A Field Study on the Response of *Anopheles dirus* to DDT and Fenitrothion Sprayed to Huts in Phetchabun Province, Thailand

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Abstract: A field study was carried out in a village of Phetchabun Province, Thailand to evaluate the behavioral resistance of *Anopheles dirus* to indoor residual spraying of DDT and fenitrothion (FNT). Among four experimental huts three were sprayed with 2g and 1g of DDT, and 1g of FNT per m^2. Indoor and outdoor human bait collections were performed before and after the treatment for six months. The ratio of indoor biting density to outdoor one (IBD/OBD) was prominently reduced after the treatment in a hut with 2 g of DDT. The reduction was also ascertained in huts with 1g of DDT and FNT. The reduction on the ratio of indoor resting density to indoor biting density (IRD/IBD) after the treatment suggested presence of the behavioral resistance of the species to those insecticides.

Key words: Behavioral resistance, *Anopheles dirus*, DDT, Fenitrothion, Thailand

INTRODUCTION

Malaria is one of the most important mosquito-borne diseases in Thailand. The Malaria Division, Ministry of Public Health reported 302,674 and 321,508 malaria cases in 1987 and 1988. The major malaria vectors are *Anopheles dirus* (Scanlon and Sandhinand, 1965; Ismail *et al.*, 1974, 1975; Peyton and Harrison, 1979) and *An. minimus* (Ayurakit-Kosol and Griffith, 1962), and it has been believed that these species have been still susceptible to DDT (Ismail *et al.*, 1975; Nutsathapana *et al.*, 1986). Therefore a main control measure against the vector has been residual house spraying of the insecticide once or twice a year in the country. In 1982 fenitrothion (FNT) was introduced to some areas as another candidate of insecticide. In 1988 a field study was conducted to clarify recent

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response of malaria vectors to DDT and FNT especially focusing the behavioral resistance of *An. dirus*. The results obtained by this study are reported here.

Study Area and Methods

The study was carried out from July to December in 1988, in the village No.6, Ban Tap-Woi, Wang-Kwang Canton, King Nam-Nao District, Phetchabun Province, Thailand, where any insecticides had never been sprayed for malaria vector control before the study. The study site was surrounded by a deep forest about 3㎞ far from the nearest village where 430 people were populated. As shown in Fig. 1, four local farm huts, numbered from 1 to 4, were used as the experimental huts. On July 13, 1988 inside walls of three huts, No. 2, 3 and 4 were sprayed with 2g and 1g/m^2 of DDT and 1g/m^2 of FNT, respectively. The hut No.1 was unsprayed as a control hut. Just before and after the treatment, indoor human bait collection in each hut and outdoor one at two points shown in Fig. 1 were conducted monthly in eight successive nights from 18 : 00 to 24 : 00. Fifty minutes human bait collection and ten minutes resting mosquito collection were made hourly in each of four huts. Two human baits, who worked as collectors also, were stationed a collection point and rotated everyday. Besides the indoor collections, thirty minutes human bait collection was made hourly at two outside points.

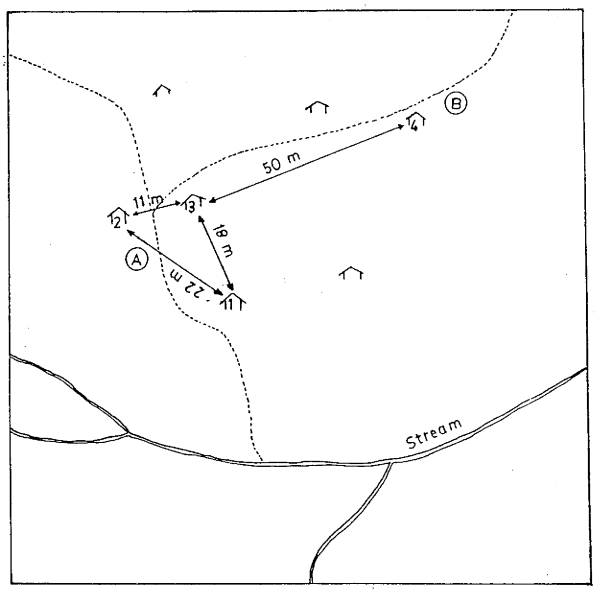

Fig. 1. Sketch of study area in village No. 6 Ban Tap.-Woi, Wang-Kwang Canton, King Nam-Nao District, Phetchabun Province, Thailand.

Ⓐ, Ⓑ : outdoor collection points.

1 : Control hut 2 : DDT 2g/m^2 3 : DDT 1g/m^2 4 : FNT 1g/m^2

RESULTS AND DISCUSSION

Seasonal changes of total number of *An. dirus* collected outdoor by human baits are shown in Table 1. It fluctuated throughout the experimental period without clear seasonal trend except high density in December. *An. minimus* and *An. maculatus* were also caught by the collection. These species also increased in December, and they were not abundant in other months. Total number of *An. dirus* collected for eight successive nights just before the spraying and the average number of the species per eight nights for six months after the spraying were 120 and 99 as the sum of two stations, respectively.

