FIELD EVALUATION OF NEW MOSQUITO LARVICIDES AND THEIR IMPACT ON SOME NONTARGET INSECTS

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ABSTRACT. Two synthetic pyrethroids and 5 new organophosphate larvicides were evaluated in the field against stagnant and floodwater mosquitoes. The acute effects of some of these larvicides on some nontarget aquatic insects were also assessed.

The synthetic pyrethroid FMC-33297 [3-Phenoxybenzyl (± *cis-trans*-3-(2.2-dichlorovinyl-2 dimethylcyclopropanecarboxylate] was the most effective, yielding complete control of larvae and pupae of *Culiseta inornata* Williston at the rate of 0.025 lb/acre. At this rate, it also yielded almost complete control of *Psorophora confinnis* (L-A) in an irrigated hay field. At lower rates (0.005–0.01), this material was as toxic to mayfly naiads and dragonfly naiads as it was to the target mosquitoes.

Among the OP larvicides, CGA-15324 [*O*-(4-bromo-2-chlorophenyl) *O*-ethyl *S*-propyl phosphorothioate] was the most effective one. At 0.05 lb/acre, it produced complete control of *Culex tarsalis* Coquillett larvae and pupae. At this rate, it also yielded complete control of *P. confinnis* in irrigated hay pasture. At larvicidal rate (0.05 lb/acre) this material produced complete mortality of mayfly naiads, but had no marked effect on dragonfly naiads.

The other synthetic pyrethroid and some of the OP larvicides studied, showed good to low activity against the target mosquito species, producing good control at the rates of 0.025–0.1 lb./acre. Most of these possessed high level of toxicity to mayfly naiads, but showed lower toxicity to dragonfly naiads.

INTRODUCTION

In earlier studies, some synthetic pyrethroids showed good activity against larvae and pupae of various species of mosquitoes in the laboratory and field (Darwazeh and Mulla 1974). A number of these compounds were also active against the adults of the pasture mosquito *Aedes nigromaculis* Ludlow, as well as other species, when applied by air or with a nonthermal ground aerosol generator (Mulla et al. 1973, Darwazeh and Mulla 1975, Mount and Pierce 1975, Haskins et al. 1974).

Recent field evaluation of some experimental pyrethroids showed exceptional activity against larvae and pupae of *Culex tarsalis* Coquillett and *Ae. nigromaculis*. At the rate of 0.025 lb/A, FMC-33297 [3-Phenoxybenzyl (±) *cis-trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate] produced complete control of larvae and pupae of *Culex* species in experimental ponds, while complete control of larvae of a resistant strain *Ae. nigromaculis* was achieved at the rate of 0.01 lb/A (Mulla et al. 1975). From these findings, it is apparent that the *Aedes* larvae, in general, are more susceptible to the synthetic pyrethroids, regardless of their susceptibility to other commonly used larvicides.

The current studies were conducted to determine the optimum rate of application of these, as well as other newer larvicides, against several species of mosquitoes and some non-target organisms. The efficacy of these new compounds was assessed under field conditions against larvae and pupae of *Aedes* and *Culex* mosquitoes.

MEHODS AND MATERIALS

Several chemicals were screened in the laboratory against 4th-instar *Culex pipiens quinquefasciatus* Say. Those materials with an LC_{90} of <0.01 ppm were evaluated further under field conditions. These were SD-43775 [Benzeneacetic acid 4-chloro-alpha-(1-methylethyl)-cyano(3-phenoxyphenyl) methyl ester], FMC-33297 [3,Phenoxybenzyl (±) *cistrans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate)], CGA-15324 [*O*-(4-bromo-2-chlorophenyl)-*O*-ethyl *S*-propyl phosphorothioate], CGA-12223 [*O*-5-chloro-1-(1-methylethyl)-1 H-1,2,4-triazol-3-yl *O,O*-diethyl phosphorothioate], CGA-18809 [S-(6-chloro-2-oxoxazolo [4,5-b] pyridin-3 [2H]-yl) methyl *O,O*-dimethyl phosphorothioate], N-2596 (*O*-ethyl-*S*-*p*-chlorophenyl ethyl phosphonodithioate), S-2957 (Diethyl 2,5-dichloro-4-methylthiophenyl posphorothionate).

