# PROCEEDINGS OF THE TENTH ANNUAL MEETING

OF THE

# UTAH MOSQUITO ABATEMENT ASSOCIATION

*held at the*

University of Utah

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*edited by*

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## *Eleventh Annual Meeting*

# PROCEEDINGS OF THE TENTH ANNUAL MEETING
## OF THE
# UTAH MOSQUITO ABATEMENT ASSOCIATION

## LARVICIDING EXPERIMENTS IN THE MILK RIVER VALLEY, 1956*

G. R. Shultz and V. I. Miles

In field experiments at Chinook, Montana, in 1955, water emulsions and granular formulations of dieldrin and heptachlor at 1.0 and 1.5 pounds of toxicant per acre respectively, gave effective control of irrigation mosquitoes for the entire season when applied as preflood and postflood residual larvicides (1).

Additional field tests were made in the vicinity of Chinook in 1956 to evaluate the effectiveness of several chlorinated hydrocarbons and organophosphates as preflood and postflood residual larvicides for controlling mosquito production in various types of habitats associated with irrigation. Plots ranging from about 0.1 to 2 acres in size were selected for treatment and check sites in areas where mosquito production had been observed in previous years. The plots on pastures, bluejoint meadows, alfalfa fields, wasteland, and roadside ditches were situated in low areas where ponded irrigation water was most likely to accumulate. None of the plots had been larvicided during the previous year and care was taken to select sites that would not be flooded by runoff from other treated areas. Some of the plots were subject to outflow at maximum water levels. The insecticide, formulation, type of treatment, location, date treated, pounds of toxicant per acre, and the number of floodings for each plot are given in table 1.

In May and June, water emulsions and granular formulations of DDT, dieldrin, and heptachlor were applied at rates of 3, 1, and 1.5 pounds of toxicant per acre, respectively; granular chlorthion and EPN were applied at the rate of 1 pound of toxicant per acre. The emulsions were applied at the rate of 25 gallons per acre with a 3-gallon compressed air hand-sprayer, or with a 50-gallon compressed air type power-sprayer which was mounted on a pickup truck. A domestic type flow meter, equipped with a bronze registering disc, was installed on the discharge line of the power sprayer to measure the amount of finished emulsion applied. Each sprayer was equipped with a "boomjet" spray nozzle assembly consisting of two 4186-¼-2TOC12 nozzles. With a nozzle pressure of 40 psi, and with the operator holding the spray nozzles 2½ feet above the ground and walking at 3 mph, the finished spray covered a 16-foot swath width. For the granular formulations, 20/30 mesh attaclay was the carrier for DDT, 30/40 mesh bentonite for dieldrin, No. 4 vermiculite for heptachlor, and fine-to-coarse graded panacalite (certified plaster aggregate) for chlorthion and EPN. The granular formulations were broadcast by hand, except for the dieldrin which was broadcast by a hand-operated seeder.

Both treated and untreated check plots were sampled for mosquito larvae throughout the season to evaluate the effectiveness and duration of the various treatments. When the plots were flooded, they were sampled twice each week for larvae by means of a pint-size white enamel dipper. During each inspection a minimum of 20 dips were made on each plot in places that appeared to be most suitable for mosquito production. When mature larvae were present, samples were collected for identification.

The treated plots were flooded from 1 to 5 times during the season (table 1). Each flooding resulted in conditions which appeared to be favorable for mosquito production. The length of time the various treatments were observed to be effective and other pertinent data are summarized in table 2. Although early drying of several plots prevented observations on the duration of effectiveness for certain treatments, those applications which were effective during all floodings included: all preflood and postflood treatments with dieldrin and heptachlor granules and emulsions; all postflood treatments with DDT granules and emulsions; and the postflood treatment with EPN granules. Preflood treatments with DDT granules and emulsions were effective for 6 to 14 weeks. No mature larvae were found on plots during the first floodings which occurred within 8 days after preflood treatment with DDT emulsions, or 16 days after preflood granular DDT treatment. Fourth-instar larvae were found on several plots which were flooded for

*From the Communicable Disease Center, Bureau of State Services, Public Health Service, U. S. Department of Health, Education, and Welfare, Greeley, Colorado.

the first time 5 to 7 weeks after the DDT was applied. This suggests that extended exposure during long dry periods may have caused the DDT to become ineffective. Both the preflood and postflood treatments with granular chlorthion were effective for 6 weeks.

The species composition of larvae collected from the check plots was as follows: *Aedes dorsalis*, 77 percent; *Culex tarsalis*, 13 percent; and *Aedes vexans*, 6 percent. These same three species were also predominant on the treated plots where mosquito larvae survived to the fourth instar.

Observations were also made in 1956 to determine how chemical control of mosquito production in a one-mile zone around Chinook would affect adult mosquito populations in town. In May and June, water emulsions and granular formulations of DDT, dieldrin, and heptachlor were applied with hand and power equipment as preflood and postflood residual larvicides to all potential mosquito sources in Chinook and in the one-mile control zone. Mosquito sources were retreated when necessary in order to provide continuous control of larvae. The DDT, dieldrin, and heptachlor were applied at rates of 3, 1, and 1.5 pounds of toxicant per acre, respectively. Control of mosquito production was evaluated by random larval inspections made throughout the season. Adult mosquito populations were sampled by two New Jersey light traps, one located at the Courthouse in Chinook and the other at a farmstead outside the control Zone. Records for both of these traps were also available for 1953, 1954, and 1955. The effect of larval control on adult mosquito populations in Chinook was determined by using the light trap data in the following formula, which is adapted from Abbott's formula (2):

$$\text{PERCENT REDUCTION IN 1956} = 100 - 100\left(\frac{\text{(1956 URBAN POP.)}}{\text{(1953-55 URBAN POP.)}} \div \frac{\text{(1956 RURAL POP.)}}{\text{(1953-55 RURAL POP.)}}\right)$$

Larval inspections indicated that there was essentially 100 percent control of mosquito production in the one-mile control zone throughout the season. Random field observations showed that heavy mosquito production occurred outside the control zone, particularly during the months of July and August when rural light trap catches usually averaged well over 150 female mosquitoes per trap night. The urban and rural light trap data for the years 1953-1956 indicated that prevention of mosquito production in the one-mile zone significantly reduced adult mosquito populations (50 to 80 percent) in Chinook during the beginning and end of the season, but was ineffective during the midsummer peak of mosquito production (figure 1). When the mosquito populations outside the control zone (principally *Aedes vexans*, *Aedes dorsalis*, and *Aedes nigromaculis*) reached a peak between mid-July and mid-August, the urban trap catches averaged well over 150 female mosquitoes per trap night for several weeks.

## SUMMARY

In field tests at Chinook, Montana, in 1956, plots were treated with water emulsions and granular formulations of DDT at 3 lbs./acre, dieldrin at 1 lb./acre, and heptachlor at 1.5 lbs./acre, with granular chlorthion at 1 lb./ acre, and with granular EPN at 1 lb./ acre, all applied as preflood and postflood residual larvicides for mosquito control (except EPN as postflood only). The preflood and postflood applications of dieldrin and heptachlor, and postflood applications of DDT were effective for essentially the full season (June 1 to Oct. 1), although early drying prevented complete observation on some of the DDT and heptachlor plots. Preflood applications of granular DDT were effective for 6-9 weeks and emulsions for 8-14 weeks. Preflood and postflood application of granular chlorthion were effective for 6 weeks, and a postflood application of granular EPN for at least 7 weeks.

Complete control of mosquito production in a one-mile zone around Chinook, Montana, in 1956 by means of residual larvicides resulted in a significant reduction (50-80 percent) of adult mosquito populations in town during the beginning and end of the season, but was ineffective during the midsummer (July-August) peak of mosquito production.

The species composition of mosquito larvae collected from the untreated check plots was: 77 percent *Aedes dorsalis;* 13 percent *Culex tarsalis;* and 6 percent *Aedes vexans*.

## LITERATURE CITED

1 Smith, J. V. and G. R. Shultz
1957. Tests of residual larviciding for mosquito control. Proc. 9th Ann. Meeting Utah Mosq. Abatement Assn., 1956, pp. 15-17.

2 Abbot, W. S.
1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18:265-267.

## TABLE 1

### RESIDUAL LARVICIDING EXPERIMENTS, CHINOOK, MONTANA, 1956

| Insecticide | Formulation | Pre or Post Flood | Location of Plot | Date Treated | Lbs. Tox. Per Acre | No. of Floodings | Ave. No. Mature Larvae and Pupae Per Dip | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | May | June | July | Aug. | Sept. |
| DDT | 10% Granular | Pre | Pasture | 5/21 | 3.0 | 3 | Dry | 0 | 0 | 2.4 | 0.3 |
| | | | Alfalfa Field | 6/6 | 3.0 | 1 | | Dry | 0 | 0.3 | Dry |
| | | | Bluejoint Mead. | 6/7 | 3.3 | 1 | | Dry | 0.2 | Dry | Dry |
| | | Post | Pasture | 6/5 | 3.1 | 2 | | 0 | 0 | 0 | Dry |
| | 1.5% Emulsion | Pre | Roadside Ditch | 5/3 | 2.9 | 2 | 0 | 0 | 0 | 0 | Dry |
| | | | Wasteland | 5/4 | 2.9 | 2 | Dry | 0 | 0.1 | 0 | 3.3 |
| | | | Wasteland | 6/6 | 2.9 | 2 | | 0 | 0 | 1.1 | Dry |
| | | Post | Roadside Ditch | 5/4 | 2.8 | 2 | 0 | 0 | 0 | 0 | Dry |
| | | | Wasteland | 6/5 | 3.0 | 4 | | 0 | 0 | 0 | Dry |
| DIELDRIN | 10% Granular | Pre | Alfalfa Field | 6/4 | 1.0 | 2 | | Dry | 0 | 0 | 0 |
| | | | Bluejoint Mead. | 6/7 | 1.0 | 1 | | Dry | 0 | Dry | Dry |
| | | Post | Alfalfa Field | 5/22 | 1.0 | 3 | 0 | 0 | 0 | 0 | 0 |
| | | | Pasture | 6/6 | 1.0 | 1 | | 0 | Dry | Dry | Dry |
| | 0.5% Emulsion | Pre | Roadside Ditch | 5/8 | 0.9 | 4 | 0 | 0 | 0 | 0 | Dry |
| | | | Wasteland | 5/8 | 1.1 | 4 | 0 | 0 | 0 | 0 | Dry |
| | | Post | Wasteland | 6/1 | 1.0 | 3 | | 0 | 0 | 0 | 0 |
| | | | Roadside Ditch | 6/5 | 1.1 | 3 | | 0 | 0 | 0 | 0 |
| HEPTACHLOR | 5% Granular | Pre | Alfalfa Field | 6/4 | 1.5 | 1 | | Dry | 0 | Dry | Dry |
| | | | Bluejoint Mead. | 6/7 | 1.5 | 1 | | Dry | 0 | Dry | Dry |
| | | Post | Pasture | 7/3 | 1.5 | 1 | | | 0 | Dry | Dry |
| | 0.75% Emulsion | Pre | Wasteland | 5/18 | 1.5 | 2 | Dry | 0 | 0 | 0 | Dry |
| | | Post | Roadside Ditch | 5/17 | 1.4 | 3 | 0 | 0 | 0 | 0 | 0 |
| | | | Wasteland | 7/11 | 1.5 | 1 | | | 0 | 0 | 0 |
| CHLORTHION | 14.3% Granular | Pre | Alfalfa Field | 6/8 | 0.9 | 5 | | 0 | 2.1 | 0.2 | 30.0 |
| | | Post | Pasture | 6/13 | 1.2 | 2 | | 0 | 15.0 | Dry | Dry |
| EPN | 14.3% Granular | Post | Pasture | 6/8 | 1.0 | 2 | | 0 | 0 | Dry | Dry |
| CHECK PLOTS | | | Pasture | | | 1 | Dry | 1.4 | Dry | Dry | Dry |
| | | | Alfalfa Field | | | 2 | Dry | Dry | 0.5 | Dry | 0.8 |
| | | | Alfalfa Field | | | 1 | Dry | Dry | 7.0 | Dry | Dry |
| | | | Bluejoint Mead. | | | 1 | Dry | 3.2 | Dry | Dry | Dry |
| | | | Bluejoint Mead. | | | 1 | Dry | Dry | 0.5 | Dry | Dry |
| | | | Roadside Ditch | | | 1 | Dry | 0.1 | 0 | Dry | Dry |
| | | | Wasteland | | | 1 | Dry | 0.6 | Dry | Dry | Dry |
| | | | Wasteland | | | 2 | 0 | 16.7 | 0 | Dry | Dry |
| | | | Wasteland | | | 1 | Dry | Dry | 0 | 14.0 | Dry |

TABLE 2

SUMMARY OF RESULTS OF RESIDUAL LARVICIDING EXPERIMENTS

CHINOOK, MONTANA

1956

| Insecticide | Formulation | Pre or Post Flood | No. Plots | Dates Treated | Lbs. Tox. Per Acre | Period Effective from June 1 to Oct. 1 |
|---|---|---|---|---|---|---|
| DDT | 10% Granular | Pre | 3 | 5/21-6/7 | 3.0 | 6-9 weeks |
| | | Post | 1 | 6/5 | 3.0 | At least 9 weeks |
| | 1.5% Emulsion | Pre | 3 | 5/3-6/6 | 3.0 | 8-14 weeks |
| | | Post | 2 | 5/4-6/5 | 3.0 | Entire period |
| DIELDRIN | 10% Granular | Pre | 2 | 6/4-6/7 | 1.0 | Entire period |
| | | Post | 2 | 5/22-6/6 | 1.0 | Entire period |
| | 0.5% Emulsion | Pre | 2 | 5/8-5/8 | 1.0 | Entire period |
| | | Post | 2 | 6/1-6/5 | 1.0 | Entire period |
| HEPTACHLOR | 5% Granular | Pre | 2 | 6/4-6/7 | 1.5 | At least 9 weeks |
| | | Post | 1 | 7/3 | 1.5 | At least 6 weeks |
| | 0.75% Emulsion | Pre | 1 | 5/18 | 1.5 | At least 13 weeks |
| | | Post | 2 | 5/17-7/11 | 1.5 | Entire period |
| CHLORTHION | 14.3% Granular | Pre | 1 | 6/8 | 1.0 | 6 weeks |
| | | Post | 1 | 6/13 | 1.0 | 6 weeks |
| EPN | 14.3% Granular | Post | 1 | 6/8 | 1.0 | At least 7 weeks |

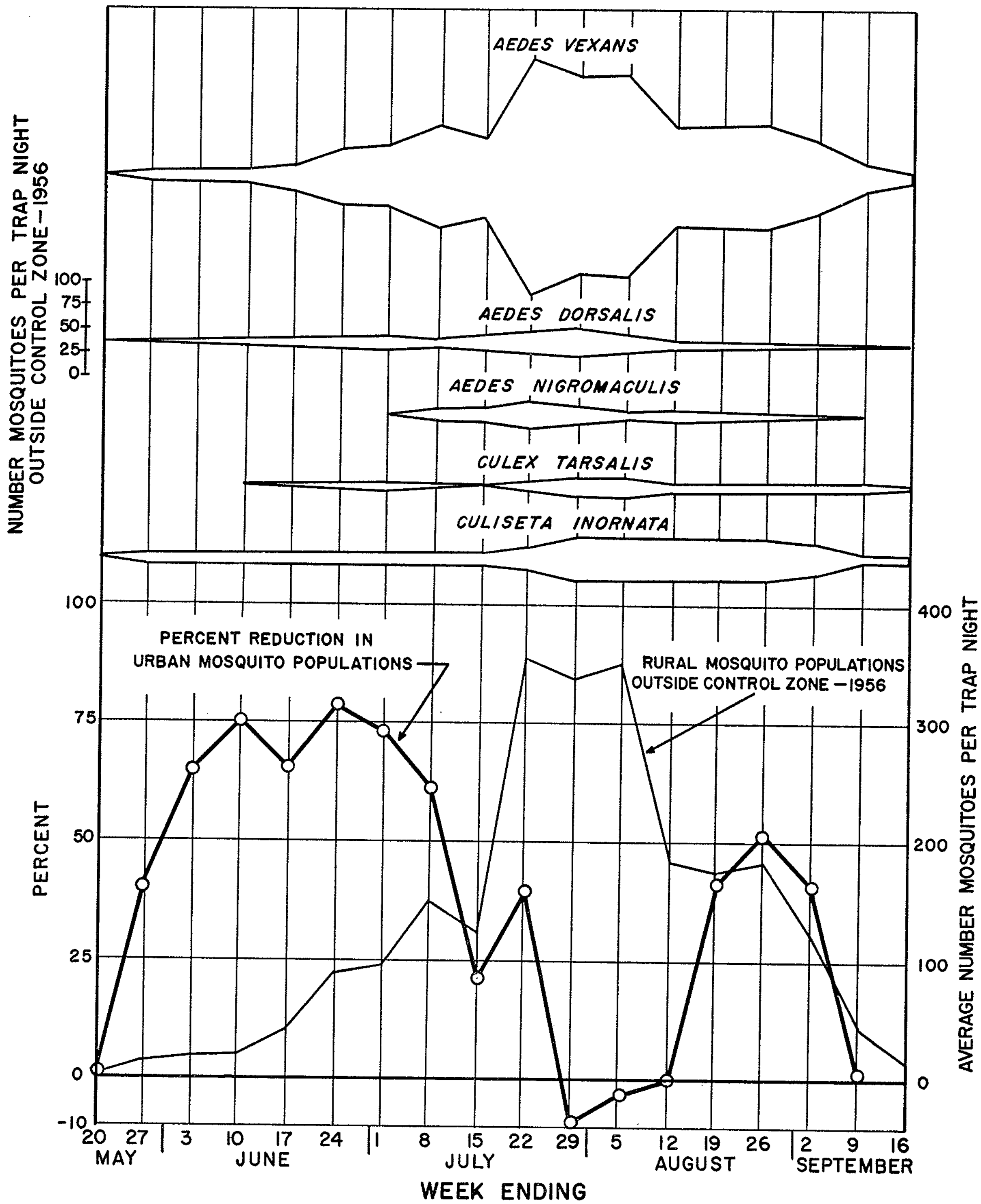


Figure 1. Effect of Prevention of Mosquito Production in a One-Mile Zone around Chinook, Montana, upon Adult Female Mosquito Populations in the Town, 1956. (Curves are based on 3-point moving averages.)

## A COMPARISON OF MOSQUITO COLLECTIONS MADE WITH PORTABLE ($CO_2$) BAIT TRAPS AND NEW JERSEY TYPE LIGHT TRAPS

By Glen C. Collett[1] and Don M. Rees[2]

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The success and efficiency of a mosquito abatement program is generally determined by the number of adult mosquitoes which are annoying to the residents in the area of control. It is important, therefore, that the administrators of mosquito abatement districts have adequate and uniform methods of sampling the adult mosquito population as a means of evaluating and thus determining the effectiveness of the program in their district. The data obtained are not only useful in planning the work from day to day, but have a greater value as a means of comparing the effectiveness of the abatement programs from year to year. The public often wonders what progress has been made in mosquito abatement work and the majority of the people have a very short memory as to how annoying the mosquitoes were in the past. It has been stated that one mosquito bite today is more annoying than a thousand bites received last year.

