RESIDUAL AND SPACE SPRAYS FOR THE CONTROL OF SNOW-WATER *AEDES* MOSQUITOES IN CAMP AREAS

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The snow-water *Aedes* mosquitoes of the Cascade Mountain area of Oregon are very annoying to workers, campers, sportsmen, and livestock, and are a major obstacle in the development of the area for recreational purposes. Throughout the Cascade range the adult mosquitoes, principally *Aedes communis* (DeG.), *A. fitchii* (Felt and Young), *A. hexodontus* Dyar, *A. cinereus* Meigen, and *A. excrucians* (Walker), may be active from May through mid-August depending somewhat on elevation and seasonal snow conditions. As the economy of the area is based largely on the logging industry and the natural recreational attractions, a serious problem has developed during the mosquito months.

In 1950 and 1951 studies were conducted to find a practical means of protecting the work camps, campers or picnickers, summer residents, and others from mosquito annoyance. Both residual treatments and space sprays were utilized in these tests.

RESIDUAL SPRAYS

Several insecticides have been used as residual sprays on vegetation in experiments on the control of salt-marsh *Aedes* mosquitoes and certain anophelines. Madden *et al.* (1945) treated foliage and ground litter on ½- and 1-acre plots with DDT, and obtained good control for as long as 2½ months. Fluno *et al.* (1949) obtained effective control of *A. taeniorhynchus* and *A. sollicitans* with DDT, chlordane, benzene hexachloride, or toxaphene for at least 11 days under favorable weather conditions. Ludvik (1950) reported satisfactory control of *Anopheles quadrimaculatus* with DDT by treatment of a barrier strip 50 feet wide.

Relation of Mosquito Habits to Effectiveness of Residual Sprays—For a residual spray to be effective the mosquitoes must remain in contact with the toxic residue long enough to become affected and reinfestation of the area must be at a slow rate. Observations of the flight habits of the snow-water mosquitoes revealed that each day large-scale movement occurred only between 8 and 10 p.m. (D.S.T.) at temperatures of 50° to 64° F. and under sunset to twilight conditions. Since activity invariably ceased at an evening temperature of 50–52° F., campers were able to spend the late evening and night without mosquito annoyance.

Selection of resting places by adult mosquitoes varied with the available foliage, but grass in moist situations appeared to be preferred. In pine or fir forests adults could be found on both surfaces of low-hanging leaves and in cracks and crevices of tree trunks where no low foliage was available. These habits and the fact that only one generation matures each year indicated that application of an insecticide on foliage could provide at least fair control of the adult mosquitoes within the treated area.

The experimental plots were scattered over the mountain area in order to provide variation in foliage conditions, altitude, and topography. Ground cover ranged from dense grass to bare ground, secondary cover from thickets of rhododendron, bitter brush, and scrub pine to none at all, and the primary cover from open pine to dense Douglas-fir forests. Altitudes ranged from 3600 to 5600 feet above sea level.

Tests with Residual Sprays—In the two years in which the tests were conducted, 41 plots varying in size from 0.25 to 50 acres were treated in June or July with either wettable powder suspensions or emulsions of DDT and of lindane. In 1950, 20 plots were treated with an

orchard-type sprayer capable of delivering 4 gallons per minute at a pressure of 300 pounds per square inch. Where service roads were available, this equipment was very satisfactory, but in plots remote from roads great lengths of hose were necessary.

In 1951 the applications were made with a portable mist blower (Potts and Spencer 1947). With this blower it was possible to obtain good coverage with small volumes of concentrated sprays and thus reduce the amount of fluid and the application time. The portability of the equipment also made it valuable in treating brushy areas inaccessible with a larger conveyance.

A 50 per cent wettable powder and a 25 per cent emulsifiable concentrate of each insecticide were used as the stock preparations. They were generally diluted with water to 5 per cent for use in the mist blower and to 1 per cent for the orchard sprayer. The sprays were applied in about 20- to 30-foot swaths wherever possible, and an attempt was made to distribute the material on all foliage or structures to a height of approximately 10 feet.

Control was evaluated by counting the mosquitoes alighting on the front of a person's clothing in 30 seconds after the person had stood motionless for the previous 30-second period. Many such counts were taken each day, both before and after treatment, and the counts of any one day totaled and averaged. Counts made in adjacent untreated areas were used to compute per cent control.

