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SOME FACTORS AFFECTING KILL OF THE STABLE FLY, *STOMOXYS CALCITRANS* (L.), WITH INSECTICIDAL THERMAL AEROSOLS

B. W. CLEMENTS, JR. AND A. J. ROGERS
West Florida Arthropod Research Laboratory, Florida State Board of Health, Panama City, Florida [1]

Insecticidal thermal aerosols have attained wide use as space treatments for control of adult mosquitoes during the past two decades. The spectacular appearance of "fogs" probably is the basis for the popular acceptance of this method by the public; however, this spectacular aspect of fogging also might be the basic cause of some misuse of the method. Fogging is not different from spraying or dusting with respect to the basic requirements of effective dosage and good coverage for insect control, for the mere visible presence of an insecticidal fog in a target area does not ensure effective insect kill.

Tests of naled (Dibrom) in thermal aerosols against adult stable flies, *Stomoxys calcitrans* (L.) at Panama City, Florida during 1965 revealed some factors relating to dosage, volume, and drift which illustrate basic principles of the aerosol method.

METHODS. Test plots were established in a residential area at Panama City Beach, Florida, approximately one-fourth mile inland from the beach. The area consists of beach sand sparsely covered with low growing vegetation, an occasional tree, and single-story dwellings. Streets are 300 feet apart in one direction and approximately 600 feet in the other.

The test was designed for multiple swaths in a manner similar to that described by Rathburn and Rogers (1959).

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Each plot contained four stations 400 to 600 feet apart on each of three parallel streets 300 feet apart. The three streets were designated A, B, and C. At each station a stake 6 feet long was established on the upwind side of the street, and a 2½" x 6" cylindrical screen cage containing 20 unsexed adult stable flies was attached at the top of each stake, making a total of 12 cages containing 240 flies for each test. The test flies were from a laboratory colony and were between 2 and 9 days of age when exposed. All flies had been fed citrated cow's blood 7 to 10 hours prior to exposure.

The aerosol was applied by driving the vehicle along three parallel streets, starting one block (300 feet) upwind of street A. Since aerosol droplets drift on the wind for 900 feet or farther (Yeomans, 1960), this course of travel resulted in stations along street A receiving one swath that had drifted 300 feet; stations along street B received the drift of the first swath (600 feet away) plus a second swath of 300 feet distance; and stations along street C received the drifts of the first swath (900 feet away), the second swath (600 feet away), and the third swath 300 feet away. Therefore, the flies at stations on streets B and C theoretically received an increasingly larger dose respectively than the flies at stations on street A, which were exposed only to one swath. Tests were replicated in time, only two tests being conducted in a single day.

The thermal aerosol generator used was a Leco 120[2] operated at 850° F. burner temperature for volumes of 40 gallons per hour and at 1000° F. for 80 gallons per hour. The machine was calibrated prior to testing and the operation was checked constantly throughout the tests. Formulations were made by diluting Dibrom 14 concentrate with No. 2 diesel oil to which a sludge inhibitor had been added.

Wind velocities were recorded at 6 feet above the ground during the tests and ranged between 2 and 9 miles per hour, with an average of 5.6 miles per hour. The temperature at 6 feet above the ground ranged between 70° and 84°, averaging 79.6°. Relative humidity ranged between 57 percent and 83 percent with an average of 76 percent.

After the flies were exposed to the aerosol they were knocked down with CO_2 and transferred to clean cages. Twelve cages of untreated flies used as checks for each test were transported to and from the test site. The untreated flies were knocked down with CO_2 but were not transferred to other cages. Both treated and untreated flies were held in the laboratory under moist cotton pads for a 24-hour post treatment count. Mortality was determined by counting all flies that were unable to fly as being dead.

RESULTS. Data in Table 1 show that 1¾ oz./gal. of naled applied at the rate of 40 gals./hr. with the vehicle traveling at 5 miles per hour was not effective against the stable fly. This is the recommended dosage of naled for mosquito control in Florida. However, this formulation was effective against stable flies when the volume was increased from 40 to 80 gals./hr. This increased volume theoretically doubled the dosage of naled applied. When this dosage was kept constant by increasing the naled from 1¾ to 3½ oz./gal. and decreasing the volume from 80 to 40 gals./hr. with the vehicle speed remaining the same, there was no significant difference in the kill by statistical analysis. In the treatment where the dosage was kept the same by applying 3½ oz./gal. at 80 g.p.h. and increasing vehicle speed to 10 m.p.h., the kill again remained unchanged.

Data in Table 2 show the effects of drift of ground thermal aerosols on kill of the stable fly in these tests. These data clearly show that drift was a factor affecting the kill at streets B and C. Analysis of variance of 12 replications of 1¾ oz./gal. applied at 40 g.p.h., 5 m.p.h.

[2] Lowndes Engineering Company.

