RESIDUAL EFFECTIVENESS OF ELEVEN INSECTICIDES UNDER WEATHERING CONDITIONS AGAINST *AEDES AEGYPTI*

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The last step in any scheme for evaluating new and promising insecticides is the determination of effectiveness of the compounds under field conditions. Numerous physical and chemical elements influence the behavior of such materials after application. Thus the evaluation must include assessment of the interplay of such factors as fluctuating temperature, humidity, rainfall, sunlight, surfaces to which applied, etc. Collectively, these components of the environment are of major significance when searching for broad spectrum compounds that have potential for use as a combined outdoor residual larvicide and adulticide. The treatment of premises for *Aedes aegypti* eradication has made the detection of such compounds highly desirable. These studies were designed to evaluate the effectiveness of 11 experimental materials against *A. aegypti* under actual weathering versus protected conditions in the field.

MATERIALS AND METHODS. The compounds tested as larvicides are listed in Table 1. Each material was sprayed on the internal surface of 18-inch sections of used automobile tires and to the inner surfaces of rusted #10 tin cans. H-9485, Mobam, DDT, GC-9879 and Dursban were applied at 2 g/m^2 only, while all others were sprayed at both 1 and 2 g/m^2. All compounds were applied as emulsions with the exception of Mobam which was sprayed as a suspension.

Application of the test compounds was made at 40 psi by passing the cans and tire sections on a moving chain conveyor belt beneath a stationary spray nozzle. The solution and suspension were applied with #8001 and #8002 T-jet nozzles respectively. The treated containers were held in the spray room until dry and then transported to the field. Two replicates for each chemical and dosage were placed under sheltered conditions protected from direct sunlight, rain, etc., and two replicates exposed directly to weathering conditions (Fig. 1). Water was added to all containers after which the tires and tin cans held in the open were subjected to periodic flooding by natural rainfall. The water levels in the containers under shelter were replenished manually as needed.

To evaluate the effectiveness of larvicide treatments, third instar larvae of *A. aegypti* (Charlotte Amalie strain) were introduced into the water. Mortalities obtained were recorded at 24 and 48 hours after exposure. A mortality of 70 percent was considered as the criterion of effectiveness. Biweekly assessments were carried on throughout 19 weeks of testing.

Tests for residual adulticidal qualities were carried out utilizing these same materials and dosages on tin, rubber, wood panels, and on plant foliage. For treatment of the tin, the rubber and the wood panels, the test equipment and techniques as described by Jakob and Schoof (1963) were used. For the foliage studies young plants of Japanese Plum *(Eriobotrya japonica)* of approximately 3 feet in height were sprayed to the run-off point utilizing a #8002 T-jet nozzle and a 1-gallon compression hand sprayer. After drying, the plants were moved to field areas where they were subjected to the same two types of exposures as were the containers of the larvicide tests. Plants held under protected conditions were placed in a shed covered on two sides with polyethylene

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TABLE 1.—Chemical composition of toxicants[1] used.

Designation	Chemical Composition	Mammalian oral toxicity mg/kg
Baygon[2]	o-isopropoxyphenyl-N-methylcarbamate	104
Bromophos[3]	o,o-dimethyl o-(2,5-dichloro-4-bromophenyl) thionophosphate	3750–6100
DDT	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane	118
Dursban[4]	o,o-diethyl o-(3,5,6-trichloro-2-pyridyl) phosphorothioate	135
Fenitrothion[5]	o,o-dimethyl o-(3-methyl-4-nitrophenyl) phosphorothioate	503
GC-9879[6]	alpha (diethoxyphosphinothioylthio) gamma-butyrolactone	>1000
H-9485[7]	2-alloxyphenyl N-methylcarbamate	200
Malathion	S-(1,2-dicarbethoxyethyl)-o,o-dimethyldithiophosphate	480–580
Mobam[8]	4-benzothienyl-N-methylcarbamate	235
Schering 34615[9]	3-methyl-5-isopropylphenyl-N-methylcarbamate	35
SD-8447[10]	Phosphoric acid, 2-chloro-2-(2,4,5-trichlorophenyl) vinyl dimethyl ester	4000–5000

[1] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service or U. S. Department of Health, Education, and Welfare.
[2] Furnished by the Chemagro Corp., Kansas City, Missouri.
[3] Cela Chemical Co., Ingelheim/Rhein, West Germany.
[4] The Dow Chemical Co., Midland, Michigan.
[5] Sumitomo Chemical Co., Ltd., Osaka, Japan.
[6] Allied Chemical Corp., Morristown, New Jersey.
[7] Hercules Powder Co., Wilmington, Delaware.
[8] Mobil Chemical Co., Metuchen, New Jersey.
[9] Schering AG, Halchtersche Strase 33, West Germany.
[10] Shell Development Co., Modesto, California.

plastic sheeting (Fig. 2). Panels subjected to weathering were hung on racks approximately 15 degrees off vertical as seen in Figure 3.

