CHEMICAL CONTROL INVESTIGATIONS ON ECONOMICALLY IMPORTANT MOSQUITOES IN CALIFORNIA, 1960–1961 [1]

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Introduction. Although the technology of mosquito control with chemicals has developed to a high level in California, there is a continuing need for research to provide improved methods and formulations. Some of the factors that must be considered in the further development and improvement of chemical control programs are as follows: (1) highly variable aquatic habitats with resultant variations in the effectiveness of chemicals, dependent in part upon formulations; (2) development of insecticide-resistance; (3) insecticide residue problems; (4) safety of handling; and (5) concern over the effects of insecticides upon wildlife and beneficial insects.

The testing and evaluation of new insecticides constitutes a major portion of the effort directed toward accomplishing improved chemical control programs. The use of organophosphorus compounds has predominated in mosquito larvicide testing programs in California for about the past ten years (Gjullin *et al.* 1953, Lindquist 1953, Gjullin and Peters 1955, Gahan and Mulhern 1955, McFarland 1957, Lewallen 1958, Lewallen and Brydon 1958, Lewallen 1959, Lewallen and Gjullin 1960, Mulla *et al.* 1960, Mulla 1961, and Mulla *et al.* 1961), while the use of carbamates, synthetic botanicals, and chlorinated hydrocarbons has played a minor role in such programs.

Some of the organophosphorus compounds have a high degree of specificity for controlling mosquitoes, with minimal effect on predator populations. These compounds are important in that they provide one means of achieving an improved and integrated control program (Lewallen and Brydon 1958) (Lewallen 1959a) (Mulla 1961) (Mulla and Isaak 1961).

Many organophosphorus compounds are rapidly hydrolyzed when applied to aquatic habitats; the use of these materials is to be encouraged where residues are undesirable.

Resistance to organophosphorus compounds by mosquitoes appears to have been quite specific in California, and it has been possible to regain control by substituting different organophosphorus materials (Gjullin and Isaak 1957) (Lewallen and Nicholson 1959). In time, however, it is likely that organophosphorus multi-resistant strains will develop.

Field Tests with Conventional Insecticides. The results of field tests conducted on 1/32-acre irrigated pasture plots are presented in Table 1. These tests were conducted during the summers of 1960 and 1961. Test methods were the same as outlined previously (Lewallen 1958) except that the finished spray was made with 1/2 gallon of water.

Baytex® and Bayer 34098 were the most effective organophosphorus compounds tested against 4th instar *Aedes nigromaculis, Culex tarsalis* and *Anopheles freeborni*. American Cyanamid EN 18133 exhibited a high degree of toxicity to mosquito larvae; however, it is highly toxic to mammals and fish. Hercules AC5727 was the most effective carbamate tested, and appears to offer promise as a mosquito control agent. Dimethrin, a chrysanthemumic acid ester, when combined with piperonyl butoxide did not perform as well

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as barthrin, another synthetic botanical which was tested earlier (Lewallen and Gjullin 1960).

Methyl Trithion was very effective against *A. freeborni* at 0.25 lb/acre. Earlier work with this compound on *A. nigromaculis* and *C. tarsalis* indicated that it was highly effective at this same dosage (Lewallen and Gjullin 1960).

Butonate, carbophenothion (Trithion®), Bayer 41831 (Sumithion), Stauffer R-1504 and Hercules 7522H exhibited a fair degree of toxicity as mosquito larvicides at from 0.25 to 1.5 lb/acre. Carbopheno-

TABLE 1.—Field tests 1960–1961.

Compound	Dosage lb./acre	24 hr. % mortality of 4th instar larvae		
		A. nigromaculis	*C. tarsalis*	*A. freeborni*
Hercules AC5727	0.1	99	80	87
" "	0.25	100	99	..
EN18133 (Cynem ®)	0.05	96	93	3
" "	0.1	100	99	15
" "	0.15	..	100	100
Bayer 41831 (Sumithion)	0.05	..	67	7
" " "	0.1	..	100	35
" " "	0.25	..	..	96
" " "	0.3	99	..	100
Stauffer R-1504 (1 lb./gal.)	0.25	22	..	35
"	0.5	..	72	76
"	1.0	42	..	100
"	2.0	100	..	..
Stauffer R-1504 (4 lb./gal.)	0.25	15	..	..
"	0.75	..	99	8
"	1.0	65	100	25
"	2.0	96	..	..
Hercules 7522H	0.5	41	99	41
" "	1.0	99	100	80
" "	1.5	..	..	92
Bayer 34098	0.025	..	..	44
" "	0.05	38	90	100
" "	0.1	93	100	..
Dimethrin	0.5	..	..	..
"	+0.5 syner.	98	97	..
"	0.75	..	..	..
"	+0.75 syner.	..	100	..
Baytex ®	0.0125	94	71	..
"	0.025	100	100	91
	0.05	100	100	100
Trithion ® (Carbophenothion)	0.3	..	..	98
" "	0.5	..	..	100
Methyl Trithion ®	0.1	..	..	96
" "	0.25	..	..	100
Butonate	0.1	40	..	..
"	0.5	60	20	..
"	1.0	60	55	..

thion (Trithion®) is very stable in alkaline water and persists up to 72 hours after application at 0.5 lb/acre (Lewallen 1963).

