RESIDUAL FUMIGANTS

Their Potential in Malaria Eradication

WILLIS MATHIS, B.S., RICHARD W. FAY, Ph.D., H. F. SCHOOF, Ph.D., and K. D. QUARTERMAN, M.P.H.

RESIDUAL fumigants offer a new technique of vector control which is potentially capable of revolutionizing the insecticidal approach to malaria eradication.

Current malaria eradication programs depend primarily on interrupting the transmission of the disease through the use of residual insecticides, chiefly DDT and dieldrin. Although considerable success has been achieved with this method during the past decade, similar accomplishment in some areas is being hampered by (*a*) development of vector populations resistant to these insecticides, (*b*) variation in the efficacy of residues caused by the type of surface to which they are applied, (*c*) destruction or removal of the insecticidal deposits by replastering, washing, or other modifications of the treated surfaces, and (*d*) variation in the behavior of the mosquitoes. Consequently, a method which would reduce or eliminate the influence of any of these factors would hasten the achievement of the ultimate goal of global malaria eradication.

The authors are with the Technical Development Laboratories of the Communicable Disease Center, Public Health Service, in Savannah, Ga. Mr. Mathis is a medical entomologist, Dr. Fay is assistant chief, and Dr. Schoof is chief of the Biology Section. Mr. Quarterman is chief of the laboratories. (Manuscript received for publication March 23, 1959.)

That certain toxicants, such as lindane, DDVP, Diazinon, and malathion, possess fumigant properties is an established fact. Moreover, in recent studies of the effectiveness against *Anopheles quadrimaculatus* of malathion deposits on walls, it was noted that 75 to 100 percent of the mosquitoes remaining in the entrance cages attached to the outside of the animal-baited huts were killed (*1*).

The death of these mosquitoes was presumed to result from malathion vapor being carried to the entrance cages from the interior of the huts by air currents. The magnitude of the fumigant action of organophosphorus compounds against mosquitoes was first detected accidentally through the unexpected mortality of mosquitoes in use as "check" insects in laboratory tests. Apparently, they were killed by fumes from an unopened bag of fly bait containing malathion and DDVP. To confirm this premise, two cages of *A. quadrimaculatus* were placed 1.5 and 3.5 feet above floor level in a small room (5 by 9 by 10 feet) at sites approximately 7 to 10 feet from the same unopened bag of bait located at floor level in an adjoining room (10 by 14 by 10 feet). The rooms were unoccupied and closed to the exterior, and the connecting door remained open. All specimens died within 2.5 hours. The fact that the unopened bag contained a plastic liner emphasized the mobility of the vapor.

To evaluate this fumigant action under less favorable conditions, the tests described below were conducted in an unoccupied two-room house and in two small huts.

House Test

Each room was 13 by 12 by 8 feet. One contained an exterior door and a window, and the other, two windows. All these and an interior door between the rooms were fully open. Cages of both susceptible *Aedes aegypti* (400 adults) and *Musca domestica* (200 adults) were placed in five positions in the two rooms as follows: room I–A, sheltered corner; room I–B, in open window; room I–C, above interconnecting door; room II–D, exposed corner; and room II–E, sheltered corner.

Four 5-pound bags of fly bait composed of 2.0 percent malathion and 0.5 percent DDVP were placed in room I on the floor, 5 to 8 feet from cage sites A, B, and C, and 13 and 17 feet respectively from sites D and E. The bait containers were double-paper bags lined with plastic. One was opened, and the others remained sealed. All specimens were exposed for 1 hour, during which time a gentle breeze (estimated 10 m.p.h.) passed through both rooms. After 24 hours, mortality for female houseflies was 21 to 24 percent at cage sites A, B, and C, and 2 and 0 percent at sites D and E. For female mosquitoes, the values were 95 to 99 percent at sites A, B, and C, and 64 and 52 percent at sites D and E.

