

EFFICACY OF VARIOUS GROUND-APPLIED COLD AEROSOL ADULTICIDES AGAINST *ANOPHELES QUADRIMACULATUS*¹

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ABSTRACT. Ground-applied ULV, cold aerosol insecticides were tested against adult female *Anopheles quadrimaculatus*. Treatments included high (H) and low (L) rates of Permanone® (permethrin), bioresmethrin and esbiothrin. Malathion was applied as a standard. Mortality at 24-h posttreatment was highest with Bioresmethrin H at 15 m. Permanone H exhibited good control out to 60 m (88.9%), but dropped to an unacceptable level (65.5%) at 90 m. The low rates of all compounds produced unsatisfactory results at 24-h posttreatment. Recovery from knockdown occurred in all treatments with the exception of malathion.

INTRODUCTION

Most of the mosquito problems of eastern Arkansas emanate from rice fields and poorly drained flood plains (Coombes and Meisch 1976). Ultra low volume (ULV) cold aerosol generators continue to be important for the control of adult mosquito populations in this region. Control of adult mosquitoes within the city of Stuttgart, AR, is primarily accomplished by truck-mounted ULV sprayers, with aerial applications supplementing ground treatments when warranted (Weathersbee et al. 1989). Although excellent control may be achieved immediately following ULV ground applications, migration of mosquitoes from untreated areas often necessitates nightly treatments (Walker and Meisch 1982, Weathersbee et al. 1986). Presently, the selection of available insecticides is limited because of restrictions in labeling for application on land designated for agricultural use. In an effort to avoid resistance, new alternative insecticides must be developed and placed in a rotational scheme to reduce the selective pressure placed on mosquito populations by the few available compounds. Resmethrin continues to be an effective means of controlling *Anopheles quadrimaculatus* Say in the region whereas fenthion was ineffective at the maximum allowable rate (Weathersbee et al. 1989). The following study was undertaken to evaluate 2 new alternative insecticides, bioresmethrin and esbiothrin, against *An. quadrimaculatus* adults as compared with 2 previously labeled standards, Permanone® and malathion.

MATERIALS AND METHODS

Adult *An. quadrimaculatus*, primarily blooded females, were collected with handheld (Meek et al. 1985) and backpack aspirators (U.S. Department of Agriculture, Medical and Veterinary Entomology Research Laboratory, Gainesville, FL 32604) from a livestock barn near Stuttgart, AR. The mosquitoes were placed in cooled polystyrene containers, and transported to a holding facility near the test site. They were anesthetized with CO₂ and transferred to cylindrical screened test cages as described by Sandoski et al. (1983). Approximately 25 mosquitoes were placed in each test cage. The caged mosquitoes were stored in polystyrene containers and transported to the test site. Mosquitoes were tested within 3 h following capture for the evening test. Mosquitoes for the morning test were placed in the test cages and held overnight prior to the test and offered a 10% sugar water solution for nourishment. This was done because of the difficulty of collecting resting *Anopheles* early in the morning. Three replicated tests were conducted between 1900 and 2100 h on July 31–August 2 and between 0600 and 0800 h on August 1 and 2, 1989. The test site was located on nonagricultural land near the University of Arkansas Rice Research and Extension Center approximately 14.5 km east of Stuttgart, AR. Wind speed, monitored with a ball movement anemometer, was between 1 and 8 km/h. Temperatures ranged between 26 and 32°C and between 24 and 26°C for the evening and morning tests, respectively. The test plots consisted of 2 rows of stakes placed at 15, 30, 60 and 90 m downwind and perpendicular to the spray path. Cages of mosquitoes were suspended from these stakes approximately 100 cm above the ground.

Experiments were conducted using a Leco Model 1600 HD cold aerosol generator driven at 11.3 km/h for the low dosage application and 24.1 km/h for the high. A nozzle pressure of 422 g/cm² was used. Droplet size was calibrated by the volume median diameter (VMD) method prior to each test.

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Bioresmethrin and esbiothrin were mixed 2:1 with Orchex[®] 796 and applied at 1.1 and 0.55 g AI/ha. Droplet sizes were 20.43 and 20.26 μm , respectively. Permanone was mixed 1:4 with Orchex 796 and applied at 1.7 and 0.85 g AI/ha with a droplet size of 20.15 μm . Malathion was applied at 56.8 g AI/min with a droplet size of 16.27 μm .

The treatment cages were positioned just prior to each test and removed 5 min after exposure. They were then immediately transported to the holding facility. Control cages were handled similarly but in a separate area near the holding facility. The mosquitoes were anesthetized with CO_2 within 1-h posttreatment and transferred to clean, 237-ml paper cups with screen lids. An aqueous solution containing 10% sugar was provided on cotton placed on top of the screen lids. Mosquitoes were observed at 1- and 24-h post-treatment to determine initial knockdown and 24-h mortality.

