THE EFFECTIVENESS OF AERIAL SPRAYS FOR THE CONTROL OF ADULT MOSQUITOES IN FLORIDA AS ASSESSED BY THREE METHODS[1]

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The degree of control of adult mosquitoes obtained with aerial sprays is usually assessed by one of three methods: caged mosquitoes, trap collections, or landing rates. Each method may be prone to serious errors. Obviously, cages offer some protection to the mosquito as well as limiting flight activity. The protection afforded by the cage, however, may not be nearly as much as that offered by vegetation, structures, etc., where mosquitoes rest during the daytime, the time that most aerial sprays are applied. Nevertheless, the cage is not a natural place for mosquitoes to be when exposed to sprays. Landing rates are prone to serious errors associated with the activity and natural behavior of mosquitoes. Meteorological conditions, especially light intensity, as well as variations in the degree of attraction of different individuals may lead to erroneous conclusions when landing rates are the only means of assessing the degree of control obtained. Also, the time involved in obtaining most landing rates is extremely short and may not give a true picture of the presence or absence of mosquitoes in a particular area. Traps are also prone to many of the errors associated with landing rates, but since the sample is collected over a very much longer period of time the chances of obtaining a more reliable estimate of the population are significantly better. Since each method is subject to serious errors, it is more likely that a combination of all three methods may lead to the most reliable estimate of the degree of control obtained. The following series of tests were designed to determine the relative merit of the use of caged mosquitoes, traps, and landing rates for assessing the degree of control obtained by aerial sprays.

Methods. All tests were conducted with a 220 h.p. Stearman airplane flown at 80 miles per hour at an altitude of 75 to 100 feet. All swaths were marked by flagmen at each end. Flat spray nozzles positioned at a 45 degree forward angle at the trailing edge of the wing were used in all tests. The center of the treated area was fairly high, open and sandy and was partly overgrown with rows of planted pines and scattered turkey oaks 4 to 8 feet high. Surrounding this center area were small cypress ponds, open grassy areas, and some low swampy areas.

The traps, miniature CDC light traps baited with dry ice, were situated about 1,000 feet apart in both the higher center area and in the adjacent lower area. Check areas were located about 3 miles upwind in a habitat similar to that of the treated area. In tests 1 and 2 there were three traps in the treated area and three in the check area. In tests 3 and 4 there were four traps in each area. Trap collections were made each night for two nights before treatment and the night after treatment except in the case of test 1, where traps were set each night for two nights both before and after treatment.

In all tests, sprays were applied between 6:10 and 7:45 a.m. The landing rates were taken at the trap stations by the same individuals. In test 1, pretreatment landing rate counts were taken 10 to 25 minutes before sunrise and post-treatment counts were taken 5 minutes after conclusion of spraying (35 to 45 minutes afer sunrise).

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No landing rates were made in the check area for this test. In test 2, landing rates were taken 35 to 50 minutes before sunrise on the morning of treatment and at the same time the morning after the treatment. In tests 3 and 4, landing rates were taken immediately after dark one and two nights before treatment and at the same time the night after treatment.

The caged mosquitoes used in the tests were obtained from laboratory colonies and were from 2 to 8 days old. Three to four cages of each species, *Culex nigripalpus* and *Aedes taeniorhynchus*, each containing approximately 25 female mosquitoes were hung close to the ground in pairs (one *Aedes* and one *Culex*) in the vicinity of each of the traps in the treated area. The mortality of the untreated mosquitoes, which were placed in the check area during the treatment time, averaged 0.3 percent for *A. taeniorhynchus* and 1.2 percent for *C. nigripalpus*.

Shown in Table 1 are the operational data for all tests. It should be noted that because of the volume per acre discharged in tests 2 and 3, it took two plane loads to cover the treated area. The time interval between loads was approximately 45 minutes. Since the wind velocity, temperature, and relative humidity varied greatly between the time that the first and the second loads were applied, they are shown separately as averages for each time period in that sequence.

The formulation used in test 1 consisted of 6 gallons of Dibrom 14 plus 12 gallons of Ortho Additive in 82 gallons of diesel oil. For tests 2 and 3, it was 2 gallons 7½ pints of Dibrom 14 plus 2 gallons 7½ pints of Ortho Additive in 94 gallons 1 pint of diesel oil. The fourth test was conducted with Dibrom 14 only. The dosage of naled was 0.1 lb./a for all tests.

RESULTS. The results of all tests are shown in Table 2. Where pre- and post-treatment trap collections or landing rates were made on two nights, the figures shown are the averages of the two nights. The mosquitoes obtained by trapping were predominantly *Aedes mitchellae, Psorophora confinnis,* and *Culiseta melanura* with fewer numbers of *Anopheles crucians, Culex nigripalpus,* and *Culex* (*Melanoconion*) spp. There appeared to be no significant variation in the relative numbers of each species trapped before and after treatment, therefore, no selective mortality of species was noted. It is evident that good to excellent control of caged mosquitoes was obtained in these tests, but there was no significant reduction in the number of trapped mosquitoes in any of the tests. In tests 1 and 3, the trap counts increased in both the treated and check areas after treatment, although the increases were not as great in the treated area. This indicates perhaps some slight reduction due to the treatment. The apparently good reduction in landing rate in test 1 probably only reflects the reduction in mosquito activity with time since pre-treatment landing rates were taken before sunrise on the morning treated and post-treatment counts were taken 55 minutes later, which was well after sunrise. The landing rates in test 3 increased in both the treated and check area as did the trap collections. Landing rates taken before sunrise and just prior to spraying in test 3 showed no difference between the treated and check areas, averaging 11 and 13 per man per 3 minutes respectively (data not included in Table 2).

