A PROGRESS REPORT ON DOSAGE TESTS WITH MOSQUITO ADULTICIDES

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This paper presents a discussion of what is believed to be a new concept of dosage with aerosols applied under field conditions and a progress report on insecticide dosage tests with aerosols against adult salt-marsh mosquitoes in Florida.

CALCULATING DOSAGE WITH AEROSOLS. Collins (1955) summed up the complex problem of dosage with aerosols when he stated ". . . We are still hazy as to what we mean by dosage when we speak of fogs. Many of us regard the expression of so many pounds or gallons per acre as out of place in referring to fogs or mists. The expression is especially meaningless with respect to fog."

The following discussion of this subject presents a method of calculating dosage with out-door aerosols which is believed to be sound from the standpoint of the established principles of insect control by chemicals, and which will permit a more accurate expression of dosage than other methods in use.

The pounds-per-acre method of expressing insecticide dosage appears to have more real significance in relation to insect control under field conditions than other methods. This concept has largely replaced the "per cent-concentration" method in control of agricultural pests. A certain amount of toxicant per given area is required to give control of insects under field conditions. Therefore it usually makes little difference whether the insecticide is applied as a 1 percent spray or a 10 percent spray, provided the required amount of insecticide is applied and adequate coverage is obtained.

This same sound principle of dosage can be applied to the control of adult mosquitoes with aerosols, but the calculation must be different from that used in control of agricultural pests. For example, a modern aerosol operation using 7½ percent DDT at 40 gallons per hour, 5 m.p.h., would release 8 gallons containing 5 pounds of DDT along one mile of front. If an arbitrary swath of 900 feet is assumed, the treated plot would contain 109 acres. The usual procedure in calculating the dosage in this example is to divide 5 pounds by 109 acres—dosage .05 lb. per acre.

Since this method assumes an equal distribution or deposit of insecticide on each acre, this may be termed the "deposit" method of calculating dosage. This concept of dosage is correct for use with coarse sprays to control plant pests, but it does not meet the requirements for aerosol applications. There are several reasons for this: 1. Aerosols drift horizontally and do not deposit in the same manner as do coarse sprays. 2. Aerosols are primarily space sprays, meaning that they treat the space above the soil. In terms of acres, this may be visualized as the cubic volume of air above an acre of soil through which the aerosol cloud passes. 3. The insecticide in an aerosol which treats the space above an acre of soil is of more importance in killing adult mosquitoes, or other flying insects, than the very small quantity which deposits on the soil or plants.

Yeomans' paper on directions for applying wind-borne aerosols was concerned primarily with deposits from aerosols to control agricultural pests (Yeomans, 1950). However, Yeomans' paper contains data which may be used to calculate correctly in pounds per acre the dosage when applied as an aerosol to control adult mosquitoes. This may be called the "space" method of calculating dosage to distinguish it from the "deposit" method

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TABLE 1.—(After Yeomans, 1950) Effect of particle size on the percent of total insecticide depositing on 100-foot strips across a field. (Wind 3 m.p.h.)

Distance from Release front (feet)	Percent Deposit in Each 100-ft. Section	
	40 micron m.m.d.	25 micron m.m.d.
0–100	7.6	1.4
100–200	7.5	1.4
200–300	6.5	1.4
300–400	4.7	1.4
400–500	2.8	1.4
500–600	1.8	1.4
600–700	1.7	1.4
700–800	1.7	1.0
800–900	1.7	0.7
Totals	36.0	11.5

already described. Yeomans' data on deposits from aerosols are reproduced in part in Table 1.

Data in Table 1 show that in a 3 m.p.h. wind, 88.5 percent of the insecticide in an aerosol of 25 microns mass median diameter is still air-borne at 900 feet, and 64 percent is still air-borne at this distance when the mmd is 40 microns. Based upon the 40-micron data in Table 1, the correct calculation of the dosage in pounds per acre for the 7½ percent DDT example previously cited would be as shown in Figure 1.

