FOG OIL AND FUEL OIL AS DILUENTS OF FENTHION, NALED, AND MALATHION IN THERMAL AEROSOLS USED TO CONTROL ADULT STABLE FLIES AND SALT-MARSH MOSQUITOES [1, 2]

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Rathburn *et al.* (1965) found no difference between the biological effectiveness of thermal aerosols of fog oils and diesel oil at either great distances or low concentrations of insecticide. Their tests with adult mosquitoes were conducted at night when inversions are usually the most favorable for aerosol space treatments. Our objective was to determine whether a fog oil of medium viscosity would increase the efficiency of insecticides applied as thermal aerosols during the daylight hours when wind speeds were high and/or there was no inversion.

METHODS AND MATERIALS. The tests were conducted with caged adult stable flies, *Stomoxys calcitrans* (L.), and caged female *Aedes taeniorhynchus* (Wiedemann) from laboratory colonies, and natural populations of salt-marsh mosquitoes, *A. taeniorhynchus* and *A. sollicitans* (Walker). Caged insects were 2–7 days old when exposed to the aerosols.

The thermal aerosol generator used was a Leco model 120® calibrated to deliver 40 gallons per hour of either fog oil or No. 2 fuel oil used as a diluent. Pressure was about 16 psi for fog oil and about 12 psi for fuel oil. A No. 3526 formulation disc was used for both oils. The aerosol generator was operated at 850° F. for both types of oil in all tests except one in which the temperature was 1000° F. for the fog oil. The aerosol generator was moved at a speed of 5 m.p.h.

The fuel oil was a No. 2 grade purchased locally. The fog oil had a medium viscosity, a molecular weight of 300, a specific gravity of 0.92, and an aniline point of 145° F. The insecticides used were malathion (natural population only), fenthion (Baytex®) (caged insects only), and naled (Dibrom®). A 0.5-percent concentration of a sludge inhibitor (mixed amide oleate from modified fatty acids and polyamines) was used in the fuel oil formulations to retard the formation of precipitates. No sludge inhibitor was used in fog oil formulations. Both species of caged insects were also exposed to thermal aerosols of fog oil and fuel oil with no insecticide added as a check of natural mortality.

TESTS WITH CAGED INSECTS. The experimental plots for the tests with the caged stable flies and mosquitoes were located at an airport near Gainesville, Florida. These plots were fairly level and open. The insects were placed in groups of 25 in 16-mesh screen wire cages located downwind from and perpendicular to a line over which the truck-mounted generator passed. The cages of stable flies (4 per test) were placed at heights of 1 and 5 feet above the ground at distances of 125 feet and 250 feet from the line of aerosol discharge. The caged female mosquitoes (6 cages per test) were placed on the ground and 2 feet and 6 feet above the ground at distances of 150 feet and 300 feet from the line of aerosol discharge. In each test, the aerosol was allowed to drift across the experimental plot before the cages of insects were removed.

In the field, all caged insects were kept in insulated chests containing ice in cans except during exposure to the aerosols.

[1] The authors are indebted to Basil E. May, Jr., Director of the Levy County Mosquito Control District, Bronson, Florida, for cooperation received in tests with natural populations of mosquitoes.

[2] Mention of a proprietary product does not necessarily imply endorsement by the U.S.D.A.

Stable flies were returned to the laboratory 1–2 hours after each series of tests and transferred to clean screen holding cages in a cold room (34° F.). Mosquitoes were blown into plastic tubes lined with clean paper immediately after each test. After the test, the caged stable flies were given a 10 percent honey-water solution for a 24-hour holding period; the mosquitoes were given a 10 percent sugar-water solution for either an 18- or 24-hour holding period. Mortality counts were made at the end of the holding periods.

Tests with caged stable flies were conducted during conditions of no inversion, from 1:00 to 3:00 p.m. (Inversions were determined largely by whether a major portion of the aerosols ascended to levels of 10 feet or more above the ground. Also temperature measurements were made at ground level and at 6 feet above the ground to help determine inversions.) Air temperatures ranged from 68 to 84° F., with an average of about 76° F.; wind speeds were 5–20 m.p.h., and averaged about 9 m.p.h. One series of tests with the caged female mosquitoes was conducted during conditions of no inversion, between 10:00 and 11:00 a.m.; air temperatures were 78–90° F., an average of 80° F.; wind speeds were <2–8 m.p.h. and averaged about 4 m.p.h. Another series of tests was conducted during inversions between 4:30 and 6:00 p.m.; air temperatures were 70–88° F. and averaged 79° F.; wind speeds were <2–10 m.p.h. with an average of 4 m.p.h.