To evaluate each compound as a residual adulticide on the panels, 3-day-old adult female *A. aegypti*, Charlotte Amalie strain, (DDT-dieldrin resistant) were used as the test insect. The specimens were anesthetized with CO_2 for transfer from the emergence container to the holding cage. Following a 1-hour recovery period, 50 to 100 mosquitoes were transferred into the exposure chamber, exposed for 1 hour, and then removed into a clean screen wire holding cage. The mosquitoes were provided with cotton pads saturated with a 10 percent honey solution and held at 80° F. and 70 percent relative humidity for 24 hours. Female mortality determinations were then made with the criterion of effectiveness considered at the 70 percent mortality level.

Evaluation of residual deposits on foliage was made by confining 10 to 15 female *A. aegypti*, Charlotte Amalie strain, on leaves removed from the test plant. The leaf surface was tested beneath a transparent plastic cone (WHO, 1958), 8.5 cm. in diameter at the base and 5.5 cm. high. Each cone was equipped with a sponge rubber stripping around the periphery to insure an escape-proof chamber when placed over the treated leaf. Ten x ten cm. ¼ inch plywood blocks were covered with disposable wax paper sheets and the leaf placed with the treated surface up. The cone was then placed over the leaf and board, then secured with masking tape. Each cone chamber was placed with the block oriented vertically and the test specimens introduced

FIG. 1. Treated containers under weathering for *A. aegypti* (L.) residual larvicide studies.

FIG. 2.—Treated plant foliage being held under protected conditions for *A. aegypti* residual adulticide tests.

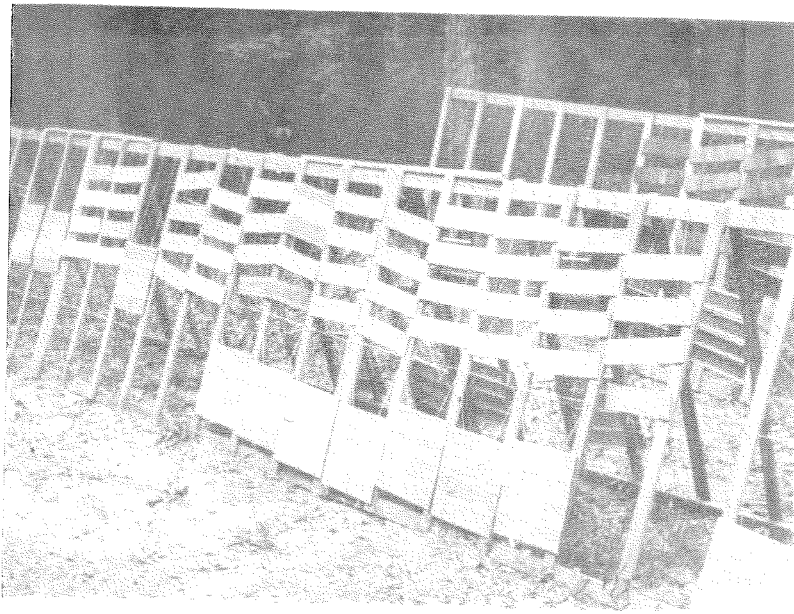

FIG. 3.—Treated panels being held under weathering conditions for *A. aegypti* residual adulticide tests.

and removed by means of an aspirator. After exposure, specimens from the foliage test were held as described for the panel tests.

RESULTS. Data for the larvicide tests are presented in Table 2. Under weathering conditions, Dursban, Schering 34615, fenitrothion, and SD-8447 were most effective in both containers. Satisfactory kills were obtained in tin cans for 12, 12, and 19 weeks with bromophos, SD-8447, and Schering 34615, respectively, at the 1 g/m^2 dosage. At 2 g/m^2 Schering 34615 and SD-8447 were effective for 14 weeks, while fenitrothion, bromophos and Dursban produced kills for 17, 18, and 19 weeks, respectively. In rubber tires these compounds produced satisfactory mortalities through the full 19-week test period with the exception of bromophos which failed to give greater than 6 weeks kills at both treatment levels. Baygon, GC-9879, H-9485, Mobam, DDT, and malathion showed less than 12 weeks of effectiveness, as applied on either surface, when exposed continuously to weather.

