Salmon Creek (Juneau), Greenhouse Creek, and Butte Creek.

Symphoromyia kincaidi Aldrich. The larger size and bright yellow halteres of *kincaidi* females distinguish them from *atripes*. In *atripes* females the halteres are dark brown or black. Under the binocular microscope the abdominal hair of *kincaidi* is mostly yellow or golden; it is black in *atripes*. We have seen only four specimens of *kincaidi*, but it does not appear that the double dark median thoracic stripe of *kincaidi* differs consistently from the many variations of single, double, or 3 stripes with or without indefinite lateral areas of *atripes*. The *Symphoromyia* from Sheep Creek, Alaska, which Aldrich was reluctant to assign to *kincaidi* because his specimen had yellow pile all over, was not encountered. It could be separated easily from our *kincaidi* females which have the jet black hair on front and thorax normal to the species. Material examined came from Juneau on June 1, June 9 and August 28.

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LABORATORY SCREENING OF SOME MOSQUITO LARVICIDES [1]

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I. INTRODUCTION

The control of mosquitoes in California with DDT has been very successful since World War II. However, the suspected appearance of resistance to DDT and other insecticides (Bohart, 1950; Deonier, 1950; Smith, 1949) in the last few years presents the necessity for testing newer materials in order to have on hand a replacement should certain resistance makes the ones currently in use no longer effective.

During the summer and fall of 1950 the Bureau of Vector Control, State Department of Public Health, conducted a laboratory screening program at the University of California at Davis. Its main purpose was the testing of various insecticides, both old and new, to determine their value as mosquito larvicides.

Because of its availability the species chosen for these tests was *Culiseta incidens*. The toxicants used were aldrin, lindane, pyrenone, Lethane, DDD, parathion, and other promising insecticides as they were made available.

II. MATERIALS AND METHODS

The laboratory technique, with some modifications, was adopted from the procedure described by Bohart (1948). Egg rafts of *Culiseta incidens* were collected at Green Valley, Solano County, in a location never subjected to control by insecticides. The rafts were taken from a series of three shallow pools situated within an area of

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[1] Conducted under the guidance of Dr. Richard M. Bohart, Assistant Professor of Entomology, University of California at Davis, Davis, California, and in cooperation with the Bureau of Vector Control, California State Department of Public Health.

[2] Employed as Entomologist by the Bureau of Vector Control, California State Department of Public Health, during the period of this work.

approximately 10 yards. Pill boxes lined with damp tissue paper were used to transfer the rafts to the laboratory where they were placed in rearing pans filled with tap water (23° ± 1° F.). The larvae were fed daily a mixture of finely ground dog biscuit and yeast. Care was taken to prevent overcrowding, water spoilage and contamination of laboratory equipment by insecticides.

The young fourth stage larvae, used in the toxicity tests, developed in about 15 days. Tests were carried out in one-half pint paper cartons containing 100 cc. of water (105 cc. to compensate for evaporation). Ten larvae were placed in each carton by means of a net-covered wire loop. Food was not provided during the test but this did not appear to affect the well-fed larvae.

Mortalities at 24 and 48 hour readings were recorded. Larvae which were unable to control their movements, that is, to come to the surface, to go to the bottom, or to swim in a normal manner were regarded as mortally affected (Bohart 1949).

The minimum number of tests for each larvicide was regarded to be three. However, in some cases a wide range of results indicates the necessity for more than three tests. At least two replications were made for each dilution and one check for each 100 larvae (one check to ten cartons).

Unless otherwise stated, a one per cent stock solution of each toxicant was prepared. One-half gram of the technical grade insecticide was made up to 50 cc. in xylene containing 5 cc. Triton X-100 (Rohm & Haas Co.). One cc. of the one per cent stock solution was added to 99 cc. of distilled water to give one part in 10,000 by weight (disregarding weight of solvent and emulsifier). One cc. of the latter added to 99 cc. of distilled water yielded one part in one million which was used as the stock solution for further dilutions.

Standard emulsions were used in preference to other stock solutions because it is believed that the use of an emulsion more closely parallels the field application of larvicides. Preliminary tests with DDT emulsions and DDT acetone suspensions failed to show any significant differences in toxicity.

Used pipettes and flasks were flushed several times in tap water and subsequently washed in acetone. With the exception of those containing controls, all cartons were discarded at the end of each trial.

III. EXPERIMENTS AND DISCUSSION

Table I summarizes the approximate LD50 and LD90 of the larvicides used on the young fourth stage *Culiseta incidens* larvae. The comparative per cent mortality in dilutions from 1–1 million to 1–400 million (one part by weight in distilled water, disregarding weight of solvent and emulsifier) are shown in Table II.

Based on the approximate median lethal dose Velsicol heptachlor [1] (Velsicol AR-50, Altox 1045 A-2), aldrin [2], parathion [3], heptachlor [4] (with xylene-Triton X-100), and DDT with Lethane-384 [5] used as a solvent are, respectively, 8.6, 8.4, 5.5, 2.8, and 2.2 times as toxic as DDT.