Emulsifiable concentrates and granular formulations were utilized in field studies conducted in experimental ponds against *Culex* and *Culiseta* and floodwater mosquitoes in field plots in alfalfa fields and irrigated pastures. Experimental ponds are located at the Aquatic Research Facilities in Oasis in the Coachella Valley and at the University of California at Riverside. Detailed description of these facilities were published elsewhere (Mulla and Darwazeh 1971).

EXPERIMENTAL PONDS. The granular formulations were applied by hand from the sides, covering the entire pond. The required amount of EC formulation for each rate was mixed with 100 ml of water and applied with a 1 qt. all-purpose household sprayer. Mosquito populations in the Oasis ponds consisted of all immature stages of either *Culex tarsalis* Coquillett or *Culiseta inornata* Williston, while *Cx. tarsalis* prevailed in the ponds at Riverside. In each test, 2 ponds were utilized per dosage and 2 ponds left untreated. Either 5 or 10 dips per pond were taken prior to treatment and at indicated intervals after treatment. Percent reduction was calculated from the number of 3-4 stage larvae and pupae recovered in the pre- and post-treatment counts. In the tests conducted in the Oasis ponds, the 5 dips were concentrated into one sample after removing excess water through a cup with holes covered with 125 mesh stainless steel cloth. The 5 dips composite sample was preserved with 95% ethyl alcohol, and the mosquitoes present in the sample were identified and counted in the laboratory under a dissecting microscope.

FIELD PLOTS. Tests were conducted against larvae and pupae of floodwater mosquitoes, the California population of the *Psorophora confinnis* (L-A) complex in the Palo Verde Valley, and *Aedes nigromaculis* Ludlow in the southern San Joaquin Valley. In the Palo Verde Valley, the trials were conducted in 1/16-acre plots in Seeley and Jiminez alfalfa fields, located on 16th Avenue and Defraine Blvd., and Robinson alfalfa on 10th Avenue, east of Intake Blvd., near the city of Blythe. In the San Joaquin Valley, 1/32 acre plots were used in Fornasero pasture, located on Avenue 182, southwest of the Golden State freeway in Tulare County.

In each test, 2 plots were used per rate, and 2 plots left untreated as checks. The required amount of toxicant was mixed with 500-1000 ml of water, according to plot size, and applied with a ½ gallon handsprayer. Ten dips per plot were taken prior to and 4 and 24 hours after treatment, and percent reduction was based on the number of larvae and pupae recovered in the pre- and post-treatment counts.

RESULTS AND DISCUSSION

CGA-15324 showed high biological activity against *Cx. tarsalis*, yielding complete control of larvae and pupae 7 days after treatment at the rates of 0.05-0.10 lb/A (Table 1, Test 1). At these same rates, poor results were obtained with CGA-12223 and CGA-18809. At higher rates (0.25-0.5 lb/A), almost complete control of larvae and pupae was obtained with CGA-12223, and only 51-67% reduction was obtained with CGA-18809 (Table 1, Test 2). The synthetic pyrethroid FMC-33297 produced excellent control of larvae and pupae. These findings were similar to those reported earlier (Mulla et al. 1975). At the rates of 0.025 and 0.05 lb/A, 98 and 100% control of larvae and pupae was obtained 7 days after treatment (Table 1, Test 2). As noted in the earlier studies, the effective dosage (producing complete mortality) of this material against stagnant water mosquitoes is in the order of 0.025 lb/A.

Mulla et al. (1975) reported that an emulsifiable concentrate formulation of the OP larvicide S-2957 gave excellent control of *Cx. tarsalis* at the rate of 0.025 lb/A. In order to determine the efficacy of this and another OP material, N-2596, 3 granular formulations were evaluated against *Cs. inornata* at 0.025 and 0.05 lb/A. The formulations were either quick or slow releasing, and induced gradual reduction of the population, producing the bulk of mortality 7 days after treatment (Table 1, Test 3). Larvae were almost completely eliminated by all treatments, but the pupae were still found in fair numbers. Since these compounds are organophosphates, marked reduction in pupal numbers was not expected. It appears that, under the test conditions, the release from granular formulations is not adequate to yield a high level of control of *C. inornata* at the administered rates.