Data in Figure 1 show that the first 100-foot strip of the 109-acre plot would receive a dosage of .412 lb. per acre. Deducting the 7.6 percent (see Table 1) of insecticide that deposits on the first 100-foot strip, the dosage for the second 100-foot strip is .381 lb. per acre, etc., etc. This dosage takes into account both the amount of insecticide that deposits on the soil and the amount that treats the air above the 12.12 acres of each strip. Thus the true average dosage in pounds per acre in the theoretical example is .321 lb. instead of .05 lb.

This principle is graphically represented in Figure 2, which shows the dosage curves for the equal distribution or "deposit" method compared with the "space" method corrected to two droplet sizes.

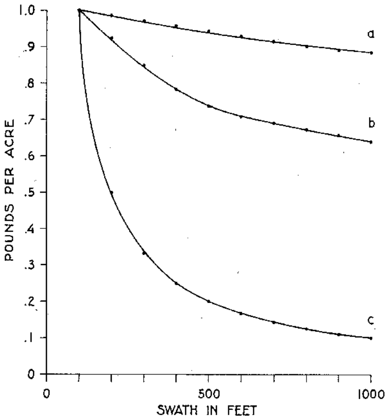

FIG. 2.—Comparison of dosage curves: a. Corrected to 25μ mmd; b. Corrected to 40μ mmd; c. Equal Distribution.

Thus, using the "deposit" method of calculating dosage, the dosage in pounds per acre is reduced by one-half as the swath width is doubled. This would indicate a substantial decrease in mortality with an increase in distance. However, good kills in these tests were obtained at a distance of 660 feet, and with the better dosages, kills of 90 percent and better were obtained at a distance of 1,320 feet. As may be seen from the distance-mortality curves (Figure 3), the kill at increased swath widths falls off only slowly, giving a curve that is more comparable to that of

← Vehicle course (5280' front) →

Direction of drift ↓

Distance in feet	Number of acres	Per cent deposit	Dosage-lbs/acre deposit + air-born
0–100	12.12	7.6	0.412
100–200	12.12	7.5	0.381
200–300	12.12	6.5	0.350
300–400	12.12	4.7	0.323
400–500	12.12	2.8	0.304
500–600	12.12	1.8	0.292
600–700	12.12	1.7	0.285
700–800	12.12	1.7	0.278
800–900	12.12	1.7	0.271
	Total 109.08	Total 36.0	Average 0.321

FIG. 1.—"Space" method for calculation of dosage with wind-borne aerosols.

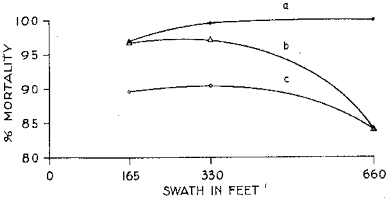

FIG. 3.—Distance-mortality curves: a. 0.54 lbs./a. malathion; b. 0.13 lbs./a. malathion plus 3% v/v Lethane 384; c. 0.27 lbs./a. malathion.

the corrected curves (based on Yeomans' data) than that of the equal distribution curve c of Figure 2.

An important aspect of these two concepts of dosage with aerosols is the effect they may have on the interpretation of data already published. For example, in a frequently cited paper, Brescia (1946) recommended as an aerosol 15 gallons per 1,000 front feet of DDT emulsion containing .3235 lb. DDT per gallon. Brescia concluded that this dosage would control adult salt-marsh mosquitoes up to one mile down wind in open country. Converting Brescia's operation of pounds per acre by the "deposit" method, the dosage was .04 lb. per acre; but calculated by the "space" method, Brescia's dosage was approximately 2.00 lbs. per acre.

Although Brescia did not state this himself, it could be concluded by using the "deposit" method of calculating dosage that a modern aerosol generator discharging 5 percent DDT at 20 gallons per hour would apply the same dosage in pounds per acre over a swath of one city block (330 feet) as Brescia applied per acre over a swath of one mile. However, calculated by the "space" method, and assuming a wind velocity of three miles per hour, Brescia's dosage over the first 330 feet of his swath was 2.08 lbs. per acre and the modern machine in this comparison applies only .14 lb. per acre over the same swath. Therefore Brescia's operation in terms of dosage was equal to 15 of the modern machines moving en masse down the same street at five miles per hour and applying 5 percent DDT at 20 gallons per hour over a swath of one city block (330 feet).