The Salt Lake City Mosquito Abatement District has been using the New Jersey type light trap every year since 1932, to sample the mosquito population in Salt Lake City. The data obtained are available and provide evidence of the effectiveness of the program. Six *New Jersey type light traps* located around the perimeter of Salt Lake City are operated two nights weekly from May 1 to October 15. During the past two years two additional traps have been operated nightly in the northwest section of the city where the migrant mosquito, *Aedes dorsalis* first appears.

During the 1956 season, preliminary tests were made with a portable type bait trap using $CO_2$ (dry ice) as bait. It was intended to use this trap in areas which were without an electric power supply and the conventional New Jersey type traps could not be used. The purpose of the portable bait trap was to obtain information to determine if *Aedes dorsalis,* when migrating into the city from the marshes bordering the Great Salt Lake, dispersed over a wide area, or if the migration pattern tended to be more localized along the Jordan River and other waterways. Observations made in the past indicated that the principal routes of migration have been along the waterways. In using the portable ($CO_2$) bait trap it was necessary to determine if the $CO_2$ trap would provide samples of the mosquito population that could be used for comparison with samples obtained from light traps. Most investigators agree there is a question as to whether the New Jersey type light trap provides a valid index of an Aedes population or for that matter, any mosquito population. Mulhern and others have been working for several years to standardize collections taken with this light trap in order to make them comparable.

The portable bait trap used in this investigation was developed by Bellamy and Reeves (1952)[1] to supplement the larger stable trap used in their study on arthropod-borne encephelitis. The trap is constructed from a standard 50 pound lard can with a hole nine inches in diameter cut in both the bottom and lid. A screen funnel 5½ inches deep directed into the can is soldered to the rim of each opening. At the apex of each funnel is a hole ¾ inch in diameter which allows the mosquitoes to enter.

For bait a block of dry ice, approximately 3 to 4 pounds, is sufficient to last all night. The dry ice is wrapped in several thicknesses of paper and a small hole is torn in the paper to allow the $CO_2$ to escape.

During June the portable $CO_2$ bait trap was operated several nights and gave interesting results. From the last of May until past the middle of June great numbers of *Aedes dorsalis* were present along the entire lake shore area through Box Elder, Weber, Davis, and Salt Lake counties. These *Aedes dorsalis* mosquitoes migrated from the marshes into adjacent cities appearing in Salt Lake City on May 17th.

On June 18 collections were made in Salt Lake City using a New Jersey type trap with both the light and dry ice ($CO_2$), a similar trap with the light only, and a portable bait trap using dry ice. The traps were operated in the same general locality and under similar conditions.

Comparison of Total Trap Collections
Taken in Salt Lake City, June 18, 1956

| | A. dorsalis | C. tarsalis | Others |
|---|---|---|---|
| New Jersey Type Light Trap | 6 | 0 | 0 |
| New Jersey Type Light Trap with $CO_2$ | 161 | 0 | 0 |
| Portable Bait Trap ($CO_2$) | 34 | 0 | 0 |

Comparison of Total Trap Collections
Taken in Salt Lake City June 19, 20, 21, 1956

| | A. dorsalis | C. tarsalis | A. vexans |
|---|---|---|---|
| New Jersey Type Trap | 9 | 3 | 1 |
| Portable Bait Trap ($CO^2$) | 113 | 20 | 0 |

From these preliminary studies conducted during 1956 it appears that the portable bait trap, using dry ice has certain advantages over the New Jersey type trap. The portable $CO_2$ bait trap is inexpensive and simple to construct; it is light in weight and can be operated in many locations where electric power is not available and therefore the New Jersey type light trap cannot be used. Apparently the bait trap collects a higher percentage of the *A. dorsalis* in the area than the unbaited New Jersey type of trap. Accordingly the bait trap should constitute a more accurate sampling of a mosquito population. Additional collecting is planned for the 1957 season using these traps and with more data it may be possible to make a more accurate evaluation and comparison of the two types of traps as a means of sampling mosquito populations.

## REFERENCE

[1]Bellamy, R. E. and Reeves, W. C.
1952. A portable bait trap. Mosquito News 12(4) 252-258.

## PRELIMINARY REPORT ON POPULATIONS OF MOSQUITO LARVAE IN SALT LAKE COUNTY

By Jay E. Graham and Russell D. Anderson
*South Salt Lake County Mosquito Abatement District*

During 1956 an attempt was made by the South Salt Lake County Mosquito Abatement District to determine as accurately as possible the number of larvae produced by each species of mosquito in the district and to determine how these populations varied in different parts of the district throughout the year. The district covers approximately 200 square miles of Salt Lake County between 4800 West and foothills south of Salt Lake City to the county line.

Inspectors employed by the district collected mosquito larvae from all bodies of water where they were found. The average number of larvae taken per dip in a pint dipper was recorded and the area of the mosquito producing water was estimated. The larvae were later identified in a laboratory provided by the University of Utah.

The species taken in this survey were *Aedes campestris, A. dorsalis, A. increpitus, A. nigromaculis, A. spencerii, A. vexans, Anopheles freeborni, Culex erythrothorax, C. pipiens, C. tarsalis and Culiseta inornata*. The most important of these, so far as control operations are concerned, are *Aedes dorsalis, A. vexans, Culex pipiens, C. tarsalis* and *Culiseta inornata*.

So far as the authors could determine there is no accurate way to convert larvae per dip to larvae per square foot of breeding area. To obtain an approximation of the total number of larvae produced in each breeding area the number of larvae per dip was multiplied by 16 and the product was multiplied by the number of square feet in the breeding area. The number 16 was obtained by assuming that the top 3 inches of water was taken per dip in the pint dipper. The volume of water in 3 inches is 16 pints per square foot. The approximation of total numbers of larvae derived by using the factor of 16 is useful but is not considered to be very accurate.

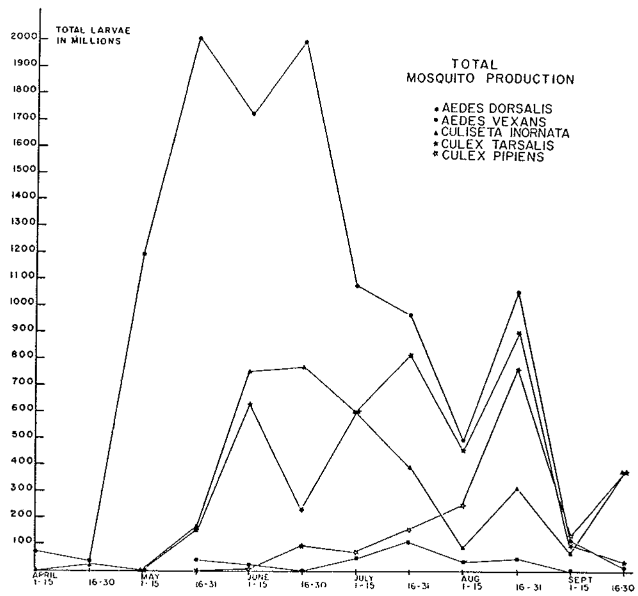


Figure I. The approximate total larval production of the more abundant species of mosquitoes in south Salt Lake County in 1956.

The number of areas producing each species of mosquito is important to the control program and was determined with a high degree of accuracy.

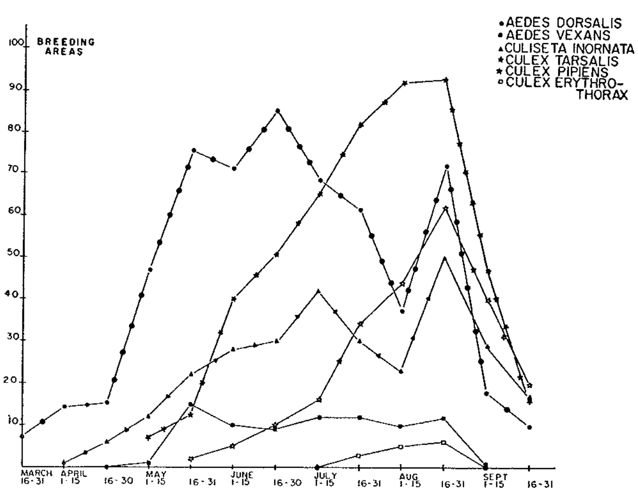


Figure II. The number of areas containing larvae of the more abundant species of mosquitoes in south Salt Lake County in 1956.

The graph shown in Figure II is based on the actual number of areas containing mosquito larvae. The various species of mosquitoes do not maintain the same relative positions in the graphs in Figures I and II because the areas containing larvae of *Aedes dorsalis* were larger and the number of larvae per dip was greater than for other species.

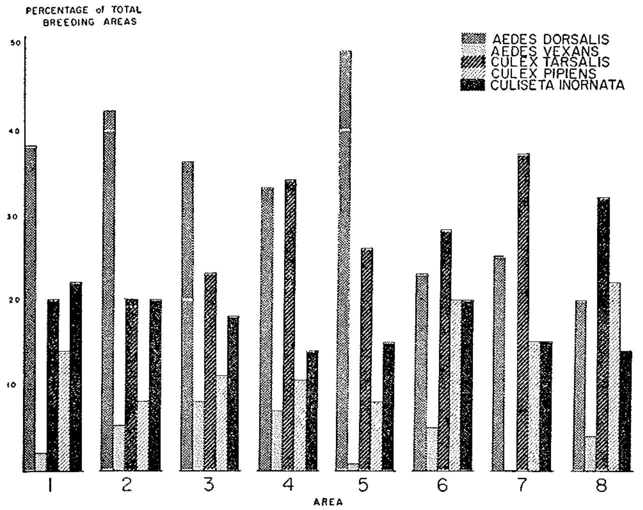


Figure III. The relative numbers of areas containing lavae of the more abundant species of mosquitoes in different parts of south Salt Lake County in 1956.

Area 1 is from 2100 South to 3500 South and from 5600 West to 1700 West. Area 2 is from 2100 South to 3500 South and from 1700 West to 300 West. Area 3 is from 3500 South to 4800 South and from 1700 West to 300 West. Area 4 is from 4800 South to 9000 South and from 1700 West to 300 West. Area 5 is from 9000 South to 14700 South and from 1700 West to 300 West. Area 6 is from 2100 South to 4500 South and from 300 West to Wasatch Blvd. Area 7 is from 4500 South to 14700 South and from 300 West to 400 East. Area 8 is from 4500 South South to 14700 South and from 400 East to Wasatch Blvd.

Figure III is based on the number of areas containing mosquito larvae and shows the relative importance of each species in different parts of the district. Areas 6, 7, and 8 have a denser human population than the first 5 areas due partially to extensive suburban housing developments.

## CONCLUSIONS:

*Aedes dorsalis* is the most abundant species of mosquito in the South Salt Lake County Mosquito Abatement District. It led all other species of mosquitoes in the approximate numbers of total larvae at all times during the mosquito producing part of the year but was most abundant during May and June. After the first week in July more places were found producing *Culex tarsalis* than were found producing *A. dorsalis* but the areas with *A. dorsalis* produced more mosquitoes.

*Culex tarsalis* is a more serious problem to the abatement district than any other mosquito because it reaches a peak in production in the hottest part of the summer when the control program is under greater stress and the water containing larvae of this species are in the vicinity of populated areas. The peak of production for *A. dorsalis* occurs, for the most part, at a considerable distance from densely populated areas and at a time when the abatement district has more time for control operations.

*Culex pipiens* is similar to *C. tarsalis* so far as the pattern of larval production is concerned but the larvae are not produced as early and do not reach as high a peak.

*Culiseta inornata* is an important pest mosquito from May through September. The pattern of larval production is similar to *Aedes dorsalis* but it is not as abundant.

*Aedes vexans* larvae were first found towards the end of May and their numbers remained fairly constant throughout the season.

*Culex erythrothorax* larvae appeared during the first part of July but did not become numerous and declined in numbers at the same time as other Culex species.

## THE RESISTANT-MOSQUITO PROBLEM AND ITS EFFECT ON FUTURE RESEARCH

By W. C. McDuffie

*Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland*

As a former baseball player I was amused several years ago to read a newspaperman's report of an interview with "Satchel" Paige, the great Negro pitcher, concerning his philosophy of life after some 30 years in the game. One comment in particular struck me as humorous, and at the same time wise. It was this — "Never look back; somebody may be following you." Now this is unquestionably a good philosophy for the average man who is prone to worry about past mistakes, but I do not believe it is a safe philosophy for us who are engaged in research on or in practical control of mosquitoes.

Perhaps if we had looked back ten years ago we might have seen that resistance was likely to catch up with us and we would have been able to justify intensified efforts to determine how to avoid or delay it, or at least to develop substitute insecticides or other methods for control before the problem became acute. Today we do not need to look back, because we know resistance is with us to stay. It forces us to think and plan for the future in mosquito research and control. Nevertheless, let us review the past for a moment and then speculate on the future.

The discovery of DDT ushered in a new era in mosquito control. Almost overnight control became a mechanical thing — a mere matter of distributing the DDT over the mosquitoes' habitats. By and large we neglected ecology, biology, and the basic principles of eliminative and preventive control. We were so complacent that even our search for new insecticides came to a virtual standstill. Thus, when resistant mosquitoes caught up with us in 1948 we suddenly realized we were right back where we started from.

Since that time we have been working diligently to catch up, and we have made much progress. However, it is evident that in order to maintain our standards for chemical control, we must expand our search for more effective insecticides. It is also apparent that insecticides are not the only or final solution to the resistance problem. Thus, we have dual responsibilities: we must not only maintain current standards for chemical control, but we must also broaden our research to look for a long-range and permanent means of control in the future. Since resistance is unquestionably with us to stay, it is essential for all of us to appraise current research and to plan for future research along lines that may provide a permanent solution to this problem.

*Insecticide Research*

Insecticides are indispensable in our fight against mosquitoes. They afford us a means of quickly abating a nuisance or breaking an epidemic of mosquito-borne diseases. It is hoped that future research will provide alternative methods that will enable us to place less reliance on insecticides, but we cannot dispense with them entirely in the foreseeable future. We must therefore continue to search for cheaper, safer, and more effective insecticides for use against mosquitoes.

Research on such insecticides falls along three broad lines — namely, larvicides, outdoor adulticides, and indoor residual adulticides. At one time DDT fulfilled the requirements in all these lines, but in the future different insecticides may be required for each purpose. We must therefore keep in mind the requirements for each phase of control.

Each year our Orlando, Florida, laboratory screens hundreds of new insecticides from industrial sources and from our Division's synthesis program. These materials are first tested on a parts-per-million basis against mosquito larvae. Those that show a high toxicity are then evaluated further to find materials sufficiently water-soluble for use in irrigation water and thus obviate the need for solvents.

A third and new phase of larvicide research is to determine the effectiveness of promising materials in different granular formulations. This work is basic, involving studies of adsorption and absorption, rates of release, the influence of mesh size of granular materials, optimum concentrations of insecticides, and other factors influencing their effectiveness.

A fourth phase of our research on larvicides has to do with their use as prehatching treatments. Such studies were initiated in Oregon several years before World War II, but the materials then available, such as paris green, phenothiazine, and rotenone, were ineffective. When DDT became available, winter and spring applications of this insecticide were found to control breeding in many types of flood-water areas. Considerable use has been made of this method in areas where only one or two broods occur each year. Here in Utah and in Oregon it has been employed with good results against snowwater *Aedes*. Good results were also obtained for almost a full season in salt-marsh areas of Florida, but then resistance to DDT and related insecticides developed. The question now is whether prehatching applications of any insecticide might accelerate the development of resistance. However, we do not believe this possibility should deter research along this line, because the principle is good.

In many sections of the country mosquito-control operations are confined chiefly to spraying and fogging for adult control. There are several reasons for this. First, extensive breeding areas make it impractical to apply a larvicide. Second, where the population is concentrated in communities or towns, control of adults meets the demand for protection from mosquitoes at a nominal cost. Third, it is the easiest means of combating the problem. Several years ago I was astonished to hear a reputable mosquito-control worker state that adult control was so easy that he had abandoned every other means of control. Within two years resistant mosquitoes destroyed this conception and forced him to resume a comprehensive insecticide and eliminative program. We must keep in mind that mosquito control is not simple and employ simultaneously every weapon at our disposal.

Resistance to the chlorinated hydrocarbon insecticides has greatly reduced their usefulness for adult control in Florida, California, and several other areas. We can assume that resistance to these insecticides will become more widespread and the demand for substitutes will become correspondingly greater.

At the present time the phosphorus insecticides malathion and chlorthion are giving good control of resistant adults in most locations. However, scattered reports of resistance to malathion are already appearing, the most serious being from Fresno County, California, where this material has been in general use for the last 2½ years. Gjullin and Isaak (1957) found larvae of *Culex tarsalis* Coq. collected there to be 21 to 33 times as resistant as strains from areas where malathion has not been used. Adults showed an even greater (90 to 100 times) resistance to malathion residues. Applications of malathion aerosols in areas of lesser resistance failed to give satisfactory control of *Culex* adults or were completely ineffective (Gjullin and Isaak, unpublished). These results are clear indications of things to come and suggest a continuing need for research to find new insecticides for adult control.

Perhaps the most serious aspect of the resistance problem is the failure of DDT as a residual treatment in homes for the control of malaria and other mosquito-borne diseases. Reports of failures are coming from all parts of the world, and programs for disease eradication are in jeopardy. In some countries DDT has already been abandoneed in favor of dieldrin. There are indications that this insecticide is not as effective as DDT once was and that it creates a toxicity hazard to workers and the residents of treated homes. Several of the new phosphorus insecticides possess excellent residual properties, but it is not known whether any of them are safe for home treatments. Here again there is an immediate need for safe insecticides to combat resistant vectors and to insure future progress in reducing mosquito-borne diseases.

Research during the past year has provided several promising materials, but it is already apparent that none of them possess the all-round virtues of DDT. Obviously, therefore, an expanded, carefully planned synthesis program is needed to provide new insecticides specifically for use in mosquito control.

*Biological Control*

Entomologists have recognized for a long time the value of predators, parasites, and diseases in controlling many of our important agricultural pests. Research in this field has resulted in the finding of many parasites and predators of economic value. In recent years increased emphasis has been given to insect pathogens. Certainly this is one of the most intriguing fields for researchers today. Insect pathogens offer the best possibility of solving our two most pressing problems - resistance and residues.

Insects are susceptible to bacteria, fungi, viruses, protozoa, and nematodes (Steinhaus 1952), and good progress has been made in developing certain pathogens for practical control. Two outstanding examples are the milky disease for control of the Japanese beetle and *Bacillus thuringiensis* for control of the alfalfa caterpillar. These and numerous other insect diseases occur in nature, but apparently are held in check by an immunity in insects, by their low biotic potential, localized distribution, inability to disperse, and perhaps other factors. Yet, these two examples of diseases turned to practical use demonstrate that research can over-come these limiting factors. To my mind the possibilities of developing some of these organisms represent the greatest challenge to the ingenuity of those of us engaged in research.

We will concede at the outset that researchers face many obstacles in developing specific diseases for use in mosquito control. They may be insurmountable insofar as outdoor control of adults is concerned. Indoor control by the application of disease organisms to resting surfaces may be just as remote. However, I am optimistic over the possibilities of pathogens for larval control. It is conceivable that effective pathogens can be produced in quantity and distributed in the same way as insecticides. The ideal, of course, would be an organism adapted to aquatic situations, which would operate continuously to destroy the larvae and perhaps the eggs. Even this utopian hope is not above attainment if we can determine and alter the factors that tend to make aquatic environments unfavorable for mosquito breeding. In any event, as scientists we are obligated to explore this field. As Steinhaus advocated, "If for no other reason, therefore, it behooves the entomologist and agriculturalist interested in the ecology of insects to be cognizant of those micro-organisms capable of causing disease among animals and the effect of the disease on insect populations and activity."

