PRELIMINARY FIELD TESTS WITH THE RESIDUAL FUMIGANT TECHNIQUE [1]

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Although the fumigant properties of several insecticides have been recognized and used for controlling insects (Tenhet *et al.*, 1957), the possibility of malaria control through such means apparently has been explored very little. However, recent investigations with malathion as a residual spray in plywood huts (Mathis and Schoof, 1959) indicated that this compound could kill mosquitoes through fumigant action, since the mosquitoes in the entrance cage without exposure to residues were also killed. Of greater significance was the discovery that commercial fly-bait containing DDVP and malathion readily killed mosquitoes through its fumigant action for periods up to 4 weeks (Mathis *et al.*, 1959). The potential of this residual fumigant technique for controlling anopheline vectors prompted further investigations of the technique.

Since the material used in the 1958 tests (Mathis *et al.*, 1959) was still effective when the tests were discontinued at the end of the mosquito season, these experiments were repeated in 1959. Four (8′ x 8′ x 7′) plywood huts, each with two open windows (3′ x 3′) on opposite sides, were used. Commercial fly-bait [2] (1.0 percent malathion, 0.5 percent DDVP) was placed in two huts. One or three 5-lb. bags were opened and placed in the center of each hut on the floor. In two huts, a formulation containing 10 percent technical DDVP (wt/wt) on an inorganic material (Perlite) was used. The quantity of DDVP/Perlite formulation in each hut gave an amount of DDVP equivalent to that contained in 1 or 3 bags of commercial fly-bait. Each of the four formulations was placed in a multiple wall bag (paper and polyethylene film) which originally contained commercial fly-bait. Caged adult female *A An. quadrimaculatus* (100 per cage) were placed in the same four positions in each hut about 3:30 p.m. and left overnight. Any survivors were held for an additional 24 hours and mortality determined. A fifth hut served for check purposes.

Other tests were conducted in plywood huts (11′ x 12′ with 6′ walls and a gable roof) with a volume of approximately 1000 cubic feet. Each hut had an eave opening (3″ wide) on two sides and a window (2′ x 2′) on four sides, all of which could be opened or closed as desired. To prevent excessive heat, a sprinkling system was installed on the roof. This system lowered the maximum indoor temperatures to approximately 85° F. With huts of the above type, preliminary tests were run to determine the effect of ventilation and vaporizer position on the effectiveness of the technique. DDVP vapor was obtained from 3″ x 6″ sealed polyethylene (0.004″ thick) bags, each of which contained 14 g. of purified DDVP on 5 g. of glass wool. These vaporizers were placed in huts at least one hour before the insects were introduced. Caged *A. quadrimaculatus* females were placed at 6 positions on the walls at elevations ranging from 1 to 10 feet above the floor. The mosquitoes were exposed for 4 hours, transferred to clean cages, fed, and held for 24-hour mortality.

Table 1 gives the mortality obtained from the DDVP-malathion fly-bait and DDVP-Perlite formulations. In the hut containing one 5-lb. bag of commercial fly-bait, mortalities of 89 to 100 percent were obtained for 7 weeks. With three

[1] From the Technical Development Laboratories, Technology Branch, Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Savannah, Georgia.

[2] Furnished through the courtesy of California Spray Chemical Company. Use of commercial materials or trade name does not constitute endorsement by the Public Health Service.

TABLE 1.—Results obtained with exposure of caged female *Anopheles quadrimaculatus* to DDVP or DDVP-malathion in ventilated huts for approximately 16 hours

Toxicant	Percent mortality at indicated weeks							
	3	4	6	7	8	9	10	12
1	100	100	35	3	..	..	..	..
2	100	100	100	100	24	5	..	..
3	100	91	100	89	55	5	..	..
4	100	100	100	100	100	100	85	59
5	2	1	8	6	2	5	0	1

[1] 11.4 g. of DDVP on Perlite (10 percent DDVP).
[2] 34.2 g. of DDVP on Perlite (10 percent DDVP).
[3] 5 lb. fly-bait (1.0 percent malathion, 0.5 percent DDVP).
[4] 15 lb. fly-bait (1.0 percent malathion, 0.5 percent DDVP).
[5] Check.