In terms of one small-capacity modern aerosol generator discharging 40 gallons per hour at 5 miles per hour, the single generator in order to equal Brescia's true dosage in pounds per acre would be required to use a concentration of approximately 40 percent DDT (w/v).

It is not intended to imply by these comparative statistics that small-capacity generators cannot be used effectively in controlling adult mosquitoes. But the figures do illustrate the fallacy of computing dosage with outdoor aerosols by the "deposit" method. Also, these figures seem to justify a re-evaluation of existing dosage recommendations for small-capacity aerosol generators.

RESULTS OF DOSAGE TESTS. Using the cage-test technique described in another paper by the same authors in this issue of *Mosquito News*, dosage tests with various insecticides against adult salt-marsh mosquitoes were conducted at Vero Beach, Florida, from September 1956 to April 1957.

These tests were all made with a Tifa aerosol machine operated at 1,000° F., formulation pressure of 25 p.s.i., 40 gallon per hour discharge, and vehicle speed of five miles per hour. Number 2 diesel oil was the basic diluent used in all formulations. The testing time was from about 8:00 p.m. to 11:00 p.m. under good conditions of inversion and wind velocities ranging from 1 to 10 m.p.h.

Based upon 12-hour mortality of female mosquitoes, the results of these tests are shown in Table 2.

DISCUSSION. The data show that malathion was by far the most effective insecticide used in these tests at the dosage levels indicated. Unfortunately, interpretation of dosage with DDT against Florida salt-marsh mosquitoes is clouded by the resistance factor. However, based upon the "space" method of computing dosage and upon findings and recommendations like those of Provost's (1952), it seems reason-

TABLE 2.—Results of dosage tests with aerosols against *Aedes taeniorhynchus* and *Aedes sollicitans* in screened cages under field conditions, 1956–57.

Insecticide	Formulation lbs./gal.	Formulation % v/v	Average Dosage in lbs./acre[1]	Number of Replications	Percent Kill (660 foot swath)[2] Average	Percent Kill (660 foot swath)[2] Range
Malathion	1.00	...	0.54	3	99	95–100
Malathion + Lethane 384	0.25 /	... / 3.0	0.13 /	3	92	87–96
Malathion	0.50	...	0.27	18	88	60–100
Malathion + Thanite	0.25 /	... / 3.0	0.13 /	3	74	72–77
Malathion	0.25	...	0.13	3	60	49–65
Lethane 384	....	5.0	....	2	41	30–47
DDT	1.00	...	0.54	5	30	15–58
Cubetoid	....	10.0	....	3	30	23–38
Lethane 384 special	....	10.0	....	3	30	28–37
Thanite	....	5.0	....	3	23	17–35
Pyrethrum + Piper. butoxide	.... /	0.06 / 0.3	.... /	3	17	15–22
DDT + Thanite	0.625 /	... / 3.0	0.10 /	3	10	7–14

[1] Average dosage over a 660-foot swath considering both deposit and treatment of space above the soil.

[2] Data corrected to check mortalities using a modification of Abbott's formula by Sun and Shepard.

able to assume that there has been considerable underdosing with DDT in aerosol generators.

Dosage levels in these tests with Lethane, Thanite, and Cubetoid Extract were based upon label recommendations or upon dosage levels most frequently used in control operations with thermal aerosols. The pyrethrum-piperonyl butoxide dosage was based upon costs that were comparable with malathion at 0.5 lb. per gallon.

With the exception of Lethane 384 in combination with malathion, the results with all of these materials were unsatisfactory at the dosage levels used.

Malathion at 0.5 lb. per gallon was used as a standard in most of the tests, which accounts for the large number of replications with this formulation. In the 18 replications with this dosage of malathion, *Aedes sollicitans* comprised only 5 percent of 3,339 mosquitoes used, but the kill was the same as for *Aedes taeniorhynchus*, namely, 88 percent.

Dosage levels reported on in this paper have been tested to date only in open terrain and with the Tifa aerosol generator. Therefore it is not intended to imply that the same results would be assured under various conditions of terrain and with other kinds of aerosol equipment.

These tests were conducted during the season of the year (September to April) when minimum temperatures prevail in

Florida; the maximum temperature during the tests was 76.5° F. and the minimum was 56.5°.

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