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INVESTIGATIONS ON THE CONTROL OF INSECTS OF PUBLIC HEALTH IMPORTANCE

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The Biology/Chemistry Section is concerned with development and evaluation of materials and techniques for control of insects of public health importance. Considerable effort is being directed toward providing technical information to projects involved in the control of these insects, for example, the *Aedes aegypti* eradication program. This program, started in 1964, has active control areas at the present time in the Virgin Islands, Puerto Rico, southern Florida and southern Texas. Eventually the program will be extended to cover the distribution range of *A. aegypti* in nine Southeastern states with the objective of species eradication (Schliessmann, 1964).

In this *A. aegypti* eradication program, satisfactory surveillance methods for detecting field population of the species when densities reach very low levels are required. For this purpose investigations are being made on factors that influence the selection of egg-laying sites by the female *A. aegypti*. Data indicate that the females have definite preference for color, black being the favorite; for lining surfaces, rough corrugated water-absorbent surfaces being preferred; for the pH value of the water, with choice for slight alkalinity; and for the angle at which the container and the water surfaces meet, a vertical angle being preferred (Fay and Perry, 1965, in manuscript). Other investigations on the usefulness of odor, sound, and visual stimuli for surveillance purposes are being carried out.

Evaluations of insecticide resistance in field strains of *A. aegypti* from various areas under treatment have shown DDT resistance to be prevalent in local strains from Florida. Dieldrin-resistant strains are scattered in Florida and Texas. In Puerto Rico and the Virgin Islands resistance to both insecticides is marked. However, no malathion resistance has been detected in any of the field strains (Flynn and Schoof, 1965a, in manuscript).

In selecting candidate compounds* as possible larvicides for use in potable waters, attention has been given to those having relatively low mammalian toxicity (expressed as mg./kg. for acute oral LD_{50} values for rats). Sumithion (503 mg./kg.) at 0.1 ppm, malathion (1,000 mg./kg.) at 0.5 ppm, Bayer 37342 (3,000 mg./kg.) at 2.5 ppm, bromophos (3,000 mg./kg. mouse) at 0.1 ppm, Shell compound SD-8447 (5,000 mg./kg.) at 0.5 ppm, and dimethrin (40,000 mk./kg.) at 2.5 ppm all show promise, giving 95-percent mortality of DDT-resistant *A. aegypti* (Schoof and Jakob, 1964).

In the Virgin Islands the only fresh-water sources are rain water collections; and since the collecting containers are the principal source of mosquito breeding, direct treatment of the drinking water is a necessary control technique. For this purpose a granular formulation of dimethrin-piperonyl butoxide has been applied with success using 20 ppm of each ingredient. A single application in laboratory studies gives 8 to 10 weeks of effective kills of resistant *A. aegypti*. Other compounds showing comparable results are AC-52,160 at 0.25 ppm, Shell compound SD-7438 at 2.5 ppm, and Shell compound SD-8447 also at 2.5 ppm (Jakob, 1965, in manuscript).

Another problem site of *A. aegypti* breeding is in cisterns. Here the use of dichlorvos as a residual fumigant is under investigation using wax or resin formulations to treat the air above the water line of the cistern. The installation of one vaporizing unit per cistern is giving complete control for approximately 3 to 4 weeks. During this period the concentration of dichlorvos in the water was determined chemically as less than 0.01 ppm. Since 0.1 ppm has been designated as a toxicologically safe level, this type of application is not considered harmful (Brooks *et al.*, 1965, in manuscript).

In the evaluation of candidate insecticides for residual applications against adult mosquitoes, laboratory tests are made on plywood panels. An acceptable level of control for these tests is better than 70-percent mortality following a 1-hour exposure of DDT-resistant specimens. Based on these criteria RE-5353 at 100 mg. and 200 mg./sq. ft. was effective for 6 and 13 weeks, respectively; Bayer 39007 at 100 and 200 mg./sq. ft. for 10 weeks in each case; RE-5305-3 at 100 mg./sq. ft. for 12 weeks; OMS-122 at 100 mg./sq. ft. for 16 weeks; Bayer 41831 at 100 and 200 mg./sq. ft. for 12 and 16 weeks, respectively; HRS-1422 at 200 mg./sq. ft. for 20 weeks; Bayer compound B-37344 at 50, 100, and 200 mg./sq. ft. for 15, 48, and 48 weeks, respectively; and malathion at 200 mg./sq. ft. for 24 weeks (Schoof and Jakob, 1964). In current operations in Puerto Rico and the Virgin Islands, malathion is the insecticide of choice. Applications are made to dense shrubbery and adjacent exterior surfaces of dwellings in areas shown to be positive for *A. aegypti*.

Other investigations of the Biology/Chemistry Section involve the development of purchase and performance specifications for insecticide formulations, as well as for storage and shipping containers, and the testing of various types of application equipment in order to determine effectiveness and maintenance problems. This research provides the technical information necessary to the Agency for International Development for carrying out a world-wide malaria eradication program.