TESTS WITH NATURAL POPULATIONS. Tests with natural populations of saltmarsh mosquitoes, *A. taeniorhynchus* (the predominant species) and *A. sollicitans,* were conducted at Cedar Key, Florida (Levy County). The experimental plots were moderately wooded and partly covered with underbrush and grass. The aerosols were dispersed at 5 m.p.h. for a distance of about ¼ mile on roads running along the upwind side of the plots to allow the wind to drift the aerosols across the plots.

The relative abundance of mosquitoes in each plot was sampled by counting the number landing per man per minute on two observers placed at each of six stations. These counting stations were aligned somewhat parallel to the aerosal discharge roads. The stations were 75–200 feet from the roads and 50–100 feet apart. Counts were made immediately before each test, at 3, 6, and 24 hours after treatment with

TABLE 1.—Effectiveness of fog oil and fuel oil used as diluents for fenthion and naled in thermal aerosols against caged adult stable flies (aerosols applied during conditions of no inversion).

Insecticide (% concentration)	Diluent	Percent 24-hour mortality at indicated height above ground[1] 1 ft.	5 ft.	Average
Fenthion				
0.5	Fog oil	11	10	11
1		38	27	33
0.5	Fuel oil	20	33	27
1		36	33	35
Naled				
0.5	Fog oil	15	15	15
1		26	42	34
0.5	Fuel oil	16	32	24
1		18	32	25
None				
..	Fog oil	0	6	3
..	Fuel oil	4	10	7

[1] Average of results obtained at 125 and 250 feet; 2 tests of 4 cages (25 flies each) per test.

malathion, and at 3 and 24 hours after treatment with naled.

The tests were conducted during inversions, from 9:30 to 11:30 a.m. Air temperatures were 76–84° F., with an average of 80° F. Wind speeds were 3–12 m.p.h., and averaged about 6 m.p.h.

RESULTS. A comparison of fog oil and fuel oil as diluents for fenthion and naled in tests against caged adult stable flies is presented in Table 1. The mortalities of stable flies exposed to aerosols of both types of oil were low and rather similar. None of the differences was considered to be meaningful.

The results obtained with caged female mosquitoes during conditions of no inversion (Table 2) were also poor with both types of oil formulations. Again, none of the differences was large. Table 3 compares the results obtained when fog oil and fuel oil formulations were applied during inversions: fuel oil was slightly better than fog oil as a diluent for fenthion and naled. Much lower mortality occurred at ground level than at 2 and 6 feet above the ground; for example, a fuel oil solution containing 2 percent naled produced only 14 percent mortality at ground level compared with 90 and 92 percent mortality at heights of 2 and 6 feet, respectively.

Table 4 presents the results of a test designed to indicate whether a higher temperature in the generator burner would increase the effectiveness of fog oil formulations, which have greater viscosity than fuel oil formulations. The data indicated that an increase in temperature from 850° F. to 1000° F. adversely affected the effectiveness of fog oil formulations.

Fog oil and fuel oil are compared as diluents for malathion and naled in tests against natural populations of salt-marsh mosquitoes in Table 5. The reductions in population obtained with both types of oil were low. Malathion at 4 percent in fog oil produced a reduction of 50 percent at the 6-hour interval, but the population had increased 18 percent at the same time in the plot treated with the same concentration in fuel oil. Malathion at 8 percent produced no reduction at the 3-hour interval, regardless of which type of oil was used; in this test, no counts were made after 6 or 24 hours. Tests with naled diluted in fog oil or fuel oil at concentra-

TABLE 2.—Effectiveness of fog oil and fuel oil used as diluents for fenthion and naled in thermal aerosols against caged female *Aedes taeniorhynchus* (Wiedemann). Aerosols applied during conditions of no inversion.

Insecticide (% concentration)	Diluent	Percent 24-hour mortality at indicated height above ground[1]			
		0	2 ft.	6 ft.	Average
Fenthion					
1	Fog oil	2	14	6	7
2		4	18	50	24
1	Fuel oil	12	48	44	35
2		15	37	50	34
Naled					
1	Fog oil	2	8	10	7
2		12	30	35	26
1	Fuel oil	8	18	10	12
2		4	21	43	23
None					
..	Fog oil	8	4	4	5
..	Fuel oil	6	2	2	3

[1] Average of results obtained at 150 and 300 feet; 2 tests of 6 cages (25 mosquitoes each) per test.

