VILLAGE-SCALE TRIAL OF LAMBDACYHALOTHRIN (ICON, OMS-3021) FOR CONTROL OF THE MALARIA VECTOR *ANOPHELES ACONITUS* IN CENTRAL JAVA*

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ABSTRAK

Lambdacyhalothrin (Icon, OMS-3021) suatu racun serangga baru kelompok pirethroid sinthethis telah dinilai terhadap populasi vektor malaria ***Anopheles aconitus*** *yang sudah resisten terhadap DDT di Jawa Tengah. Dua formulasi, yaitu 10% EC masing-masing diaplikasikan dengan penyemprotan rumah dosis 25 mg/m² dua kali, pada bulan Februari dan Juli 1987.*

Hasil penilaian dengan penangkapan nyamuk menunjukkan bahwa formulasi 10% WDP adalah lebih efektif dari formulasi 5% EC. Penyemprotan pertama menggunakan 10% WDP efektif selama 3 minggu dan formulasi 5% EC efektif 1 minggu untuk menekan jumlah vektor yang menggigit orang. Jumlah vektor yang istirahat di kandang, di dalam dan di luar rumah masing-masing dapat ditekan selama 9 minggu pada semua penyemprotan. Pada penyemprotan siklus kedua efektivitas formulasi 10% WDP meningkat menjadi sekitar 11 minggu) pada semua parameter, sedang penyemprotan kedua 5% EC efektivitasnya sama seperti pada penyemprotan pertama.

Hasil kontak bioassay kedua formulasi tersebut pada penyemprotan pertama menunjukkan bahwa kematian nyamuk ⩾ 70% pada permukaan kayu lebih lama (19 minggu untuk 10% WDP dan 15 minggu untuk 5% EC) bila dibanding dengan permukaan bambu (9 minggu untuk 10% WDP dan 5 minggu untuk 5% EC). Pada penyemprotan kedua, umur residu yang efektif lebih lama bila dibanding penyemprotan pertama. Sampai akhir penilaian (21 minggu) kematian nyamuk masih ⩾ 70%. Daya bunuh kontak tidak langsung kedua formulasi lambdacyhalothrin adalah sangat lemah, kematian nyamuk 1 minggu setelah penyemprotan hanya 8,00% untuk 10% WDP dan 9,18% untuk 5% EC.

INTRODUCTION

As a function of the WHO Pesticides Evaluation Scheme[1] candidate compounds are tested in vilage-scale trials to determine the effectiveness of their for residual house spraying against natural populations of malaria vectors.

Lambdacyhalothrin (OMS-3021) is a new synthetic pyrethroid insecticide produced by ICI, available under trade mark "ICON" for the control of public health and pests vectors. In the laboratory lambdacyhalothrin has shown good residual activity on a variety substrats, including painted and unpainted plywood, harboard, cement, vinyl and metal panels[2]. Contact bioassay on plywood surfaces treated with the very low dosage of 5 mg/m² showed that lambdacyhalothrin has long residual effect: *Aedes aegypti* mortality rates of 100% resulted from 1 hour exposure to plywood treated up to 40 weeks previously and stored under tropical conditions.

A village-scale trial of lambdacyhalothrin was therefore undertaken for field evaluation of its residual effectiveness against DDT resistant population of the malaria vector *Anopheles aconitus* in Centrai Java.

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* This field trial was carried out by Vector Control Research Unit, as work contract among ICI, WHO and Institute of Health Research and Development.

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MATERIAL AND METHOD

Trial Area

The trial was carried out during 1987 in Sub-district Boja, Central Java Province, 4 km the South was selected as unsprayed area[3]. Both Subdistricts are located on the northern foothill of Ungaran Mountain at an elevation of 300–350 m, about 25 km inland from the coastal city of Semarang (Fig. 1). Description of the area and the ecology of *An. aconitus* have been given by Joshi et al[4,5]. Malaria transmission no longer occurs regularly in the area and regular spraying with DDT discountinued in 1975.