TABLE 1.—Effects of formulation, volume and vehicle speed in ground thermal aerosol of naled on the kill of caged adults of the stable fly, *Stomoxys calcitrans* (L.), 1965.[1]

Formulations (oz./gal.)	Volume (gals./hr.)	Vehicle Speed (m.p.h.)	Percent kill in 24 hrs.[2]	Range
1¾	40	5	70	46–91
1¾	80	5	89	86–98
3½	40	5	96	94–100
3½	80	10	96	89–99

[1] Four replications each treatment.
[2] Corrected to check mortalities by Abbott's formula.

TABLE 2.—Effects of overlapping swaths of ground thermal aerosols of naled on the kill of caged stable flies, *Stomoxys calcitrans* (L.), 1965.

Formulations (oz./gal.)	Volume (gal./hr.)	Reps.	Speed (m.p.h.)	Percent kill[1] at indicated streets (A, B and C)		
				A	B	C
				One Swath	Two Swaths	Three Swaths
1¾	40	12	5	46	64	75**
1¾	80	4	5	76	96	98
3½	40	4	5	90	99	100

[1] Corrected to check mortalities by Abbott's formula.

showed highly significant differences in kill between swaths A, B, and C, and the data reflect the progressive effects of drift on mortality. The other data shown in Table 2 support these results, but the treatment differences cannot be confirmed statistically based on four replications.

DISCUSSION. In this study, various procedures by which the toxicant was applied did not appear to have a significant effect on insect kill provided the amount of toxicant remained the same for a given area. However, it is not intended to imply that ground thermal aerosols can be applied effectively with all arbitrarily selected volumes and/or vehicle speeds just by keeping the amount of toxicant constant. The general principle of effective dosage with aerosols revealed by these tests is applicable only within the limits of the volumes and vehicle speeds used in the tests. Tests of other volumes and speeds would be required for determination of the limitations of the dosage principle with aerosols.

The effect of overlapping swaths on kill has been demonstrated many times in field tests of ground thermal aerosols in the control of mosquitoes but has never been measured scientifically. Rathburn and Rogers (loc. cit.) obtained similar results with dusts against mosquitoes, which is not surprising since finely ground dust particles behave in a manner similar to aerosol-size droplets. These results of the effect of drift with aerosols support the usefulness of the aerosol method for space treatments against flying insects, especially where wide swaths must be used. Owing to the layout of rights-of-way within a municipality, there are many situations where only one swath must be effective for distances of 600 feet or more. Ground aerosols offer a solution for effective control of adult insects in these situations, provided the basic characteristics of the method are understood by the operator.

Finally, the data show that naled is effective against adults of the stable fly when effective dosage and operations are used.

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STUDIES OF INSECTICIDE RESISTANCE IN FLORIDA MOSQUITOES

CARLISLE B. RATHBURN, JR. AND ARTHUR H. BOIKE, JR.

West Florida Arthropod Research Laboratory, Florida State Board of Health, Panama City, Florida

The first instance of mosquito resistance to insecticides in Florida was DDT resistance in the salt-marsh mosquitoes *Aedes taeniorhynchus* and *A. sollicitans* reported by Deonier and Gilbert in 1950 (Deonier and Gilbert, 1950). Resistance to DDT was soon followed by resistance to BHC and then to dieldrin (Keller and McDuffie, 1952, and Keller and Chapman, 1953). As a result, satisfactory control of these species could not be obtained in some areas of the state from about 1950 to 1956. In 1955 malathion was first introduced as a mosquito adulticide (Gahan *et al.,* 1956) and by 1957 it was widely used throughout Florida.

It was at this time that the Florida State Board of Health, fearing resistance to malathion, developed a policy of limiting the use of malathion to adulticiding in non-breeding areas. It was felt that frequent treatment of large populations of larvae and adults in breeding areas would result in the rapid selection of resistant individuals with the subsequent development of a high degree of malathion resistance. As a result of the policy, malathion has found only very limited use as a larvicide in the state, but has been used extensively and with good results as an adulticide for 10 years. Since mosquitoes have been shown to develop resistance to malathion after a period of only 2 years of extensive use as a larvicide (Gjullin and Isaac, 1957), it appears that this policy has greatly prolonged the effectiveness of malathion in Florida.

In 1964 the Florida State Board of Health, realizing the necessity of obtaining reliable information on the current status of insecticides used in the State, began to obtain baseline data for various insecticides on susceptible mosquito species (Rogers and Rathburn, 1964). In the summer of 1965 came reports of poor mosquito control with malathion adulticides in Lee County. These reports were investigated concurrently and resistance confirmed by this laboratory and the U. S. Department of Agriculture (Gahan *et al.,* 1966).

Although the more important pest species in the state over the years have been *Aedes taeniorhynchus* and *A. sollicitans,* recent research on arboviruses has pointed to the importance of many other species, namely, *Culex nigripalpus, C. quinquefasciatus* and *Aedes infirmatus.* This study has attempted to obtain data on several species of mosquitoes from several areas of the state and with all of the insecticides presently used. It is hoped that this research will be expanded in the future to include more species from