.03)	1.09 ± 0.10
4	6.57 (3.97–9.06)	23.10 (15.77–50.48)	3.01 ± 0.13
6	13.61 (12.46–14.75)	35.74 (31.00–43.29)	3.92 ± 0.19

Aedes aegypti

Based on probit analysis, the KT_{50} value was 1.43 min at week 0, increased slightly to 1.53 min two weeks later and further increased to 5.10 min and 10.63 min at 4th week and 6th week, respectively, indicating an increase of about ten folds, six weeks after spraying (Table 1a). Similarly, KT_{95} had also increased from 4.48 min at week 0 to 16.84min by 6th week, an increase of about four times.

On the brick surface, similar trend was observed. The KT_{50} value was 3.17 min initially, increased to 8.15min at second week, increased slightly to 8.93min on the following observation and finally reached 12.82 min on the sixth week after spraying (Table 1b). This indicated that the final value observed was about four times from week 0, whereas for KT_{95} values, similar trend was observed with 5.35, 16.88, 17.33 and 22.77 min, respectively for the 6 weeks of test. As with KT_{50} values on the sixth week of spraying, the KT_{95} value was increased about four times.

Aedes albopictus

Based on probit analysis, the KT_{50} value for *Ae. albopictus* on the wooden surfaces was 4.79 min after spraying. The value

increased to 5.56 min and 6.57min two weeks and four weeks later, respectively, further increased to 13.61 min on the 6th week after spraying. This showed that the value has increased about 2.8 times from the first weeks of knockdown observation (Table 2a). The same pattern was observed for KT_{95} values, as the value increased from 18.09min, 181.87min, 23.10min and finally 35.74 min.

For bioassay on the brick surfaces, the KT_{50} value was 6.88 min at the first week, followed by an increase to 11.39min, 13.79min and 17.18 min, respectively. For KT_{95} values on the brick surface the value was 15.08min, 24.65min, 24.97min and 32.14 min, respectively for each six weeks post treatment of bioassay conducted (Table 2a and Table 2b).

Based on the KT_{50} values, it was obvious that *Ae. aegypti* adults were more susceptible to deltamethrin on both surfaces. On the wooden surfaces, *Ae. aegypti* was 3.3 times more susceptible than *Ae. albopictus* at 0 week, and 1.3 times more susceptible at 6th week. On the brick surfaces, *Ae. aegypti* was also more susceptible than *Ae. albopictus* by 2.2 times at 0 week and 1.3 times by 6th week. The adulticidal effect of deltamethrin was more pronounced on the wooden surfaces for both species. As noted in previous study, even among stable compounds, including pyrethroids, effectiveness and residual life span were affected by the surface onto which it was sprayed (Rohani *et al.*, 1997). Insecticides degrade much faster on porous surfaces like brick than on wooden or thatch materials which are less biologically active and does not suffer from attrition (Mpofu *et al.*, 1988). Present results obtained were similar to results obtained by Rohani *et al.* (1997) who reported that the effect of etofenprox (a pyrethroid) against *Anopheles dirus*, *Ae. aegypti* and *Cx. quinquefasciatus* was of the following descending order: plywood > bamboo> cement based on the mean mortality.

Bioassay also indicated complete mortality for both species up to 6 weeks. This showed that the insecticide still remained in the wall surfaces even though there are many factors that could affect its residual activity such as rain, humidity and temperature in the area since Malaysia is a tropical country with wet and dry periods throughout the year. Increase of temperature can hasten breakdown rate, thereby contributing to faster degradation of insecticides like pyrethroids, thus reducing its insecticidal activity against mosquitoes (Narahashi, 1971).

Population surveillance

Figure 1 showed the pre-treatment and post-treatment fluctuation of the *Ae. albopictus* larval population with respect to time in the study area. All larvae collected were *Ae. albopictus*. A total of 2,704 larvae were collected during the pre-treatment weeks and 2,572 larvae were collected 6 weeks post-treatment (Fig. 1). The result showed that this area has a high *Ae. albopictus* population as indicated by high ovitrap index of 66~100%. The mean

Table 3. Ovitrap index and mean number of larvae per ovitrap pre- treatment and post-treatment of deltamethrin residual spray at the study area

Treatment	Ovitrap index (%)		Mean no larvae per ovitrap	
	Outdoor	Indoor	Outdoor	Indoor
Treated				
Pre treatment	83.32 ± 3.79	74.00 ± 2.34	29.28 ± 6.63	20.96 ± 6.63
Post-treatment	94.44 ± 2.49	88.89 ± 5.74	30.41 ± 3.96	17.22 ± 3.24
Untreated				
Pre treatment	86.11 ± 5.12	80.56 ± 7.95	22.33 ± 3.99	9.00 ± 1.85
Post-treatment	63.89 ± 12.49	94.44 ± 3.51	32.81 ± 6.71	26.28 ± 3.89