In 2 field experiments conducted in alfalfa hay pastures against *P. confinnis*, the synthetic pyrethroid FMC-33297, yielded a low level of control at the rates of 0.005 and 0.01 lb/A (Table 2). However, at the higher rates of 0.025 and 0.05 lb/A, this compound yielded almost complete control of larvae. The synthetic pyrethroid SD-43775 was ineffective at the rates of 0.01 and 0.05 lb/A but yielded a mediocre level of control (80% reduction) at 0.1 lb/A.

Table 1. Evaluation of various mosquito larvicides against larvae and pupae in experimental ponds (Oasis, California)

Material and formulation		Rate lb/A	Avg. no. of larvae and pupae/5-dip sample and % reduction							
			Pretreatment		Posttreatment (days) 2			7		
			3–4	P	3–4	P	(% R)	3–4	P	(% R)
			Test 1,[a] November 1974							
CGA-12223	EC 4	0.05	50	1	32	3	0	2[illegible]	26	10
		0.10	92	1	43	1	53	17	11	70
CGA-15324	EC 4	0.01	40	1	49	1	0	23	6	5
		0.05	25	1	2	1	88	0	0	100
		0.10	59	1	2	1	95	0	0	100
CGA-18809	EC 4	0.05	42	2	102	6	0	67	19	0
		0.10	45	0	49	0	0	3[illegible]	3	27
Check		——	30	0	41	2	0	31	7	0
			Test 2,[b] December 1974							
CGA-12223	EC 4	0.25	29	4	3	4	79	1	1	94
		0.50	54	11	0	12	82	0	2	97
CGA-18809	EC 2	0.25	6	15	12	14	0	3	16	10
		0.50	53	51	11	24	67	7	44	51
FMC-33297	EC 0.8	0.025	35	15	3	0	94	1	0	98
		0.05	23	13	1	0	99	0	0	100
Check		——	11	3	14	3	0	12	5	0
			Test 3,[b] December 1974							
N-2596 1 G 15/30		0.035	18	7	10	9	24	1	4	80
		0.050	21	35	21	28	12	4	23	52
S-2957 1.5 G 15/30		0.025	33	40	4	38	45	1	20	72
Quick release		0.05	10	16	2	17	27	1	8	65
S-2957 1.5 G 15/30		0.025	18	31	12	32	11	0	11	78
Slow release		0.050	18	21	11	13	39	0	7	83
Check		——	12	7	15	10		7	12	0

[a] *Culex tarsalis.*
[b] *Culiseta inornata.*

Table 2. Evaluation of various mosquito larvicides against larvae and pupae of *Psorophora confinnis* in alfalfa (Blythe, Calif.).

Material and formulation		Rate lb/A	Avg. no. of larvae and pupae/10 dips				
			Pre-treat		Post-treat (24 hrs)		
			L	P	L	P	(% R)
Seeley—Aug. 28, 1975							
FMC-33297	EC 0.8	0.005	1180	0	490	470	19
		0.010	1550	0	550	840	17
SD-43775	EC 2.4	0.01	2580	0	860	1230	19
		0.05	1230	0	920	1090	0
CGA-15324	EC 4	0.025	1080	0	190	330	52
		0.05	790	0	0	0	100
Check		——	520	0	340	210	0
Robinson—Aug. 29, 1975							
FMC-33297	EC 0.8	0.025	40	0	1	0	97
		0.050	60	0	0	0	100
SD-43775	EC 2.4	0.05	110	0	50	0	55
		0.10	40	0	8	0	80
Check		——	30	0	30	0	0

The latter compound is thus less effective than FMC-33297.

The pyrethroid SD-43775 was further studied against *C. tarsalis* in experimental ponds and against *A. nigromaculis* (resistant strain) in an irrigated pasture. At 0.1 lb/A, this material yielded a high level of control of the former species (Table 3) killing both larvae and pupae (dead pupae observed in treated plots). This material,

Table 3. Evaluation of the synthetic pyrethroid SD-43775 (EC 2.4) against larvae and pupae of 2 mosquito species.