The importance of minnows in the control of mosquito larvae has been recognized for many years. Several species have been used frequently to solve specific breeding problems. Yet, attempts to utilize them on a large scale have not been successful. Perhaps our lack of success is due, in some measure at least, to the fact that we have not learned how to use them and how to manage or adapt aquatic environments to their liking. The possibility of utilizing other species of minnows in various aquatic habits needs to be studied, but we cannot expect minnows or other predators to do the whole job for us. However, we believe that additional research might lead to a better understanding of their requirements and to their effective utilization under certain conditions.

*Basic Research*

Although resistance in flies, mosquitoes, and other insects has created many serious problems in control, it has had several beneficial effects. Perhaps the most important effect has been to emphasize the need for more basic research on physiology, morphology, and genetics. Research in these fields has of necessity progressed slowly, but it has provided us with some understanding of the mode of action of insecticides, insect detoxification mechanisms, and genetic aspects of resistance. Our knowledge is far from complete, even for the few species on which work has been concentrated, and little or no basic work has been done on many important species. There simply are not enough insect physiologists, biochemists, and geneticists or funds for such work at the present time. Thus, two important objectives are to sell basic research programs and to encourage young men to specialize in these fields. Only in this way can we insure adequate support and competent personnel for the investigation of special problems in the future.

Although much has been done in recent years to encourage basic research on certain lines, we have not promoted the complete basic program needed to solve our current resistance problems. Very little of our new-found knowledge has been of value in combating resistant house flies and mosquitoes. Perhaps the fault is ours for not knowing how to make use of this information. Apparently, we need basic information along other lines in order to solve the puzzle.

There is little doubt that intensive ecological research would help us to make better use of other basic findings. By classical definition, ecology is the study of the relation of organisms to their environment. Broken down to simple everyday terms, it is the study of where an organism lives, what it lives on, and why its life requirements exist in a particular habitat. Nutritional and physical factors have to be considered separately and in combination, because narrow balances in nature can permit a species to thrive in one place and not in another. However, a full understanding of ecological data may well depend on physiological and genetics research. These sciences are so closely related that we need to consider them as one in delving into the resistance problem. We must keep this in mind in order to make the greatest possible progress in this field.

There is a great deal of skepticism about the value of basic research. Many people are prone to say, and rightly so, that basic research is a long-time proposition and that it offers no assurance of solving an insect problem. Nevertheless, this is no valid reason for not conducting research. Frankly, we cannot promise that intensive basic or applied research will solve our present and future resistant-mosquito problems. However, no one can dispute the value of ecological research. The knowledge of the breeding habits of *Aedes aegypti* certainly simplified its control and hastened the eradication of yellow fever. Much of the success in the virtual eradication of malaria in the United States can be attributed to our knowledge of breeding, resting, and flight habits of *Anopheles quadrimaculatus*. In Malaya, only through ecological study was it learned that the principal malaria vector, *Anopheles minimus*, bred only in sunny environments and could therefore be controlled by promoting vegetative growth along stream margins. Similar studies have shown that certain species are selective in their breeding habits, and this knowledge has enabled us to control them with a minimum of effort, either by source-reduction methods or with insecticides. Thus, ecological information can make our job of control much easier even if it is not a panacea.

One of the most intriguing fields for future basic research concerns attractants. We know that all insects are susceptible to sex and food stimuli, but over the years our efforts to isolate or reproduce the attractive principles have not been very successful. Several years ago geraniol and eugenol were found to be attractive to Japanese beetles, and they are still widely employed in traps for control and survey purposes. Foods of various kinds have been employed as fly attractants in traps and baits, and effective control of flies and other insects has been obtained by incorporating toxicants in attractive materials. More recently spectacular success has rewarded efforts to develop attractants for fruit flies. Investigators succeeded in determining nutritional requirements of the flies, which led to protein hydrolysate-malathion bait sprays for eradicating this pest. Other materials highly attractive to males only have been found useful for the detection of the flies in an eradication program. The phenomenal results obtained in this program emphasize the need for research to develop equally good attractants for other insects. We, of course, do not know that sex or food attractants can be found for adult mosquitoes, but research along this line seems worth while. It should at least provide information on the sex responses and nutritional requirements of adult mosquitoes which might be used to advantage in applying conventional control methods.

*Research on Water-Management and Eliminative*

We know that the need for new insecticides and new approaches to control will increase as resistance becomes greater and more widespread. However, we should not expect developments along these lines to solve all our mosquito problems. We must continue to emphasize eliminative or source-reduction methods, with the objective of gradually reducing the necessity for direct control measures. From the long-range standpoint the surest method is to eliminate mosquito breeding by drainage, filling, and proper land and water management.

Much progress has been made in reducing the reproductive potential of mosquitoes through source reduction and water management. The Tennessee Valley Authority has been able to minimize mosquito breeding by fluctuating the water levels in impoundments and by controlling shoreline vegetation. In many coastal areas salt-marsh mosquito breeding has been reduced by the ditching and draining of prolific breeding marshes and the diking and permanent flooding of areas that could not be properly drained. In many western States careful management of irrigation water has been found to minimize mosquito production and reduce correspondingly the need for insecticides. Yet, in spite of the demonstrated value of these procedures, we are not making the most of them in many locations.

In some places eliminative and source-reduction measures are not feasible owing to lack of funds or authority to enforce such a program. In others current conceptions of these measures are not applicable. Additional research is needed to develop specific land- and water-management procedures and other eliminative measures for these areas. In fact, it is our belief that further research along these lines, with greater attention to the ecology of mosquitoes, would lead to much more efficient eliminative and source reduction programs.

## REFERENCE

Gjullin, C. M., and Lewis D. Isaak.
1957. Present status of mosquito resistance to insecticides in the San Joaquin Valley in California. Mosquito News (In press).

## THE SAFE HANDLING OF MOSQUITOCIDES

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The term "Mosquitocides" allows freedom of reference to all chemicals which can be used in the control of mosquitoes. It is unnecessary in this instance to identify insecticides as larvicides, pupacides, or adulticides; reference to dusts, solutions, suspensions, emulsions, sprays, residuals, aerosals, mists or fogs is not required.

There is a sincere problem among us when someone criticizes safety practices. "To be or not to be alive" is the question we shall ask of the expert. "Which is the greatest hazard — insect or insecticide?" is the question Dr. Edward F. Knipling placed before the American Association of Economic Entomologists in 1952. He answered the question by "Alarmists are telling the American people that insecticides are the greatest danger . . . we entomologists must not underestimate our responsibility to the public in seeing that insecticides are used safely."

This attention to use is strained by our desire to obtain efficiency. Therefore, we may overlook safe storage and handling practices. We must find the straight and narrow path which is so clear to the well informed manager. The very fact that there are Food and Drug Administration regulations does not relieve the directors of operations from planning for proper practices in receiving, storing, and issuing of these poisons. Observe carefully the gullible one who buys certain products because (1) they must be safe if every grocery store sells them, (2) the salesman described this item as non-toxic. In 1948, one medical observer wrote, "DDT is a death-dealing terror acting more like bullets than such soluble poisons as its distant cousin carbolic acid (phehol), or tetraethyl lead." This alarming statement made headlines. Today, as then, those who know how to handle DDT in its numerous forms, respect it with adequate precautions. The latest reports show that a number of deaths have been reported following ingestion of DDT solutions. In these instances the clinical picture has frequently been characteristic of solvent poisoning. In consideration of many reported tests we can be influenced to fear with impossible precautions or to laxity with absence of safety. In our work we believe that with proper precautions, all recommended insecticides can be used safely. These precautions begin with considerable study before any mosquitocide is procured. It is too late after it has been received.

One operator ordered a quantity of pyrethrum. In his careless haste, the name of the item was spelled wrong and he had always mispronounced it. His spelling was "parathreon." The procurement agency soon discovered that this material was not available. However, the supplier suggested that they had plenty of Parathion on hand. When the operator was contacted with this information he remarked, "That's it. I can't keep up with these new names." So he received Parathion — not Pyrethrum.

Another operator reported that his parathion was safely stored. Although it was in a wooden building and in a wooden locker, the safety factor was based on the condition that no one knew he had it. And too, no one could open the lock because the key was lost and he was the only one who knew where to strike the lock with a hammer to cause it to open. All this, even though death had followed accidental splashing (with parathion) of the body and clothing of one worker. In Brown's "Insect Control by Chemicals" we read, "The third case involves a laborer in Florida who was engaged in loading speed sprayers with 25% wettable powder. He had previously been incapacitated by the parathion and had been warned to be more careful. But he would not wear a respirator, and was rash enough to stir the powder with his bare hands; he was killed by skin contact and inhalation of the poison.

Training programs must include "safety precautions" in handling, mixing, transportation, as well as application techniques. In this training we begin with the basic expression, "Materials that are effective in the destruction of pests are, with few exceptions, toxic to humans." This is equally true of most of the solvents used in the preparation of mosquitocides. However, no serious effects will normally result to control operators if the necessary precautions are followed. In our military instruction we observe, "Areas in which on-hand quantities of toxic materials are stored and mixed should be inclosed and locked to prevent access by unauthorized personnel. Storage space should be located so there is no danger of food contamination or creation of fire hazards." In addition to providing for safe storage of toxic materials, insect control shop space should have facilities for the protection of personnel and the safe mixing of materials. Hot and cold running water, soap, and shower facilities are needed to permit rapid and adequate decontamination of skin areas on which insecticides may be spilled. Locker space should be provided for the storage of work clothing. Special equipment vehicles with bodies or compartments that can be locked should be provided for use by operational crews to eliminate the possibility of children or other unauthorized persons gaining access to toxic materials.

A. *When Ordering Mosquitocides.*

1. Know the characteristics of the material.
2. Know the danger it offers to man and other animals.
3. Know the effect it may have on plants, finished surfaces, fabrics, and other material.
4. Know the specifications and use them. Try to order materials which meet your need exactly.
5. Know the supplier to be reliable and capable of delivering exactly what you ordered.
6. Know where the material can be stored.

B. *When Receiving Mosquitocides.*

1. Check all labels carefully. Be sure to secure the labels to the containers.
2. Check contents with your order. Be satisfied that you received what you ordered.
3. Check them into the storage room. Be sure you know where they are stored.

C. *When Storing Mosquitocides.*

1. Make certain all storage areas are inclosed and can be locked.
2. Be sure mosquitocides are stored in spaces which are not used for storing herbicides, strongly oxidizing materials, or foods.
3. A cool, dry well ventilated storage space is the safest for personnel and the stored mosquitocides.
4. Do not store these chemicals in the vicinity of open flames.
5. Keep storeroom clean for safety.

D. *When Issuing Mosquitocides.*

1. Be certain the material is issued to one who is responsible.
2. Be certain the container carries the label which properly identifies the contents.
3. Issue the material which has been stored longest. Some mosquitocides may lose some toxic strength while in storage.

E. *When Mixing Mosquitocides.*

1. Read all labels carefully and completely.
2. Wear the required protective devices and clothing before you open any container.
3. Mix, dilute, agitate, or what-ever you have to do, according to directions. Use only containers or sprayers which are specifically designed.
4. Prepare only the amount of material which you plan to use. Diluted mosquitocides are difficult to return to storage.
5. Return all unopened concentrates to storage in the original containers.

F. *When Handling Mosquitocides*

1. Avoid (a) Contamination of mouth, eyes and skin.
   (b) Inhalation of materials.
   (c) Contamination of clothing.
2. Do not smoke.
3. Wear all protective devices and clothing as recommended.
4. Bathe and change clothing as often as necessary to keep chemicals from the skin. Bathe and change immediately if concentrated mosquitocides are spilled on skin or clothing. Contaminated clothing should be laundered before being worn again.
5. Be sure to consult your physician if nausea, vomiting, loss of weight, or loss of appetite develops.
6. Do not work alone.

A few first aid suggestions may be the safety margin between you and your future. It is suggested that you

1. Keep your physician advised of the chemicals you use frequently, and especially, if you plan to use any new material.

2. Keep sample labels which can be given to the physician for his reference.

3. Know the recommended antidotes and first aid indicated for an emergency.

4. Train all persons who handle mosquitocides for their protection and your benefit.

5. Keep a special first aid kit ready, easy to get, but in a place where it will not become contaminated with vapors and dusts of your chemicals.

Suggestions for your first aid kit

| Equipment | Quantity |
|---|---|
| Canteen, metal, 1 quart size<br>Note—This should be kept filled with water which should be changed every 1 to 2 weeks. | 1 |
| Cup, aluminum or stainless steel 8 oz. size | 1 |
| Eye cup, glass or metal | 1 |
| Standard tablespoon, metal | 1 |
| Standard teaspoon, metal | 1 |
| *Item* | |
| Coffee, instant, powdered | 4 oz. |
| Heater, portable sterno with refill | 1 |
| Sugar, packets, teaspoon size | 6 oz. |
| Soap, ivory, bar | 1 |

Note: Your local Pharmacist should be consulted about the following items.

| | |
|---|---|
| Boric acid solution (1 teaspoon/pint) (replace every 4 months) | 1 qt. |
| Magnesium sulfate (Epsom salts) | 8 oz. |
| Sodium chloride (table salt) | 8 oz. |

Other items may be desirable as new mosquitocides are involved.

*FIRST AID*

*General Procedure*

1. Call for medical aid immediately.
2. Give appropriate first aid.
3. Give recommended antidote.
4. Take victim to hospital.
5. Never give anything by mouth to an unconscious individual.
6. If the victim is cold, cover with a light blanket.
7. If breathing is impaired, give artificial respiration.

*Universal Antidote Procedures for intension poison*

1. Give one tablespoon of common table salt dissolved in one cup of luke warm water to cause vomiting. Repeat until vomit is clear.
2. Give a cup of hot coffee or tea without milk or cream.
3. Give two tablespoons of Epsom salts dissolved in a cup of water. NEVER GIVE OIL OR FATTY SUBSTANCES.
4. Be careful that you do not contaminate yourself.

## THE RECIRCULATION SYSTEM AS APPLIED TO MOSQUITO SOURCE REDUCTION

By Robert H. Peters

*Manager, Northern San Joaquin County Mosquito Abatement District, Lodi, California*

The Northern San Joaquin County Mosquito Abatement District, located in the center of the heavily irrigated Central Valley of California, has actively carried on a mosquito source reduction program for the past eleven years, since its formation in 1945. While the bulk of our effort in mosquito source reduction has of necessity been directed toward the elimination of natural sources along the bottomland jungles of the Mokelumne River, our second most important problem, cost-wise, has been the undrained pastures (and alfalfa fields) where tail-end water has been responsible for the production initially of two Aedes species, *nigromaculis* and *melanimon;* and secondarily of *Culex tarsalis,* our main encephalitis vector.

A recent estimate by mosquito control workers in the Central Valley of California indicated that pastures in this State are actually producing crop yields at an estimated 80 to 90% of area efficiency due to the adverse effects of ponded and tail-end water which remains after each irrigation. To state this condition otherwise, it can be pointed out that about 10 to 20% of the area of these pastures have consequently retrogressed to where aquatic weeds and mosquitoes now occupy the low, undrained areas of these fields.

Immediately it becomes apparent that if any crop is producing far less than the 100% potential for the field, then certainly there appears to be a practical basis for altering the field to increase crop production as well as to minimize mosquito production.

In order to meet this problem, as well as to cope with the widespread increase in irrigation, a two-fold program has been undertaken by this Agency, including drainage (where possible) and the installation of recirculation systems where conditions indicate. Those conditions favoring the installation of recirculation systems to solve the tail-end water problem are:

1. Shortage of underground water.
2. High cost of water (usually obtained from deep wells).
3. Lack of drainage outlets within reasonable range of field.
4. Availability of excess water from neighboring ranches.

In establishing a recirculation system, the basic principle involved is to remove the tail-end water, storing it in a sump or pond which is so located that this water can be re-used by pumping into the irrigation ditches or pipelines where it may be returned to the same field or some adjacent field. The layout for these systems varies somewhat according to the size of the field, elevations and general topography, and cooperatively these factors are planned with the property owner in order to accomplish the desired objective.

Fortunately, our agency owns heavy equipment which includes two D-7 Cat Tractors equipped with dozers, ripper and scrapers and a 3/8 yard dragline. These items of equipment are rented, with District operators, on a cost basis to accomplish the desired jobs. In addition, our local Soil Conservation Agency encourages and financially assists such water conservation practices.

Besides the reclamation of the low-ends of these fields and reduction of the mosquito breeding area, the following additional advantages are usually realized after the completion of such a recirculation system.

1. Pumping costs for re-use of water are usually only about one-third of that required to lift water from deep wells.
2. The water from these sumps is usually 10 to 30 degrees warmer than water obtained from deep wells, thereby stimulating plant growth.
3. Water from recirculation sumps usually contains a high fertilizer content after initially flowing over pasture fields.
4. Sumps are built with sufficient side slopes and depth to actually discourage future tule and aquatic weed development.
5. These sumps can be planted with mosquito fish to practically eliminate the need for further larviciding.

To date this agency has planned and built an average of about one system each month during the past year (in addition to our other land reclamation projects), with a consequent sharp decline in the need for mosquito control operations on these properties.

The recirculation system is indeed one of the most effective ways of accomplishing mosquito source reduction in a positive type mosquito abatement program.

## THE USE AND ADAPTATION OF WEED BURNING EQUIPMENT BY CALIFORNIA MOSQUITO ABATEMENT AGENCIES

Thomas D. Mulhern[1], W. Donald Murray[2]
Howard Greenfield[3]

The control of aquatic and terrestrial weeds has long been an important problem to mosquito abatement agencies. These weeds, when permitted to grow unchecked, rapidly choke drainage channels, promote silting and other rapid deterioration of ditches and canals, interfere with access to mosquito sources, and colonize the shallow portions of ponds and lakes. Thus conditions are created that encourage the development of mosquitoes. This problem is difficult of solution on projects concerned with the control of mosquitoes arising from swamps and wastelands. It is even more complicated and difficult in agricultural areas where mosquito control is being practiced. The methods employed to control weeds in these areas must be such that damage to the agricultural crops, which are often more susceptible than the weeds, is avoided.

Perhaps the most frequent need is for control of the weeds which colonize the waterways and ditch banks. This problem has influenced mosquito control methods for many years. In the early days of the Canal Zone program this requirement was met by frequent hand cleaning of the ditches, hacking away the ditch bank vegetation with machetes, and by spraying with heavy "bunker" oils. In the east coast salt marsh programs, it was found that vertical sided narrow ditches inhibited the regrowth of vegetation by limiting the amount of sunshine that could penetrate into the ditch. Thus, a ditch only 10 inches wide, with a depth of 20 to 30 inches was adopted as "standard." Generally speaking, wherever mosquito

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control was secured by ditching or draining, provisions for frequent maintenance were necessary, usually through ditch cleaning with hand labor, or with draglines, backhoes, dredges, plows, or special ditch cleaning machines. Much ingenuity has been exhibited in the development or adaption of unusual machines. Weed cutters and reed crushers were devised for use on the New Jersey salt marshes to control the ditch bank growth of Phragmities which would otherwise produce nearly impassible stands of reeds growing to heights of 10 to 12 feet. Heavy disc harrows came into use in Delaware. Tractor drawn chains and discs have been developed to dislodge rooted aquatic weeds in canals. An efficient "tule-roller" was constructed for the same purpose by a California irrigation district. In addition to these, a variety of special "weed-buckets," mechanical forks, and other special devices have been developed. A wealth of information about the use of special equipment, as well as other well-known methods of weed control, is found in the publication, "Control of Weeds on Irrigation Systems," published by the U. S. Bureau of Reclamation, as well as in "Chemical Weed-Control Equipment," Circular 389, California Agricultural Experiment Station.