The treated village area covers about 10 km^2 and consists of 14 hamlets with 1370 houses, a human populations of 6324 and approximately 300 buffaloes and 19 cows in 120 cattle shelters (Fig. 1). Hamlets are separated by rice fields and agricultural land to facilitate testing two formulations of lambdacyhalothrin the trial area was Sub divided.

Klesem area, with 6 hamlets with 596 houses human population of 2911 and 58 animal shelters treated with ICON 10% WDP. Entomological evaluation was undertaken in the central hamlet of Klesem.

Kenteng area, with 8 hamlets with 774 houses, human populations of 3413 and 69 animal shelters treated with 5% EC. Entomological evaluation was undertaken in the central hamlet of Kenteng[3,6]

The climate is perennially warm and humid, with average temperatures from 20°C minimum to 34°C maximum. Annual rainfall is about 3000 mm with a rainy season from December to April. Some rain occurs during every month of the year, but June to August are usually the driest month.

Spraying Operations

House spraying operations were carried out twice a year; the first spray cycle was implemented 2–18 February 1987, the entomological evaluation sites (Kenteng and Klesem) being sprayed on 14 February, the second spray cycle was implemented from 20 July to 6 August 1987, entomological evaluation sites being sprayed on 1 August.

Hudson X-pert^R compression sprayers holding 8 liters suspension were used for the application of the insecticide. They are fitted with pressure gauges and operated at pressure of 25 to 55 pounds per square inch (psi) with spraying system Teejet^R C-HSS 8002 E new nozzle tips. Discharge rates of nozzle tipe were checked to ensure that all gave flow rates of 750 ml/min at 40 psi. The two formulations of lambdacyhalothrin to be evaluated were 5% EC and 10% WDP, both applied at 25 mg a.i./m^2. ICON 5% EC was supplied in 100 ml bottles for each pump charge. ICON 10% WDP was supplied as 50 gr packs in soluble sachets of transparant gelatin each scaled in an aluminium foiled bag. All inner surfaces of walls and roofs of houses were sprayed up to 3 m height. Spraying was also applied underneath beds, behind cabinets and furniture. Outer surfaces of walls were sprayed if the roof projected one meter or more. Cattle shelters and all other building were also sprayed inside to 3 m.