Rate lb/A	Avg. no. of larvae and pupae/10 dips							
	Pre-treatment		Post-treatment (hrs.)					
			4			24		
	L	P	L	P	(% R)	L	P	(% R)
Culex tarsalis [a]								
0.05	50	2	22	2	54	6	2	85
0.10	42	0	12	0	72	2	0	95
Check	28	2	46	4	0	48	2	0
Aedes nigromaculis [b]								
0.005	580	250	0	60	93	0	30	96
0.010	230	260	0	180	64	0	40	92
0.025	650	560	0	100	92	0	40	97
0.050	650	390	0	50	96	0	40	96
0.100	1420	930	0	80	87	0	40	98
Check	230	150	200	350	0	150	280	0

[a] Experimental ponds, Riverside Aquatic Research Facilities.

[b] Fornasero Pasture, Tulare, California.

Table 4. Effect of various mosquito larvicides on nontarget insects in experimental ponds (Oasis, Calif., 1974).

Material and formulton	Rate lb/A	Avg. no. of nontargets/5-dips post-treatment (days)							
		MFN[a]				DFN[b]			
		Pre	2	7	14	Pre	2	7	14
CGA-1223 EC 4	0.05	36	0	0	0	0	0	4	14
	0.10	22	0	0	0	0	1	1	19
	0.25	51	0	0	–	9	5	4	–
	0.50	60	0	0	–	7	3	2	–
CGA-15324 EC 4	0.01	18	1	0	2	0	0	8	19
	0.05	20	0	0	0	0	1	0	7
	0.10	19	0	0	0	2	1	0	6
CGA-18809 EC 2	0.05	12	7	16	36	2	2	40	26
	0.10	11	0	1	6	0	1	56	27
	0.25	10	0	0	–	7	2	5	–
	0.50	98	0	0	–	24	5	19	–
FMC-33297 EC 0.8	0.025	6	0	0	–	7	1	0	–
	0.050	5	0	0	–	13	0	0	–
Check	–	46	30	60	30	1	0	20	28
	–	8	10	12	–	15	14	18	–
N-2596 1 G	0.025	48	6	0	–	13	7	3	–
	0.050	105	91	0	–	14	8	0	–
S-2957 1.5 G Quick release	0.025	47	0	0	–	22	12	2	–
	0.050	8	0	0	–	21	7	0	–
S-2957 1.5 G Slow release	0.025	96	102	1		21	14	4	–
	0.050	60	42	0		20	12	3	–
Check	–	33	48	54		21	22	8	

[a] Mayfly naiads.
[b] Dragonfly naiads.

however, showed exceptional activity against larvae and pupae (dead pupae recovered from treated plots) of *A. nigromaculis* in the irrigated-pasture habitat. Larvae were completely controlled, but pupae were not controlled completely. This larvicide proved somewhat inferior to the pyrethroid FMC-33297 as evaluated against *A. nigromaculis* earlier (Mulla et al. 1975), and its minimum dosage producing high mortality has yet to be determined.

NONTARGET ORGANISMS. Mayfly naiads (Baetidae) were highly susceptible to all chemicals tested (except CGA-18809) at the rate of 0.025-0.1 lb/A (Table 4). CGA-18809 at 0.25 and 0.5 (rates below larvicidal) produced heavy mortality of mayfly naiads. This compound is not a good larvicide and has to be employed at higher rates. CGA-12223 at rates below those required for larviciding severely affected mayfly naiads. CGA-15324 at rates lower than larviciding also caused almost complete mortality of mayfly naiads with no recovery up to 14 days after treatment. FMC-33297 also decimated these organisms at larvicidal rates. Dragonfly naiads (Libellulidae) were not affected by most of the treatments with these materials. The synthetic pyrethroid FMC-33297, however, suppressed their populations at the larvicidal rates of 0.025-0.05 lb/A.

The granular formulations of N-2596 and S-2957 markedly suppressed dragonfly naiads. The impact of these materials at the rates of 0.025-0.05 lb/A was almost equal to that of FMC-33297. As was the case in earlier studies (Mulla et al. 1975), the nontarget organisms generally resurged

2-3 weeks after treatment, as do the target species.

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