Under protected versus weathering conditions, longer periods of satisfactory results were recorded from most treatments held in a protected state. Baygon at 2 g/m^2 and GC-9879 at 2 g/m^2 applied to tin cans and rubber tires, respectively, were the only exceptions; each produced satisfactory kills for slightly longer periods under weathering conditions. Compounds showing the greatest differences in effectiveness caused by weathering when applied to tin cans were fenitrothion (1 g/m^2), GC-9879 (2 g/m^2), Schering 34615 (2 g/m^2), and SD-8447 (1 and 2 g/m^2). With these treatments the periods of effectiveness were reduced by 5 to 8 weeks. Materials sprayed on rubber with shorter periods of effectiveness due to weathering were Mobam (2 g/m^2) and malathion (1 and 2 g/m^2) which showed a decrease in effectiveness of 8, 14, and 8 weeks, respectively. Protection of the remaining treatments from direct weathering did not materially increase or decrease the residual activity of the compound.

TABLE 2.—Weeks of effective 70 percent kill of resistant 3rd instar larvae (Charlotte Amalie strain) by 11 chemicals under weathering and under protected conditions.

Toxicant	g./sq.m.	Tin Cans		Rubber Tires	
		Weather	Protected	Weather	Protected
Baygon	1	5	5	9	11
	2	7	5	9	11
Bromophos	1	12	12	5	5
	2	18	>19	6	10
Dursban	2	>19	>19	>19	>19
Fenitrothion	1	6	12	>19	>19
	2	17	17	>19	>19
GC-9879	2	4	12	5	4
H-9485	2	1	2	3	3
Mobam	2	4	5	11	>19
Schering	1	>19	>19	>19	>19
34615	2	14	>19	>19	>19
SD-8447	1	12	>19	>19	>19
	2	14	>19	>19	>19
DDT—[a]	2	5	7	3	3
—[b]		4	4	4	4
Malathion	1	4	5	5	>19
	2	4	5	11	>19

[a] Resistant strain.
[b] Susceptible strain.

Table 3 presents the data from the adult residue tests on four protected and weathered surfaces. DDT at 2 g/m^2 and SD-8447 at 2 g/m^2 were the only compounds to show more than 5 weeks effectiveness on weathered tin. This same surface under protected conditions produced kills for greater than 11 weeks with all formulations with the exceptions of fenitrothion (1 g/m^2), GC-9879 (2 g/m^2), H-9485 (2 g/m^2), SD-8447 (1 and 2 g/m^2), and DDT (2 g/m^2) against a resistant strain.

Fenitrothion and Dursban at 2 g/m^2 produced 7 and 15 weeks effectiveness on weathered rubber. All other formulations tested on this exposed surface yielded less than 3 weeks of kill. Under protected conditions, however, Baygon (1 and 2 g/m^2), Dursban (2 g/m^2), fenitrothion (1 and 2 g/m^2), Mobam (2 g/m^2), Schering 34615 (1 and 2 g/m^2), and malathion (2 g/m^2) gave better than 11 weeks of satisfactory results. The remaining nine dosages of five formulations killed for less than 7 weeks under this condition of exposure.

Dursban, fenitrothion, and bromophos sprayed at 2 g/m^2 and SD-8447 at 1 g/m^2 produced kills of 15, 7, 5, and 5 weeks when applied to wood exposed to weather. The remaining 14 dosages of 11 formulations tested on this surface and under these conditions yielded kills of 3 weeks or less. On protected wood surfaces all but H-9485 and DDT applied at 2 g/m^2 produced effective kills for 13 weeks or greater against resistant *aegypti*. These two formulations failed at 6 weeks and 1 week, respectively.

Dursban at 2 g/m^2 displayed 4 weeks of residual effectiveness while Schering 34615 (1 and 2 g/m^2) and SD-8447 (1 and 2 g/m^2) were effective for 2 weeks only. All other formulations yielded less than 1 week. When protected from weather Mobam (2 g/m^2), SD-8447 (1 g/m^2), and Schering 34615 (1 g/m^2) gave 6, 6, and 4 weeks of kill, respectively. The remaining treatments failed at 2

TABLE 3. Weeks of effective kill of resistant adult *A. aegypti* (Charlotte Amalie strain) with residues of 11 toxicants applied to tin, rubber, wood and foliage. [(D) = defoliated].