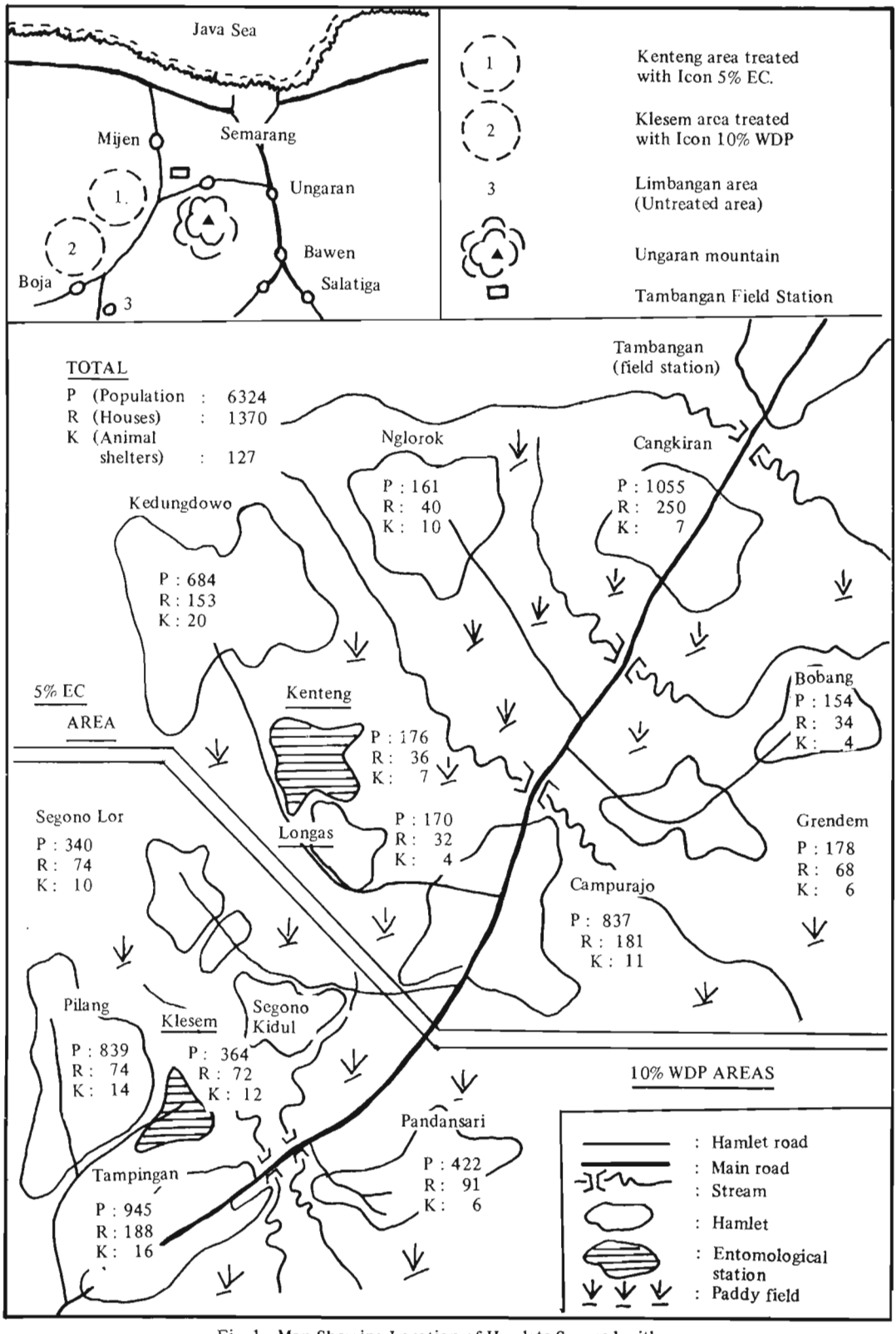

Fig. 1. Map Showing Location of Hamlets Sprayed with Lambdacyhalothrin (OMS-3021), 10% WDP and 5% EC.

Safety precautions and toxicology

Safety and protective measures for sprayman and inhabitants were as described by Joshi et al[4]. Each sprayman wore a peaked cap, respiratory filter, overalls and boots. As pyrethroids do not inhibit cholinesterase, tests of this were not done. However, spray personal were checked for anyover symptoms and opinions on their exposure to lambdacyhalothrin.

Entomological evaluations

Densities of *An. aconitus* were measured at fortnightly intervals in treated and in untreated areas.

Indoor and outdoor resting collections were made at 06.00–08.00 hours from houses and natural outdoor resting sites, especially on earth banks beside streams and irrigation canals. Nocturnal resting collections were made in cattle shelters for 15 minutes per hour from 18.00 – 22.00 hours. Human bait collections interupted mosquitoes l landing on pairs of catchers indoors and outdoors from 18.00 – 22.00 hours. Pre treatment entomological data were collected from 11 July 1986 up to January 1987 and post-treatment evaluation continued until 24 December 1987.

Estimation of the relative longevity of the mosquito populations were made from the parous rates of the mosquitoes.

The period of residual effectiveness of the treatment measured with bioassay test (contact and air bioassay test) once a week for the initial four weeks and fortnightly thereafter.

Mosquito densities, parity rates and bioassays were carried out in accordance with standard WHO procedures (Anonymous, 1976).

Percentage reduction of *An. aconitus* density after spraying was calculated using the following formula: $(1-\frac{AD}{CB})$ 100%, where A and B represent mosquito densities in the untreated area before and after spraying, C and D represent mosquito densities in the treated area before and after spraying (Mollineaux et al., 1979 in Fleming, 1983)[7]

RESULTS

Insecticide applications

The first and second spray cycles were completed on schedule. In the first cycle of spraying, a total of 592 houses were sprayed with 10% WDP, an average of 5.69 houses/man/day, and some 777 houses were covered with 5% EC giving an average of 5.68 houses/man/day. There were 6 new houses, 4 demolished and 1 refusal for house spraying recorded during the course of the round. A combined total of 1,586 pump charges were used in spraying 1,369 houses, averaging 1.16 charges per house.