Table 1 gives results obtained in selected plots treated with DDT. All plots larger than 0.5 acre gave good daytime control but little or no control during the evening migration period. The smaller plots provided more erratic results, but they received daytime protection from 17 to 95 per cent above that of untreated adjacent areas (not shown in table).

Failure in two plots to control adults for 10 days or longer in 1951 is attributed to their location adjacent to a meadow that was considered to be the principal source of mosquitoes for the entire area (data not shown in table). It is believed that sufficient adults were able to fly into the treated areas without contacting treated foliage to maintain populations great enough to invalidate residual control measures. On all plots control varied somewhat with the environment, but in general control of 65 to 100 per cent was obtained for the remainder of the mosquito season (30 to 45 days).

In plots treated with lindane at one and three pounds per acre, populations were 55 to 93 per cent below those in adjacent untreated areas during 42 days of observation. The 3-pound dosage gave about the same control as the DDT treatments at four pounds, but at one pound lindane was less effective than DDT at two, four, or six pounds.

No difference could be demonstrated between suspensions and emulsions of DDT. The emulsions, however, were easier to apply with the mist blower and appeared to give more rapid knock-down of mosquitoes. Results of application of residual sprays with either of the two types of equipment previously mentioned did not appear to differ, and it is believed that any available and convenient spray equipment will give similar results.

SPACE SPRAYS

In 1950 protection of a camp area from snow-water *Aedes* mosquitoes was tried by use of stationary mist sprayers placed to the windward of the area. The equipment consisted of six to eight hand-made spray heads of the suction-feed type secured to Mason-jar lids, quart Mason jars, 50-foot lengths of ¼-inch air hose, and a compressor capable of supplying 4 cubic feet of air. When six units were used, each unit was capable of delivering approximately 7 cc. of fluid per minute. A solution containing 20 per cent of DDT in an aromatic oil was used as the spray. No DDT crystallized from this solvent at temperatures above 30° F.

Operation of the equipment during the evening flight period did not provide very good control, mainly because DDT is

TABLE 1. Results of typical tests with DDT residual sprays applied on vegetation for control of snow-water *Aedes* mosquitoes.

Dosage, Pounds Per Acre	Area of Plot, Acres	Foliage Conditions of Plot	Pre-treatment Count	Per Cent Control After— 1 day	2 days	6 days	8 days	13 days	21 days	28 days
1950										
6	0.8	Semi-open	15	—	—	—	91	—	100	97
4	0.6	Open and semi-open with tall grass ground cover	8	67	—	—	100	89	[1]	—
	1.0	Dense tree cover with shrubs and grass ground cover	20	—	—	74	—	[1]	88	93
	1.2	Very dense grass, shrub, tree area	17.5	95	—	—	100	91	[1]	—
2	1.0	Dense tree cover, shrub secondary dense, heavy grass ground cover	10	—	—	83	—	[1]	66	90
1951										
2	2.0	Narrow trail with dense brush margins	14.75	—	100	—	98	77	[2]	—
	0.8	Semi-open primary cover; dense grass ground cover	5.4	100	—	—	76	72	—	7
1	0.5	Dense	13.7	—	100	—	90	77	100	—
	3.0	Semi-open to dense	6.03	—	100	—	96	95	100	—
	2.0	Open grass to dense cover	5	91	—	—	—	85	76	[1]

[1] No activity.
[2] Very little activity.

slow-acting and did not kill the mosquitoes fast enough. Application of DDT in this manner, however, did leave a residue on vegetation in the surrounding areas so that good daytime control was obtained.

Reductions of 73 to 86 per cent of the mosquitoes resulted from a daily 10-minute morning operation of this equipment, and this control was maintained throughout the day until the evening migration.

In 1951 mist-spray tests were devised primarily for the control of snow-water mosquitoes in a small area such as might be used for a family picnic or camping site. Since it was obvious that quick knock-down agents would be necessary, pyrethrum and allethrin were used as toxicants. DeVilbiss spray heads of the suction-feed type were utilized, as they were more easily adjusted and maintained than the home-made spray heads used in 1950. The spray units were connected by 50-foot lengths of hose, so that they could be moved about freely and placed in position to obtain the most value from the spray. A portable gasoline-powered compressor provided the air pressure. All tests were conducted in the evening during the peak of mosquito activity.

