STUDIES ON THE EFFECT OF LAMBDACYHALOTHRIN ON *ANOPHELES MACULATUS* THEOBALD AND ITS RESPONSE TO RESIDUAL SPRAYING AT JERAM KEDAH, NEGERI SEMBILAN, MALAYSIA

I Vythilingam, GL Chiang, S Mahadevan, KL Eng, ST Chan and K Inder Singh

Entomology Division, Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur, Malaysia

Abstract. A field trial was carried out to study the effect of lambdacyhalothrin on *Anopheles maculatus* in trap huts in Jeram Kedah, Negeri Sembilan, Malaysia. Two trap huts were built, of which one was sprayed with lambdacyhalothrin at a dosage of 25 mg ai/m^2 and the other served as control. Eight collectors commenced collecting mosquitos from 1900 to 2400 hours, two each indoors and outdoors. Bioassay was also carried out in the treated and control huts to determine susceptibility of adult mosquitos to lambdacyhalothrin. In the treated hut more mosquitos were present during the pre- spraying period. Lambdacyhalothrin gave a mortality of 100% against *An. maculatus* for 8 months.

INTRODUCTION

Malaria continues to be a public health problem among the rural and aboriginal populations living in the interior in hilly cleared jungles. *Anopheles maculatus* is considered the most important vector of malaria in Peninsular Malaysia. In Malaysia residual house spraying using DDT emulsifiable concentrate at 2 gm/m^2 has been carried out as part of the malaria control program since 1967.

The present policy is to continue applying DDT (2 cycles per year) as the principal antimalaria measure in malarious areas (VBDCP, 1988). Studies indicate that DDT is still effective against *An. maculatus* in Peninsular Malaysia (Loong *et al*, 1989). There is also evidence to suggest that the effect of DDT house spraying reduces man-vector contact through its deterrent and irritant effects rather than through its effect on the vector's longevity (Colless, 1953; Cheng, 1968).

The development of mosquito resistance to chemical insecticides is making the control of mosquitos and the diseases they transmit more difficult. As such, studies on newer insecticides for vector control is relevant to the overall vector control strategy in this country. Synthetic pyrethroids, being effective at low dosage and having a low mammalian toxicity offer promise as candidates for vector control.

Thus the objective of the present trial was to study the effect of lambdacyhalothrin on *An. maculatus* in trap huts.

MATERIALS AND METHODS

The study was undertaken in an Aboriginal village in the State of Negeri Sembilan, which lies to the south of Kuala Lumpur. The study area, Kampung Asli Jeram Kedah is situated on the west coast of Negeri Sembilan bordering the state of Selangor. It is a hilly area surrounded by rubber and fruit trees. The inhabitants are Aborigines living in bamboo or wooden huts with zinc or attap roofs. The wooden floors of the houses are usually raised about 0.6 m to 1.2 m above ground level. The houses are acattered about in the area, usually in the clearings of the foot hills.

This kampong was selected for the study as malaria cases were reported regularly from this area and also entomological investigations had shown a reasonable density of *An. maculatus* in this kampong.

Experimental huts

Two trap huts were built with attap roofs among the houses in Jeram Kedah. The plan of the huts were similar to that used by Thevasagayam *et al* (1979). Each hut was 3.5 m long, 2.6 m

wide, had 2.4 m high walls with a roof 3 m high at the highest point. The wooden floor was raised 0.76 m above the ground. The walls were of wooden plank and roof of attap. Each hut had a door 2 m × 1 m and five entry louvers each 1.8 m × 0.6 m with louvers at an angle of 30° to the vertical and 3.8 cm apart. Four exit traps of the cone type each 38 cm cube were fitted one to each side of the hut. One of the huts was intended as the test hut which was sprayed with lambdacyhalothrin and the other as unsprayed control hut.

Insecticide

Lambdacyhalothrin a broad spectrum insecticide and the most active enantiomer of cyhalothrin, is a novel photostable pyrethroid. It is effective as a contact and stomach poison at low rates against a wide range of insect pests (Jutsum *et al*, 1984). It can be used to give rapid knockdown or persistent residual protection. Lambdacyhalothrin has only moderate acute mammalian toxicity and is listed in the WHO (1988) pesticide classification as being only "moderately hazardous" (class II) like most other pyrethroids and other well-known insecticides such as BHC, DDT, Chlorpyrifos and fenitrothion. The acute oral LD_{50} is 79 mg/kg for male rats and 56 mg/kg for female rats. Acute dermal toxicity on male and female rats is 632 mg/kg and 696 mg/kg respectively. Technical lambdacyhalothrin is Ames-negative in mutagenicity tests (Lim and Visvalingam, 1990).