Weed control methods may be classified in three major categories: (1) mechanical removal, (2) destruction by oil or chemicals, and (3) elimination by burning. Each method has some advantages, and some disadvantages. All of the methods are of value in mosquito control, and any extensive weed control program will probably benefit by using all of them. The mechanical and chemical methods are reported in the references cited above, as well as in many other publications. The balance of this report will be devoted to the use of the burning methods.

Burning has been used in an effort to avoid the disadvantages of the other methods, which include: (1) the propagation of new plants following the disturbance of the soil which usually occurs in any mechanical weed removal operation, and (2) the danger of accidental damage to crops which is inherent in the use of any oil or chemical weed control methods.

Burning should not be practiced in the immediate vicinity of dry grain fields, or on peat lands, or in any other place where there is a fire hazard.

The first burning attempts in California mosquito control were made with petroleum oils applied by hand or power spray equipment; however, the relatively low-temperature flames produced were only effective where the plants were already dead or dormant and dry. The blow-torch type of gasoline burner has been tried. Its medium temperature flame can kill living plants, but the small size of the available units and the high cost of labor and fuel have limited its utility. The development, however, of propane burning units, which produce extremely high temperatures*, has made weed control by burning a much more satisfactory operation. Whether used singly as hand operated units, or in batteries mounted on trucks or tractors, the operating procedure should follow certain principles. It is desirable to burn before the plants have made their full growth since less fuel is required to burn the smaller plants. Also, burning should take place before the plants produce seed. For greatest economy, no attempt should be made to completely consume the plants at the first burn. Instead, the operator should plan upon a second treatment, about a week after the first, at which time regrowth will be minimal and the vegetation which was seared or killed by the first burn will be consumed, leaving the burned area completely cleared. Some operators substitute for the first burn a heavy treatment with a weed oil, thereafter delaying the burn until a week or ten days later, when the damaged vegetation can be completely consumed.

*Triple-Headed Burner Unit for Use on Pick-Up Truck*

Some years ago the various sewage disposal plants in the Delta Mosquito Abatement District were responsible for heavy mosquito production. Sewage effluent was permitted to run more or less continously into broad, shallow, weedy areas in such a way that insecticides and weedicides could not be effectively used. The District successfully persuaded its cities to construct large, deep, holding reservoirs with banks as steep as practical. These ponds are filled to a depth of six or seven feet during much of the year, a practice which eliminates all weed growth from the bottom. Mosquito production in the open water is rarely if ever a problem. However, a heavy mat of Bermuda, water and Johnson grasses grows out from the banks, creating a very favorable environment for *Culex* breeding.

Mowing prevented the grass from growing in height but did not eliminate the mat. It also contributed to undesirable floatage. Oiling killed the grass tops but did not remove them. Hand burning was tried but was very time consuming and expensive. The propane weed burner offered an economical method of eliminating the grass mat.

After thoroughly investigating the available burning equipment, the Delta District selected for its use a unit developed by Agri-Quip Agricultural Equipment Corporation (La Junta, Colorado) designated as "Model 40." This unit has three burner heads mounted at the end of a hand controlling boom, 15

*About 2700° F. when operated where the air temperature is about 70° to 80°, and about 3200° when operated where the air temperature is 100° to 110°.

feet in length. The boom attaches to a frame set up in a pick-up truck. This was the smallest unit available with a range sufficient to do the weed control required about the margins of the sewage lagoons.

The manufacturers of the burner recommend several applications, one to kill the tops and another to burn them. Experience in the Visalia area indicates that in some cases this one tool is adequate, but the most effective elimination of the growth has been through a combination of weed oil to kill the tops followed in about a week by the burner.

*Large, Hydraulically Controlled 6-Headed Burner*

The Northern Salinas Valley Mosquito Abatement District has responsibility for maintaining 26 miles of main drainage channels which serve as the main outlet for more than 150 miles of tributary farm drainage channels, serving the intensely farmed irrigated area in that vicinity. The land is heavily fertilized throughout the long growing season. The excess irrigation water which is drained off the fields therefore contains a high percentage of fertilizer, thus promoting an exceptionally rank vegetative growth in the drainage ways. Soon after the District was formed in 1951, it became evident that the vegetation had to be controlled if excessive drain maintenance costs were to be avoided. Eight months after a section of main canal had ben regraded by dragline, the vegation was choking it again. A variety of other weed control methods were tried before arrangements were made to see a demonstration of a truck-mounted burner which had been built by the James Irrigation District of San Joaquin. This appeared to be an effective unit, but did not have sufficient range to do the work required on the larger canals in the Salinas area. A larger burner was used on an experimental basis through the cooperation of the Van Horn Butane Company, but the boom on this unit was still not long enough to reach all of the vegetation along the wide and deep canals at Salinas. Subsequently, a decision was reached to construct a special machine with an adjustable boom which extends to a maximum length of 30 feet and retracts to a minimum length of 16 feet. It has six burner heads to burn an eight-foot wide swath at one pass, at speeds of one to three miles per hour, depending upon the density of the vegetation. The Salinas Steel and Hardware Company was given the contract to do the detailed design and construction. Total cost of the finished machine, ready to operate, mounted on a 6 x 6 surplus weapons carrier chassis, amounted to just under $5000. On a new truck chassis, the cost would probably have been $2000 higher. The weapons carrier had to be lengthened, the frame was strengthened, dual wheels were fitted, and the engine was overhauled, the costs being included in the above figures.

The machine has a propane tank of 500 gallons (water) capacity. In addition to the main burners, there has been added at a cost of about $60.00, a separate single hand-operated burner with a 50-foot extension hose to permit burning the weeds about bridges and culverts where the large burner head cannot be used. The boom is made of steel tubing, and is extended by the operation of a hydraulic cylinder. The pivoting upright mast which supports the boom is made of 6 7/8" steel tubing, with "A" frame bracing of 2½" and 1½" pipe. The boom may swing to right or left, depending upon the placement of an adjustable pin, through an arc up to 90 degrees, the movement being controlled by a hydraulic ram. The boom is also positioned vertically through the operation of another ram. The position of the manifold, to which the six "Agri-Quip" burner heads are attached, is also controlled hydraulically by the operator from the driver's seat on the vehicle. The "Vickers" hydraulic pump which operates all of the hydraulic rams is driven by a separate 5½ HP gasoline motor, and the hydraulic operations are regulated by "Moline" controls. The hydraulic system was originally driven from a power take-off from the truck motor, but this was found to be an inconvenient arrangement.

The original design has proved to be quite satisfactory, but a few refinements might be incorporated in any similar machine to be constructed in the future. The boom might be made of aluminum alloy in a lattice design. This would result in a much lighter unit, thereby allowing lighter construction of the supporting frame. Since not more than 350 gallons of propane can be used in one day, a propane tank of about 350 gallons capacity might be substituted for the present 500 gallon tank, thereby reducing the weight and allowing the use of a lower, oval shaped tank which would give the operator better visibility. In order to operate at lower pressures, some of the hydraulic rams should probably be of larger diameter. Conveniently placed strainers must be provided in the fuel supply lines. Otherwise, clogging may produce deviations from the normal flame at the burners, which can in turn damage them to a point where they will need replacement, at a cost of about $60.00 each. By cleaning the strainers as soon as any malfunctioning of the burners occurred, replacements have to date been avoided, although nearly 8000 gallons of fuel have been burned.

The driver should be provided a seat that can be easily turned to face the side or the rear while burning is in progress. Mirrors should be provided at strategic locations, of a sufficient size and setting to allow a wide field of vision. The hydraulic lines and controls should be spaced to increase visibility in all directions. These lines and the fuel lines should be kept to a minimum length, with pipe substituted wherever possible. All flexible lines should be amply protected against heat and mechanical damage, and those near the burner heads should be asbestos wrapped. Propane works very satisfactorily as a fuel, being both efficient and economical.

This unit has been in use for over a year, and operating costs have been as follows:

| | |
|---|---|
| Propane fuel used: (335 on hand) gal | 7,698 |
| Cost: ............................................Gross: | $1,077.13 |
| Refund of $.06 per gallon Vehicle Gas Tax (exclusive of $.06 paid on 1% of total fuel consumed)........................Tax | 437.36 |
| Cost of propane ........................................ | $ 639.77 |
| Insurance: ................................................ | 200.00 |
| Operators salary (actual burning time, no inspection maintenance, etc.)............ | 351.26 |
| Depreciation (10 year write-off) ........ | 500.00 |
| | $1,691.03 |

| | |
|---|---|
| 60 acre/miles* covered at a cost of: per 7363 gallons used. Per acre consumption ..................................(gal.) | 122.7 |
| Net cost of gas/acre @ 8.5c gal............ | $ 10.429 |
| Net cost of gas/lineal ft. (8 ft. wide).. | .0019 |
| Gross cost per lineal ft. (8 ft. wide)............ | .0053 |

These costs are based upon a first year's usage and could be lowered by improved technique, increased use, and modification of design.

They do not reflect the cost of inspection, supervision, depot maintenance and incidentals (oil, hose replacements, painting, etc.) that are standard for most machinery.

*The swath width burned averages eight feet in width. A single swath one mile long therefore, equals an area of about one acre.

## THE PASTURE MOSQUITO

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The Delta Mosquito Abatement District has undertaken a vigorous program of public education. Media for mass education, such as movies, have been considered of prime importance.

People today are highly gregarious, forming clubs and groups of various kinds, such as Rotary, Lions, Women's Clubs, Farm Bureau, Chamber of Commerce, Church groups, etc. Varied programs of community interest are a fundamental part of the business of most such organizations, and program chairmen must usually work hard to arrange for suitable speakers or movies. They are usually glad when someone approaches them with a request to present a program.

Also, high school science and biology classes are in need of local, practical information when available, and a program by an agency such as a mosquito abatement district can fill this need.

With the help of movies, the audiences can be taken outdoors to see the mosquito problems and the many activities of the District in its effort to bring about control. Scenes of local people and local places, when well presented, are far more interesting than scenes from other parts of the country or world.

Movies to satisfy service clubs, school classes, etc., usually must be in color and sound to satisfy today's highly pampered society. However, the usual optical sound applied to a film with full synchronization of voices and background music is usually quite expensive. A fairly recent offshoot of the magnetic tape recorder is the magnetic sound stripe for use with home-made films. The cost is very nominal, and the words of the narrator can be placed on the stripe for the life of the film or removed and replaced with other words at any time.

The procedure used by the Delta Mosquito Abatement District in preparing its movies is as follows:

1. The story is developed in outline form.
2. Various scenes needed to develop the story are shot as convenient. The sequence of shooting is not important, rather the scenes should be shot when available.
3. The film is spliced into its desired sequence and cut to proper length.
4. The original film is sent to Eastman for duplication and addition of the sound stripe to the duplicated film. The original is then

stored and only the duplicated film is used for development of sound and for showings.

5. The narration is prepared and placed on the film, together with suitable background music. The film is now ready for showing.

The Delta MAD movie, The Pasture Mosquito, has been shown to 46 organizations, to a total of 2,200 persons. We anticipate another 50 showings to a total of perhaps 1,500 persons during the coming year, after which we hope to begin developing a new movie for future showings. The Pasture Mosquito is a general movie which illustrates the terrific swarms of mosquitoes which may plague a farmer, the background of why the farmer has the mosquito problem, what the mosquito abatement district can do to help, and how the farmer may also contribute towards a mosquito-free community.

## THE INFLUENCE OF CLIMATOLOGICAL FACTORS ON THE BITING ACTIVITIES OF THE MOSQUITO *AEDES DORSALIS* (MEIGEN)

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The enemy has massed for a sneak attack. "H" hour will be shortly after sunset. The plan of attack is to hit hard and fast and to beat a rapid retreat before the defenders have a chance to organize effective resistance.

Those of you who have been at Black Rock Beach during evening twilight have undoubtedly been victims of this type of attack. Not by any human agency, but rather by our natural enemy, the mosquito. The sudden appearance of great numbers of mosquitoes on a previously mosquitoless scene, the rapid attack and hasty withdrawal resembles greatly the work of some military genius. It has been reported by some observers, that, at times, the invaders can actually be seen coming in against the background of dimming light.

During the summer of 1956, an attempt was made to determine the influence of certain climatic factors on the activity of these mosquitoes. The factors considered were temperature, relative humidity, wind direction and velocity, light intensity, cloud coverage and barometric pressure.

Black Rock Beach is a resort located on the shore of the Great Salt Lake at the juncture of Salt Lake and Tooele counties. The main bathing area and concession booths are located on a sand spit extending for a short distance into the lake. As it is devoid of vegetation, the spit is free of the natural resting places of the adult mosquitoes and as a result of its location between the lake and the Oquirrh Mountains mosquitoes do not approach the beach from the mountains to the south.

Within a radius of about a mile from the beach proper, there are numerous mosquito producing sites. Mosquitoes were found developing in semi-permanent water near the beach during the entire period of this study. Large numbers of adult *Aedes dorsalis* were observed in the vegetation near the beach during the day. This fact and the report that they would probably be plentiful throughout the entire breeding season, led to the selection of this species for the study.

The biting rate was used as an indication of adult activity. As stated by Marston Bates (1949), "It is, of course, easiest to measure the time of activity of any given mosquito species by the time of biting since this can be observed with relative facility." Using a chloroform tube, the biting collections were made by Marlor from his exposed right leg.

Since it was apparent that the evening activity was the more intense, samples were taken each Tuesday and Friday evening during the period 12 June to 24 August (except Friday, 20 July). Three morning samples were taken to check the activity during morning twilight when light conditions were similar to the evening twilight period. Samples were taken during 15 minute periods, always starting in advance of sunrise or sunset.

The instruments used in making the meteorological observations were the following: General Electric Light Meter, Model 84W40Y16; an Alnor Velometer, type 8100, for wind velocity; a Lensatic hand compass for wind direction; a Taylor Humidiguide, Stewart Model, for relative humidity and dry bulb temperature and a Taylor portable barometer.

To supplement the hand collections, a New Jersey type light trap was operated at the same times hand samples were taken. The trap was new and untested, but was rated by the manufacturer at 200 cubic feet of air per minute.

Arriving in the test area at least one-half hour prior to the time of the first observation, the equipment was set up and prepared for use. The Taylor Humidiguide requires at least 30 minutes of adjustment time before it will produce reliable readings. The chloroform tubes, four in number, were "sweetened" and the light trap positioned. The light trap was suspended on a "two by four" which was nailed to a telephone pole. The height of the trap was adjusted so that the top of the trap was about six feet from the ground. The trap was approximately 15 feet from the position occupied when hand collections and other data were taken.

The state of the various factors was determined at the beginning of each 15 minute interval and recorded. The order was as follows: light intensity first due to the rapid change in this factor, wet and dry bulb temperatures, wind direction and velocity and barometric pressure. The cloud coverage was noted at the beginning of each evening or morning sampling period and was not again recorded unless considerable change occurred.

A wind vane was used for the first three nights, but proved to be inadequate for determining the direction of light breezes. The vane was discarded in favor of the "wet finger" method of determining wind direction.

When the first bite was received, the time, light intensity and, on those occasions when time permitted, wind velocity were noted. At the end of each interval, the mosquitoes which had been collected were removed from the chloroform tube and placed in a pill box to await later identification. The specimens taken were grouped under the starting time of each interval. The contents of the cyanide killing jar, attached to the light trap, were transferred to a pill box at the end of each evening for later sorting and identification.

The Taylor Humidiguide was equipped with a direct conversion scale for temperatures within the difference range of 1 to 21 degrees. At times, the difference exceeded these limits and the conversions of wet and dry bulb temperature to relative humidity were made from tables contained in "Lange's Handbook of Chemistry."

To check the results of the Black Rock samples, a second site was selected at the residence of Mrs. H. A. Barton at 6850 West below 2700 South in Salt Lake County, about one and one-half miles east of Magna, Utah. Observations were made at the Barton site on the 13th and 15th of August.

The following mosquitoes were taken during the study:

BLACK ROCK BEACH

Biting in the evening

528 *Aedes dorsalis*

6 *Aedes campestris*

6 *Culex tarsalis*

Evening light trap collection

4 ♀ *Aedes dorsalis*

Biting in the morning

11 *Aedes dorsalis*

BARTON RESIDENCE

Biting in the evening

14 *Aedes dorsalis*

1 *Aedes campestris*

61 *Culex tarsalis*

Light trap collection

1 ♂ *Aedes dorsalis*

2 ♀ *Aedes dorsalis*

RESULTS:

TEMPERATURE

During the period of this study, the temperature ranged from a low of 57°F. to a high of 91°F. The temperature when collections were made during any given evening did not vary more than 9°F. The biting rate for the coldest and warmest evenings attained a maximum of one bite per minute in each instance.

RELATIVE HUMIDITY

The minimum relative humidity recorded was 9% and the maximum was 58%. The humidity was far more variable for a given evening than was the temperature. Yet, on the days when these extreme readings were obtained, the biting rate reached a maximum of one bite per minute in each case. The activity pattern was the same on evenings when a large variation in relative humidity occurred as when the humidity remained fairly constant.

BAROMETRIC PRESSURE

The variation in the barometric pressure for the entire period did not exceed 0.31 inches. As would be expected, the pressure was normally very stable for any given evening.

WIND DIRECTION AND VELOCITY

The direction of the wind varied within the arc 325° to 250° and the velocity ranged from dead calm to speeds in excess of 27 miles per hour. The maximum velocity recorded while the mosquitoes were biting was 19.8 miles per hour.

LIGHT INTENSITY

The highest intensity recorded simultaneously with a bite was 47 footcandles. The majority of the "first bites" recorded were at light intensities of 25 footcandles or below. There was a marked increase in activity when the light intensity was below 20 footcandles. The biting continued for a short time after the light intensity measured zero.

MORNING SAMPLES

The samples taken during morning twilight displayed a similar acivity pattern to the evening samples. Biting started before there was any measurable light on one occasion and, on the other days, when the intensity was below 5 footcandles. Activity ceased at a maximum of 33 footcandles.

SAMPLES TAKEN AT THE BARTON SITE

The activity of the adult mosquitoes at this site was identical to the activity pattern found at Black Rock Beach. However, *Culex tarsalis* was the major species present. It is of interest to note, that the peak biting rate for *Culex tarsalis* was simultaneous with the peak for *Aedes dorsalis*.

LIGHT TRAP SAMPLE

The light trap catch of 7 mosquitoes as compared to 627 taken by hand during the same interval leads to two possible explanations. Either the collector was too close to the light trap while taking biting samples, 15 feet at Black Rock and 36 feet at Barton's, or that the species involved are more readily attracted to human bait, when available, than they are to the light within the trap.

*General Observations*

The most intense biting rate was observed between 8:15 and 8:30 P.M. 12 June 1956. The biting rate at this time was 4.87 bites per minute.

CONCLUSIONS

*Temperature*

Temperature appeared to have little effect on the activity of the species present in the range of temperature encountered when this study was made. No exceedingly low temperature was involved. The temperature tolerance range as described for *Aedes dorsalis* in Utah by Rees and Nielsen (1947) of between 50 and 90°F. was not exceeded. The usual range of temperatures recorded during this study was 70° to 90°F.

*Relative Humidity*

No correlation could be detected between the relative humidity and the activity of mosquitoes. This is supported by Lumsden (1947) in his studies of *Aedes aegypti* (L.).

