will increase as the development of the Canadian north continues. It is expected that regulation of control will become more strict, that probably proof of the need of control may be required, and that some monitoring of the effects of chemicals on the environment may become an integral part of control operations.

The awakening public response to the current ecological era has been a sudden education for entomologists. It is now our responsibility to educate the public.

THE RELATIVE EFFECTIVENESS OF MALATHION THERMAL AEROSOLS AND GROUND-APPLIED ULV AGAINST THREE SPECIES OF MOSQUITOES [1]

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Recent studies by Mount *et al.* (1968, 1970) indicated that ground-applied ULV aerosols were at least as effective as high volume thermal aerosols against *Aedes taeniorhynchus* (Wiedemann). A particle size of from 11 to 16 microns, mass median diameter, was important in obtaining effective kills. Anderson and Schulte (1970) reported that an air pressure of 3.0 to 3.5 psi at flow rates of 2.85 to 3.0 fl. oz./min. would produce this optimum particle size. In Savannah, Georgia, in 1970 tests were conducted with comparable equipment against three mosquito species in open and wooded areas.

METHODS AND MATERIALS. The test area was previously described by Taylor and Schoof (1968). The thermal aerosol applications were made with a Leco 120 [2] fog generator; a Curtis 55,000 cold aerosol generator modified with a Leco ULV nozzle head was used for the ULV treatments. Malathion thermal fogs were dispersed at 85 fl. oz./min. (6 fl. oz. malathion/gal. No. 2 fuel oil) at a vehicle speed of 5 mph and 170 fl. oz./min. at 10 mph. ULV aerosols of 95 percent malathion were dispersed at 1.7 to 10.0 fl. oz./min. at the same vehicle speeds. The nozzle of the thermal fogger was set at a slight angle down and away from the vehicle, but the ULV nozzle was directed at a 45° angle up and away from the vehicle.

Treatments were made in the evenings just after sundown. The line of travel of the vehicle was 1,300 feet, with a running time of 1.5 min. at 10 mph and 3.0 min. at 5 mph. Prevailing southwest winds of from 0 to 5 mph allowed the aerosols to drift over the test area. During the test period, average temperatures and relative humidities were 82° F and 80 percent. Caged *Anopheles albimanus* (Wiedemann), *Aedes taeniorhynchus* (Wiedemann) and *Culex pipiens quinquefasciatus* (Say) (approximately 100 females/cage) were suspended 6 feet above the ground along three blocks 270 feet apart. Cages in the open area were 150, 300, 450 and 600 feet from the line of discharge. Cages also were placed in wooded areas (fairly dense) at the same height at the 150- and 300-foot stations for the 5 mph

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[2] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health, Education, and Welfare.

vehicle speed and at the 150-, 300- and 450-foot stations for the 10 mph vehicle speed.

Each night of testing began and ended with a ULV application, with the thermal aerosol dispensed in between. Approximately 15 min. after each test run, the cages were removed to the laboratory and the specimens transferred to clean cages and held for 24-hour female mortality counts. Check insects were transported to the test site before each test run and then returned to the laboratory grounds where they were suspended (in cages) outdoors as were treated specimens. Subsequent handling was the same as that for the treated insects.

Droplet size of the ULV aerosol was determined by waving silicone (SC-87 Dri-Film) treated glass microscope slides through the aerosol at a distance of 25 feet from the point of discharge. Mass median diameters were computed according to the methods of Yeomans (1949).

Results. Data for the 5 mph vehicle speed are given in Table 1. They represent two to four runs at each flow rate with the ULV equipment and six runs with the thermal fogger. The 1.7 fl. oz./min. flow rate was fairly effective against *A. albimanus* at 150 and 300 feet, giving 81 and 72 percent kills at these distances. Against the other two test species, however, this rate was completely ineffective, giving only 67 and 47 percent kills of *Ae. taeniorhynchus* and *C. p. quinquefasciatus* at the 150-foot station. To give greater than 70 percent kills of these species at 150 feet, the flow rate had to be increased to 3.6 fl. oz./min. At 3.9 fl. oz./min. excellent kills of *A. albimanus* and *Ae. taeniorhynchus* were obtained through 600 feet, but those of *C. p. quinquefasciatus* were marginal. Complete kills of all species were obtained at 4.1 fl. oz./min. up to 600 feet; the same was true for the thermal fogger (standard).