Two spray heads about 30 feet apart effectively controlled adults in an area approximately 40 feet square while dispensing 7.5 ml. of 0.2 per cent allethrin per head per minute. However, control was obtained only while the unit was in actual operation; as soon as it was shut off, immediate infiltration of the area was noted. No definite mosquito mortality was observed, but they showed a tendency to avoid the area as if the spray were a repellent.

In tests with 0.4 per cent of allethrin or pyrethrins dispensed at 8 to 10 ml. per head from two spray heads, excellent control was obtained in an area 30 by 40 feet. In one series in which the units were alternately operated for 5 minutes and shut off for 10, complete protection was provided during the operating periods and at least 50 per cent during off periods. No outstanding difference in control was noted between the toxicants at this concentration under our rough field-test conditions. Affected mosquitoes, as well as other insects, were observed during spraying of both toxicants at a concentration of 0.4 per cent, which demonstrates that the protection obtained resulted from mortality of insects rather than a repellency.

In one series in which two units dispensing 7.5 ml. of 0.4 per cent allethrin per head were set up 25 feet apart, good control was obtained in an area 30 feet square while the units were operating, but large numbers of mosquitoes again infested the area soon after the units were turned off. Sprays containing both 0.2 and 0.4 per cent of pyrethrins gave similar results.

Summary.—Tests with residual and space sprays were conducted during 1950–51 in the Cascade Mountain areas of Oregon for the control of snow-water *Aedes* mosquitoes. These mosquitoes were found to migrate very little during the daytime, but in the evening between 8 and 10 p.m. (D.S.T.) at temperatures of approximately 64° to 52° F. migration and biting activity were high.

Residual treatments on plots of 0.5 to 50 acres controlled adults at all times of the day except during the 2-hour migration period. DDT at one to six pounds of active material to the acre gave satisfactory control. Lindane at three pounds gave control similar to DDT at four pounds, but at one pound was somewhat less effective.

Space sprays applying DDT in oil for two 10-minute periods about 12 hours apart provided protection except during migration. Space sprays containing 0.2 or 0.4 per cent of pyrethrins or allethrin gave satisfactory control in limited areas during the evening migration period.

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PROTECTION FROM NORTHERN BITING FLIES

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INTRODUCTION

A great deal has been published on the use of repellents against biting, and especially disease-transmitting insects. Rather less has been written on the use of protective clothing. The general subject of the protection of the individual, whether human or animal, has received but little attention.

In malaria control, this problem is one of the absolute prevention of biting. In relation to northern species of biting flies, which are principally of importance on account of the more direct effects of their attentions, the approach is different. The absolute prevention of biting, even if it were possible, is unnecessary and perhaps even undesirable. The general nature of the northern biting fly problem has been reviewed by West (1951) and by Twinn (1952). The only presently available alternative solution to the mosquito and blackfly problem is the direct use of insecticides. For the tabanids there seems to be no alternative. There are no immediate prospects of ecological or biological controls for any of the three important groups. The use of insecticides is less promising against northern species than against *Anopheles*, largely because of their much greater dispersal power. Treatment of areas in proportion to the square of this range of dispersion is necessary if lasting relief is to be obtained, and travel and transportation over these areas are also more difficult. The methods of personal protection are thus practically promising as well as being ethically attractive.

THE FACTORS WHICH ATTRACT BITING FLIES

No scientific approach to the problem of personal protection from biting flies is possible without an understanding both of the factors which attract these insects to their hosts, and those which stimulate them to feed. This understanding has only recently been much sought after, and, although important contributions have recently been made by Brown *et al.* (1951), Sarkaria and Brown (1951), Peterson and Brown (1951) and Brown (1951), it is still far from complete. It is itself dependent on a knowledge of the sensory physiology of the insect in question, which also, in spite of recent contributions (Roth, 1951), is still inadequate. Some of the more important information on this subject is summarized in Table 1. Scientific methods of personal protection must be directed at interfering with this mechanism of attraction and stimulation, and when this interference fails, at mitigating the resulting effects.

THE EFFECTS OF BITING FLIES ON MAN AND ANIMALS

Direct effects

There are many reports, not all of them authentic, of men and animals being killed by northern biting flies. Current