*Barometric Pressure*

No correlation could be found between barometric pressure and mosquito activity.

*Wind Direction and Velocity*

The species involved in this study appear to be able to fly against the wind as with the wind. Wind velocities of less than 20 miles per hour do not appear to inhibit their activity although activity increases with velocities less than 10 miles per hour.

*Light Intensity*

That the light intensity plays the greatest role in the initiation of adult activity has been claimed by other workers. W. E. Snow (1955) stated "Marked changes in light intensity at dawn and dusk was considered to be the activating and deactivating influence for the nocturnal and diurnal populations observed." L. Colin Curtis (1953) in his study of mosquitoes in the Yukon Territory of Canada observed, "on several occasions, an increase in activity occurred concurrently with a reduction in light intensity when all other factors were relatively stable".

From the results of this study, it is concluded that light intensities of below 50 footcandles initiate biting activity for *Aedes dorsalis*. The peak of activity appears to occur at light intensities below 10 footcandles. Activity ceases for this species shortly after attaining total darkness or full daylight. It must be borne in mind that the authors are referring to the cyclic activity of *Aedes dorsalis* and are only considering the periods of most intense biting activity. *A. dorsalis* will bite at any time of the day if a suitable host passes within the area where this mosquito is resting, as can be attested by any worker who has come into contact with this species in the field.

The total length of time involved for the evening biting activity of *A. dorsalis* at Black Rock Beach is normally about 45 minutes and is only slightly less for the period of morning activity.

SELECTED REFERENCES

Bates, Marston
1949. The natural history of mosquitoes. The MacMillan Co., New York. 379 pp.

Curtis, L. Colin
1953. Observations on mosquitoes at Whitehorse, Yukon Territory. The Canadian Entomologist 85:353-370.

Lange, Norbert Adolph
1952. Lange's handbook of chemistry. Handbook Publishers Inc. Sandusky, Ohio, 8th Edition. pp. 1450-53.

Lumsden, W. H. R.
1947. Observations on the effect of the microclimate on biting by Aedes aegypti (L.). Journal of Experimental Biology 24:361-373.

Marlor, Russell L.
1957. The influence of climatological factors on the biting activities of the mosquito *Aedes dorsalis* (Meigen). Unpublished thesis in the Library, University of Utah.

Rees, D. M. and Nielsen, L. T.
1947. On the biology and control of *Aedes dorsalis* (Meigen) in Utah. Proc. 34th Ann. Meet. N. J. Mosq. Exter. Assoc. pp. 160-165.

Snow, W. E.
1955. Feeding habits of some blood-sucking Diptera with reference to vertical distribution in bottomland forest. Annals of Ent. Soc. of Amer. 48:512-521.

## THE EDUCATIONAL APPROACH TO SOURCE REDUCTION

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In order that a mosquito abatement agency may present effectively to the mass population of the District its philosophy of progressive reduction of all mosquito breeding sources, it should employ all the means of communication which are available. These procedures are referred to as "mass media."

Mass media are those instruments of communication which convey identical messages to large numbers of persons who are physically separated. These identical messages may be: printed, as in newspaper articles, books, pamphlets (such as brochures), comics, and magazines. They may be on film. This mass media may include television, radio, and recordings. Some of the mass media are new — very new. Only the book, the magazine, and the newspaper antedate the present century, and in this period even these have greatly increased their effectiveness and circulation. All of these means serve to gradually mold the public mind toward one common goal; in this instance the individual responsibility toward mosquito control and the awareness of all responsible persons to the always constant threat of mosquitoes as transmittors of disease or as irksome pests or as economic non-essentials.

Any source reduction program to be effective must be organized and have a definite goal in sight: such programs should be written out in as much detail as is possible so that no one can mis-construe the meaning of all its phases nor its implications. These programs then must be properly documented for reference and for use in the public relations aspects. This is the responsibility of management. Integration of the entire source reduction program thru and to all the staff members will follow in due course by staff sessions and individual consultation. If management is to function effectively it must function openly and in an orderly manner. The source reduction program must be based upon sound agricultural and engineering principles; it must be forthright and carried boldly forward, once the outline and goals have been marked. I believe that such a program must be, basically, an educational one. The truth of the remarks made by Mr. W. C. McDuffie this afternoon, has caused California mosquito control workers to consider source reduction as a more and more important phase of their programs. Mosquito resistance to the chlorinates first focused our attention along these lines. More recently, (1956) the appearance of mosquito resistance to Malathion, has made this emphasis on the progressive reduction of mosquito sources of even greater importance. Other sections of the country have experienced similar results. Our only hope of coping with the ever increasing mosquito problem lies in greater and greater emphasis on this all-important phase.

The only nearly permanent mosquito control is source reduction. We have had many papers in the past on source reduction telling of the basic procedures used. Rather than repeat this work I will attempt to develop some of the philosophy of the educational aspects of this phase of mosquito abatement.

The educational approach may be divided into many categories. All of the divisions are overlapping to some extent, however, they are sufficiently distinct in themselves to need careful study to produce the maximum effectiveness.

A division of the education approach might be:

1. Those aspects which employ mass media.
2. Those aspects which employ individual contact.

These two concepts confront each mosquito abatement agency embarking upon a source reduction program; namely, that of communicating to the mass population within the district as compared to the individual approach. The latter is usually accomplished by the person designated as the source reduction technician and, in fact, all members of the staff participate if the program has been properly integrated.

Mr. Lynn Thatcher, this morning suggested a phase of our educational program which I'm afraid most of us have neglected except at the time our legislatures are in session. We all too frequently forget to keep these people and others in high authority properly informed about our mosquito programs. Perhaps we would have much greater support in the legislature if we always kept in contact with these persons. They are in position to help us in many ways if only they were better informed. How about sending them our brochures, proceedings and other publications? Since education is a continuing process and all must cooperate to develop a successful pattern of source reduction we must constantly employ all of the available resources of education; be they by mass media or by individual personal contact with the householder, rancher or industrialist.

Since we have instituted a more formal type of source reduction program with a specialist to head up the work, we have noticed a change of attitude toward our total program. Thru the every day contacts made by this person we believe that farmers, irrigators and others have come to understand the problem and have, on many occasions, come to us for assistance in learning how they can properly prepare the land and subsequently handle their irrigation water without causing a mosquito problem. These things don't happen over-night but by constant contact, the ideas gradually take hold. I know this approach will bring about the desired results — it has in the Turlock Mosquito Abatement District and in many other mosquito control agencies of California and elsewhere.

I have discussed some of the mass media which we may employ, to the mass population, as well as to the individual, but what are some of the functions of these media?

The service functions of mass media are threefold:

1. Informational functions
2. Entertainment functions
3. Sales or advertising messages

The source reduction programs would fall into the first or informational function and the last or sales messages. Rarely, if ever, has entertainment been employed to "put-across" the idea desired. Perhaps the few television programs presented would fall into this category but I believe they have been more educational in nature than pure entertainment. The Disney film entitled "The Winged Scourge" is a good example of the use of entertainment. The "Rival World" movie which we saw today is another example of this aspect. This area might well be explored for its possibilities.

In recent years a wide use has been made of advertizing messages to sell, not goods, but ideas. The purpose of such advertising is to convince the audience of the mass media of the soundness or unsoundness of a social, political, or economic belief, sometimes but not always in a controversial context. Examples of this procedure are about us daily in the newspaper, and on the radio and television.

Selling and advertising messages employ one of the basic principles of education to put across their idea — repetition. On the air, on the screen and in the newspapers and magazines we find the same slogan or catch phrase, (like 'LS-MFT') which instantly envisions a product or a principle. Too often we write news articles, perhaps an entire series of fine ones but we use the plan but once and expect miracles to happen. Only by repeating and repeating our message can we hope to arouse public interest. A healthy advertising budget in a mosquito abatement program could produce some notable change in public attitude toward our aims and goals. Most budgets do not contain any such item.

I firmly believe that all the planning, staff conferences, newspaper articles, or television programs are for naught unless the mosquito abatement agency is prepared with an adequately trained and experienced staff; particularly the source reduction specialist, to carry the "message" to the individual parties. It is somewhat a travesty upon our modern methods of communication that the general public is still so totally ignorant of the basic concepts of mosquito biology, particularly as they affect mosquito abatement programs. Somewhere along the line we have not been able to obtain the attention or motivation necessary for success. All of the devices of mass media communication must be employed more effectively to inform the public body of their responsibilities if the agency hopes to achieve success.

In any education process there are four principles of communication which *must* be fulfilled before any message can arouse its intended response; they are:

1. The message must be so designed and delivered as to gain the attention of the intended receiver. In other words we must be able to "speak their language" and discuss these matters in terms the property owners can understand. A knowledge of farming is of inestimable help here.
2. The message must employ signs which refer to experience common to both sender and receiver, as to "get-the-message-across." One of the most convincing ways of "getting-the-message-across" is to show, by visible evidence, the problem that is to be solved. Such might be mosquito larvae in a poorly constructed drain ditch.
3. The message must arouse personal needs in the receiver and suggest some ways to meet those needs. Often the economic factors will help here. We have found that best results are usually obtained when the mosquito problem is referred to as an agricultural problem. In this day of scientific and highly competitive farming no rancher can afford to have land out of production because of poor drainage or over irrigation.

4. The message must suggest a way to meet those needs which is appropriate to the group situation in which the receiver finds himself at the time when he is moved to make the desired response. The example of a neighbor, who has completed a successful drainage program, is often more help than can be obtained by persuasion or by days of talk. Each ranch problem must be considered as a community problem and not just one affecting an individual farmstead, since mosquitoes are no respectors of property lines.

The importance of fulfilling each of the four points can not be stressed too much. Some one or more of the principles have not been fulfilled when our educational approaches do not meet our goals.

It is possible and certainly within the means of mosquito abatement agencies to develop all of the mass media of communication for source reduction purposes. I believe if they were more carefully planned and more methodically carried out that the present day need of the personal contact could be lessened with the consequent larger return for funds expended. Few, if any of us, have employed mass media as is done by industry. Great strides forward in our educational approaches to the source reduction programs could be made when more careful consideration is given to these concepts.

## REFERENCES


Fields, Morey, R.
1953. Public health education in mosquito abatement operations. 22nd Proceedings and Papers of California Mosquito Control Association, Inc.

Gray, Harold F.
1953. Education methods in mosquito control. 22nd Proceedings and Papers of California Mosquito Control Association, Inc.

National Society for the Study of Education
1954. Mass media and education. University of Chicago Press.

Nyswander, Dorothy B.
1956. Education for health. Some principles and their appreciation. California's Health, Vol. 14, No. 9.

Nyswander, Dorothy B.
1946. The place of education in a mosquito abatement program. 17th Proceedings and Papers of California Mosquito Control Association, Inc.

Peters, Robert H.
1955. Economic and legal aspects of mosquito source reduction. 23rd Proceedings and Papers of California Mosquito Control Association, Inc.

Thelan, Herbert A.
1954. Dynamics of groups at work. University of Chicago Press.


## BLUE-GREEN ALGAE AS A POSSIBLE MOSQUITO CONTROL MEASURE


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The first person to work on the mosquito deterrent properties of the *Myxophyceae* was Dr. William C. Purdy (1925). In the course of his experiments at Nelson, California, Dr. Purdy attempted to demonstrate that the water of a rice field which was dominated by a growth of blue-green algae was toxic to mosquito larvae. Examination of Purdy's experimental evidence suggests the following: incoming water of the Nelson Rice Field was not harmful to mosquito larvae; half-grown larvae (probably second or third instars) placed in the field water under varying circumstances died within a few days; adult female mosquitoes confined in a large cage over the surface of the Nelson Rice Field oviposited normally; the resulting eggs hatched normally but the larvae failed to survive.

The general incompatability of the *Myxophyceae* and mosquitoes has been observed by other workers, notably Bradley (1932). With the foregoing factors in mind the writer undertook to investigate this problem for the first time during 1952 (Gerhardt, 1953).

During the seasons of 1952 and 1953 an extensive field survey determined the distribution of blue-green algal species in numerous rice fields, and correlated the abundance of mosquito larvae with this distribution. Of 55 rice fields examined for dominant algal types and mosquito larvae, 46 fields were found to support a dominant growth of blue-green algae. Without exception mosquito larvae were virtually absent from these fields. Fields in the same area which were not dominated by blue-green algal growths, were found to produce many mosquitoes.

Specimens of *Myxophyceae* collected from rice fields of the Nelson area (*Anabaena unispora* Gard) were cultured in the laboratory. Mosquito larvae were placed in filtrates of the cultures under varying conditions and with suitable controls. These tests indicated that the alga was producing some water soluble metabolite which was toxic to mosquito larvae.

During 1952 attempts were made to transplant blue-green algae from the Nelson area to rice fields in Placer County which were known not to support abundant blue-green growths. The method used consisted of harvesting rice stubble from a rice field which supported abundant growth of *Anabaena* the previous season and broadcasting this stubble as an inoculum in the new area. This method was retested on an expanded scale during 1954. Of five trials, 4 were successful and the fields inoculated showed reduced mosquito populations after mid July.

The question of water quality associated with blue-green algal dominance has been considered. During 1952 extensive analyses were completed by the Sanitation Laboratory of the California State Department of Public Health. These included chemical and spectrographic tests solutes which might be toxic to mosquito larvae. No unusual solutes were found. Blue-green dominated fields were found to contain virtually the same amounts of dissolved organic compounds as normal mosquito producing rice fields (Gerhardt, 1956).

These observations have been partially confirmed by Kachroo (1956), and Kachroo and Neogy (1956) India, and by Griffin (1956) in Utah.

Additional evidence that a toxin is produced by certain blue-green algae was obtained during 1956.

A box was constructed of marine plywood which was open at the bottom and fitted with a light tight lid. The box was placed in a rice field with its bottom edges pressed into the soil surface. Several large mats of *Aulosira implexa* were collected from the rice field and placed in the box.

Anaerobic conditions developed rapidly when the light was excluded from the box. Mosquito larvae placed in the box died quickly under such conditions. Air was bubbled through the water to prevent the development of anaerobic conditions. This air was supplied from a compressed air tank through a polyethylene tube at the rate of 1/2 liter per minute.

In the first test 100 larvae were placed in the box and the box was covered to exclude light and prevent the photometabolism of the algae. The box was opened three days later and the number of surviving larvae or pupae estimated by random dipping within the box area. Of the 100 larvae introduced into the box, 12 were recovered in six dipping samples. After dipping, 100 larvae were added to the box and the box was again covered. Of the 100 larvae added to the closed box, nine were recovered in four dipping samples after a three-day period.

Following the first two tests during which the box remained closed, the lid was removed and the box was covered with ordinary window screen to retain any adults which might emerge during the next test. Thus, light was allowed to enter the box so that photometabolism could be resumed by the algae contained in the box. 100 larvae were again introduced. Of the 100 larvae introduced, none could be found in a 12 dip sample three days later. The test was then repeated with essentially the same results.

The mosquito larvae survived if light was excluded and algal photometabolism prevented. When light was admitted the larvae died. The data from these experiments indicate that *Aulosira implexa* excretes a photometabolite which is toxic to larvae of *Culex tarsalis*. The production of this photometabolite can be prevented by excluding light. The lethal effect is quickly dissipated when photometabolism is blocked. It seems likely that the metabolite is an organic compound which is unstabled or is readily decomposed by microorganisms. The composition of the toxin produced by *Aulosira implexa* is unknown and its characterization must await further research. It may be related to the nitrogenous substances excreted during active photosynthesis by species of the genus *Anabaena*. In review, the following statements are supported by experimental evidence: (1) Certain species of blue-green algae are associated with an absence of mosquito larvae in the aquatic environment. (2) Considerable evidence indicates that there is a cause-effect relationship between the presence of blue-greens and the absence of mosquitoes. (3) Experimental evidence exists that a metabolite is produced by the blue-greens studied which is toxic to mosquito larvae.

The question arises: Will we be able to use these micro-organisms in practical mosuito abatement?

There is little question that they will be valuable in California rice fields if we can learn to manipulate the distribution and abundance of the algae. It is doubtful if toxic blue-green algae present much hope for other irrigated crop areas because of their slow growth. It is possible that the algae can be made to grow in certain shallow, permanent bodies of water such as marshes. It may be possible to enrich the blue-green growths normally present in these environments by selective fertilization.

Many native species of blue-greens may have larvacidial properties under proper conditions. The species which have been observed to possess this property are: *Anabaena flos-aquae, Anabaena variabilis, Anabaena unispora, Aulosira implexa, Tolypothrix tenuis, Plectonema nostocorum, Oscillatoria princeps*. Undoubtedly other species will be found which affect larvae in some degree.

The California State Department of Public Health and the University of California at Berkeley are co-operating in a study of the toxic mechanism of blue-green algae as associated with mosquitoes. This study should result in the chemical identification of the toxin responsible for the larvicidal activity of blue-green algae. The possibility that the toxin, if extracted or synthesized, might be useful as a larvicide does not appear to offer much hope. It is doubtful if it would prove to be more effective than larvicides now in use. The problem of costly, repitative applications of larvicides would not be solved. The principal value of blue-green algae in mosquito control will be in taking advantage of their antibiotic activity within the limitations of the natural environment.

## REFERENCES CITED

Bradley, G. H.
1932. Some factors associated with the breeding of *Anopheles* Mosquitoes. Journal of Ag. Res. 44 (5):381-399.

Gerhardt, R. W.
1953. Blue-green algae — A possible anti-mosquito measure for California rice fields. Proceedings and Papers 22nd Annual Conference California Mosquito Control Association, p. 50-53.

1956. Present knowledge concerning the relationship of blue-green algae and mosquitoes in California rice fields. Proceedings and Papers 24th Annual Conference California Mosquito Control Association, p. 47-50.

Griffin, G. D.
1956. An investigation of *Anabaena unispora* Gardner and other blue-green algae as a possible mosquito control factor in Salt Lake County, Utah. Thesis, Department of Zoology, University of Utah, Salt Lake City, Utah, 1956.

Kachroo, P.
1956. *Myxophyceae* as possible antilarval agents. Proc. & Papers 24th Ann. Conf. Cal. Mosq. Control Assoc. pp. 52-53.

Neogy, B. P. and P. Kachroo
1956. Observations on association of blue-green algae with mosquitoes. Proc. & Papers 24th Ann. Conf. Cal. Mosq. Control Assoc. pp. 50-52.

Purdy, W. C.
1924. Biological investigations of California rice fields and attendant waters with reference to mosquito breeding. Pub. Health Bull. #145.

## COMPARISON OF LIGHT TRAP RECORDS AND COMPLAINTS IN WEBER COUNTY

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This study is based on the recorded complaints and light trap records of the Weber County Mosquito Abatement District for the year of 1956.

### COMPLAINTS

Prior to May 15 four complaints were received, but when checked out were found to be concerned with gnats. On May 18th a complaint came in from the northern part of Ogden City, and *Aedes vexans* adults were found in the area. A complaint was recorded from the south part of Ogden City on May 22nd; *Aedes dorsalis* adults were found in the vicinity. The next complaint came June 7th; the cause of the complaint was found to be leaf hoppers. All complaints of mosquito nuisances investigated for the remainder of the season were found to be valid. Five species of mosquitoes were found, and they appeared in the following number of areas: *Aedes dorsalis* 4, *Aedes nigromaculis* 4, *Culex pipiens* 2, *Aedes vexans* 1, and *Culex tarsalis* 1. The five species of mosquitoes in the complaint areas were found in the following species associations: *Aedes vexans* occurred alone; *Aedes dorsalis* was found alone twice and with *Aedes nigromaculis* twice; *Culex pipiens* was found alone once and with *Culex tarsalis* and *Aedes nigromaculis* once; *Culex tarsalis* was found once with *Culex pipiens* and *Aedes nigromaculis; Aedes nigromaculis* was found alone once, with *Aedes dorsalis* twice, and once with *Culex pipiens* and *Culex tarsalis.*

The earliest complaint came on April 25th and the last request for fog was made on September 15. The actual range of complaints because of a mosquito nuisance was from May 15 to September 6. No complaints were recorded on Sundays. In order to compare the number of complaints with the light trap counts, the complaints were grouped according to the light trap operation dates.