Methods of collection

The study was carried out from November 1990 to June 1992. Before spraying lambdacyhalothrin, both huts were operated simultaneously for about five months to detect possible differences in attraction to *An. maculatus*. Subsequently in April 1991 one hut was sprayed with lambdacyhalothrin wettable powder at a dosage of 25 mg ai/m^2. The other hut served as control. Eight collectors commenced collecting mosquitos biting/landing from 1900 to 2400 hours, two each indoors and outdoors. After 2400 hours two collectors slept in the hut under mosquito nets. The following morning, adult females caught in the exit traps were transferred to paper cups and observed for mortality 24 hours later. The floor of the hut was also searched for dead mosquitos. All mosquitos caught were dissected and examined for infection and parous rate.

Bioassay procedure

Bioassay was carried out in the treated and control huts at regular intervals of about 1 month using the WHO standard test method of insecticidal deposits on wall surfaces with some modifications to determine susceptibility of adult mosquitos to insecticides (WHO, 1970). Transparent plastic conical chambers, 5.8 cm in diameter at the base and 5.5 cm high, were used as exposure chambers. Fifteen *An. maculatus* Jeram Kedah strain bred in the insectary of IMR were collected using a suction tube and introduced into conical chambers fastened to the walls by blowing gently. After 10 minutes exposure, the mosquitos were transferred to paper cups covered with netting. Cotton pads soaked with sugar and vitamin B complex solution were placed on the nettings of the cups. It was ensured that a high humidity was maintained during the holding period. Mortality readings were recorded 24 hours later.

Excito repellency tests

According to WHO (1975) irritability can be measured by the excito-repellency test box. This method measures the irritant as well as the toxic effect exercised by an insecticide used in a formulation similar to that used in the field. The box similar to that described by Rosendall (1989) was used. The control box was lined with unsprayed absorbent poster paper and the test box was lined with similar paper sprayed with lambdacyhalothrin wettable powder at 25 mg ai/m^2.

Sugar fed laboratory bred *An. maculatus* was used for the study. The test was conducted in a dark room with a very dim light. The mosquitos were released into the box through the funnel of the exit trap. The funnel opening was closed for 5 minutes during which mosquitos could adapt themselves to the environment. After opening the funnel, mosquitos were collected from the exit trap at intervals of 10 minutes during a total period of one hour. A flash light was used to facilitate collection of mosquitos from the exit trap with an aspirator. The box was opened at the end of the test period by carefully lifting the removable lid. All living and dead mosquitos still in the box were collected and counted. 30 mosquitos were used per test and six replicates were carried out.

RESULTS

During the pre and post spraying periods *An. maculatus* was biting more outdoors than indoors. However in the treated hut the numbers indoors was higher than the control hut before spraying commenced. After spraying there was a sudden increase of *An. maculatus* outdoors and then there was a reduction in the biting rate and with time the biting rate increased as shown in Fig 1. The peak biting season seems to be around April-May and this coincides with heavy rainfall during the previous month. There seems to be a smaller peak around September-November.

The peak biting time for *An. maculatus* was found to be between 2100 and 2300 hours as shown in Fig 2. Earlier all-night catches were carried out but later this was stopped as very few mosquitos were caught after 2400 hours. This peak biting time coincides with the study carried out by Wallace (1948) and Wharton (1951). No mosquitos were found in the exit traps throughout this study.

A total of 1,938 *An. maculatus* were dissected for malaria infection during the period 1990 to 1992. Two were positive for gland infection, one from indoor collection with a sporozoite rate of 1.4% and the other from outdoor collection with a sporozoite rate of 0.05% giving an overall infection rate of 0.1%. Of the 1,938 dissected, 1938 were also examined for parity. The parous rate was 55.4%.

Table 1 shows the percentage mortality of *An. maculatus* in treated and control huts. Lambdacyhalothrin gave a mortality of 100% against *An. maculatus* for 8 months. At the 9th month the mortality was 96% and subsequently the mortality dropped.

Table 1

Percentage mortality of *An. maculatus* exposed to treated and control huts.

Months	Treated hut	Control hut
1	100	0
3	100	0
5	100	1.3
7	100	0
9	96	1.3
11	89	3

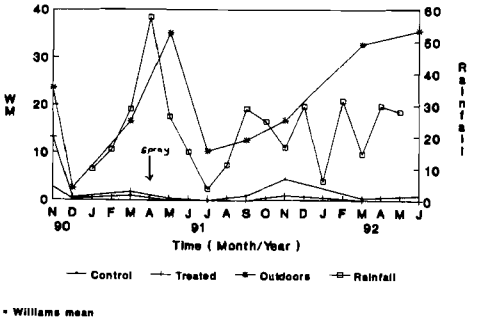

Fig 1—Seasonal abundance of *An. maculatus* in Jeram Kedah.