In the second spraying, 594 houses were sprayed with 10% WDP, giving an average of 5.71 houses/man/day and a total of 769 were covered with 5% EC averaging 5.69 houses/man/day. A record of 3 new houses, 3 demolished and 3 refused houses was made during the round. A combined total of 1572 pump charges were consumed to spray 1363 houses, averaging 1.15 charges per-house.

The combined total coverage with both formulations of lambdacyhalothrin in the two spray rounds was 2727/2732 = 99.8%.

No serious toxicological complaint was lodged by the spray personnel or householders. The spraymen daily experienced a warm sensation on their faces, irritating particularly the delicate skin around the eyes. This symptom increased on bathing after work and gradually diminishing thereafter lasting about five to ten hours. However, this phenomenon did not reddened or roughened the affected skin. The EC formulation smelled mildly, probably due to the solvent, caused minor coughing by some spray personnel and villagers.

Domestic poultry and animals remained safe during both spray rounds, except one incident involving the deaths of 22 ducks (2–4 months old) exposed to EC spraying during the second round in one house in Kedungdowo hamlet of Kenteng area.

Lambdacyhalothrin was popular with the householders due to its rapid killing and flushing of household pests such as cockroaches, flies and ants. Also the application of both formulations left no unsightly staining or unpleasant smell.

Entomological Evaluation.

1. **Klesem area, treated with 10% WDP lambdacyhalothrin.**

   Klesem of entomological evaluation before and after spraying are given in (Tables 1–3).

Indoor landing collections

Indoor landing rates of *An. aconitus* on man after the first spray round were reduced for about 3 weeks (i.e. 0,96 per manhour average before spraying to 0,32 three weeks after spraying) and after second spraying round showed that the mosquito densities remained low during the whole evaluation period, with appearrent the insecticidal impact for about 15 weeks or longer (Table 1).

Outdoor landing collections

Outdoor landing rates of *An. aconitus* on man after the first spray round showed slight reduction one week after spraying (i.e. 1,16 per man-hour average before spraying to 0,75 one week after spraying), but the reduction in the untreated area was higher (i.e. 1,64 per man-hour average before spraying to 0,37 one week after spraying). After second spray round, the insecticidal efficacy lasted for about 11 weeks (Table 1).

Due to very low numbers of mosquitoes collected landing on man indoors and outdoors before and after spraying, parous rates could not be used to evaluate the insecticidal impact.

Resting collection in cattle shelters

During the first month after first and second spray rounds there was little change in mosquito densities resting at night in cattle shelters. Thereafter the mosquito densities declined until about 15 weeks post-spray and then increased again (Table 1).

Parous rates were not reduced after the first spray round (i.e. 56% average before spraying and 60%

Tabel 1. Percent reduction[1)] of *An. aconitus* densities and percent parous after spraying with ICON 10% WDP.

Weeks after spraying	Landing on man		Resting in cattle shelters			Resting in houses	Resting in natural outdoor		
	Indoor	Outdoor	Dens.	Parous		Densities	Dens.	Parous	
	Dens.	Dens.		Tr.	Utr.			Tr.	Utr.
X				56	50			34	54
				1st spray round					
1	+30	−186	+767	60	40	+ ~	−20	33	43
3	+27	−167	+586	59	55	+795	+50	15	43
5	−335	+	+113	86	40	+95	+14	43	57
7	−3515	−2256	−129	71	53	− ~	+42	42	50
9	− ~	−753	+36	62	61	+ ~	+37	43	55
11	−867	−413	+35	57	55	+67	−77	34	47
13	−86	−41	+83	35	71	+25	30	49	67
15	+ ~	−265	+66	44	76	+77	-15	8	61
17	+85	+66	+33	74	65	+91	+77	5/8	65
19	+15	−131	+53	68	61	−2	−100	41	56
21	+74	+ ~	+26	67	73	+45	−9	51	56
23	− ~	+ ~	+35	61	93	+ ~	−18	75	50
				2nd spray round					
1	−251	−86	+72	38	48	+ ~	+72	3/5	70
3	+ ~	+ ~	−1	4/5	8/10	−22	−28	5/5	45
5	+ ~	+32	−72	52	70	+ ~	+91	1/1	52
7	+ ~	− ~	+79	2/4	75	+ ~	+ 85	2/2	43
9	+ ~	+ ~	+96	3/3	78	+ ~	+86	1/1	56
11	+ ~	+ ~	+96	1/2	73	+ ~	+93	2/2	35
13	+ ~	− ~	+ ~	4/6	74	+ ~	+86	1/2	27
15	+ ~	−41	+ ~	8/10	72	+ ~	+93	2/2	27
17	− ~	−14	+ ~	87	60	+ ~	+1	5/26	53
19	+ ~	+45	+58	77	62	+ ~	+41	57	50
21	+93	+83	+33	77	67	+ ~	−136	29	54