The control of anopheline vectors of malaria through the use of residual applications is under continuous examination. In Haiti, special areas treated to compare residual deposits of several experimental compounds and DDT showed that 1 gram and 2 grams DDT per square meter gave better than 70-percent mortality of susceptible *Anopheles albimanus* for 18 and 23 weeks, respectively. Parallel comparisons with residual deposits of 2 gr. carbaryl per square meter from a 50-percent water-wettable formulation gave 70-percent or higher mortalities for 26 weeks. Deposits of 2 gr. carbaryl per square meter from an 80-percent water-wettable formulation lasted 22 weeks. Deposits of 1 gr. or 2 gr. of Bayer 37344 per square meter both gave adequate control for 18 weeks (Schoof *et al.*, 1964).

In comparison to these residual applications, the use of residual fumigation with dichlorvos using one dispenser for 165 cubic feet of air space in houses produces very good control of *A. albimanus* for approximately 12 weeks at which time the dispensers must be replaced.

With dieldrin-resistant *Anopheles quadrimaculatus* as the test species, 90-percent or higher 24-hour mortalities were obtained in 1-hour exposures to test surfaces of plywood, whitewashed mud, mud, and cement plaster for 16, 4, 0 and 8 weeks, respectively, with 2 gr. malathion per square meter. The same effectiveness was obtained for 14, 6, 0 and 4 weeks with 2 gr. of Sumithion; for 22, 22, 8, and 22 weeks with 2 gr. of carbaryl; for 20, 14, 6, and 16 weeks with 2 gr. of B-39007; for 20, 16, 4 and 16 weeks with 2 gr. of B-37344; and for 16, 6, 0 and 16 weeks with 2 gr. of H-1422 (Mathis and Schoof, 1963).

In house fly control, evaluations of effectiveness are based on grill count indices. The numbers of flies landing on a standard grill when it is placed in locations of fly concentrations are recorded, and the average of the highest count in each of five stations is taken as the daily index. Average counts of 10 or less flies are designated as excellent control. Counts of 10 to 20 flies are designated as satisfactory control, and with average counts of over 20 flies the control is designated as unsatisfactory.

* Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service.

Residual applications of H-1422, Shell 8211, and Shell 8448 at 1 gr. per square meter have given 3 to 4 weeks of satisfactory control. MC-A-600 at 1 gr. per square meter gave 5 weeks, while Shell 8447 showed variable results at 2 gr. per square meter with satisfactory control for 4, 8, and 12 weeks, respectively, at three dairies (Mathis, 1965, in press).

Field tests with chemosterilants for house fly control were limited to dispensing a liquid bait containing 0.5 percent apholate in sugar water using a modified chicken watering device that had proved successful with diclorvos baits. Applications were started in early spring before a build-up of fly populations occurred. The data, based on grill count indices, indicated a delay of approximately 8 weeks in the build-up of the fly populations. After this period there was no definite reduction in the numbers of adult flies (Mathis, 1965, in press).

Laboratory tests evaluating the effectiveness of residual deposits for controlling adult German cockroaches are made on panels of four test surfaces using 3-hour exposure periods and specimens from a chlordane-resistant strain. Based on the number of weeks of 70-percent mortality, 1 gr. per square meter deposits of selected chemicals on painted metal, metal, masonite, and tile gave the following results: diazinon—2 weeks on painted metal and masonite, 1 week on metal and tile; naled—1 week on all four surfaces; dichlorvos—2 weeks on tile, 1 week on painted metal and masonite, 0 weeks on metal; B-39007—5 weeks on metal, 3 weeks on painted metal and tile, 2 weeks on masonite; B-52957—8 weeks on metal, 6 weeks on masonite, 1 week on painted metal, and 0 weeks on tile; Sumithion—8 weeks on metal, 2 weeks on masonite, 1 week on painted metal, and 0 weeks on tile; and fenthion—2 weeks on metal, 1 week on masonite, and 0 weeks on painted metal or tile.

A second method of evaluation of residual deposits utilizes colony boxes equipped with double end and side walls that can be entered by the cockroaches through a one-half inch opening at the bottom. Various amounts of the top portion of these double walls are treated with insecticide, and the cockroaches, seeking darkened hiding places, enter the double walls and either contact or avoid the residual deposits. Evaluations are based on the rate of mortality of 100 male and 100 female adult cockroaches housed in each colony for an 18-day period. Under these test conditions results with Baygon and diazinon have been essentially equivalent giving complete mortalities within the test period. Comparison of the effectiveness of 0.125-percent Kepone bait with and without additional food in the colony boxes gave essentially complete mortality of adult males in 9 days, whereas the females required 16 to 25 days for complete mortality (Flynn and Schoof, 1965b, in manuscript).

The Biology/Chemistry Section is also conducting studies on the disinsection of aircraft. Applications of dichlorvos vapor treatments for the control of flies and mosquitoes are now being tested in DC-7, C-97, and Boeing 720 aircraft. The dichlorvos is contained on a cellulose filter in a metal cartridge and is released into air supplied from a pump and conducted through heated stainless steel tubing to various portions of the aircraft where the insects might harbor. Vapors are dispensed for a 30-minute period to maintain a concentration of 0.2 microgram of dichlorvos per liter of air. The treatment and timing are under automatic control. Although a slight odor may be detected initially, the passengers are generally unaware that the treatment is being made. Mortality results of the insects placed in baggage and passenger compartments are most satisfactory from treatments made while the aircraft is in flight (Jensen *et al.*, 1965, in press).

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