TABLE 3.—Effectiveness of fog oil and fuel oil used as diluents for fenthion and naled in thermal aerosols against caged female *Aedes taeniorhynchus* (Wiedemann). Aerosols applied during inversions.

Insecticide (% concentration)	Diluent	Percent 18-hour mortality at indicated height above ground[1] 0	2 ft.	6 ft.	Average
Fenthion					
1	Fog oil	18	36	46	33
2		10	64	62	45
1	Fuel oil	24	55	65	48
2		40	96	98	78
Naled					
1	Fog oil	6	10	4	7
2		3	62	73	46
1	Fuel oil	0	2	24	9
2		14	90	92	65
None					
..	Fog oil	3	5	0	3
..	Fuel oil	4	0	4	3

[1] Average of results obtained at 150 and 300 feet; 2 tests of 6 cages (25 mosquitoes each) per test.

tions of 2 and 4 percent showed little difference between the two types of oil.

DISCUSSION. Thermal aerosols applied under conditions of no inversion gave unsatisfactory kills of caged stable flies and female *A. taeniorhynchus* with either fog oil or fuel oil as the diluent. Tests with caged female *A. taeniorhynchus* demonstrated that fuel oil was at least equal to fog oil when applications were made during inversions. These results are in agreement with those obtained by Rathburn *et al.* (1965).

The results with caged insects were confirmed by tests with natural populations of salt-marsh mosquitoes. Thermal aerosols of malathion and naled produced low reductions, regardless of whether fog oil or fuel oil was used as the diluent.

Little mortality was observed in cages of mosquitoes placed at ground level. However, the grass on the experimental plots was 6–12 inches high; therefore, it is possible that higher air speeds above the grass prevented the aerosol particles from reaching the mosquitoes placed at ground level,

TABLE 4.—Effectiveness of fog oil and fuel oil used as diluents for fenthion and naled in thermal aerosols against caged female *Aedes taeniorhynchus* (Wiedemann). Aerosol generator burner operated at 850° F. for fuel oil and 1000° F. for fog oil.

Insecticide	Diluent	Percent 18-hour mortality at indicated height above ground[1] 0	2 ft.	6 ft.	Average
Fenthion, 2%	Fog oil	2	42	54	33
	Fuel oil	30	98	100	76
Naled, 2%	Fog oil	0	0	4	1
	Fuel oil	10	76	80	55
None	Fuel oil	0	0	2	1

[1] Average of results obtained at 150 and 300 feet; 1 test of 6 cages (25 mosquitoes each) per test.

TABLE 5.—Effectiveness of fog oil and fuel oil used as diluents for malathion and naled in thermal aerosols against natural populations of salt-marsh mosquitoes. Aerosols applied during inversions.[1]

Insecticide (% concentration)	Diluent	Percent reduction at indicated interval after treatment[2] 3 hr.	6 hr.	24 hr.
Malathion				
4	Fog oil	24	50	+54
	Fuel oil	+51	+18	+64
8	Fog oil	+11	[3]	[3]
	Fuel oil	+17	[3]	[3]
Naled				
2	Fog oil	35	..	+26
	Fuel oil	23	..	+13
4	Fog oil	39	..	34
	Fuel oil	32	..	9
None (check)				
..	..	+15	+9	+2

[1] Two tests with 4 percent naled; 1 test with other treatments.
[2] + indicates percent increase.
[3] No counts were made at these intervals.

as suggested by Rathburn *et al.* (1965). Also the dense grass cover may have prevented penetration of particles of insecticide. Since these insects normally rest close to the ground during the day, our results may partially explain the low reductions normally obtained in field tests with natural populations of salt-marsh mosquitoes.

SUMMARY. Little or no difference was found between a fog oil of medium viscosity and No. 2 fuel oil as diluents in thermal aerosols in tests with caged stable flies, *Stomoxys calcitrans* (L.), caged females of *Aedes taeniorhynchus* (Wiedemann), and natural populations of salt-marsh mosquitoes, *A. taeniorhynchus* and *A. sollicitans* (Walker). Poor control was obtained with both types of oil when treatments were applied during conditions of no inversion. Much less mortality was observed in cages of mosquitoes placed at ground level in 6–12 inches of grass than above the ground at heights of 2 or 6 feet. These results may explain the poor control obtained in daytime tests with natural populations of salt-marsh mosquitoes.

Literature Cited

RATHBURN, C. B., JR., CLEMENTS, B. W., JR., and ROGERS, A. J. 1965. Comparative tests of fog oils and diesel oil as thermal aerosols for control of adult mosquitoes. Mosq. News 25(2):101–106.