Cages placed in wooded areas were exposed to ULV applications at 3.6 and 4.1 fl. oz./min., but both rates gave erratic and ineffective results against the test species (except for *A. albimanus* at the 150-foot site). The standard thermal fog was more effective against the three species than the ULV applications, but the kills of *Ae. taeniorhynchus* and *C. p. quinquefasciatus* were marginal.

Data for the 10 mph vehicle speed are presented in Table 2. Eleven test runs at flow rates of from 2.6 to 10.0 fl. oz./min. were made with ULV equipment, and six, with the thermal unit. As with the 5 mph vehicle speed, *A. albimanus* were killed at the lowest flow rate (2.6 fl. oz./

TABLE 1.—Comparison of ULV and thermal aerosols (std.) of malathion against three mosquito species (vehicle speed 5 mph).

Fluid oz./min.	*An. albimanus*				*Ae. taen.*				*C. p. quin.*			
	150	300	450	600	150	300	450	600	150	300	450	600
					Cages in open							
1.7	81	72	63	41	67	48	40	8	47	34	29	1
3.1	87	63	50	65	74	43	43	21	62	51	46	49
3.6	100	98	..	..	84	50	..	..	96	56	..	..
3.9	100	100	100	100	100	97	95	86	99	95	75	67
4.1	100	100	100	100	100	100	100	100	98	100	100	100
Std.*	100	100	100	100	100	100	100	100	100	100	100	100
					Cages in woods							
3.6	100	56	..	..	45	9	..	..	70	1	..	..
4.1	54	45	..	..	41	8	..	..	38	8	..	..
Std.*	93	77	..	..	77	55	..	..	77	56	..	..

* See page 346 for details.

TABLE 2.—Comparison of ULV and thermal aerosols (std.) of malathion against three mosquito species (vehicle speed 10 mph).

Fluid	*An. albimanus*				*Ae. taen.*				*C. p. quin.*			
oz./min.	150	300	450	600	150	300	450	600	150	300	450	600
					Cages in open							
2.6	92	94	85	31	76	74	61	20	87	76	54	15
4.3	100	79	44	55	86	90	35	46	48	41	28	20
4.5	100	95	..	50	99	94	..	29	99	81	..	13
5.6	100	100	98	96	98	99	34	8	100	99	61	27
5.7	100	100	..	27	100	100	..	19	96	90	..	9
6.3	99	100	95	91	89	90	9	52	78	84	69	33
10.0	100	100	100	98	100	100	99	56	99	97	45	31
Std.	100	100	98	76	100	100	98	50	100	100	95	27
					Cages in woods							
4.3	48	38	60	..	17	8	27	..	3	1	52	..
4.5	47	16	..	..	20	5	..	..	6	11	..	..
5.6	93	18	93	..	37	16	11	..	95	25	20	..
5.7	100	23	..	..	99	1	..	..	66	0	..	..
6.3	70	5	94	..	6	0	95	..	0	0	92	..
10.0	98	58	74	..	69	9	73	..	20	5	68	..
Std.	100	95	100	..	100	53	68	..	81	24	46	..

min.) which gave 94 percent kill at 300 feet. Satisfactory kills of *A. albimanus* up to 600 feet were obtained with a flow rate of 5.6 fl. oz./min. This rate also produced satisfactory kills of greater than 90 percent of the other two test species up to 300 feet. Against *C. p. quinquefasciatus*, none of the flow rates gave satisfactory kills at 450 and 600 feet. The thermal fog treatments gave consistently high kills of each species except at 600 feet.

