EFFECTIVENESS OF NINE PYRETHROIDS AGAINST *ANOPHELES QUADRIMACULATUS* SAY AND *PSOROPHORA COLUMBIAE* (DYAR AND KNAB) IN ARKANSAS[1]

R. H. ROBERTS, K. F. BALDWIN, J. L. PINSON

Insects Affecting Man and Animals Research Laboratory, Agricultural Research, Science and Education Administration, USDA, Gainesville, FL 32604

AND

TODD W. WALKER AND M. V. MEISCH

Arkansas Experiment Station and Extension Service, University of Arkansas, Fayetteville 72701.

ABSTRACT. Nine pyrethroids, both alone and synergized with piperonyl butoxide, were tested as wind-tunnel-generated aerosols against field-collected females of *Anopheles quadrimaculatus* Say and *Psorophora columbiae* (Dyar and Knab). All pyrethroids tested were more effective than malathion and their toxicity was enhanced by combination with piperonyl butoxide. The reciprocal LC–90 ratios to malathion for the unsynergized pyrethroids ranged from 11.9 to 313.6 against *An. quadrimaculatus* and from 1.3 to 25.4 against *Ps. columbiae*. The least effective unsynergized pyrethroid, fenvalerate, was enhanced the most (5.2X–8.8X) by the synergist. The malathion standard had an LC–90 of 2195 μg/ml against *An. quadrimaculatus* and 355 μg/ml against *Ps. columbiae*.

Nine pyrethroids previously evaluated against a laboratory strain of *Anopheles quadrimaculatus* Say at the Insects Affecting Man and Animals Research Laboratory, Agricultural Research, Science and Education Administration, USDA, were further evaluated against field-collected specimens of *An. quadrimaculatus* Say and *Psorophora columbiae* (Dyar and Knab) at the Arkansas Rice Branch Experiment Station, Stuttgart, Arkansas. These studies are a continuation of a cooperative research program to evaluate the potential of new insecticides as mosquito control agents in the field (Mount et al. 1972, Pierce et al. 1973, Coombes et al. 1977).

MATERIALS AND METHODS

The mosquitoes used in this study were females of *An. quadrimaculatus* and *Ps. columbiae* collected from naturally occurring populations in rice fields near Stuttgart, AR. Battery powered aspirators fitted with plastic holding tubes were used to collect specimens attracted to humans and from various resting places in barns and other buildings. The tubes, which contained ca. 200 adults each, were placed in insulated chests with can ice and moist cotton. At the laboratory mosquitoes were anesthetized with carbon dioxide and placed in groups of ca. 25 each in cardboard exposure cages, 8.65 cm X 5.12 cm high with 16 mesh galvanized screen wire ends. Each of the 9 pyrethroids was tested across a range of 4–6 discriminating concentrations with 6 replicates of 25 mosquitoes/concentration. The wind tunnel and testing procedures used were described by Mount et al. (1976). Concentration-mortality data obtained in these tests were analyzed on a Hewlett-Packard Model 9810A calculator with a probit analysis program written according to the procedures given by Finney (1971).

The pyrethroid adulticides evaluated were: *d*-phenothrin ((3 - phenoxyphenyl) methyl *cis,trans* - (+) - 2,2 - dimethyl - 3 - (2 - methyl - 1 - propenyl) cyclopropanecarb-

[1] This paper reflects the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture or the Arkansas Experiment Station and Extension Service nor does it imply registration under FIFRA as amended. Also, mention of a commercial or proprietary product does not constitute an endorsement of this product by the U.S. Department of Agriculture or the Arkansas Experiment Station and Extension Service.