There were five periods during which more complaints were received per day than at any other time. These dates and the average number of complaints per day are as follows: May 23-25, 6.16 complaints per day; May 29-June 1, 23.5 complaints per day; June 2-4, 5 complaints per day; June 5-8, 4.66 complaints per day; and June 27-29, 5.4 complaints per day. It is worthy of note that these heavy complaint periods were all before June 30. The number of complaints received before June 15th was over twice that received for the remainder of the season. There were more complaints filed on May 31st than in the entire month of July or August. During the four-day period from May 29th to June 1st ninety-four complaints were received. The next greatest number of complaints was nineteen, which were recorded between May 23-25.

### *Light Trap Data*

Six light traps were operated from April 17th to October 8th inclusive. Two of the light traps caught more mosquitoes than the remaining four combined. The three species most frequently found in the light traps before June 15th were collected in the following order of abundance: *Aedes dorsalis, Culex tarsalis* and *Culiseta inornata.* From June 16th until the end of the season the species of mosquitoes found most abundantly in the light traps were in order of numbers taken: *Culex tarsalis, Aedes dorsalis* and *Culiseta inornata.*

The light trap counts rose to four peaks during the season. The dates of and average nightly catches during these peaks are as follows: May 29th to June 1st, 72.12; July 7-9, 209.2; July 23-25, 212; and August 11-13, 179. Only the smallest of these peaks was reached before July 6th.

Prior to May 14th the light trap counts averaged below three per night and 69% of the counts averaged less than one per night. After September 17th the highest count was 40 per night of which 30 were *Culex tarsalis.* After September 17th 66.7% of the counts were less than four per night.

### *Comparison of Light Trap Data with Complaints During the Outbreak*

Of ninety-four complaints recorded between May 29th and June 1st, 55 were from Ogden City, and of the remainder, 32 came from north and west of Ogden. At this time each light trap collected an average of 72.12 mosquitoes per night. Of the 72.12 average, 64 were *Aedes dorsalis,* 0.33 were *Aedes vexans,* 6.04 were *Culex tarsalis,* and 1.75 were *Culiseta inornata.* The counts from the light trap catches were in agreement with observations made in the complaint area in that *Aedes dorsalis* was the species reported by the operators of the fogging machines.

No typical *Aedes dorsalis* breeding areas have been found in Ogden City, or directly north of Ogden.

The light traps in the northern part of the county collected over four times as many mosquitoes as those from the southern part of the county (northern 1268, southern 268). Although the numbers of mosquitoes in the light traps increased tremendously as the traps were checked from the east to the west, the complaints were much more numerous as they were counted from the west to the east. Men working in the area observed that more mosquitoes were found in the vicinity of the Pleasant View light trap than the light trap count indicated. The Pleasant View light trap was located in the north-east part of the county. In view of the foregoing facts it seems likely that this outbreak was caused by a migration of *Aedes dorsalis* from the northwest; that the migrants are not as strongly phototropic as non-migrating mosquitoes of the same species; and that when mosquitoes begin a migration they are not as blood meal conscious as they are when they approach the end of the migration.

### *Summary*

1. Only one of four periods with large light trap collections coincided with one of the five periods during which large numbers of complaints were received.

2. All five of the major complaint periods were prior to June 30th and three of the four light trap periods with large collections were after July 6th.

3. The largest average light trap collection was 212 per night and it occurred between July 23rd and July 25th. During the same time there was an average of 0.66 complaints per day.

4. *Aedes dorsalis* was the dominant mosquito during each of the high complaint periods, but it appeared in greater numbers later in the season. Only once during these later *Aedes dorsalis* outbreaks was the complaint average over one per day.

5. People living in heavy mosquito producing areas are less prone to complain than people who seldom see a mosquito. Hooper and Pleasant View will be compared to illustrate this point. The maximum light trap collection for one night in Pleasant View was sixteen mosquitoes, and during this time five complaints were called in. The maximum light trap collection average for one night in Hooper was five hundred and forty-four mosquitoes, and in this length of time no complaints were received.

6. No correlation was found regarding the number of mosquitoes caught in light traps and the number of complaints called in.

7. There is no correlation between requests to have areas fogged prior to social events and the numbers of mosquitoes in current light trap collections.

8. No correlation was found between the species of mosquitoes caught in the light traps and the number of complaints filed in the same period of time.

# PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING

OF THE

# UTAH MOSQUITO ABATEMENT ASSOCIATION

*held at the*

Weber College

Ogden, Utah

March 14 and 15, 1958

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# PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING
## OF THE
# UTAH MOSQUITO ABATEMENT ASSOCIATION

### NAVAL MOSQUITO CONTROL OPERATIONS IN RELATION TO SURROUNDING COMMUNITIES

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We tax payers traditionally visualize the Federal Government, either as a money-grabber who snatches away our savings and scatters them with abandon on OTHER people's projects, or as a wealthy uncle from whom we demand money without a qualm when WE have a pet project to propose. Rarely do we consider the Government in the aspect which Government workers would most like to have considered, that of the good neighbor, who tries to do a very special job efficiently and who wishes neither to prod the community into impossibly idealistic projects nor to lag reluctantly behind it. This good neighbor of a Federal Government acts, not as an entity of itself, but as the agency of each and all of us, to accomplish the general welfare and to utilize the public funds fairly, wisely and for the accepted purposes for which we have, through Congress, allotted them.

The Department of the Navy often receives requests from communities and organizations in the vicinity of naval establishments desiring assistance in the application of insecticides by aircraft and ground equipment for insect control operation which are deemed to be too large for local effort. In general, however, it is considered an improper use of Navy funds to conduct operations outside the jurisdictional limits of Navy property, which embody competition by the Navy with civilian firms engaged in pest control activities, or that cover areas over which local, State or Federal Government agencies other than the Navy have already been given responsibility.

In making specific determinations several criteria are applied. Application of insecticides by any means on property other than that under the jurisdiction of the Navy is primarily the responsibility of the individual, group, governmental or other agency owning or controlling the property. Prior approval of the Secretary of the Navy is required before funds, supplies, equipment or personnel of the Navy can be used for the benefit of individuals, except in an emergency, when they may be used on the authority of the local commander alone. It can readily be seen that using Navy assets in the absence of such an emergency, for the benefit of restricted communities, might cause sharp criticism by communities which were not receiving this aid. Therefore, the Navy may assist in meeting local problems, where no emergency exists, only upon the request of the United States Public Health Service, the United States Department of Agriculture or the United States Department of the Interior.

The Naval installation requesting the secretary of the Navy for approval to assist its surrounding community or even for performing services in an emergency, is also required by law to be responsible for providing necessary funds, material and personnel. Obviously, agreements for reimbursement of the actual costs incurred must necessarily be made in advance between the Naval installation and the Civilian community, if the limited operating funds of the installation are not to be depleted.

"When the Naval installation and the civilian community have a joint interest in the problem, Navy participation shall be in proportion to the interest of the Navy," say the regulations, and approval must be asked in the same manner as outlined in the preceding statement. Only when the primary interest is the Navy's rather than the landowner's, may the Navy work outside its boundaries without Secretarial approval. In this case, permission is asked of the landowner and easements are arranged, usually through the local control agency doing similar work in other sites where the beneficiary is the civilian community.

Often, rather than being the one who provides manpower, equipment and materials for mosquito control, the Navy is the *beneficiary* of already established community projects. In such cases, the Navy area may be so small a part of the whole area to be considered that it is swallowed up, and the combined areas are most efficiently treated by the community. agency. This is the situation at Moffett Field and at Port Chicago, in California, at opposite ends of San Francisco Bay. Sometimes, the problem is one of breeding sites which are remote from the Navy base, yet which are fed by drainage from that area, or which are producing populations of mosquitoes that fly into the Navy area and create a nuisance there. Such is the case in Ogden, where the Navy is the grateful recipient of mosquito reduction benefits brought about by the mosquito abatement district, working on a problem which the Navy neither creates nor helps to solve, but to which it is subject by its mere proximity.

To you, we can only say, "Thank you", from the bottoms of our hearts. There is little we can do to aid you other than to assist with the ever constant struggle for adequate public recognition. In this, we can and do try to help. Our employees are members of your communities and in their private capacities, local taxpayers. In them, we can instill a respect for and a willingness to support your community control projects. When we conduct indoctrination campaigns to teach our people to avoid creating and to remove existing sources of backyard mosquito breeding in their immediate work areas and when we teach them to cooperate with our organized military control programs so that there shall be no breeding within the Navy installation, we are also trying to teach them the fundamentals of community mosquito control, in order for them to understand its benefits and to desire them. We hope that this constant effort on our part results in widening ripples of community acceptance of the whole concept of mosquito and pest control.

You may wonder, what *does* the Navy do in the way of mosquito control? How does it go about its program? The answer is. . .just about the same way a mosquito abatement district does. First, we locate the problem, examine the sorts of mosquitoes we have, look for breeding places within the boundaries of the installation. Then we set about removing these breeding sites, controlling them, or blocking the mosquitoes as they enter from outside.

Taking the census of our mosquito population is the job of the Medical Department of the Navy and for this purpose the Civil Engineer Corps, which at the Navy shore establishment is called Public Works, supplies light traps. In addition, the Medical men search for breeding places and dip samples of any mosquito larvae and , if so, what instar they are. We figure that first or second instar larvae indicate that we are not *over*-dosing, whereas fourth instar larvae obviously indicate that we are on the verge of not doing enough. In this way, the Medical survey acts as a guide to the Engineer control so that we neither waste the public moneys nor allow mosquitoes to breed to maturity. Our control men are also trained to spot breeding sources as they go about, and we keep ourselves and the entire Navy force reminded to look constantly for tin cans, pot holes, holes in trees, rain gutters, drains, forgotten vases, cesspools and fire barrels, ornamental shell casings and other potential troublemakers.

Control starts at the center of a military installation, and the places mentioned above in the inhabited areas are cleaned up first, either by removing them or by applying a residual spray. At this same time, screens and doors are sprayed and sometimes a residual spray is applied to the interior of a building, although this usually is not done unless diseases are endemic in the area. Ditching and filling are considered essential first steps in eliminating salt marsh and swampy areas in the outer parts of the installation, usually occurring only in air fields and ammunition depots with their runways and igloo areas.

Ditches, in many cases, are tied into the general drainage system established by the local mosquito abatement district. At least one activity furnishes an impounding area for farmers of surrounding lands where surplus irrigation waters need to be drained away to prevent high water tables from ruining crops as well as from breeding mosquitoes. Subsurface tiles drain water into permanent ditches leading to the impoundment where it can be treated easily and from which it can be drained at appropriate seasons.

In another large Naval installation, hydraulic dredge spoil from the channel side is pumped to the low-lying public lands surrounding the other sides of the military base and this is allowed to dry and is then plowed, thus permanently eliminating the swamp, reclaiming tidelands from the bay and preventing breeding in the deep cracks during the settling period.

When all the breeding areas lying under Naval jurisdiction have been controlled, we turn to barriers against immigrant mosquito adults and for this purpose we use, first, residual applications of dusts and sprays and, second, fogs which are applied usually in the early morning hours. If the mosquitoes are the pasture or salt marsh breeders, this early fogging kills the immigrant populations before they can become a pest. Applications of wettable powders, used as dusts, penetrate vegetation well, settle over lawns and shrubbery and leave residuals which kill the harboring adults.

Airplane spraying is a matter on which Navy assistance is most frequently asked. When the situation justifies this sort of treatment and when the Navy interest is not less than that of the community, airplane spraying has been done. However, the Medical Department, which decides whether or not it shall be done requires that first there shall be clearly evident breeding areas where airplane spray can be effectively applied, and secondly that the costs of air spray shall not be greater than the cost of doing an equal job from the ground. Airplane spray is quite costly and, like fogging, is quite spectacular, so that it is often desired for psychological reasons quite unconnected with the needs of control.

Also it takes a little time to arrange properly conducted air sprays. Because the pilot must sometimes be a person who has had no previous experience in mosquito spraying or whose experience is infrequent, he must be well briefed and probably will need to take a flight or two over the area for reconnaisance. Sometimes, even when air spray would be useful, the time element is such that before it could be accomplished the breeding situation will have changed and there will be no further emergency. This is particularly true in control of *Aedes squamiger*, which is seasonal, and *Aedes dorsalis* which rises and falls with the tides and has also brief periods of peak abundance. Here, survey predicts emergencies before they occur and permits preparation for spraying in advance of critical need.

Just as the continued operation and success of a mosquito abatement district makes easier the establishment of further control areas, so too, we think, has the military program helped to condition people to expect and to support local community programs. People returning from overseas assignments or living on military establishments in this country and enjoying the benefits of control have notably demanded them more and more from their home communities, when they returned. As the recent war-engendered waves of migration and counter migration across the length and width of the land begin to subside and people become more settled in the new, burgeoning communities, established control programs will get even greater attention from residents.

## CONTROL OF SNOW MOSQUITOES IN THE MOUNTAINS OF UTAH[1]

Lewis T. Nielsen
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Snow mosquitoes of the genus *Aedes* are a source of considerable annoyance throughout most of the mountainous areas of the western United States from late May until early August. At least fifteen species are known to occur in our western mountains in the montane, subalpine and alpine zones. All of these species may become sufficiently abundant within their ranges to serve as an extreme nuisance to humans who invade their domain. Under certain conditions, it may become desirable to attempt control procedures. Actually, effective control against snow mosquitoes is generally not difficult or costly. All of the species are single brooded and a single effective treatment will produce excellent results for an entire season. Another factor favoring control is the limited flight range of these mosquitoes. This appears, in certain species, to be due more to the restrictions on flight imposed by the nature of mountainous terrain than on the inherent flight capacities of the species (Nielsen, 1957). It has been our experience in Utah that control can be effective if extended one mile beyond the area where control is desired.

Control of snow mosquitoes has been successfully accomplished in two recreational areas in the Wasatch Mountains of Utah since 1937. One of these areas is a resort area containing more than one hundred private summer homes and visited by thousands of people during the summer months. The other area is a camp attended by several hundred Girl Scouts during the summer season. Both areas lie at elevations above 8500 feet in typical montane and subalpine vegetational zones. The principal pest species for both areas are *Aedes cataphylla* Dyar, *Aedes communis* (De Geer), *Aedes hexodontus* Dyar and *Aedes pullatus* (Coquillett). A thorough review of the history of control work in these two areas from 1937 to 1951 is presented by Rees and Nielsen (1952).

### *Control Measures*

Inspection: As is the case in any mosquito control program, careful and thorough inspections are esential for effective control. This is especially true in mountainous areas due to the great diversity of larval habitats and the rugged nature of the terrain. New breeding sources are formed almost yearly due to snowslides, depressions formed by the roots of fallen trees, variations in snow fall, etc. A thorough inspection each year over the entire control area is necessary if control is to be successful.

Source Reduction: Elimination of breeding areas by drainage or filling is of limited value in most mountainous areas. Although drainage may be used to lower the water level in certain large breeding areas, it is usually inadequate. This is due to the fact that the melting of snow in late spring or early summer may occur gradually over a period of several weeks; thus a pond may be supplied with enough water to hatch eggs even though it is continually draining. Drainage in these situations may actually spread larvae over a wider area and make control more difficult.

The use of filling to eliminate breeding areas is generally impossible due to the difficulty of getting heavy equipment to breeding sites over rugged terrain when generally no roads exist. The cost of filling would be prohibitive.

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[1]The author is indebted to the University of Utah Research Fund for granting monies which have aided in the control studies reported herein.

It has been our experience in Utah that the expense involved in using effective source reduction methods is considerably greater than the cost of a single effective larviciding program each year. (Rees and Nielsen, op. cit.)

Larvicides: The application of larvicides has proved to be the most effective and economical control of snow mosquitoes.

Petroleum oil was the exclusive larvicide used against snow mosquitoes in Utah until the summer of 1949. The results obtained by oiling were generally excellent. However, the lack of a residual effect and the difficulty of transporting oil over steep mountain terrain in knapsack sprayers resulted in its replacement by DDT and other organic insecticides. Numerous tests with DDT in 1949, 1950, and 1951 revealed this insecticide to be very effective when applied directly to water containing larvae or when used as a prehatch larvicide to known breeding areas. Both spray and dust applications were made. Residual effects in some instances lasted for more than one year. The most economical effective treatment with a pronounced residual effect was obtained with a 25% DDT emulsion applied in aqueous solution at the rate of 0.3 lb. DDT per acre. These applications were made with a knapsack type sprayer. DDT was not effective against pupae, the kill ranging between 40-70%. However, when used as a prehatch larvicide, this presented no problem. The nature of the mountainous terrain did present problems. Many of the breeding sites were some distance from the nearest roads and of a rather extensive nature. Thus, the transportation of larvicides became a burdensome problem requiring either horses or considerable manpower. This difficulty was resolved at first by the use of "Tossits." These were small gelatinous capsules containing 12% DDT and 4 1/2% BHC. They could be carried easily in large numbers over rough terrain; each Tossit would effectively cover about 100 sq. ft. of water surface. Tossits, also proved to be more satisfactory against pupae than DDT emulsion spray due to the BHC content. The principal deficiencies of Tossits were the slowness with which the gelatinous coverings dissolved in cold snow water, and the fact that they could be used with full effectiveness only on larger more open pools. In dense willow growths or if the breeding site consisted of many small depressions of hoofprint size (as was often the case) uniform coverage was impossible to accomplish economically. These difficulties were finally overcome with development of granular larvicides. Granular preparations of insecticides can be easily carried over the roughest terrain and can be applied uniformly by hand on any type of pond or depression. When a carrier such as bentonite, which forms a swollen gel-like mass in water, is used, it is possible to see exactly where applications have been made and uniform coverage is easily accomplished, even in dense underbrush and willow growths. Although a number of granular materials have been used, we have achieved excellent results with 2 1/2% heptachlor and 2 1/2% dieldrin preparations. These are broadcast by hand at the rate of 10-15 lbs. granular material per acre. This appears to be the minimum amount that can be uniformly spread by hand. If stronger treatments are desired, 5% granular preparations of these insecticides may be used, although entirely satisfactory and more economical applications can be made with the 2 1/2% materials. The dieldrin preparations appear to have a residual effect comparable to DDT and for this reason will generally be preferable to materials containing heptachlor.

*Summary*

Control of snow mosquitoes in the mountains of Utah has been carried on successfully since 1937. At the present time the program consists of intensive yearly inspections and the application of larvicides either as a prehatch to known breeding areas or directly to water containing larvae. In larval producing areas, which are readily accessible by road, DDT in aqueous solution, is applied with knapsack sprayers at the rate of 0.3 lb. DDT per acre. Areas which are more remote are treated with granular preparations containing 2 1/2% heptachlor or 2 1/2% dieldrin. Granular materials are dispersed by hand at the rate of 10-15 lbs. per acre or the equivalent of 0.25 to 0.38 lbs. active chemical per acre. Effective control has been obtained by extending treatments only one mile beyond the area where control is desired.