FIELD TESTS WITH SPECIAL COMPOUNDS. Certain quaternary ammonium compounds developed primarily for use as germicides have been effective for mosquito control when applied to water in containers such as pickle barrels, olive vats, etc. (Anonymous 1960). The possible use of this type of compound in the field was investigated by applying the material to 1/32-acre irrigated pasture plots containing water 6 inches deep. Results obtained with one of these compounds are presented in Table

TABLE 2.—Field tests with Hyamine—1960.

Compound	Dosage lb./acre	24 hr. % mortality of 4th instar larvae	
		C. tarsalis	*A. nigromaculis*
Hyamine 2389 ®	20 (28 p.p.m.)	98	18
" "	40 (56 p.p.m.)	88	..

TABLE 3.—Field tests with DDT+Antiresistant—1961. 4th instar *Culex quinquefasciatus* susceptible and DDT-resistant strains.

Strain	Compound and dosage	24 hr. % mortality
Bakersfield (susceptible)	DDT 0.4 lb./acre	95
Orange County	DDT 0.4 lb./acre	54
Orange County	DDT 0.4 lb./acre+ antiresistant 0.08 lb./acre	64
Orange County	DDT 1.0 lb./acre+ antiresistant 0.2 lb./acre	69
Orange County	DDT 1.25 lb./acre+ antiresistant 0.25 lb./acre	85

TABLE 4.—Chemical names of compounds evaluated in field tests.

Common name or code	Chemical name	Source [1]
EN 18133 (Cynem ®)	O,O-diethyl O-(2-pyrazinyl) phosphorothioate	AC
Antiresistant-DDT	N-di-*n*-butyl-*p*-chlorobenzene-sulfanamide	W
Baytex ®	O,O-dimethyl O-[4(methylthio)-m-tolyl] phosphorothioate	C
Bayer 34098	O-(4-methylthio-*m*-tolyl) dimethylphosphinothioate	V
Bayer 41831 (Sumithion)	O,O-dimethyl O-3 methyl-4-nitrophenyl phosphorothionate	V
Butonate	O,O-dimethyl 2,2,2-trichloro-1-*n*-butyryloxyethyl phosphonate	W
Dimethrin	2,4-dimethylbenzyl chrysanthemumate	MGK
Hercules AC5727	*m*-isopropylphenyl N-methylcarbamate	H
Hercules 7522H	2-chloro-5-isopropylphenyl N-methylcarbamate	H
Hyamine 2389 ®	methyl dodecyl benzyl trimethyl amonium chloride and methyl dodecyl xylene bis trimethyl ammonium chloride	R
Methyl Trithion ®	O,O-dimethyl *S*-(*p*-chlorophenylthiomethyl) phosphorodithioate	S
Stauffer R-1504	phthalimidomethyl-O,O-dimethyl phosphorodithioate	S
Trithion ®	O,O-diethyl S-(*p*-chlorophenylthiomethyl) phosphorodithioate	S

[1] AC, American Cyanamid Co.; C, Chemagro Corp.; H, Hercules Powder Co.; MGK, McLaughlin Gormley King Co.; R, Rohm & Haas Co.; S, Stauffer Chemical Co.; V, Vero Beach Laboratories, Bayer Chemical Co.; W, Wisconsin Alumni Research Foundation.

2. Incomplete kills at high dosage rates, and damage to plant growth, indicated that it is not feasible to use the compound for control in irrigated pastures.

Early work with DDT synergists indicated that DDT could be rendered effective against DDT-resistant strains of insects (Summerford *et al.* 1951) (March *et al.* 1952). Although combinations of synergist and DDT were initially demonstrated to be effective against DDT-resistant house fly strains, continued application of synergized DDT resulted in the development of strains resistant to the combination (March *et al.* 1952).

A compound known as "WARF antiresistant" (designated chemically as N-di-*n*-butyl-*p*-chlorobenzene-sulfanamide) was available for field tests in combination with DDT during 1961. The results of tests conducted on a DDT-resistant strain of *Culex quinquefasciatus,* designated as the Orange County strain, are shown in Table 3. No significant increased toxicity of DDT on the resistant strain was demonstrated by the results obtained. Ordinarily DDT is not used at rates in excess of one pound per acre. Even at 1.25 lb/acre, DDT combined with "antiresistant" gave only 85 percent control. This may be due in part to the fact that the "antiresistant" compound was unstable in alkaline water and therefore was lost before it could be absorbed by mosquito larvae.

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