THE EVALUATION OF A NOVEL BENDIOCARB ULV FORMULATION AGAINST ADULT MOSQUITOES

R. G. TAPLEY, PH.D.
Fisons Limited, Agrochemical Division, Hauxton, Cambridge, CB2 5HU England, U.K.
E. HUTCHINSON, B. S.
Fisons Research Unit, Combes, Texas
E. M. FUSSELL, M.P.H.
Micro-Gen Equipment Corporation, San Antonio, Texas

ABSTRACT. A newly developed ULV formulation containing 25% bendiocarb suspended in a non-volatile oil and applied through a Micro-Gen® aerosol generator ED2-20A at 74 ml (2.5 fl oz)/min and at 16 km/h (10 mph) successfully controlled caged mosquitoes in a series of field tests at Lake Charles, La., during late October, early November 1979. Cages were placed at 40 cm (16") and 160cm (64") above ground at 50 m (165') and 100 m (330') from the spray route. The species of mosquitoes controlled include *Aedes aegypti, Ae. sollicitans, Ae. taeniorhynchus, Culex pipiens* and *Anopheles albimanus*. Safety assessments were made by taking air samples at points 5–100 m downwind from the sprayer while spraying at 98 ml (3.3 fl oz)/min from which it is concluded that there is no significant hazard to human health, the concentration in air being well below established Threshold Limit Values.

INTRODUCTION

The carbamate insecticide, bendiocarb, is highly active against adult mosquitoes. As Ficam®[1] W, an 80% wettable powder, it is used in house sprays for long-term control of mosquitoes, but little progress has been made with bendiocarb as a ULV spray because of formulation limitations, due to the crystalline nature of the active ingredient and its insolubility in suitable solvents.

During late June/early July 1979 a series of trials was conducted with caged mosquitoes at Anahuac, Texas and Lake Charles, La. with a suspension of bendiocarb in oil. This first series of trials was not very successful because it was found that the oil carrier evaporated too quickly after dispersal, leaving dry insecticide particles suspended in air. Sometimes the particles were effective in controlling *Psorophora columbiae,* other times less so, but it was clear that this formulation had no future as it did not compare with malathion as a standard. A tank mix of 10% bendiocarb suspended in a mineral oil prepared in the field gave very promising results against *Cx. pipiens* and *Cx. quinquefasciatus* in a limited series of trials.

A new laboratory-developed formulation of bendiocarb suspended in a non-volatile oil was tested at Lake Charles, La. in October and November 1979, rather late in the season, but this was considered preferable to delaying tests until the following season. This paper is an account of these trials.

MATERIALS AND METHODS

The insecticide tested was 25% ai bendiocarb (250 g ai/l) suspended in a non-volatile paraffinic oil base. Insecticide particles were ground to 1–10 microns but mostly fell within the range of 3–5 microns. On dispersal the insecticide crystals were contained within the oil droplets. The formulation is stable, has a high flashpoint, a low phytotoxicity and does not corrode equipment or surfaces.

The insecticide was applied through a Micro-Gen® aerosol generator ED2-20A with digital flow control, and operated at a manifold pressure of 0.35 bar (5 lb in^2).

[1] Ficam is a registered trade mark of Fisons Ltd.

The VMD was 10 microns as determined by sampling on coated glass slides by the hand wave technique. In all trials the sprayer was conveyed at 16 km/h (10 mph). A single pass along the base line was made for each trial.

The insecticide was applied at the following rates, assuming an effective dispersal of 100 m (330') from the spray route in assessing rates per ha:-

ml/min (fl oz)	*g ai/min*	*g ai/ha*
53 (1.8)	13.3	5
74 (2.5)	18.5	7
98 (3.3)	24.4	9

Female mosquito adults, either bred from laboratory stock or collected in the field as larvae or pupae, were placed in disposable cylindrical bioassay cages 15 cm diameter × 4.5 cm deep with a fine nylon mosquito net with a 1.5 mm mesh at each end (Townzen and Natvig 1973). These were suspended from brackets placed in the field so that the cage centers were 160 cm (5'4") and 40 cm (1' 4") above ground in all tests. Three such brackets were set 15 m apart at 50 m from the spray route with another three sets at 100 m. Therefore 12 cages were exposed in each test. Four control (unsprayed) cages were held upwind from the spray. About 25 mosquitoes were placed in each cage, more or less depending on the numbers available.