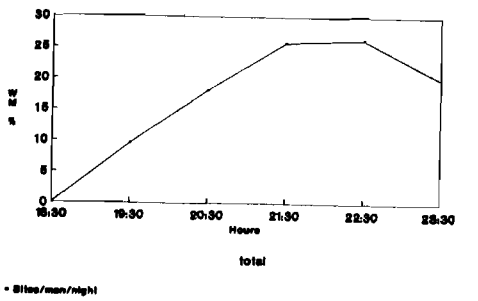

Fig 2—Biting cycles of *An. maculatus* in Jeram Kedah.

In Table 2 the combined results of 3 replicates of the excito repellency tests with an unsprayed and six replicates with a sprayed test box are presented. The escape rate was highest from the sprayed box for the first 20 minutes. After that almost no additional escapes were observed. 100% of the mosquitos that remained in the control box for 1 hour were alive, while in the treated box 88.5% were dead.

DISCUSSION

While it is widely accepted that newer insecticides will not match the residual efficacy of DDT (Goose, 1983), the problem of vector resistance and behavioral change has necessitated a change from DDT. Presently, synthetic pyrethroids are preferred chemicals used widely in vector control operations in many parts of the world. These chemicals are

Table 2

Results from the excito-repellency tests with unsprayed and lambdacyhalothrin sprayed test boxes.*

Type of test box	Mosquitos remaining in test boxes; % of total number						No. still in box; 1 hour			
	10	20	30	40	50	60	Alive	Dead	% Dead	No of rep
control	98.9	90	90	90	90	90	81	0	0	3
sprayed	90	85	82	82	82	82	17	131	88.5	6

* Percentages of *An. maculatus* remaining in the boxes after intervals of 10 minutes with a total exposure time of 1 hour are presented, together with the number of living and dead mosquitos in the boxes at the end of the experiment.

assuming increasing importance by virtue of their high potency and quick knock down effects against vector insects and low toxicity/hazard to warm-blooded animals. Among these, lambdacyhalothrin was developed during the 1980s for Public Health use.

In the present study no attempt was made to compare DDT to lambdacyhalothrin but rather to assess the residual effectiveness of the latter. With only 10 minutes exposure time lambdacyhalothrin gave a mortality rate of 100% up to 8 months. These results are comparable to other studies carried out in various parts of the world (Barodji *et al,* 1989; Shrestha *et al,* 1989; Asinas *et al,* 1991). In the Philippines Asinas *et al* (1991) showed that lambdacyhalothrin gave a residual effect of up to 8 months on wood surfaces against *An. flavirostris.* It was also found that the people preferred lambdacyhalothrin to DDT as it also controlled other domestic pests especially bed bugs and cockroaches as well as the lack of smell or staining. Studies in Brazil showed mortality indices of *An. darlingi,* 12 months after spraying, of only 53% for DDT compared to 91% for lambdacyhalothrin (Alecrim *et al,* 1989).

Although fewer mosquitos were caught in the sprayed hut compared to the control hut, there was no significant difference ($p > 0.05$). Some workers have shown that DDT and permethrin have repellent effects on *Anopheles* species (Cullen and Zulueta, 1962; Bondareva, 1984; Han and Loong, 1989). However the results from the excito repellency tests showed that lambdacyhalothrin did not have any repellent effect with *An. maculatus* as most of them remained in the box and died at the end of 1 hour.

To avert the rapid development of vector resistance to DDT and other insecticides, WHO recommended a number of measures which are "designed to delay or prevent resistance level rising to those at which the pesticide must be abandoned, while maintaining effective disease control" (WHO, 1992). Included in these measures is the rotation of insecticides which is based on the premise that if two pesticides are used sequentially the level of resistance to one will fall while the other is being used. This is with aim, of course, of prolonging the useful life of available insecticides and at the same time achieving an optimal cost/effectiveness ratio.

For the above reason and from the results obtained in this trial it is recommended that large scale field trials be carried out in this country to study the effecttiveness of lambdacyhalothrin in relation to malaria transmission, vector density and sporozoite rate.

ACKNOWLEDGEMENTS

The authors wish to thank Dato' Dr M Jegathesan, Director of IMR for his permission to publish this paper, staff of Entomology Division, IMR for their technical assistance and finally ICI for the supply of lambdacyhalothrin. This study was partly supported by R and D grant No. 89-18 of the Ministry of Health, Malaysia.

REFERENCES

Alecrim WD. Tests with lambdacyhalothrin (ICON) against vectors in Brazil. Paper presented at XXV Congresso da Sociedade Brasileria de Medicina Tropical, Florianopolis-SC, Brazil 1989.