		Tin		Rubber		Wood		Foliage	
Toxicant	g./sq.m.	Weather	Pro-tected	Weather	Pro-tected	Weather	Pro-tected	Weather	Pro-tected
Baygon	1	1	11	1	>13[a]	1	>13[a]	0	2
	2	1	11	1	>13[a]	1	>13[a]	0	2(D)
Bromophos	1	3	>13[a]	1	0	3	>13[a]	0	0
	2	3	>11[a]	1	1	5	>13[a]	1	2
Dursban	2	3	>19[a]	15	18	15	>19[a]	4	2(D)
Fenitrothion	1	1	7	1	11	3	13[a]	0	0(D)
	2	1	11	7	>15[a]	7	>13[a]	0	(D)
GC-9879	2	1	7	1	3	1	>13[a]	0	2
H-9485	2	1	6	1	7	0	6	0	(D)
Mobam	2	3	>13[a]	1	>13[a]	1	>13[a]	0	6
Schering 34615	1	3	11	1	>13[a]	1	>13[a]	2	4
	2	2	>11[a]	3	>13[a]	3	>13[a]	2	(D)
SD-8447	1	3	5	1	1	5	>13[a]	2	6[d]
	2	5	5	1	5	1	>13[a]	2	2(D)
DDT—[b]	2	1	1	1	1	1	1	1	1
—[c]		11	>11[a]	1	0	1	13	0	0
Malathion	1	1	>11[a]	1	0	1	>13[a]	0	2
	2	1	>11[a]	3	11	3	>13[a]	0	2

[a] Week at which test terminated.
[b] Resistant strain.
[c] Susceptible strain.
[d] Erratic, failed at 4 weeks but gave satisfactory kill at 6 weeks.

weeks or less. With all materials applied to foliage, slight to heavy chemical burning occurred after spraying. Seven of the compounds were found to rapidly defoliate the test plant (Table 3).

During the 19-week test period considerable rainfall occurred, a total of 32.05 inches. With the exception of test week 3, each of the weeks received at least trace levels. The monthly totals varied greatly, ranging from a high of 11.35 inches during the month of August to a low of 5.90 inches for September.

DISCUSSION. Of the compounds tested as residual larvicides in tin cans and rubber tires, the data indicated Dursban, SD-8447, fenitrothion, and Schering 34615 to be superior to either malathion or DDT under both conditions of exposure. The duration of effectiveness of these four compounds ranged from 10 to 15 weeks greater than malathion when applied at 2 g/m^2 to tin cans and 5 weeks greater when applied to rubber tires. Bromophos, although superior to malathion when applied to tin, was 5 to 9 weeks less effective when applied to tires and was the only compound outside of DDT which demonstrated greater effectiveness on tin than on rubber.

Dursban as a larvicide applied under these conditions gave excellent results. Since no break in effectiveness occurred during the 19 weeks of testing, this compound should be retested at lower, more critical dosage levels.

The amount and continuous nature of the rainfall during the summer brought about frequent dilutions in the test containers. That rainfall did not limit the length of effectiveness of several toxicants is of major significance, since this factor is a critical deterrent to the efficacy of larvicides to be used in areas of excessive rainfall. Some of the materials were excellent toxicants under sheltered condiknow so much you wonder that they can go on learning more. DICK PETERS, TOM PECK and JACK KIMBALL led a panel in a discussion of "In Service Training" and LES BRUMBAUGH, GARDNER McFARLAND, HOWARD GREENFIELD, GEORGE UMBERGER and GORDIE SMITH discussed Interagency Cooperation. Part of the discussion, of course, centered on the non-polluting use of pesticides and proper recording procedures for same, but since California mosquitoes are now immune to nearly EVERYTHING, it hardly matters anyhow.