Drainage is the only practical source reduction method which can be used in mountainous areas of Utah, but has proved to be less effective than the larviciding program as well as more costly.

As yet no larval resistance to DDT, heptachlor or dieldrin has been noted.

## REFERENCES CITED

Nielsen, L. T.
1957. Notes on the flight ranges of Rocky Mountain mosquitoes of the genus *Aedes*. Proc. of the Utah Academy of Arts, Science and Letters. 34:27-29.

Rees, D. M., and Nielsen, L. T.
1952. Control of *Aedes* mosquitoes in two recreational areas in the mountains of Utah. Mosquito News 12 (2):43-49.

# PRESENT STATUS OF MOSQUITO CONTROL IN SOME EASTERN STATES

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In 1957 I was privileged to attend the annual meetings of the Mosquito Control Associations of Utah, New Jersey, and the Northeastern States—all within a period of one month. In August I made a tour of the Northeastern States with mosquito-control and fish and wildlife workers, and saw first hand some of the work of both groups and how they are cooperating to solve problems in areas of mutual interest. In September I returned to Florida to renew my long acquaintance with mosquito-control work in that State. In addition I have observed control work in Maryland.

My most vivid impressions from these contacts were the diversity of the mosquito problems, the difference in techniques, materials, and methods employed in control, and, above all, the progress that has been made in the last several years. When your Association invited me to attend your annual meeting again this year, I thought that it might be of interest to review the status of mosquito control in those eastern areas that I personally observed in 1957. Meanwhile I have obtained some facts about the programs in New York and Virginia.

*Massachusetts*

Salt-marsh mosquitoes in the Massachusetts Bay area were a source of extreme annoyance to the Pilgrim Fathers. Prolific breeding occurred in extensive coastal marshes, and fresh-water mosquito problems were encountered as the early settlers moved inland. Little was done about control until the early 1900's, when several communities instituted malaria control programs. However, control efforts expanded gradually under the supervision of the State Reclamation Board. At the present time nearly one-third of the State is covered by some type of control program. There are six major organized districts and numerous local programs. The major districts are expending over $500,000 annually.

Early mosquito-control efforts consisted almost entirely of ditching, drainage, filling, and water management. Virtually all the salt-marsh areas have been ditched, and this has greatly reduced the salt-marsh mosquito problem. Current salt-marsh work consists mainly of maintenance and extensions of ditches to take care of isolated pockets bordering high ground. Special attention is now being given to the elimination of fresh-water breeding areas through drainage or water management. One district has a program under way to prevent breeding in an 800-acre swamp by a combination of drainage, deepening, and water-level management. Approximately $100,000 will be required to complete the job. Similar methods are being employed to eliminate many smaller problem areas. In general, therefore, the chief emphasis in Massachusetts is on source reduction. However, insecticides are employed where such methods are not feasible or have not yet been initiated.

Among the most effective and widely used methods of control is the prehatching treatment of known breeding areas. Many such areas are swampy and inaccessible during the summer, but can be treated easily during the winter months. Applications of DDT dusts and sprays at rates of 1/4 to 1 pound per acre prevent breeding for an entire season. Small areas are treated by hand, or with ground equipment, whereas airplanes or helicopters are employed to cover large areas.

During the summer months the major effort is devoted to larvicide applications in fresh-water *Aedes*-breeding sources, especially those created by heavy rains or floods. Larvicides for *Culex* control are also applied in polluted waters, catch basins, and other sites. DDT is the most widely used larvicide, but some districts also use dieldrin, pyrethrum, or plain fuel oil, especially for *Culex* control.

Although all the districts emphasize control of larvae, a considerable amount of adult control is necessary in years of above-normal rainfall, especially in recently organized districts where source-reduction work is only partially completed. Mist blowers and fog machines are the most widely used means of applying adulticides. Aircraft is employed routinely in some of the new districts and isolated communities, but only in cases of emergency in the older districts. Only DDT is used for adult control, and it is still very effective.

*Rhode Island*

Seven cities and seventeen towns in Rhode Island have organized mosquito-control programs. Annual expenditures total about $90,000, one-fourth being paid by the State and the remainder by the cities and towns. About 75 percent of the budget is allocated for permanent control work and ditch maintenance and 25 percent for insecticide treatments.

All the salt-marsh breeding areas in Rhode Island have been ditched, and this has largely solved the salt-marsh mosquito problem. At the present time most emphasis is placed on the control of fresh-water

[1]The author gratefully acknowledges the assistance of the many district directors and State Mosquito Control officials who provided portions of the information contained in this paper.

species. Over 600,000 feet of ditches have been constructed to drain fresh-water areas as compared with 120,000 feet in salt marshes. Each year additional areas are being ditched, filled, or otherwise managed to eliminate breeding. Brush clearing and shoreline preparation are utilized in special situations.

The control of breeding in thousands of catch basins constitutes a major problem. Weekly insecticide treatments are required for control. Fuel oil and New Jersey larvicide are used to treat these places. Other breeding areas are treated with DDT. Many of them are dusted or sprayed during the winter when they are easily accessible. Most of these areas are treated by hand, but airplanes are employed on a few large inaccessible areas.

Most of the work on adult control in Rhode Island is accomplished with mist blowers and fog machines. In four locations airplanes are employed on a contract basis. DDT is used exclusively for adult control and is still giving excellent results.

*Connecticut*

Mosquito control in Connecticut was established by State law in 1915. The primary purpose of this law was to encourage and support work to control salt-marsh mosquitoes in some 11,000 acres of coastal marshes. These areas have now been ditched or are managed in such a way as to eliminate or minimize breeding. Current work consists largely of maintenance of over 4 million feet of ditches and repairs to tide gates, dikes, and culverts. Ditch cleaning is accomplished by means of scavels and back hoes developed especially for use under Connecticut conditions.

Increased attention is being given to the control of mosquitoes in fresh-water areas. Such work is organized on a local or community basis, but the State Division of Mosquito Control provides technical information and assistance.

Although source reduction is emphasized in Connecticut, insecticides are required to cope with mosquitoes in many areas. DDT is widely used as a prehatching treatment during the winter. Fuel oil, alone or with DDT added, is used for routine larviciding.

Emphasis on adult control varies considerably between areas and from year to year. In some years very little adult control is required, but when abnormally heavy rains and high tides occur intensive spraying and fogging are necessary. Fog machines and mist blowers are routinely used for this purpose. However, aerial spraying is employed in emergencies to treat large areas quickly. This is done on contract with commercial concerns. DDT is used exclusively for adult control and is still giving excellent results.

*New York*

New York City and much of Long Island are among the most densely populated areas on earth. It is difficult to conceive that such areas would have a mosquito problem. Yet Nassau and Suffolk Counties on Long Island spend about $1,500,000 a year for mosquito control. They have had organized control for nearly 40 years. Many thousands of acres of salt-marsh and fresh-water breeding areas have been ditched or otherwise managed. The number of feet of ditching amounts to an astronomical figure. Suffice it to say that most ditch maintenance is on a two-year schedule. However, despite these and other source-reduction procedures, intensive use of insecticides is necessary to cope with the mosquito problem.

In Nassau County approximately two-thirds of the $1,000,000 annual budget is devoted to permanent control and one-third for temporary control. In Suffolk County equal proportions of a $415,000 budget are spent on permanent and temporary control. In both counties temporary control includes both larviciding and adulticiding. DDT is used almost exclusively and is giving excellent results.

Adult control is conducted as needed on a county-wide basis, mostly with fog machines and mist sprayers. Larviciding of the thousands of catch basins and storm-water drains, not to mention innumerable ponds, swamps, and other wet areas, requires an immense effort. In Nassau County the maintenance and treatment of such areas require about 40 percent of available personnel and equipment.

In spite of the magnitude of the mosquito problem on Long Island, both the Nassau and Suffolk districts are doing an outstanding job. Last August I spent the better part of two days in these counties observing their operations, and saw only one *sollicitans*. Chris Williamson and Leroy Kinsey probably would be the first to admit that this was unusual, to say the least. However, they have made remarkable progress in coping with one of the most complex mosquito problems in the country.

*New Jersey*

Mosquito control work in New Jersey was initiated in 1905. At the present time there are 16 organized districts covering most of the State. The State has a special commission to advise the districts and to administer State control funds. The State Experiment Station serves as coordinator of control work and conducts research on problems peculiar to New Jersey conditions. The 16 districts are spending about $1,500,000 annually.

For many years salt-marsh mosquitoes were the foremost problem in New Jersey, and most of the effort was directed toward their control. Practically all the marsh areas have now been ditched, and some of them have been diked and converted to fish and wildlife refuges. This procedure has eliminated salt-marsh breeding, but has created favorable conditions for *Anopheles* and *Culex*.

Salt-marsh mosquitoes are still a serious problem in New Jersey despite all the effort that has been made to control them. However, at the present time as much effort is devoted to control of breeding, principally *Culex*, in polluted streams and fresh-water areas as to control of salt-marsh mosquitoes. Control work consists chiefly in larviciding. DDT, New Jersey larvicide, and fuel oil with a spreader added are used for this purpose. Prehatching applications of DDT and dieldrin in some areas during the winter have given excellent results. Dusts, granules, and sprays have proved equally effective. Applications are made almost entirely with ground equipment.

Although permanent control measures and larviciding are emphasized in New Jersey, some attention is given to adult control, particularly in resort areas. Adult control is done by airplane under a State cooperative program. Some of the districts have fog machines or mist blowers, but they are employed only on a local basis, rather than over entire districts. Only DDT is used for adulticiding and is still giving excellent results.

Although all the problem salt marshes have been ditched, some new ditches or extensions of old ones are constructed each year. Ditch maintenance is, of course, a never-ending task. Special efforts are made to clear and deepen streams subject to industrial pollution. This has eliminated breeding in some areas. Considerable attention is also given to hydraulic filling and to drainage of upland fresh-water problem areas.

New Jersey holds a unique place in mosquito control. It has demonstrated what can be done through organization and ceaseless effort. However, after half a century the State still has serious mosquito problems. This clearly demonstrates that mosquito control is a never-ending struggle and that new insecticides and new concepts of control will be needed in future years.

*Maryland*

Early in 1956 the Maryland legislature enacted a law providing for the organization and support of mosquito-control work. Prior to this time work was conducted only on a community basis. In 1956 about 80 communities were engaged in limited control work. After the State organization was formed, community participation increased to over 200 locations in 13 of the State's 23 counties. There will unquestionably be much further expansion in the next few years.

The most serious mosquito problems occur in coastal and bay areas. The State has thousands of acres of salt marsh which produce hordes of *Aedes sollicitans*. Some of the marshes have been ditched, but it will require some time to complete the job. Scavels and back hoes are employed for most of the ditching. However, in several special-problem areas ditches have been blasted with good results. Tide gates have been installed in a number of locations, and additional ones will be constructed where surveys indicate that they will function properly.

Larviciding is limited to treatment of storm sewers, catch basins, and small accessible problem areas. No attempt has been made to larvicide salt marshes. Thus, most of the control effort is directed against adults.

For adult control Tifas, Dyna-fogs, and several types of mist blowers are used. DDT and BHC are applied in about equal amounts. A small quantity of malathion was used late last season. All these materials gave excellent results. A total of $85,000 was spent on adult control in 1957. However, it is expected that two or three times this amount will be spent in the next two years.

*Virginia*

At the present time there are 15 organized mosquito-control districts in Virginia. Approximately $500,000 is spent annually, 75 percent for permanent and 25 percent for temporary control. Salt-marsh mosquitoes are the major problem in coastal areas, but fresh-water species are important inland.

Permanent control work consists in ditching and ditch maintenance on salt marshes. Some marsh areas have been filled. Fresh-water problem areas are ditched and drained wherever possible.

Temporary control programs emphasize larviciding. Prehatching treatments are applied in some locations, but the main effort is on larviciding of problem areas. DDT and oil are used exclusively for larviciding. Applications are made with hand and power sprayers.

All the Virginia districts have adulticiding programs. Tifas are most widely used. Airplanes are used only at certain Army and Navy installations. DDT was used for adult control until 1957. However, it failed to give satisfactory control in several areas late in the season, and a shift was made to BHC in these areas.

*Florida*

Mosquito-control work was initiated in Florida nearly 40 years ago, but progress was slow until WPA funds were provided in the early 1930's. During the next decade extensive ditching, drainage, and filling work was carried out in parts of the State, but especially in the coastal areas, where thousands of acres of marsh produced hordes of mosquitoes. Where tide and terrain conditions were such that ditches functioned properly, mosquito breeding was drastically reduced or eliminated. Unfortunately, it was not possible to ditch enough of the marshes to completely solve the problem in any one area. Thus, at the onset of World War II mosquitoes were still the number-one enemy in Florida and remained unchallenged during the war years.

The development of DDT at Orlando during the war gave promise of solving the mosquito problem in Florida. For several years after the war it appeared to be a panacea indeed, and ditching, drainage, and filling were neglected. By 1949 DDT was losing its effectiveness in many areas, and substitute insecticides were needed. However, fortunately for Floridians, J. A. Mulrennan, entomologist for the State Board of Health, recognized that new insecticides would provide only a temporary solution to the problem and began a campaign for a return to the principles of permanent or eliminative control. He was instrumental in getting legislation passed in 1952 to support this type of work and to establish a research laboratory to develop eliminative methods for various environments. In the five years since this legislation was enacted, mosquito control in Florida has been revolutionized. I should like to briefly discuss the progress that has been made.

From 1945 to 1952 larviciding was an important part of the mosquito-control operations in most of the coastal districts. By 1948 the extensive treatment of the breeding areas with DDT had resulted in the development of a resistance in salt-marsh mosquitoes in several districts, and by 1952 resistance was practically State-wide. During this period there was a shift to BHC, and good control was obtained for several years before the mosquitoes became resistant to this material. Some districts resorted to malathion for a year or two. However, there was a gradual tendency during these years to cease larviciding.

There were several reasons for the curtailment of larviciding. First, available insecticides were ineffective or either too costly or too hazardous for general use. Second, the State Board of Health advised against it, reasoning that its continuation would create new resistance problems. It was also believed that cessation of larviciding might bring about a gradual loss of resistance which would be reflected in greater effectiveness of adulticiding operations. Lastly, the State Board of Health encouraged an intensive State-wide eliminative control program, and many of the districts acquired draglines and other equipment and began ditching, diking, and filling of problem areas. This program has already eliminated a good part of such areas in many districts. The effects of this work have been reflected not only in the reduction in larviciding but also in fewer outbreaks of mosquitoes and in greater efficiency in adulticiding. The increased emphasis on eliminative control is without a question the most significant new development in mosquito control in Florida.

At the present time larviciding is restricted chiefly to accessible breeding areas. Fuel oil alone is employed for treating practically all such areas. In emergencies 1-percent granular parathion has been used with spectacular control of large broods which developed as a result of unusually heavy rainfalls or prolonged high tides. Airplanes are employed to apply granular larvicides over large areas. Otherwise larvicides are applied by hand or with modified Bean sprayers or Buffalo turbines.

About half the districts still use DDT for adult control. Most of them add 2 percent of Lethane or Thanite to the standard 5 percent DDT-fuel oil solution. Several districts also use some BHC, and four or five use it exclusively. During the last two years eight to ten districts have shifted to malathion. Others can be expected to use malathion in 1957, because research and practical experience have shown it to be considerably more effective in fog machines than DDT and BHC.

About one-fourth of the districts employ airplanes for adulticiding. Several own from two to seven planes (mostly Cubs) and utilize very little ground equipment. The others rely chiefly on ground equipment, and contract for aerial spraying as needed.

About 80 percent of the districts have Tifas or Dyna-fogs, about equal numbers of each. Buffalo turbine mist sprayers are the next most popular type of equipment. A few Microsols and modified orchard sprayers are also being used. Most of the districts apparently prefer to have two types of these machines, although several have standardized on one type.

There are now 50 organized mosquito-control districts in Florida, twice as many as five years ago. These districts are spending over $4,000,000 annually. The expenditure per district ranges from about $10,000 to over $200,000. Approximately 40 percent of the funds for mosquito control are provided by the State and 60 percent by district taxes.

## ANOPHELES POPULATION DECLINE IN SOUTH SALT LAKE COUNTY

by

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During 1956 and 1957 the South Salt Lake County Mosquito Abatement District conducted an extensive larval survey which consisted of collecting and identifying larvae from all mosquito sources found. One of the aims of this study was to attempt to determine the relative abundance of each species present. The results of this survey were compared in so far as possible, with data obtained by Chamberlin and Rees[1] from random larval surveys conducted for Salt Lake City Mosquito Abatement District during 1930, 1931 and 1932 which encompassed approximately the same area. Additional data were obtained from studying the specimens and locality records in the University of Utah mosquito collection and the annual reports of the Salt Lake City District.

In these early surveys *Anopheles freeborni* Aitken was collected and observed both as larvae and adults in most of Salt Lake County, being more abundant in the southeast portion of the county where larval habitats which are more favorable to Anopheles were present. During the 1956 survey only 11 small breeding areas were found in this section of the country and during the 1957 survey only three of these ponds were found to be producing *Anopheles freeborni*. In addition seven small breeding pools that had not been inspected in 1956 were found to be producing *Anopheles freeborni* during the 1957 season.

This reduction in numbers and distribution was caused by source reduction, chemical control, water pollution, and planting of the mosquito fish, *Gambusia affinis*.

Source reduction work has been carried on by South Salt Lake County Mosquito Abatement District, Salt Lake City Mosquito Abatement District, Salt Lake County Flood Control, and private individuals. With the establishment of the Salt Lake City M. A. D. in 1930, a systematic drainage program was instituted and thirty miles of drains were constructed. By 1957 this program had been extended until over 300 miles of drains were under maintenance. In 1947 the Salt Lake County Flood Control was established and started limited drainage; with the organization of the South Salt Lake County Mosquito Abatement District in 1952 more extensive drainage has been carried out along the Jordan River and some of the other streams in the county. In 1957 approximately 100 miles of drains were under maintenance, and the Jordan River has been dredged throughout its length. Supplementing this extensive source reduction program, the Cooperative Drainage Board was established in 1951 and is presently engaged in the construction and maintenance of major drains in this area. Although this drainage effects the reduction of habitats of such pest mosquitoes as *Aedes dorsalis, Aedes vexans,* and *Culex tarsalis,* it has also eliminated numerous habitats suitable for *Anopheles freeborni* larvae.

Drainage and leveling of lands by private individuals to improve farm land or provide suitable sites for subdivisions has also reduced the number of larval habitats. *Anopheles freeborni* is found in clear fresh water, often in springs or overflow from wells. Drainage by property owners has eliminated many of these sources. In the past few years, numerous subdivisions have been developed in the Cottonwood area of southeast Salt Lake County. Some of these are located on areas that previously had produced Anopheles mosquitoes.

Chemical control conducted by the mosquito abatement districts in this area have contributed to the decline of anopheline populations. In 1956 and 1957 mosquito producing areas were carefully inspected at weekly intervals, and when larvae were found the areas were treated with heptachlor either as emulsified sprays or in a granular form. Moyle's pond at 1780 East 5600 South, a chronic anopheline producer, was treated in 1956 whenever larvae were found so as to give 1 part heptachlor to 30 million parts water[2]. This was repeated whenever necessary, and good control was obtained. No Anopheles larvae were taken in this area in 1957. Shady Lake at 1900 East Spring Lane was also found to contain Anopheles larvae in 1956 and was treated several times. In 1957 only, a small hatch was found on this area. Of the seven small ponds along Big Cottonwood Creek near Highland Drive found producing *Anopheles freeborni* in 1956 and subsequently treated with granular heptachlor, only one pond was found to be a producer in 1957. A number of areas producing Anopheles larvae along Little Cottonwood Creek were not treated in 1956, but the intensive control of 1957 should reduce this problem in the future.