Table 2 shows the indoor biting density (IBD) by human bait collection and its ratio to outdoor biting density (IBD/OBD) before and after the spraying. The ratio in a hut No. 2 (DDT 2g/m^2) was 1.384 before the spraying. It reduced prominently to 0.719 on the average after the spraying. The same tendencies were observed in a hut No. 3 (DDT 1g/m^2) and No. 4 (FNT 1g/m^2). The changes of the ratio before and after the spraying were from 0.975 to 0.814 in a hut No. 3, from 0.467 to 0.431 in a hut No. 4. On the other hand it rather increased from 0.600 to 1.150 in a hut No. 1 (control). Therefore, taking into account of increase in the ratio in the control hut, it was obvious that many of *An. dirus* avoided to enter the hut No. 2 after spraying with 2g/m^2 of DDT. Avoidance of entering to sprayed huts was somewhat observed in huts No. 3 and 4. It was also suggested that the avoidance was the strongest just after the spraying.

Another aspect of behavioral resistance of *An. dirus*, the change of indoor resting behavior, was evaluated. The indoor resting density and its ratio to indoor biting density (IRD/IBD) were examined, and the result was summarized in Table 3. Both of the number and the ratio apparently decreased after the spraying in hut No. 2 and 3 in spite of no actual changes in the control hut (No. 1). The average ratios after the spraying in huts with DDT 2g/m^2 and DDT 1g/m^2 reduced to only less than 30% of those before spraying, and the avoidance from walls sprayed was observed continuously throughout the study period.

In the hut of FNT 1g/m^2 (No. 4), the avoidance was also clearly observed, but did

Table 1. Outdoor biting density per eignt nights (OBD) of *An. dirus* before and after the indoor residual spraying of DDT and fenitrothin (FNT)

Month	Conditions	Collection point		
		A	B	Total
July	Before spraying	62	58	120
July	After spraying	26	9	35
August	After spraying	61	53	114
September	After spraying	3	44	47
October	After spraying	32	98	130
November	After spraying	4	19	23
December	After spraying	138	107	245
Average	After spraying	44.0	55.0	99.0

Table 2. Indoor biting density (IBD) of *An. dirus* and its ratio to outdoor biting density (OBD) before and after the indoor residual spraying of DDT and fenitrothion (FNT)

Month	Conditions	DDT (2g/m²)		DDT (1g/m²)		FNT (1g/m²)		Control	
		IBD	IBD/OBD	IBD	IBD/OBD	IBD	IBD/OBD	IBD	IBD/OBD
July	Before spraying	166	1.383	117	0.975	56	0.467	72	0.600
July	After spraying	16	0.457	19	0.543	22	0.629	58	1.657
August	After spraying	72	0.632	56	0.491	26	0.228	56	0.491
September	After spraying	55	1.170	42	0.894	22	0.468	55	1.170
October	After spraying	65	0.500	92	0.708	30	0.231	157	1.208
November	After spraying	35	1.522	50	2.174	21	0.913	52	2.261
December	After spraying	8	0.033	18	0.073	29	0.118	27	0.110
Average	After spraying	41.8	0.719	46.2	0.814	25.0	0.431	67.5	1.150

Table 3. Indoor resting density (IRD) of *An. dirus* and its ratio to indoor biting density (IBD) before and after the indoor residual spraying of DDT and fenitrothion (FNT)

Month	Conditions	DDT (2g/m²)		DDT (1g/m²)		FNT (1g/m²)		Control	
		IRD	IRD/IBD	IRD	IRD/IBD	IRD	IRD/IBD	IRD	IRD/IBD
July	Before spraying	223	1.343	144	1.231	124	2.214	53	0.736
July	After spraying	7	0.438	12	0.632	16	0.727	63	1.086
August	After spraying	37	0.514	17	0.304	24	0.923	17	0.304
September	After spraying	14	0.255	17	0.405	28	1.273	26	0.473
October	After spraying	19	0.292	44	0.478	71	2.367	55	0.350
November	After spraying	5	0.143	6	0.120	33	1.571	40	0.769
December	After spraying	5	0.625	4	0.222	90	3.103	34	1.259
Average	After spraying	14.5	0.378	16.7	0.360	43.7	1.661	39.2	0.707

not last long. The ratio decreased just after the spraying to approximately 33% of before the spraying. It recovered month to month, and in October, three months after the spraying, it showed the equivalent ratio of that before the spraying as shown in Table 3. A similar result was reported by Nutsathapana *et al.* (1986) about *An. minimus*.

These results strongly suggest that *An. dirus* in the study area shows clear behavioral resistance to DDT, even if it was sprayed with a concentration of 1g per square meter, and that the behavioral resistance was shown not only by avoiding to enter sprayed houses but also by avoiding to rest on the walls sprayed. The behavioral resistance was also observed to FNT, but the resistance may not be so strong as that to DDT in *An. dirus*.

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