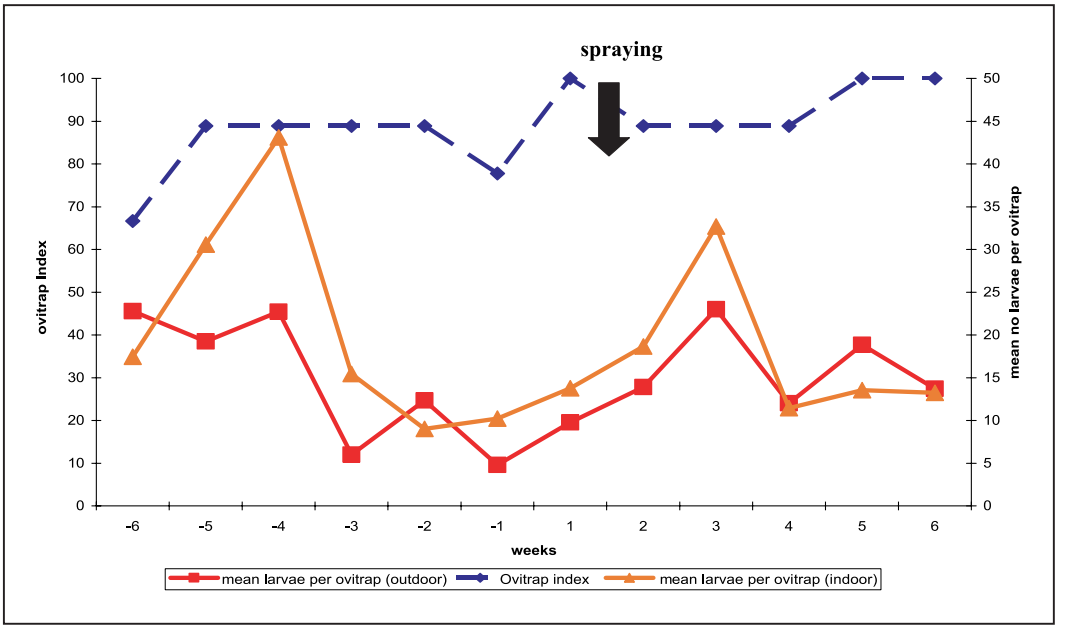

Figure 1. The mean number of *Ae. albopictus* larvae per ovitrap and ovitrap index before, during and after the treatment of deltametrin residual spray in treated area.

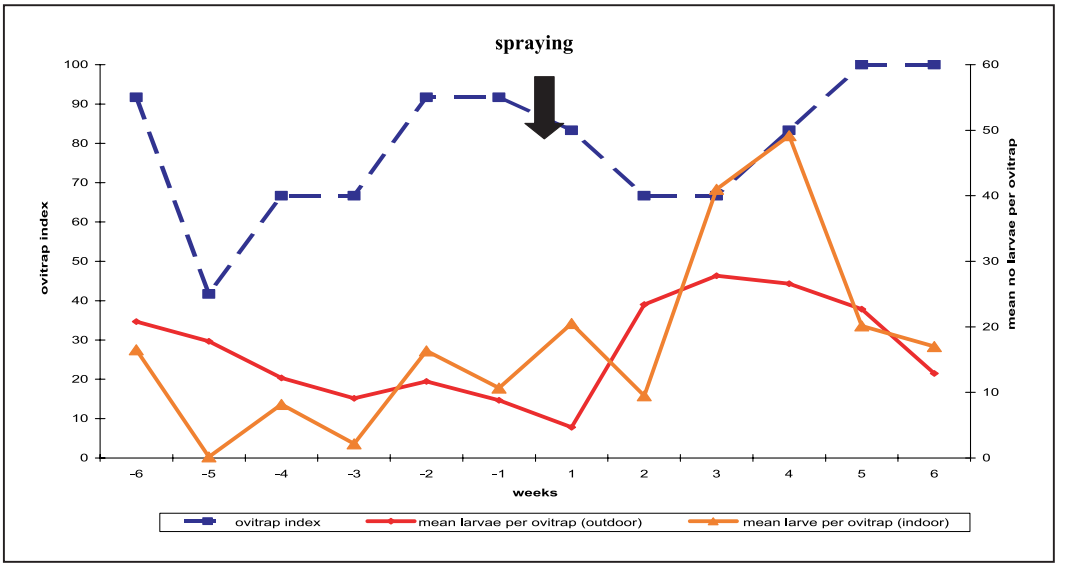

Figure 2. The mean number of *Ae. albopictus* larvae per ovitrap and ovitrap index before, during and after the treatment of deltametrin residual spray in control area.

number of larvae per ovitrap indoor and outdoor ranged between 17~30 also indicating high *Ae. albopictus* population. In comparison, the larval population in the untreated area was also high between 9 ~ 32 larvae per ovitrap.

In the study area, the post-treatment ovitrap index was not affected in both indoor and outdoor ovitraps, compared to the pre-treatment level. Similarly, the mean number of larvae per ovitrap outdoor did not change. Figure 1 also showed that

after 2 weeks of treatment, a slight decrease of *Aedes* population can be seen at the study area. Although there was a decrease in the number of larvae per ovitrap in indoor ovitraps, the reduction was not statistically significant (Wilcoxon Rank Test, $\propto$=0.05, p= 0.280). Similarly, in comparison to the control, no changes in the larval population was observed.

The field *Aedes* population did not seem to be reduced or suppressed by residual sprayed deltamethrin. Several reasons may account for the field ineffectiveness of residual spraying against *Aedes* such as (i) the resting behavior of *Ae. albopictus*. Although it was reported that *Ae. albopictus* rests outdoor, this was not known if this was the case in the study area, (ii) ovitrap surveillance may not be a good indicator, as the adults might oviposit in ovitraps prior to resting on the wall, thus accounting for the high larval population, and (iii) invasion of *Ae. albopictus* from nearby areas.

Despite these, residual spraying of pyrethroids in urban houses may be an alternative dengue control tool, especially in the slums and difficult to reach areas. However, to ensure the success of this method, several consideration need to be incorporated in future studies : (i) the resting behavior of the *Aedes* mosquito need to be studied and ascertained, (ii) use of more effective and relevant indicator such as determination of adult population by light trap, and (iii) creating a buffer zone to prevent invasion of mosquitoes from other nearby areas.

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