Hut Tests

Each hut (8 by 8 by 8 feet) had 2 windows (3 by 3 feet) on opposite sides, both of which remained open during the entire experiment. In hut I, a single 5-pound open bag of bait containing 2 percent malathion and 0.5 percent DDVP was placed in the center of the floor; in hut II, three open 5-pound bags of the same bait were located one each at the apexes of a triangle (2 ft.) near the center of the floor. One hundred female *A. quadrimaculatus* were released in each hut at 3 p.m. 1 week after the baits were installed, and at weekly intervals during the next 3 weeks. The morning following each release, all specimens, both living and dead, were collected and held for 24- and 48-hour mortality determinations. Results showed 100 percent mortality for each of the four weekly tests in each hut. The tests were discontinued after the fourth week.

During the fourth week, caged specimens (25 females per cage) were exposed for the same time interval at floor level, and at 2, 4, and 6 feet above the floor. In hut I, all specimens at floor level and at 2 feet were dead within 48 hours. At the 4- and 6-foot levels, 44 and 88 percent respectively were killed. In hut II, mortality was 100 percent for all positions. However, mortality at floor level in an untreated check hut was also relatively high (24 percent).

Subsequent tests were made to determine whether malathion or DDVP, or the combination of the toxicants, was responsible for the residual toxicity. Separate formulations of 2 percent malathion plus 0.5 percent DDVP, of 0.5 percent DDVP, and of 2.0 percent malathion were prepared in a granular inorganic material (*A*). A 5-pound lot of each formulation was bagged in a paper container, and the bag was left open and placed in the center of the hut floor. Both "free-flying" and caged *A. quadrimaculatus* were introduced into each hut at 3 p.m., 3 hours after the bait was installed.

The following morning all mosquitoes, whether "free-flying" or caged, were dead. With the combination of malathion and DDVP and with DDVP alone, all the specimens were knocked down 3.5 hours after exposure began. With malathion alone, only a few specimens were down after 4.5 hours of exposure.

Tests on the residual potency of these formulations were precluded because of the onset of cold weather.

Discussion

The potential of residual fumigants for controlling house-frequenting adult mosquitoes, although obviously successful in producing a high mortality for 4 weeks, has not been explored fully in these preliminary tests. Further studies under laboratory and field conditions are now in progress to determine which toxicant or combination of toxicants is most effective, the duration of residual action under various environmental conditions, efficient methods of formulation in small, lightweight units, and the toxicological hazards. The possibility of toxicological hazards to the occupants of treated dwellings represents a principal question concerning the practical use of the fumigants. This aspect will require extensive study before the technique can be put into general practice.

If the use of residual fumigants proves feasible, it is readily foreseeable that this technique could result in important monetary savings by simplifying malaria eradication operations. Manpower requirements would be reduced drastically; the need for spraying equipment, with its attendant burdens of maintenance, as well as problems currently encountered with wettable-powder formulations, would be minimized; and other difficulties associated with residual spraying, such as the sorption of residues by certain mud surfaces, objections to the unsightliness of residues on some walls, and the modifications of treated surfaces by replastering, washing, and the like, would be eliminated. Although mosquitoes appear more susceptible to fumigant action than houseflies, the technique may be effective also against other types of house-frequenting insect vectors and pests.

Because of the many potential advantages which the residual fumigant technique may offer in malaria eradication and in the control of other mosquito-borne diseases, it is hoped that the encouraging results of these preliminary tests will stimulate other workers to investigate the many questions which must be answered before the technique may be adopted for general use.

REFERENCE

(*1*) Mathis, W., and Schoof, H. F.: Organophosphorus compounds as residual treatments for adult mosquito control. Am. J. Trop. Med. 8: 1–4, January 1959.

EQUIPMENT REFERENCE

(*A*) Perlite, Tennessee Products and Chemicals Corp., Nashville, Tenn.

Alaskan Research Advisory Committee

An Interagency Research Advisory Committee has been formed by representatives of the Alaska Department of Health, the U.S. Air Force Arctic Aeromedical Laboratory, and the Public Health Service's Alaska Native Health Service and Arctic Health Research Center. Its purpose is to assist scientific investigators in medical and allied fields who wish to perform research in Alaska.

The committee is prepared to aid investigators sponsored by a recognized institution by explaining local situations, helping solve logistic difficulties, and making available Alaskan facilities.

Persons desiring such assistance should write to E. M. Scott, Chairman, Interagency Research Advisory Committee, Arctic Health Research Center, Box 960, Anchorage, Alaska.