Data were corrected for control reductions by Abbott's formula (Abbott 1925), arcsine transformed and subjected to analysis of variance (ANOVA). Means were separated by Duncan's multiple range test (SAS Institute 1985).

RESULTS AND DISCUSSION

Results for 1-h knockdown and 24-h mortality are presented in Table 1. Malathion exhibited significantly less knockdown than all other treatments at all distances except 90 m. At the 15 m distance, only malathion was significantly less effective than the other treatments after 1

h. Greater separation between the treatments occurred by 24 h with the high rates of bioresmethrin and Permanone exhibiting significantly ($P \leq 0.05$) greater control than all other treatments except the high rate of esbiothrin.

The knockdown produced by the high rate of bioresmethrin at 30 m was significantly greater than that produced by the high and low rates of Permanone, malathion and bioresmethrin L. Bioresmethrin and Permanone H did not differ significantly ($P > 0.05$) from the high or low rates of esbiothrin. By 24 h, Permanone H demonstrated the highest mortality and was significantly ($P \leq 0.05$) greater than all other treatments except the high rates of bioresmethrin and esbiothrin.

The knockdowns by the high rates of Permanone and both rates of esbiothrin at 60 m were significantly ($P \leq 0.05$) greater than all other treatments except the high rate of bioresmethrin. The high rate of Permanone exhibited significantly greater ($P \leq 0.05$) control at 24 h than all other treatments except the high rate of bioresmethrin. Mortalities among the remaining treatments were not significantly ($P > 0.05$) different.

The high and low rates of bioresmethrin and the high rate of esbiothrin produced significantly greater ($P \leq 0.05$) knockdown than that of Permanone L and malathion at 90 m. Permanone H produced significantly greater ($P \leq 0.05$) knockdown than that produced by malathion. The remaining treatments, the low rates of Permanone and esbiothrin and malathion,

Table 1. Efficacy of various insecticides applied by ULV cold aerosol against adult female *Anopheles quadrimaculatus* at Stuttgart, AR, during the summer of 1989.

Treatment	Rate (g AI/ha)	Distance*			
		15 m	30 m	60 m	90 m
1 h-knockdown					
Bioresmethrin H	1.10	94.6 a	98.8 a	85.8 ab	84.5 a
Esbiothrin H	1.10	96.5 a	88.6 ab	91.7 a	92.0 a
Permanone H	1.70	73.6 a	78.6 bc	88.9 a	58.7 ab
Malathion	56.80	8.8 b	8.2 e	3.5 d	2.1 c
Bioresmethrin L	0.55	82.6 a	70.5 cd	62.8 b	69.2 a
Esbiothrin L	0.55	93.8 a	93.9 ab	88.2 a	52.5 abc
Permanone L	0.85	70.8 a	47.1 d	35.9 c	14.7 cb
24-h mortality					
Bioresmethrin H	1.10	86.1 a	72.9 ab	65.0 ab	58.7 abc
Esbiothrin H	1.10	67.2 ab	70.1 ab	61.8 b	63.5 ab
Permanone H	1.70	75.9 a	79.0 a	87.6 a	65.5 a
Malathion	56.80	44.8 b	52.2 bc	39.3 b	32.1 cd
Bioresmethrin L	0.55	44.7 b	54.7 bc	31.3 b	33.1 bcd
Esbiothrin L	0.55	42.1 b	46.0 bc	32.1 b	18.0 d
Permanone L	0.85	38.4 b	35.3 c	32.5 b	13.4 d

* Means for the particular time in the same column followed by the same lower case letter are not significantly different ($P > 0.05$).

were not significantly different ($P > 0.05$). The high rate of Permanone exhibited significantly greater mortality than all the treatments other than the high rates of esbiothrin and bioresmethrin at 24 h.

Recovery of mosquitoes that were knocked down was extremely high, especially for the low rates of bioresmethrin and Permanone and both rates of esbiothrin. Resistance of Arkansas mosquitoes to pyrethroids is not suspected; however, results from topical application studies completed in the summer of 1990 appear to indicate the presence of resistance to malathion and fenitrothion (unpublished data).

Based on this study, malathion apparently is failing to control *An. quadrimaculatus* at the rate applied. It showed little capacity for knockdown, and mortality was unsatisfactory. Bioresmethrin and esbiothrin exhibited excellent knockdown but allowed a high rate of recovery that might be avoided by increasing the application rates or droplet size. Permanone H exhibited good knockdown and allowed little recovery. The performance of these new compounds warrants further experimentation to determine effective application rates. Studies done in 1988 (unpublished data), using a larger droplet size, showed Permanone to be highly effective against *An. quadrimaculatus*. These compounds appear to show potential as alternative adulticides in mosquito control programs in which avoidance of resistance formation is a primary concern.

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