PAUL HUNT REPORTS THAT THERE WAS A REGIONAL MEETING AT HIS EAST VOLUSIA (FLORIDA) MOSQUITO CONTROL DISTRICT in October, which we should have mentioned in December, at least, it would seem. Anyway, we didn't and we're sorry because Prexy GEORGE CARMICHAEL was present, along with Wayne Miller and Dr. Rogers, and what they talked about was the Federal mosquito control bill. Paul's typist made an amusing slip and said they discussed the history and *objections* of AMCA and we're glad she didn't catch it before it was sent because, you know, maybe the time has come for the AMCA to HAVE some objections. We, here in Hawaii, have found ourselves objecting to so much of what is being done by real estate developers and lumber merchants to despoil our environment while they beat us about the head for using larvicides, that we have just about set up a committee to fight back. We're going to say "Liaison" 'cause it sounds politer, but maybe we ought to have a Standing Committee on Objections to speak up when they log off a virgin forest and let in the weeds and insects and then cry that they are "managing" the forest and "saving" it from destructive pests. Maybe we ought to object when the airlines press Congress to lay off the aircraft disinsectization and surveillance, just as their potential for bringing in exotic vectors is rising. Anybody for a Demonstration???

VMCA's *SKEETER*, ALWAYS BRINGING US USEFUL FACTS AND FANCIES, CAME UP IN THE SEPTEMBER AND OCTOBER ISSUE WITH AN ADULT MOSQUITO IDENTIFICATION SLIDE RULE. Works, too. Maybe all your men eyeball any old mosquito female and rattle off her name and telephone number. But if you got any doubtfuls, this is the thing to carry. Full directions are enclosed (page 3) so if you didn't see it, ask ROLLIE DORER . . . but don't say we sent you. His postage budget may be low.

WHEN YOU READ THIS IT WILL ALL BE A LOVELY MEMORY BUT RIGHT NOW IT'S STILL AN EXCITING PROSPECT . . . the meeting of Gardner McFarland's South Pacific Region, which we mentioned last time. (We should really come out in January, April, July and like that . . . EVERYthing happens right after the deadline for the next issue the way it is now!) Well, the Program is arranged like this . . . the group arrive(d) right after the Portland meetings. Friday was a tour of Oahu (that's Honolulu, you remember) with stops at PAT NAKAGAWA's new Mosquito Control Division laboratory and field facility and then at Pearl Harbor to see DICK HOLWAY's lab and then on to Pearl City Naval Housing area to some test boondocks where the population of *Aedes albopictus*, our beer can breeder and the scourge of the Pacific, is normally allowed to be high . . . for test purposes, you understand. Unfortunately, this winter has been chilly and somewhat dry and the population failed to be exactly spectacular. The tour will fight back its tears and go on around the Island to see some of the other trouble spots Pat's men have been controlling.

Saturday, a paper-reading session at the Department of Health auditorium, including those by GEORGE KITAGUCHI; JAMES IKEDA, TED RALEY, and TOM LAURET, whom the Navy won't let off Guam except to go to Singapore and Sydney and Tokyo and like that. Saturday night, a luau put on by MCD, led by WALLY PANG and assisted by AL WATANABE, who brought all those luscious pineapples to the California meetings. Monday and Tuesday had sightseeing trips planned for mornings, with afternoons for swimming and sunbathing and a Hawaiian Entomological Society meeting Tuesday afternoon, concerned with the political pressure being applied to force a letdown in quarantine and in aircraft inspection and treatment procedures, papers by RAY JOYCE and DICK HOLWAY on mosquitoes likely to come from Southeast Asia and on those intercepted here already. We're sorry for you five hundred that didn't make it. Better luck next time! Aloha, you fifty who did!

DR. JOHN BAGBY WROTE US A NOTE VIA TED RALEY AND LOOKIE . . . IT *MADE* THE DEADLINE. He has moved from Atlanta and is now Directing the new Institute of Rural Environmental Health at Fort Collins, Colorado. The Institute is part of the College of Veterinary Medicine and Bio-Medical Sciences of the Colorado State University, with a founding grant from the Kellogg Foundation. It will coordinate research services and educational ones and in the first phase is reviewing existing records of disease, disabilities and deaths to determine specific program goals. They plan to develop a graduate training program in environmental health, to conduct seminars for medical, public health, agricultural and industrial groups, with workshops and training courses and emphasis on, among other things, chemical epidemiology and ecology, two fields in which, as we al know, public interest is ballooning. Good luck, John!

ONE LAST WORD . . . WE SHOULDN'T HAVE BAD MOUTHED HARRY PRATT's news-gathering and distribution system back there because there's MORE. Instead of re-writing everything, we'll just put it here.

THE ILLINOIS MEETING we mentioned was held at WILBUR (BUD) MITCHELL's Northside MAD at Wheeling, Illinois. They had a fine class of 90 for both days. Harry then took off for Atlanta,