Asinas CY, Santos MN, Joson NDC, Quilala JM, Luna FB. Efficacy of Lambdacyhalothrin 10% Wettable powder (ICON 10 WP) was compared with DDT 75% WP for the control of malaria transmission by *Anopheles flavirostris* in Quezon Province of the Philippines. Unpublished document of the Malaria Control Service, Department of Health, Philippines 1991.

Bardoji, Sustriayu N, Damar TB, Hadi S, Sumardi. Village scale trial of Lambdacyhalothrin (ICON, OMS-321) for control of the malaria vector *Anopheles aconitus* in Central Java. *Bul Penel Kesihatan* 1989; 17 : 9-20.

Bondareva NI, Drobozina VP, Artemev MM. The irritability of various species of *Anopheles* in USSR under effect of insecticides. *Med Parasitol Parasit* 1984; 4 : 46-51.

Cheng YF. Responses of *Anopheles balabacensis* to various patterns of DDT spraying of shelters in Sabah, East Malaysia. *Bull WHO* 1968; 38 : 469-77.

Colless DH. The effect of DDT and kerosene upon adult behavior Baisas (= *A. leucosphyrus*, Auct). *Ann Trop Med Parasitol* 1953; 47 : 261.

Cullen JR, Zulueta J. Observation on the irritability of mosquitos to DDT in Uganda. *Bull WHO* 1962; 27 : 239-50.

Goose J. The development of residual insecticides for malaria control, with special reference to bendiocarb. In: Laird M, Miles JM, eds. Integrated mosquito control methodologies, London: Academic Press 1983; 1 : 341-51.

Han IR, Loong KP. Irritability of *Anopheles farauti, An. maculatus* and *Culex quinquefasciatus* to permethrin. *Jpn J Sanit Zool* 1989; 4 : 47-51.

Justum AR, Collins MD, Perrin RM. PP 321 - A novel pyrethroid insecticide. In: Proceedings of 1984 British Crop Protection Conference—Pests and Diseases. 1984; 8.

Lim JL, Visvalingam M. Relative potency of lambdacyhalothrin and cypermethrin applied as thermal fogs for the control of houseflies *(Musca domestica)* and mosquitos *(Aedes aegypti)*. *Southeast Asian J Trop Med Public Health* 1990; 21 : 77-84.

Loong KP, Chiang GL, Yap HH. Susceptibility status of *Anopheles maculatus* Theobald (Diptera : Culicidae) to DDT in Peninsular Malaysia. *Southeast Asian J Trop Med Public Health* 1989; 20 : 415-20.

Roendaal JA, Van Hoof JPM, Voorham J, Oostburg BFJ. Behavioral response of *Anopheles darlingi* in Suriname to DDT residues on housewalls. *J Am Mosq Cont Assoc* 1989; 5 : 339-50.

Shrestha JPB, Vaidya RG, Sharma RP. Field trials of Lambdacyhalothrin (ICON OMS-3021) against malaria vectors in Nepal. Unpublished document of Nepal Malaria Eradication Organization, Kathmandu 1989.

Thevasagayam ES, Chooi CK, Yap S. Studies on the biology of *Anopheles campestris* Reid (Diptera, Culicidae) and its response to residual spraying with DDT, carried out in experimental huts in Penang, Malaysia. *Med J Malaya* 1979; 34 : 117-30.

VBDCP. Country report on malaria situation in Malaysia. Brunei-Indonesia-Malaysia-Singapore Border meeting on malaria in Bali, Indonesia. 24-25 Oct. 1988. Mimeograph Document of Vector Borne Disease Control Programe, Ministry of Health, Kuala Lumpur, Malaysia, 1988.

Wallace RB. Insecticides and *A. maculatus*. *Med J Malaya* 1948; 3 : 5-33.

Wharton RH. The habits of adult mosquitos in Malaya. I. Observations on Anophelines in window-trap huts and cattle-sheds. *Ann Trop Med Parasitol* 1951; 45 : 141-54.

World Health Organization. Instructions for the bioassay of insecticidal deposits on wall surfaces. *WHO Tech Rep Ser* 1970; 443.

World Health Organization. Manual of practical entomology in malaria. Part I + II. WHO Offset Publications 1975; 13 : 1-160.

World Health Organization. The WHO recommended classification of pesticides by hazard and guidelines to classification 1988-1989. Unpublished document *WHO/VBC/88 953*. 1988.

World Health Organization. Vector resistance to pesticides. Fifteenth report of the WHO expert committee on vector biology and control. *WHO Tech Rep Ser* 1992; 815.