Cages were left in the field for 15 min after spraying in which time the mosquitoes either became moribund or remained healthy, and the ratio of dead/moribund to healthy mosquitoes did not change appreciably up to 18 hr. Hence it was decided not to transfer mosquitoes from insecticide exposed cages to clean cages, especially as this would have been impracticable within 30 min after exposure on return to the laboratory. Mortalities were recorded at 12 hr after exposure.

Climatic conditions were not entirely favorable during the test period from 24th October to 6th November as might be expected so late in the season. The prevailing southerly breezes were interrupted by cold Pacific fronts which brought in cold and blustery north and east winds. Also temperatures were too cold for night work so tests were carried out during the last half-hour before sunset.

Three different sites were used according to wind direction. The site for south winds (Site 1) was entirely satisfactory but the other two sites less so: one because of tall grass and scrub that screened the lower cages (Site 2), and the other because of air turbulence caused by very large buildings (Site 3).

Four series of air samples were taken at 5, 10, 25, 50 and 100 m from the spray route to measure the level of bendiocarb present in air when sprayed at the rate of 98 ml (3.3 fl oz)/min. Air was sampled at the rate of 4 litres/min for 5 mins to coincide with the passing of the insecticide cloud. The method of air sampling and residue analysis has already been published (Whiteoak, Reary and Overton, 1978).

RESULTS AND DISCUSSION

The mortality data are summarized in Table 1 along with some meteorological data. The results must be interpreted against a background of far from ideal climatic conditions, particularly variable and blustery winds and also because of the variable conditions for experimental purposes of some of the trial sites. The erratic nature of the air movement is illustrated in the 2nd *Ae. taeniorhynchus* test at Site 3 where, uncharacteristically, 100% mortality was achieved at 40 cm height at 100 m distance compared with only 93% at 160 cm, at 50 m distance. A further example is the fourth *Cx. pipiens* test at Site 2 where, in the 100 m cages, the mortality was 100% in both cages on one bracket, but very low on the other two brackets.

Nevertheless the data demonstrate that the new formulation of bendiocarb does kill mosquitoes at a rate of the order of 74 ml/min. The *Cx. quinquefasciatus* of field origin used in the tests is known to

Table 1. Insecticide rates, mosquito mortalities and climatic conditions during tests, Lake Charles, La., 24th October–6th November 1979.

Females only		Site No.	Percentage Mortalities at 12 hours					Insect. Rate ml/min	Climatic Conditions		
			Control (untreated)	50 m		100 m			Wind speed	Wind direction	Temp. °C
				160 cm	40 cm	160 cm	40 cm				
Aedes aegypti	L	3	2	59	52	93	73	74	4	N	25.5
		1	1	100	97	100	91	74	6	S	24.5
		1	0	100	100	98	95	74	13	S	25.5
		1	0	100	92	91	74	74	8	S	25.5
Aedes sollicitans	F	2	1	100	100	100	100	98	8	NW	23
		2	2	89	79	94	78	74	8	N	19.5
		2	0	100	92	99	67	74	5	N	17
Aedes taeniorhynchus	L	1	0	89	79	51	32	74	3	ENE	17
		3	1	93	98	98	100	74	4	N	25.5
Aedes triseriatus	L	2	2	98	77	92	50	74	5	N	17
Culex pipiens	L	1	7	100	100	100	100	74	13	S	25.5
		1	8	100	100	98	100	74	8	S	25.5
		2	2	100	99	95	83	53	5	SE	20.5
		2	2	100	96	54	34	53	10	N	21
Culex quinquefasciatus	F	1	0	75	65	46	17	74	6	SE	24.5
		2	0	100	95	91	52	98	8	NW	23
Anopheles quadrimaculatus	L	2	2	98	78	44	13	74	6	N	22
Anopheles albimanus	L	1	0	100	100	100	100	74	6	S	24.5

L = Laboratory Stock F = Field Stock.

be difficult to control with malathion and naled. Actual insecticide tolerance to these insecticides is not proven but this species does not appear to be fully susceptible at 74 ml/min. It is unfortunate that when a higher rate of 98 ml/min was tested, the weather and site conditions were not conducive to optimum kill, but a much better mortality was achieved. No further tests on this species were possible.

The formulation functioned perfectly through the Micro-Gen sprayer. No daily cleaning or flushing out was necessary, even though the pump was primed during the intervals.

Air samples taken from four series of single pass emissions at 100 ml/min showed that the mean concentration of insecticide in air was 0.016 mg ai m^3 over the 5 min. sampling period which is well below the industrial TLV (Threshold Limit Value) TWA (Time Weighted Average) over an 8-hr day or 40-hr working week of 0.2 mg ai/m^3.

The results are extremely promising and justify further field testing under more typical climatic conditions.

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