Tests with Velsicol heptachlor (42 per cent emulsifiable concentrate) have shown it to possess a high larvicidal activity with an approximate LD50 of 1–155 million. Technical Velsicol heptachlor with xylene-Triton X-100 (LD50—1–50 million) was only one-third as effective as the emulsifiable concentrate, but 2.8 times as toxic as DDT.

Aldrin with an LD50 of 1–150 million has about the same larval toxicity as heptachlor (emulsifiable concentrate), while an LD50 of 1–18 million ranks dieldrin with DDT.

Parathion (96–98 per cent pure aryl alkyl thiono phosphate) ranked third in its toxicity to *Culiseta incidens* larvae with an LD50 of 1–100. The two additional

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[1] Velsicol Corp., Chicago, Illinois.
[2] Julius Hyman & Co., Denver, Colorado.
[3] American Cyanimid, New York, N. Y.
[4] Velsicol Corp.
[5] Rohm and Haas Co., Philadelphia, Pennsylvania.

organic phosphates tested, Compound 4041 [1], and o-o-di-isopropyl nitrophenyl thiophosphate [1] proved to be ineffective at dilutions of 1–10 million and above.

During the summer of 1950 large quantities of Navy surplus Lethane Mosquito Insecticide No. 1 were turned over to the various California Mosquito Abatement Districts. This insecticide is registered with the Bureau of Chemistry, State Department of Agriculture, as beta butoxy betá thiocyano diethyl ether (6 per cent by weight) and deodorized kerosene (94 per cent by weight).

It has been suggested [2] from field activities that an addition of Lethane to a solution of DDT might fortify a larvicidal solution by adding pupicidal qualities to it. Used as a larvicide, one part of DDT to one part of Lethane [3] and one part of DDT to one-third part of Lethane did not show any advantages over DDT alone.

A one per cent Lethane xylene-Triton X-100 emulsion resulted in a 100 per cent larval mortality at 1–100,000; 50 per cent mortality at 1–500,000; and no mortality at 1–1 million. A 100 per cent mortality at 1–100,000 and no mortality at 1–500,000 was obtained in tests using xylene-Triton X-100 alone. This would seem to indicate that as a larvicide Lethane Mosquito Insecticide No. 1 emulsion contributes little to the toxicity of DDT.

Tests using DDT with Lethane-384 [4] (active ingredients—beta butoxy betá thiocyano diethyl ether 50 per cent by volume and petroleum distillate 50 per cent by volume) as a solvent proved to be 2.2 times as toxic as DDT used alone.

Toxaphene,[5] lindane,[6] Q137 [4] and DDD [4] were below DDT in toxicity with LD50's of 1–7, 1–4.5, 1–3.5, and 1–2, respectively.

Synthetic Cinerin 1 [7] was ineffective at dilutions of 1–1 million and above.

Sample HE-761 [4] was received from Rohm & Haas Company and labeled as technical 3-4-dichloro-benzene sulfo-nitranilide-4 (approximately 95 per cent purity) with the additional statement that it was for use on rice field mosquitoes only. Since *Anopheles* sp. were not available, *Culiseta incidens* larvae were substituted. A one per cent HE-761 acetone solution was ineffective against *Culiseta incidens* at dilutions of 1–1 million and above.

It was originally planned to test the larvicides at dilutions from 1–10 million through 1–400 million; discarding those which produced no mortality at the lowest dilution. Many larvicides which would have been discarded under the original plan were encountered as the experiments progressed. Hence, it was decided to check mortalities at dilutions from 1–1 million to 1–10 million on the theory that a toxicant having an LD50 in that range may be of some value in the field depending upon its availability, expense of application, and toxicity to man, domesticated animals and wild life.

Results are not complete on Maclean's chlordane,[8] Compound 4041, o-o-di-isopropyl nitro phenyl thiophosphate, CS674A [9] and CS645A in dilutions below one part in 10 million.

Considerable variability was encountered in tests with pupae. At present only the general statement can be made that DDT, DDT-Lethane Mosquito Insecticide No. 1 (1–1), DDT with Lethane-384 used as a solvent, Velsicol heptachlor, heptachlor with xylene-Triton X-100, aldrin, lindane, toxaphene, DDD, Q137, Compound 4041 and parathion show no effect at dilutions above 1–5 million.

Summary

1. Laboratory tests were made with promising insecticide emulsions in an

[1] American Cyanimid.

[2] Dr. Isenhour (Rohm and Haas Co., San Francisco).

[3] Lethane Mosquito Insecticide No. 1.

[4] Rohm and Haas.

[5] Hercules Powder Co., Inc., Wilmington, Delaware.

[6] California Spray Chemical Corp., Richmond, California.

[7] U. S. Industrial Chemicals, New York, N. Y.

[8] Macleans Corp., San Francisco, California.

[9] Commercial Solvents Corp., New York, N. Y.

TABLE I.—LD50 and LD90 of larvicide emulsions used against young fourth stage *Culiseta incidens* Thomson; water temperatures 23°±1° F.; length of test period 48 hours.