In test 2 the reduction in the trap count in the treated area was accompanied by a greater reduction in the check area and, therefore, was not a result of the treatment. Also, a significant reduction in the landing rate in the treated area was accompanied by an increase in the check area. Since the apparent control as assessed by landing rates was not substantiated by the trap collections, the treatment cannot be considered effective. In test 4, with 1 fluid ounce of Dibrom 14 per acre, a 58 percent reduction in the trap collection in the treated area was accompanied by a 38 percent increase in the check area. This might seem significant if it were not for the fact that there was a 22 percent increase in the landing rate in the treated area and a 72 percent reduction in the check area. Pretreatment landing rate counts taken before sunrise and just prior to spraying in test 4 showed

TABLE 1.—Operational data for aerial spray tests of naled against adult mosquitoes.[1]

Test no.	Volume fl. oz. per acre	Nozzle			Swath		No. acres	Wind at 40 ft. mph	Temp. at 6 ft. °F	R.H. at 5 ft. %	Spray time			Sunrise
		no.	size	psi	ft.	no.					min.	start	stop	
1	16	10	6508	43	400	12	575	3	67	92	26	0610	0636	0605
2	32	7	6515	25	200	31	800	4–5	78–82	87–73	40	0620	0745	0609
3	32	7	6515	25	200	27	800	4–3	64–76	89–53	43	0615	0740	0612
4	1	6	8001	57	200	29	1400	2	69	92	42	0607	0649	0618

[1] All tests: 0.1 lb/a naled; plane speed 80 mph; altitude 75–100 ft.

TABLE 2.—Summary of results of aerial spray tests with naled, as assessed by caged mosquitoes, trap collections, and landing rates.

Test no.	Percent kill of caged mosquitoes		Trap collections-avg. no./trap/night						Landing rate-avg. no./man/3 min.					
			Treated area			Check area			Treated area			Check area		
	Culex	*Aedes*	Pre.	Post.	% red.	Pre.	Post.	% red.	Pre.	Post.	% red.	Pre.	Post.	% red.
1	84	58	103	162	(+57)	122	281	(+130)	69	0	100	..	..	.....
2	100	100	95	56	41	159	78	51	63	6	90	1	5	(+400)
3	98	89	82	112	(+37)	51	117	(+129)	28	30	(+7)	11	18	(+64)
4	90	77	137	57	58	176	243	(+38)	9	11	(+22)	18	5	72

no difference between the treated area and check areas, averaging 5 per man per 3 minutes in each area (data not shown in Table 2). Although obviously a result of population fluctuations and/or the influence of weather conditions on mosquito activity, it is not possible to further explain these differences based upon the data acquired in these tests. It is evident, however, that treatment 4 did not result in satisfactory control of the natural population. Also of importance is the fact that all four treatments were applied to the same area over a period of 1 month (August 7 to September 4) with no noticeable reduction in mosquito population, as measured by trapping.

Discussion. In assessing the control of natural populations of mosquitoes, there is always the question of infiltration into the treated area between the time of treatment and the time of evaluation. In tests 3 and 4, where sprays were applied just after sunrise and post-treatment landing rates were taken immediately after dark, the period of possible infiltration was limited to the daylight hours immediately following treatment. Since mosquito activity is minimal for the species concerned during this period, the landing rates taken at dusk or immediately after dark before and after treatment should offer a good indication of the control obtained.

Owing to the longer period of exposure and to the larger numbers of mosquitoes taken, it would appear that trapping might be the best method of assessing the effects of an insecticidal treatment on natural populations of mosquitoes. The treated area, however, must be of sufficient size that the traps can be placed a considerable distance from its edge so as not to be influenced by infiltration. Obviously, the mosquito species in question must be attracted to the type of trap or bait used and in sufficient numbers to be meaningful.

The considerably higher mortality obtained with caged mosquitoes as compared to that obtained with the natural population as assessed by traps and landing rates was undoubtedly due to the positioning of the cages. During the daylight hours, the time at which the treatments were applied, most mosquitoes are at rest in moist protected areas on or very near the ground. The cages of mosquitoes, although placed as close to the ground as possible, were not actually on the ground amongst the litter as were those of the natural population, because of the threat of ants. The cages were only sheltered from the spray by the vegetative barriers that happened to be in the line of drift and, therefore, undoubtedly obtained a higher dosage than would have been possible if they were on the ground and well protected by the litter or thick grass.

Caged mosquitoes are very useful for assessing the toxicity of a formulation where good contact of the spray with the mosquitoes is obtained, but this method might not accurately assess kill of natural populations. It has been stated by Bidlingmayer (1967), Provost (1955) and others that no single sampling method will give a true estimate of the total population of mosquitoes because of differences in response due to various biological and environmental factors. It is also apparent that under the conditions of these tests none of the methods used was completely reliable in assessing control of the natural population. This might not apply to all conditions where aerial sprays are used, but these results require that additional studies of this kind be made at various times, against other species, and in different habitats.

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