5-lb. bags, 100 percent mortality was obtained for 9 weeks; on week 10, the mortality was 85 percent, and by week 12, it was 59 percent. With the 10 percent DDVP-Perlite formulation, the mortality in the hut containing 11.4 g. of DDVP had dropped to 35 percent on week 6; but in the hut containing 34.2 g. of DDVP, 100 percent kill was obtained through week 7. Although no comparison could be made between the two formulations, the results indicated a similar response to an increase in dosage with each type and showed that DDVP alone produced extended fumigant action.

Tests made with the DDVP plastic bag vaporizers placed at ground level, or 6′ or 10′ above ground level, showed that a more uniform distribution of the vapor was obtained when the vaporizer was placed at the highest level.

The influence of different degrees of ventilation was studied in non-ventilated huts and huts having eaves and eaves-window ventilation. In a non-ventilated hut, one DDVP bag vaporizer gave complete mortality for 7 consecutive weeks.

With one vaporizer and eaves open, the mortality was lowered by as much as 50 percent. Under the same conditions, two vaporizers produced mortalities approaching 100 percent. With two diagonal windows open in addition to the eaves, it was necessary to use 3 bags of DDVP to produce approximately equivalent mortalities (Table 2).

In the non-ventilated hut, the vaporizer was removed after week 7; and the hut was opened to ventilation for three hours. After this ventilation, overnight exposure of caged mosquitoes in the non-ventilated hut resulted in complete mortality. A 4-hour exposure of caged mosquitoes 24 hours after removal of the vaporizer produced complete kills except at the top position (56%). After two additional days of ventilation, no mortality was obtained with a 4-hour exposure. These data suggest that the ventilation was insufficient to remove all of the vapor or that vapor-de-

TABLE 2.—Results obtained with exposure of caged female *Anopheles quadrimaculatus* to DDVP vapor in ventilated huts for 4 hours

No. of vaporizers	Percent mortality at vaporizer age in days							
	1	9	9[3]	10	14	15[3]	21	22
2[1]	91	100	99	57	98	100	86	91
3[2]	99	95	92	48	80	54	88	67

[1] Eaves open.
[2] Eaves and 2 windows open.
[3] Tests made from 7:00 to 11:00 p.m.

posited residues inside the hut continued to emit DDVP.

Table 3 gives results of tests similar to those reported in Table 2 except that a lower temperature prevailed at the end of the test period. During the first 9 days and at mean temperature of 74–78° F., high kills were obtained. However, on days 11, 12, and 13, mean temperatures were 70°, 67°, and 69° F., respectively; and the mortalities on day 13 were far below those obtained in the earlier tests. Although the DDVP vaporizer bag was 13 days old at this time, it is doubtful, in view of the data in Table 2, that age alone caused such a drastic reduction in mortality. Later tests with two new DDVP vaporizer bags also failed to give high mortalities. Therefore, temperature definitely appeared to be a factor influencing the effectiveness of this technique.

TABLE 3.—Influence of declining temperature on mortality of caged female *Anopheles quadrimaculatus* when exposed to DDVP vapor for 4-hour periods in September 1959

	Percent mortality at vaporizer age in days			
No. of vaporizers	1	2	9	13
2	100	100	99	9
3	76	100	91	17
Mean temp. (24-hr. period)	78	76	74	69

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OBSERVATIONS ON THE SNOW-WATER MOSQUITOES OF NEVADA

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During mosquito surveys of agricultural areas in 1959 and 1960, many collections and observations were made in mountainous and foothill areas in Nevada. A group of mosquitoes of the subgenus *Ochlerotatus* Lynch-Arribalzaga inhabit these areas and are often called snow-water mosquitoes because they generally breed in water resulting directly or indirectly from snow melt. All species are univoltine and exhibit a preference for moderate to high elevations, depending on the latitude.

The paucity of information on these species in Nevada is evident when one considers that of the seven species involved, four were shown to be new State records. These four are *Aedes communis* (DeGeer), *A. hexodontus* Dyar, *A. pullatus* (Coq.), and *A. schizopinax* Dyar (Chapman, 1959).

Bohart (1950) reported nine species of snow-water *Aedes* from adjacent California, mentioned the taxonomic difficulties in separating certain of the adults, and discussed the differences of some larval characters that are usually described as being quite precise. *Aedes cinereus* Meigen is considered a snow-water mosquito in

[1] In cooperation with the Nevada Agricultural Experiment Station, Reno, Nevada.