	Larvicide	*No. of Tests*	*Approx. LD50*	*Approx. LD90*	*Remarks*
1.	Velsicol heptachlor	5	1–155	1–35	
2.	Aldrin (118)	3	1–150	1–45	
3.	Parathion	4	1–100	1–80	
4.	Heptachlor	4	1–50	1–25	
5.	DDT with Lethane-384 used as a solvent	4	1–40	1–15	Larvicides 5, 6, 7, 9, and 10 contain the same amount of DDT.
6.	DDT-Lethane (1–1/3)	3	1–25	1–10	
7.	DDT-Lethane (1–1)	5	1–20	1–8	
8.	Dieldrin (497)	4	1–18	1–8	
9.	DDT	14	1–18	1–7	
10.	DDT-Acetone	4	1–15	1–7	
11.	Toxaphene	3	1–7	1–3.5	
12.	Lindane	3	1–4.5	1–2.5	
13.	Q137	3	1–3.5	1–1.5	
14.	DDD	3	1–2	1–.2	
15.	CS674A	3	1,1-bis (p-chlorophenyl) 2-nitro butane		No effect at dilutions above 1–10 million.
16.	CS645A	3	1,1-bis (p-chlorophenyl) 2-nitro propane		No effect at dilutions above 1–10 million.
17.	Compound 4041	3	Results of dilutions below 1–10 millions based on 1 test only		No effect at dilutions above 1–10 million.
18.	o-o-di-isopropyl-nitro-phenyl thiophosphate	3	Tests not conclusive at dilutions below 1–10 million		No effect at dilutions of 1–10 million and above.
19.	Maclean's chlordane	2			No effect at dilutions of 1–10 million and above.
20.	Synthetic Cinerin I	2			No effect at dilutions of 1–1 million and above.
21.	HE761-Acetone	2			No effect at dilutions of 1–1 million and above.
22.	1% Lethane	2	1–500,000	1–90,000	No effect at dilutions of 1–1 million and above.
23.	Xylene-Triton X-100	2			1–100,000, 100% mortality, 1,500,000, no mortality.
24.	Checks				1.4% mortality, 780 larvae used.

TABLE II.—Toxicity of larvicide emulsions to young fourth stage *Culiseta incidens* (Thomson); water temperature 23°±1° F.; length of test 48 hours

Larvicide	*No. of Tests*	*Average Per Cent Mortality* 1–400 million	1–200 million	1–100 million	1–50 million	1–30 million	1–20 million	1–10 million	1–5 million	1–2.5 million	1–1 million
Velsicol heptachlor	5	10	40.4	63	81	92	100	100			
Aldrin (118)	3	0	27.7	85.6	87.6	100	100	100			
Parathion	4	0	23.6	51.8	94.6	100	100	100			
Heptachlor	4		0	9.7	50.3	88.3	98.7	100			
DDT with Lethane used as a solvent	4			0	29.2	69.7	85	97.5	100		
DDT-Lethane (1–1/3)	3				0	40.7	59.3	90.5	100		
DDT-Lethane (1–1*)	5				0	28	50.8	82	100		
Dieldrin (497)	4				0	21.6	41.2	84.7	100		
DDT	14				0	10.4	40.1	70.8	100		
DDT-Acetone	4						27.2	66.6	100		
Toxaphene	3							15	71.9	100	100
Lindane	3							0	38	90	100
Q137	3							0	13	69.7	100
DDD	3							0	5	38	95

* One part by weight in distilled water.

attempt to evaluate their comparative toxicity to mosquito larvae.

2. *Culiseta incidens* was used exclusively due to its availability, vigor and high survival under laboratory conditions.

3. Table I presents the approximate LD50 and LD90 of the larvicide emulsions used against young fourth stage *Culiseta incidens* larvae.

4. The comparative per cent mortalities in dilutions from 1–1 million to 1–400 million (one part by weight in distilled water) are shown in Table II.

5. Based on the approximate median lethal dose, Velsicol heptachlor (Velsicol AR-40, Altox 1045A-2), aldrin, parathion, heptachlor (with xylene-Triton X-100), and DDT with Lethane 384 used as solvent are, respectively 8.6, 8.4, 5.5, 2.8, and 2.2 times as toxic as DDT.

6. One part of DDT to one part of Lethane[1] and one part of DDT to one-third part of Lethane do not show any advantages over DDT used by itself.

7. More tests are indicated for CS674A, CS645A, o-o-di-isopropyl nitrophenyl thiophosphate and other larvicides showing no kill at dilutions above 1–10 million.

8. Considerable variation appeared in tests with pupae. More tests are needed before definite results can be submitted.

[1] Lethane Mosquito Insecticide No. 1.

At present only the general statement can be made that DDT, DDT-Lethane (1–1), DDT with Lethane used as a solvent, Velsicol heptachlor, heptachlor (with xylene-Triton X-100), aldrin, lindane, toxaphene, DDD, Q137, Compound 4041, and parathion show no effect on pupae at dilutions above 1–5 million.

9. Other species of mosquitoes may present different reactions to the foregoing larvicides.[2] However, it is felt that tests with *Culiseta incidens* exclusively, give a general picture of comparative toxicities.

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[2] For example, DDD has been reported by Bohart (1949) as considerably more toxic than DDT to *Aedes dorsalis* and *Aedes squamiger*.