1) Percentage reduction calculated using Mollineaux formula $[(1-\frac{BC}{AD})100\%]$

A and B treated area before and after treatment,
C and D untreated area before and after treatment.

− negative impact

+ positive impact.

one week after spraying). After the second spray round there were indications of slight reduction for about 4–5 weeks (i.e. 38% one week after spraying and 52% by 5 weeks).

Resting collection in houses

The first spraying round showed that the insecticidal impact on mosquito densities resting in houses lasted for about five weeks (i.e. 3,67 per man-hour average before spraying and 0,25 five weeks after spraying and by seven weeks increased to 6,75 per man-hour). The second spraying round showed that no *An. aconitus* could be found during evaluation, except after three weeks (0,75 per man-hour) (Table 1). The number of mosquitoes collected following treatment was too low to calculate parous rates.

Diurnal resting collections in natural outdoor.

The diurnal resting densities in natural outdoor places after the first spraying round ranged from 2,31 to 11,75 per man-hour which remained below the pretreatment (except at one week after spraying) and the check area, but the insecticidal impact lasted for about 9 weeks (Table 1). Parous rates were reduced for three weeks only (i.e. 34% average before spraying to 15% three weeks after spraying and by five weeks there were 43%).

In the treated area densities after the second spraying round was shown to be lower than the pre, post treatment of first spraying round and the check area. The seasonal densities pattern of the check area at the same period were similar with the treated area. Nevertheless the insecticidal impact on densities were apparent for about 17 weeks.

The number of mosquitoes collected following treatment were too low to calculate parous rates.

Bioassay test

The number of weeks after treatment giving residual effect of 70% or greater mortalities in contact bioassay was 19 weeks on wood surfaces in the first and second spray round while on bamboo surfaces it was 9 weeks and 21 weeks (Table 3).

2. **Kenteng area, treated with 5% EC lambdacyhalothrin.**

Results of entomological evaluation before and after spraying are given in Table 2–3.

Landing on man indoor

Indoor landing rates of *An. aconitus* on man in the first and second spray round were reduced for less than one week.

In treated area indoor landing densities of *An. aconitus* after spraying were not significantly reduced, i.e. 0,29 per man-hour average before spraying to 0,19 one week after first spraying round and by three weeks three are 1,00 and 0,06 per man-hour to 0,12 one to three weeks after second spraying round (Table 2). In untreated area the reduction of mosquitoes indoor landing densities

Table 2. Percent reduction[1)] of *An. aconitus* densities and percent parous after spraying with ICON 5% EC.