Caged mosquitoes exposed in the wooded areas when the flow rates were from 4.3 to 10.0 fl. oz./min. showed erratic results. *A. albimanus* was the only species with satisfactory kills at 150 feet over the range of flow rates. The thermal fog was much more effective against *A. albimanus*, giving 95 to 100 percent kills up to 450 feet. *Ae. taeniorhynchus* and *C. p. quinquefasciatus* were effectively killed at the 150-foot station in only one of the 11 test runs. The kills of these two species by the fog applications at the 150-foot station averaged 100 and 81 percent, respectively, for the six test runs.

The mass median diameters of the ULV malathion droplets throughout the season ranged from 7.0 to 20.4 microns.

DISCUSSION. Under these test conditions, ULV flow rates of 3.9 fl. oz./min. at the 5 mph vehicle speed and 5.6 fl. oz./min. at the 10 mph vehicle speed had to be used to achieve greater than 90 percent kills of the three test species at distances up to 300 feet. These effective kills occurred in cages placed in the open. In wooded areas, results were generally erratic even at the 150-foot stations. *A. albimanus* were effectively killed at this station with certain of the higher flow rates. This finding indicates that in some instances the ULV droplets penetrated the woods. With one exception, however, this penetration was not sufficient for the other test species. Since the thermal fogs gave 80 to 100 percent kills in the same situation, it seems reasonable to assume that the ULV particles were filtered out as they passed through the vegetation.

The relatively high flow rates required to give effective kills at "open sites" are not in agreement with data by Mount *et al.* (1970) which show that at 10 mph 2.85 fl. oz./min. of malathion yielded average kills of 93 percent of *Ae. taeniorhynchus*. In the present tests at the same vehicle speed and at the nearest comparable flow rate of 2.6 fl. oz./min., the average kill of *Ae taeniorhynchus* at the 150-, 300- and 600-foot stations was 57 percent. Even at the maximum flow rate of 10.0 fl. oz./min., the average kill at the same three sites was 85 percent. Presumably, the differences in effectiveness were due primarily to the protection afforded to the "open sites" in the present tests by the wooded areas that lie between the streets on which the cage stations are located. The effect of such protection on efficacy is supported by the reduced kills in cages located at sites in the woods only 6 to 10 feet from the "open" street sites.

The poor penetration of the ULV applications into brushy or woody areas as compared to that of thermal fogs suggests that control problems may occur in such areas, particularly since the maximum dosage recommended on the current ULV label is 3 fl. oz./min. However, since all of these tests were with caged mosquitoes, the loss of efficacy against free-flying mosquitoes may be much less. This aspect will be the subject of further studies.

Despite the superiority of thermal fogs over the ULV applications in the wooded areas, the advantages of the ULV technique through cost savings, reduction of traffic hazard, mobility, and lessened environmental contamination indicate that this method has great promise as an improvement over present adulticiding practices.

SUMMARY. Malathion ULV and thermal fogs applied with ground equipment were evaluated against caged *A. albimanus*, *C. p. quinquefasciatus* and *Ae. taeniorhynchus* at distances of 150, 300, 450 and 600 feet from the discharge nozzle. Delivery rates used were 1.7 to 10.0 fl. oz./min. with the ULV equipment and 85 and 170 fl. oz./min. with the thermal fogs. Open and wooded areas were included in the test sites. At 5 mph, flow rates of 3.9 and 4.1 fl. oz./min. were required to give kills of the three species approximately those achieved with thermal fogs (85 fl. oz./min.). At 10 mph, flow rates of 4.3 fl. oz./min. or above produced kills equivalent to the thermal fog (170 fl. oz./min.) up to the 300-foot stations. Thermal fogs were superior to ULV applications in producing kills in cages held at wooded sites. ULV adulticiding, however, offers the advantages of lower cost, reduced traffic hazard, and less environmental contamination.

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