oxylate); permethrin ((3-phenoxyphenyl) methyl *cis, trans*-(±)-3-(2,2-dichloroethenyl) - 2, 2 - dimethylcyclopropanecarboxylate); Roussel-Uclaf RU-22090 (3-phenoxybenzyl *d-trans*-2,2-dimethyl- 3- (2,2- dichlorovinyl)- cyclopropanecarboxylate); fenvalerate (cyano(3-phenoxyphenyl)methyl 4 - chloro - α - (1 - methylethyl) benzeneacetate); *d-cis*-permethrin ((3-phenoxyphenyl) methyl *cis*-(+)-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane = carboxylate); Roussel-Uclaf RU-22950 (cyano(3-phenoxyphenyl) methyl *cis*-(+) - 3(2,2 - dibromoethenyl)-2,2-dimethylcyclopropanecarboxylate); NRDC 161 ((*S*)-[cyano(3-phenoxyphenyl)methyl] *cis*-(+)-3-(2,2-dibromoethenyl) - 2,2 - dimethylcyclopropanecarboxylate); FMC - 30980 ((±) - (cyano) (3-phenoxyphenyl) methyl (±)-*cis, trans* - 3 - (2,2 - dichloroethenyl) - 2,2 - dimethylcyclopropanecarboxylate); *cis*-permethrin (3-phenoxyphenyl) methyl (±) - *cis* - 3 - (2,2 - dichloroethenyl)-2, 2-dimethylcyclopropanecarboxylate). These materials were tested both alone and in combination with piperonyl butoxide (piperonal bis[2-(2-butoxyethoxy) ethyl]acetal) at a ratio of 1:1 (w/w) except for *cis*-permethrin, which was combined at a ratio of 1:5 *cis*-permethrin:synergist. These ratios were based on optimum effectiveness determined by laboratory tests at 4 different ratios. Malathion (*0,0*-dimethyl phosphorodithioate of diethyl mercaptosuccinate) was used as the standard. Controls of both species, treated with acetone only were run concurrently with all insecticide tests. Control mortality ranged from 0 to 6% for *An. quadrimaculatus* and from 0 to 3% for *Ps. columbiae*.

RESULTS AND DISCUSSION

Data for toxicity of the pyrethroids against *An. quadrimaculatus* are presented in Table 1. The most effective

Table 1. Toxicity of wind tunnel generated aerosols of 9 pyrethroids to field-collected female *Anopheles quadrimaculatus* at Stuttgart, Arkansas, 1978.

Adulticide	[a]	LC-50 (μg/ml)	LC-90 (μg/ml)	LC-90 ratio U/S	Reciprocal LC-90 ratio to malathion
Roussel-Uclaf	U	1 (0.82–2)[b]	7(5–15)	3.5	313.6
RU-22950	S	0.5 (0.4–0.7)	2 (1–4)		1097.5
NRDC-161	U	1.0 (0.4–2)	13 (6–130)	6.5	168.8
	S	0.4 (0.3–0.5)	2 (1–3)		1097.5
d-cis-permethrin	U	4 (3–6)	18 (12–37)	1.8	121.9
	S	2 (2–3)	10 (8–13)		219.5
FMC-30980	U	3 (2–4)	22 (15–40)	5.5	99.8
	S	1 (0.8–1)	4 (3–5)		548.8
cis-permethrin	U	6 (3–8)	62 (31–301)	2.9	35.3
	S[c]	4 (2–5)	21 (12–62)		104.5
Roussel-Uclaf	U	12 (9–15)	76 (53–128)	1.8	28.9
RU-22090	S	11 (8–14)	43 (30–78)		51.0
Permethrin	U	11 (7–16)	88 (48–370)	2.3	24.9
	S	11 (8–14)	39 (28–66)		56.3
d-phenothrin	U	21 (15–16)	129 (95–204)	1.6	17.0
	S	17 (14–20)	78 (60–113)		28.1
fenvalerate	U	31 (24–39)	184 (131–307)	8.8	11.9
	S	5 (3–6)	21 (14–44)		104.5
Malathion		663 (561–776)	2195 (1726–3100)		

[a] U—Unsynergized; S—Synergized with piperonyl butoxide at a 1:1 ratio.
[b] Figures in parentheses are the 95% confidence limits.
[c] Synergized at a ratio of 1:5 *cis*-permethrin:piperonyl butoxide.

Table 2. Toxicity of wind tunnel generated aerosols of 9 pyrethroids to field-collected females of *Psorophora columbiae* at Stuttgart, Arkansas, 1978.