Weeks after spraying	Landing on man		Resting in cattle shelters			Resting in houses	Resting in natural outdoor		
	Indoor	Outdoor	Dens.	Parous		Densities	Dens.	Parous	
	Dens.	Dens.		Tr.	Utr.			Tr.	Utr.
X				70	58			60	65
				1st spray round					
1	−65	−1300	+13	53	40	+13	+4	30	43
3	−487	−500	+77	58	55	+13	+24	31	46
5	−291	−734	+54	54	40	−48	+39	46	57
7	−1022	−3255	−29	68	53	− ~	−123	65	50
9	− ~	−118	+34	58	61	−72	−38	52	54
11	−117	−435	+19	72	55	−3	−53	48	47
13	+29	−864	+84	55	71	+ ~	−3	75	67
15	−334	−131	+53	54	76	+67	−147	52	62
17	+62	− ~	−38	67	65	+ ~	−68	70	66
19	−587	− ~	+69	65	61	−159	−129	44	56
21	+31	+45	+13	72	73	−763	−131	63	57
23	− ~	− ~	−65	65	97	+ ~	−172	70	50
				n^nd spray round					
1	−117	−204	−28	63	48	−245	−100	79	70
3	−117	−46	−296	81	80	+ ~	−337	62	45
5	−117	+44	−233	71	70	+ ~	−90	39	52
7	+ ~	− ~	+33	65	72	− ~	+37	63	43
9	−117	+ ~	+83	89	78	− ~	−81	68	56
11	+ ~	−131	+92	5/5	74	+ ~	+62	74	35
13	+ ~	− ~	+18	81	74	+ ~	−3	51	27
15	+ ~	−131	−9	85	72	− ~	−175	80	27
17	− ~	−86	−137	62	60	−245	−19	74	53
19	+31	−176	+54	67	62	−418	+43	66	50
21	+49	+32	−137	80	67	−353	−128	52	55

1) Percentage reduction calculated using Mollineaux formula $[(1-\frac{BC}{AD})100\%]$

A and B treated area before and after treatment.
C and D untreated area before and after treatment.

− negative impact

+ positive impact.

Table 3. Result of countact and air bioassay test of village-scale trial with 25 mg/m² ICON (OMS-3021), using *An. aconitus* breeds in laboratory.

Weeks after spraying	ICON 10% WDP			ICON 5% EC		
	Contact bioassay		Air Bioassay	Contact bioassay		Air Bioassay
	Surfaces			Surfaces		
	Wood	Bamboo		Wood	Bamboo	
			1st spraying			
1	80,00	95,00	8,00	74,19	88,33	9,18
2	81,31	91,07	8,00	68,33	91,67	4,08
3	82,26	75,81		89,47	94,91	
4	66,67	86,67	Disconti	83,33	95,67	Disconti-
5	46,67	55,00	nued	69,49	81,67	nued
7	75,81	70,69		93,33	56,67	
9	81,67	86,44		70,00	55,00	
11	86,67	51,67		75,81	53,97	
13	70,00	35,00		54,38	58,62	
15	95,08	48,33		74,60	43,33	
17	95,00	51,67		65,00	72,41	
19 1	55,00	68,33		63,33	46,67	
2	69,49	67,21		65,00	41,67	
21	93,33	25,00		55,00	38,33	
23	43,33	35,00		51,67	43,33	
			2nd spraying			
1	72,88	73,33		58,33	53,33	
3	98,32	100,00		95,57	95,00	
5	100,00	100,00		98,33	100,00	
7	100,00	100,00		100,00	100,00	
9	98,33	100,00		100,00	100,00	
11	93,10	81,97		93,55	90,91	
13	86,67	95,00		88,33	87,30	
15	98,33	96,67		89,83	96,82	
17	86,67	83,22		87,88	85,94	
19	78,33	86,67		73,33	69,64	
21	63,33	78,33		80,70	73,77	

19.1. Bioassay test with wild cought *An. aconitus*.

after first and second spraying round were higher compared in treated area (i.e. 0,63 per man-hour average before spraying to 0,25 one week after first spraying round and to 0,06 one week after second spraying round). In treated and untreated area after the second spraying the mosquito densities remained lower compared before and after the first spraying round.

Landing on man outdoor

Outdoor landing rates of *An. aconitus* on man after the first and second spray round were reduced for less than one week.

One week evaluation after the first spray round outdoor landing densities were not reduced, i.e. 0,35 per man-hour average before spraying to 2,31 one week after first spraying round and by three weeks it was 2,81 (Table 2). The densities after the second spraying round was slightly reduced during evaluations compared to before and after the spraying round, but the reduction in the untreated area was higher during the same period.

Due to very low numbers of mosquitoes collected landing on man indoor and outdoor before and after first and second spraying round, parous rates could not be used to evaluate the insecticidal impact.