Adulticide	[a]	LC–50 (μg/ml)	LC–90 (μg/ml)	LC–90 ratio U/S	Reciprocal LC–90 ratio to malathion
NRDC–161	U				177.5
	S	0.6 (0.4–0.7)[b]	2 (2–3)		
FMC–30980	U	4 (3–6)	14 (10–26)	1.8	25.4
	S	2 (1–3)	8 (6–16)		44.4
d-cis-permethrin	U	6 (2–9)	15 (10–96)	1.7	23.7
	S	2 (2–3)	9 (6–17)		39.4
Roussel-Uclaf RU–22950	U	4	18	4.5	19.7
	S	1 (0.7–1)	4 (2–7)		88.8
cis-permethrin	U	7 (4–9)	20 (14–41)	1.2	17.8
	S[c]	4 (3–5)	17 (10–44)		21.0
Permethrin	U	20 (13–28)	42 (29–108)	2.5	8.4
	S	6 (4–7)	17 (13–28)		20.9
Roussel-Uclaf RU–22090	U	9	46	3.8	7.7
	S	4 (3–5)	12 (8–25)		29.6
d-phenothrin	U	33 (26–40)	113 (88–160)	4.5	3.1
	S	9 (7–11)	25 (19–39)		14.2
fenvalerate	U	61 (42–83)	276 (174–705)	5.2	1.3
	S	15 (11–20)	53 (36–105)		6.7
Malathion		112 (92–134)	355 (278–507)		

[a] U—Unsynergized; S—Synergized with piperonyl butoxide at a 1:1 ratio.
[b] Figures in parentheses are the 95% confidence limits.
[c] Synergized at a ratio of 1:5 *cis*-permethrin:piperonyl butoxide.

insecticide was RU–22950 followed by NRDC 161, *d-cis*-permethrin, and FMC-30980. The least effective insecticide was fenvalerate. Addition of piperonyl butoxide increased the toxicity of the pyrethroids by factors ranging from 1.6X to 8.8X. Increases in toxicity were largest for fenvalerate (8.8X), NRDC–161 (6.5X) and FMC–30980 (5.5X). The reciprocal LC–90 ratios to malathion for the unsynergized pyrethroids ranged from 11.9 to 313.6. The LC–90 level for malathion, 2195 μg/ml, with field-collected *An. quadrimaculatus* was ca. 16X greater than the LC–90 level with our laboratory strain.

Toxicity data of the pyrethroids against *Ps. columbiae* are presented in Table 2. Tests were not made on unsynergized NRDC–161 and only one replicate was used with RU–22950 and RU–22090. The relative order of toxicity was similar to that for *An. quadrimaculatus*. Generally, (6 out of 9), the unsynergized and synergized pyrethroids were more toxic against *Ps. columbiae* than for *An. quadrimaculatus*. The addition of piperonyl butoxide increased the effectiveness of the pyrethroids by factors ranging from 1.4 to 5.2. The largest increase was found for fenvalerate. Three compounds, RU–22950, RU–22090 and *d*-phenothrin, were more effectively synergized against *Ps. columbiae* than against *An. quadrimaculatus*. Three other compounds, FMC–30980, *cis*-permethrin and fenvalerate were less effectively synergized. The reciprocal LC–90 ratios to malathion for the unsynergized pyrethroids ranged from 1.3 to 25.4. The LC–90 level for malathion with *Ps. columbiae* was 355 μg/ml. This contrasts to an LC–90 of 1442 μg/ml reported by Coombes et al. (1977) and 140 μg/ml reported by Pierce et al. (1973).

References Cited

Coombes, L. E., K. F. Baldwin, M. V. Meisch, G. A. Mount, N. W. Pierce and G. D. Thompson. 1977. Toxicity of pyrethroid insecticide aerosols to *Anopheles quadrimaculatus* Say and *Psorophora columbiae* (Dyar and

Knab) in Arkansas. Mosquito News 37:268–270.

Finney, D. J. 1971. Probit Analysis, 3rd edition, Cambridge University Press. 333 pp.

Mount, G. A., N. W. Pierce and K. F. Baldwin. 1976. A new wind-tunnel system for testing insecticidal aerosols against mosquitoes and flies. Mosquito News 36:127–131.

Mount, G. A., M. V. Meisch, J. T. Lee, N. W. Pierce and K. F. Baldwin. 1972. Ultralow volume ground aerosols of insecticides for control of rice field mosquitoes in Arkansas. Mosquito News 32:444–446.

Pierce, N. W., K. F. Baldwin, M. V. Meisch and G. A. Mount. 1973. Effectiveness of ten adulticides against *Psorophora confinnis* (Lynch-Arribálzaga) in Arkansas. Mosquito News 33:418–420.