Resting collections in cattle shelters

Night resting collections from cattlers revealed some reduction in densities for about 15 weeks or longer after the first spraying round and 13–15 weeks after the second compared to the untreated area (Table 2). The parous rate although apparently with a slight reduction for about 5 weeks after the first spraying round (i.e. 70% average before spraying to 54% five weeks after spraying), but the reduction in untreated area were higher (58% to 40%) while after second spraying round the parous rate was not reduced compared average before and after first spraying round (i.e. 62% one week after spraying and by three weeks thre were 81%).

Diurnal resting collections in houses

Post treatment diurnal resting in houses that after first spraying round the density of *An. aconitus* were slightly reduced for about three weeks (i.e. 0,87 per man-hour average before spraying to 0,25 three weeks after spraying) (Table 2).

Results of the evaluation after second spraying round could not clearly reveal the insecticidal impact because round could not clearly reveal the insecticidal impact because densities in the nuntreated area were also reduced to the low level observed before and after first spraying round (i.e. 0,50 per man-hour one week after spraying and up to 15 weeks there were zero except in 9 weeks there were 0,25). In untreated area, the number of diurnal resting mosquitoes collected in house was 4,51 per man-hour average before spraying and 0,75 one weeks after the second spraying round.

After this spraying round, the number of mosquitoes collected in the

treated area was to small to calculate parous rates.

Diurnal resting collections in natural outdoor

The impact of the first spray round on the mosquito densities in natural outdoor resting places lasted for about 9 weeks (i.e. 62,52) per man-hour average before spraying reduced to 48,62 five weeks after first spraying) (Table 2). After the second spraying round the mosquito densities declined and remained lower compared before and after first spraying round, these maybe also as a result of the season, because the mosquito densities in untreated area at the same were similar pattern with treated area.

The insecticidal impact of the first spraying round on parous rates lasted for about 5 weeks (i.e. 61% average before spraying and 45% five weeks after first spraying and by seven weeks there were 65%) while after the second spraying round parous rates were not reduced (i.e. 79% one week after spraying).

Bioassay test

The results of contact bioassay test (Table 3) showed that *An. aconitus* mortalities remained above 70% on wood surfaces for about 15 weeks in the first spray round and 21 weeks in the second spray round. In air bioassay test lambdacyhalothrin showed negligible fumigant effect.

DISCUSSION AND CONCLUSION

Results of the first cycle of spraying lambdacyhalothrin 10% WDP and 5% EC at the dosage of 25 mg%m^2 showed that WDP formulation of this insectiside appears more effective in reducing the number of *An. aconitus* landing on man for about 3 weeks. Resting mosquitoes in cattle Shelters, in houses and in natural outdoor places lasted for about 9 weeks. While the effectiveness of 55 EC was less than 1 week for landing mosquitoes on man, it was 5 weeks for resting mosquitoes in cattle shelters, in houses and in natural outdoor places. The effectiviness of the second spraying of WDP formulation increased for about 11 weeks in all parameters, while for EC formulation it remained the same as in the first spraying.

The parous rates for indoor landing rates on man, resting in houses and in natural outdoor places in both treated and untreated areas could not be measured, due to a low capture rate. Parous rate for resting mosquito in cattle shelters were reduced for only about 5 weeks.

The results of contact bioassay tests for both formulation of lambdacyhalothrin in the first cycle of spraying showed that a mortality rate of 70% in wood surfaces was 19 weeks for 10% WDP and 14 weeks for 5% EC, compared to bamboo surfaces i.e. 9 weeks for 10% WDP and 5 weeks for 5% EC. Air borne fumigant effects of lambdacyhalothrin were negligible. One week after spraying mortalities were 8,00% for 10% WDP and 9,18 % for 5% EC. These results were similar to the results of the village scale trial using other synthetic pyrethroid compound,

i.e. cypermethrin[8] chlorophoxim[9].

Compared to the first spraying, contact bioassay test in the second spraying showed a longer residual life for both formulations on all surfaces i.e. up to 19–21 weeks.

From the results of this trial it was shown that the 10% WDP formulation applied two cycles per-year could reduce mosquito densities for about 11 weeks for all parameters. It was concluded that lambdacyhalothrin 10% WDP formulation is a promising insecticide for malaria vector control and should be further tested in a large-scale control trial.

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