Since *Anopheles freeborni* is a clean water species, increased water pollution in Salt Lake County has reduced the number of larval habitats. The introduction of silt-laden Utah Lake water to many of the irrigation systems has eliminated many of the habitats suitable to this species. Until 1956 no sewer was available in the county, and most dwellings were equipped with septic tanks. Very often these were not of the most efficient type, and much organic pollution was introduced into the underground water and irrigation ditches in the area. Such water is unfavorable for the anopheline populations. This pollution problem reached such proportions that four new sewer districts have been established in the past few years and are now in operation.

Finally the introduction of *Gambusia affinis* into many permanent clean water ponds which are suitable for Anopheles production has aided in a reduction of the anopheline population.

In conclusion the evidence obtained from the 1956 and 1957 larval surveys indicates a significant reduction in the size and extent of the *Anopheles freeborni* population in Salt Lake County. There appears to be five causes for this decline. First, the extensive source reduction program carried on over the past years has reduced the number of suitable larval habitats. Second, the intensive larviciding and adulticiding by the mosquito abatement districts has reduced the numbers produced by the remaining breeding sources. Third, the pollution with organic matter or silt due to human practices in irrigation and sewage disposal has altered many formerly suitable habitats. Last, the successful introduction and establishment of *Gambusia affinis* as a predator has reduced the Anopheles population in many permanent ponds and clean water springs.

Continuing intensive control operations may eliminate this species in Salt Lake County in the near future.

## REFERENCES CITED


[1]Chamberlin, R. V. and D. M. Rees
1930-1936. Surveys of the mosquitoes of Salt Lake City. Presented by Department of Zoology, University of Utah to the Board of Trustees of Salt Lake City Mosquito Abatement District. Mimeographed by Salt Lake City Mosquito Abatement District. 1930-1936.

[2]Graham, Jay E. and Russell D. Anderson
1956-1957. Treatment of a trout pond with heptachlor for control of *Anopheles freeborni* Aitken larvae. Utah Academy of Sciences, Arts, and Letters. Proceedings. Vol. 34, 1956-1957.


## REFUGE MANAGEMENT IN RELATION TO MOSQUITO CONTROL


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Your work of Mosquito abatement, as ours of game management, is the result of an ever increasing human population. As this population has increased, interest in fish and game has become more acute. Likewise, as people have forced themselves out into our marginal or so-called suburban areas, there has arisen a need for mosquito control. Since mosquitoes are generally associated with submarginal areas and marshlands, they become directly involved with waterfowl management and of vital interest to our Department.

Utah has one of the greatest networks of artificial or man-made waterfowl marshes in the United States. It also has a topography composed of large basins to which surplus waters move and spread in a constant effort to reach lower elevations. Where these waters are impounded and controlled, such as on our state and federal waterfowl refuges and some of the more conservation minded gun clubs, the effects are beneficial to both waterfowl production and mosquito control. Where they are not impounded or properly controlled, they are of little value to waterfowl and provide excellent mosquito producing conditions. Controlled water levels are an important feature in developing vegetation beyond the less desirable salt grass and meadow type, typical of intermittantly flooded lowlands, to a vegatative type composed of emergent cattails and bulrushes in the shallow and upland areas and submerged pondweed, widgeon grass and musk grass in the deeper water. Such climax types are not considered high producers of mosquitoes but they provide the optimum in waterfowl habitat.

In some instances development of waterfowl refuges has interrupted natural water movements outside the refuge boundaries to form bogs and swamps which provide excellent mosquito producing habitat. An example of this is the area above Farmington Bay Refuge in Davis County. Increasing irrigation returns, drainage flows, and sewage outfall have forced such quantities of water against the upper dike that present culverts are not capable of passing the water on into the refuge. Consequently, the salt grass meadow above the refuge is flooded, and, while it provides very few of the requirements of waterfowl, it forms hundreds of acres of mosquito habitat. This situation is presently under study by Davis County, the Mosquito Abatement District, the Fish and Game Department, and the Bureau of Reclamation, and remedial measures should be forthcoming.

The Public Shooting Grounds Refuge in Box Elder County provides an example of another situation. Here, large expanses of salt grass meadow are flooded as a result of the method used in irrigating bulrush marshes. This is a matter of necessity under present management techniques used on the refuge. Changes in water use on the Public Shooting Grounds in the past four years have altered the physical pattern of vegetation development to the extent that we are developing a bulrush habitat over the old salt grass type. Marsh development of this type takes many years and this one will be no exception. Until the bulrush type has invaded the salt grass meadows, mosquito production will remain high, and the method of control must necessarily be mechanical spraying—done at a period, mutually agreeable with all interests, when disturbance of nesting waterfowl will be minimized.

Many of the smaller private marshes around Great Salt Lake have been developed on inadequate water supplies with inadequate control structures. Water level fluctuation on these areas is extreme both in latitude and frequency. In all probability, most of these marshes were developed with one thought in mind—to provide a place for waterfowl and waterfowl hunters during the hunting season. Apparently, little thought was given to waterfowl production.

Today, this picture, through our game management practices and your technical and public relations work, is changing somewhat and many marsh owners are correcting their practices to the benefit of both waterfowl production and mosquito control.

Some interest has been expressed by our group in the proposed expansion of Farmington Bay Refuge. This expansion will be in the form of a dike constructed from a point on the present west dike of the refuge around the New State Gun Club to high ground in the vicinity of the Salt Lake City Sewer Canal approximately one-half mile from its confluence with Great Salt Lake. The unit will utilize water being spilled from the refuge and club impoundments to produce additional marsh habitat for Utah's waterfowl species. We can see little trouble in this area from the standpoint of mosquito production. There are but two small marshes that will be included in this expansion and both are of the cattail and bulrush type with an extremely limited amount of salt grass. Controlled water levels will eventually expand the existing marshes and promote the growth of additional cattails and bulrushes instead of salt grass.

The Department is also contemplating marsh development in other areas, many of which are now only intermittantly flooded by high spring flows, and irregular irrigation returns. These areas are now high producers of mosquitoes and their development as waterfowl marshes should benefit your program as well as our waterfowl resources. Your group will be notified of these projects as they arise and I feel confident that your views and suggestions will receive every consideration.

Minor water fluctuations will always occur on waterfowl marshes which will provide habitats suitable for mosquito production. These occurences must be treated by some method other than water level control—probably mechanical spraying. We will give our full support to any program of mosquito control providing that program does not conflict with sound waterfowl management practices. Should there be a matter of health involved, wildlife will undoubtedly be forced into a secondary position. Where the mosquito is simply a nuisance element, we do not feel justified in sacrificing valuable marsh habitat for the limited mosquito control such a sacrifice would provide.

Effects of marshland drainage in Utah would not only be felt in this state but throughout the western states. Ducks and geese produced in Utah have been recovered in 38 states and 3 foreign countries, and band returns indicate large numbers of locally produced waterfowl being killed annually in Nevada, Arizona, California, and Mexico. It is evident that when we speak of altering or destroying marshlands, we are tampering with an invaluable and nonexpendible resource of this state and of our Nation, and every facet of such a proposal must be thoroughly explored before any action is taken.

## TESTING OF SOME ORGANIC PHOSPHORUS INSECTICIDES FOR MOSQUITO LARVICIDING IN UTAH

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During 1957 the South Salt Lake County Mosquito Abatement District conducted tests with 9 organic phosphorus insecticides to determine their effectiveness as mosquito larvicides in Utah. Most of these compounds had been tested for the control of mosquito larvae, both in the laboratory and in the field, in other parts of the county but the results obtained might not apply to local conditions and procedures.

All tests in Salt Lake County were conducted in the field using the normal operating procedures and equipment of the district so that the results obtained would apply directly to mosquito control in the county. Because of the nature of the tests, results are reported in terms of the concentrations required for effective control under field conditions. The mosquitoes involved in the tests were *Aedes dorsalis, Culex tarsalis, Culex pipiens* and *Culiseta inornata.* The insecticides tested were dibrom, dicapthon, DDVP, di-syston, dylox, guthion, phosdrin, thimet and trithion. Liquid formulations were applied by means of a Champion knap-sack sprayer and granular formulations were dispersed by hand.

Both di-syston, applied in a 2 1/2% granular formulation at 0.3 lbs. per acre, and phosdrin, applied as a diluted emulsifiable concentrate at 0.2 lbs. per acre, failed to give effective control. Both compounds are highly toxic to mammals. The acute oral LD 50 of di-syston for rats is in the range of 2.1 to 8.6 mg./kg. (Chemagro 1957). The LD 50 of phosdrin for rats as a vapor is 14.4 ppm. while the LD 50 of phosdrin for rats administered intragastrically is 6.8 and 6.0 mg./kg. for males and females respectively (Kodama et. al., 1954). Comparative figures for parathion are 18 ppm. as a vapor and 5.0 and 1.75 mg./kg. (Hazelton and Holland 1950).

Di-syston and phosdrin can be considered in a class with parathion so far as mammalian toxicity is concerned but parathion has given effective control of mosquitoes in Salt Lake County at 1/10 the concentrations that di-syston and phosdrin were applied (Graham and Rees 1956). Tests with these 2 compounds were discontinued before the minimum effective dosage was determined because of possible hazards at the rates of application higher than those tested.

Trithion was effective for the control of mosquito larvae at 0.5 lbs per acre. The acute oral LD 50 for male albino rats is 28 mg./kg. (Stauffer 1956). Trithion is many more times toxic to mammals than malathion but is not as effective against mosquito larvae. At the relative concentrations required for mosquito larval control trithion may be more toxic than parathion, and to be competitive in cost it would have to be priced at less than 1/10 the cost of parathion. In view of these factors, further consideration of trithion for mosquito larviciding is not justified under present conditions in Salt Lake County.

DDVP generally gave good control of mosquito larvae in Salt Lake County at 0.3 lbs. per acre but sometimes failed to give good control at this concentration when the water was highly polluted. At concentrations below 0.3 lbs. per acre, control was erratic and undependable. McFarland (1957) obtained 85-90% control of Culex larvae with approximately 1 ounce of DDVP per acre and 100% control with 2 ounces per acre. Issac (1957) obtained good control with DDVP at 0.15 lbs. per acre, but in polluted water at a sewer farm got only 80% control with .4 lbs. per acre although DDVP will control mosquito larvae, the concentrations required as indicated by tests in Salt Lake County, are such that other compounds would be more satisfactory.

Dicapthon gave control of mosquito larvae in Salt Lake County at approximately 0.5 lbs. per acre. Malathion has given effective control at 0.4 lbs. per acre (Graham and Rees 1956). American Cyanamid Company (1957) reports laboratory tests that indicate dicapthon is not equal to malathion as a mosquito larvicide. They also report field tests where 80% kills of *Aedes nigromaculis* larvae were obtained with dicapthon at the rate of 0.4 lbs. per acre. Dicapthon is not highly toxic to mammals or fish (American Cyanamid Co. 1957) and can be used as a mosquito larvicide but is not as satisfactory as malathion.

Thimet was tested in a 2 1/2% granule and good control was obtained in all tests where the distribution of granules was even. The lowest concentration tested was approximately 0.1 lb. per acre of active ingredient. At this concentration all of the larvae were killed. The use of the thimet is not desirable because it has an exceedingly offensive persistent odor and is highly toxic to mammals.

Guthion was applied for the control of mosquito larvae in Salt Lake County at 0.05 lbs. per acre and kills approaching 100% were obtained in all cases. Issac (op. cit.) reports that guthion is only 1/10 as toxic to mosquitoes as parathion in the laboratory but in the field good kills were obtained at 0.050 lbs. per acre. Guthion is highly toxic to mammals. Chemgro Corporation (1957) reports the acute oral LD 50 for rats as 15-25 mg./kg. The lower value is for female rats which are apparently more susceptible than males.

Dylox used as a water soluble powder in tests in Salt Lake County was effective at .5 lbs. per acre. The most promising use of this insecticide in Salt Lake County is in granular formulations. Dylox in granules does not have an offensive odor as some other toxicants do. Since much of the inspection in Salt Lake County is done in privately owned vehicles, the lack of offensive odor is an advantage. When granules are used to treat small breeding areas at the time of inspection, the tendancy is to overtreat. The use of dylox granules for this purpose reduces possible hazards to other organisms.

Dylox has a low mammalian toxicity. Dubois and Cotter (1955) report the acute oral LD 50 of this compounds for rats as 450 mg./kg. while Deichmann and Lampe (1955) report it to be 550 mg./kg. Dylox has been used in tests where irrigation water is treated before being applied to the field (Gahan and Noe 1955).

Dibrom gave effective control in all tests at 0.2 lbs. per acre. The mammalian toxicity of this compound is low. California Spray Chemical Corporation (1958) reports the LD 50 of this compound as 430 mg./kg.

## SUMMARY AND CONCLUSIONS:

During 1957 the South Salt Lake County Mosquito Abatement District conducted tests with dibrom, dicapthon, DDVP, di-syston, dylox, guthion, phosdrin, thimet and trithion to determine the concentrations required to give effective control of mosquito larvae under field conditions in Salt Lake County. Di-syston, phosdrin and trithion were more toxic to mammals than parathion at the relative concentrations required to kill mosquito larvae. For this reason they are unsuitable for mosquito larviciding in Salt Lake County under present conditions.

Dicapthon, DDVP and thimet gave good control of mosquito larvae at 0.5, 0.3 and 0.1 lbs. per acre respectively. Any of these compounds would be satisfactory for mosquito larviciding but the insecticides now in use are more suitable.

Dibrom, dylox and guthion controlled mosquito larvae at 0.2, 0.5 and 0.05 lbs. per acre respectively. Dylox in 2 1/2% granules is the most satisfactory material yet tested in Salt Lake County to treat small breeding areas at the time of inspection. Dibrom and guthion could be used to replace malathion and parathion if prices were competitive, and would obtain effective control with no greater toxicity hazards to mammals.

## LITERATURE CITED

Anon.
1956. Compound R-1303. Stauffer Chemical Company Bulletin.

——— 1956. Dictapthon technical bulletin. American Cyanamid Company.

——— 1957. Di-syston (Bayer 19639) Chemagro Corporation Bulletin.

——— 1957. Guthion (Bayer 17147) Chemagro Corporation Bulletin.

——— 1958. Experimental data sheet, Ortho Dibrom. California Spray Chemical Corporation.

Deichmann, W. B. and K. Lampe
1955. Dipterex: Its pharmacological action and an appraisal of the hazard associated with its use. Bull. of the U. of Miami, school of medicine and Jackson memorial hospital, 9:2.

DuBois, K. P. and G. J. Cotter
1955. Studies on the toxicity and mechanism of action of dipterex. A. M. A. Archives of Industrial Health, 11, 53-60.

Grahan, J. B. and J. R. Noe
1955. Control of mosquito larvae in rice fields with water soluble phosphorus insecticides. Jour. Eco. Ent. 48 (6): 665-667.

Graham, J. E. and D. M. Rees
1956. Progress report on the field testing of some organic phosphorus insecticides for mosquito control. Proceedings Ninth Ann. Meeting of the Utah Mos. Abt. Assoc. pp. 23-25.

Hazelton, L. W. and E. G. Holland
1950. Pharmacology and toxicology of parathion. Advances Chem. Ser. 1:31.

Issac, L. W.
1957. Proceedings and papers of the 25th Annual Conference of the California Mosquito Control Association: pp. 93-94.

Kodama, J. K.; M. S. Morse; H. H. Anderson; M. K. Dulap and C. H. Hine
1954. Comparative toxicity of two vinly substituted phosphates. Arch. Indust. Hug. and Occup. Med. Vol. 9, pp. 45-61.

McFarland, Gardner C.
1957. Results of field trials with DDVP in mosquito control. Mosq. News. 17(4):297-298.

## COMMUNICABLE DISEASE CENTER ACTIVITIES RELATED TO VECTOR CONTROL

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The Communicable Disease Center is a national resource to aid state and territorial health departments in the control of communicable diseases. These diseases still constitute a major public health problem despite the fact that many of the great epidemic diseases, such as yellow fever, epidemic typhus and cholera, have disappeared from this country. Well over a million cases of communicable diseases and 130,000 deaths are reported each year. One out of every 10 deaths occurring in the United States is due to communicable diseases; among children and young adults this rate is much higher with about one in every four deaths being due to communicable diseases. Much of this tragic loss is preventable.

Originally, the Communicable Disease Center was concerned only with the control of malaria and other mosquito-borne diseases and later with the control of murine typhus fever and plague. Today it bears Federal responsibility for the control of all communicable diseases except tuberculosis. The venereal disease control program which had operated for many years as a separate division was consolidated with CDC on February 1, 1957. Vector-borne diseases and related problems continue to occupy significant positions in several facets of the Center's program. These activities pertain to the diagnosis, epidemiology, and control of diseases which are transmitted by insect vectors, as well as studies on the ecology and control of insects and rodents which are of public health importance.

The Communicable Disease Center maintains its permanent headquarters in Atlanta, Georgia, but its program encompasses the entire United States. CDC services are made available to the states through a network of regional offices, which are located in New York, New York; Charlottesville, Virginia; Atlanta, Georgia; Chicago, Illinois; Kansas City, Missouri; Dallas, Texas; Denver, Colorado; and San Francisco, California. The office serving Utah and neighboring states to the north and east is located in Denver. Field investigations are conducted by the Center from its headquarters offices and from a series of laboratories and field stations located in many areas of the country. Some of the CDC field stations which are located in western United States are listed below, together with the subject of their major activities:

Logan, Utah—Arthropod-borne encephalitis; vector problems associated with water utilization.

Greeley, Colorado—Ecology of encephalitis viruses.

San Francisco, California—Plague investigations.

Phoenix, Arizona—Enteric diseases.

Wenatchee, Washington—Toxicology of economic poisons.

Las Cruces, New Mexico—Bat rabies.

The results of CDC investigations are made available to state and local health agencies through the usual publication channels, as well as through special consultation, demonstration, and training services. A corps of specialists including physicians, nurses, veterinarians, engineers, biologists, entomologists, bacteriologists, parasitologists and other scientists is maintained at the Center headquarters, and at certain field stations. These specialists are available for assignment to any part of the country where help is needed in investigating or controlling communicable diseases.

*Epidemic and Disaster Aid*

About 30 formal requests for epidemic aid are received by the Center each year. Such requests during the past year have been concerned with outbreaks of anthrax, influenza, encephalitis, diphtheria, hepatitis, staphlycoccal infections, suspected smallpox cases, pneumonia, polio, diarrheal diseases and meningitis. Epidemic aid teams determine and carry out plans of action including verifying diagnosis, estimating extent of the epidemic, gathering and analyzing epidemiological data, and collecting specimens for laboratory tests.

Personnel and specialized equipment are available for emergency sanitation and vector control activities. Disaster aid provided by CDC is now largely a matter of technical assistance, but limited quantities of equipment are stockpiled at strategic points throughout the country (including Logan, Utah) for immediate use in any emergency where CDC services are requested. Available equipment includes emergency water purification units and power sprayers for insect control. Disaster aid has been provided in several areas during the past year in connection with hurricanes and floods.

*Field and Laboratory Investigations*

Certain communicable diseases such as yellow fever and smallpox have been eradicated as epidemic infections in the United States. However, as long as they remain endemic elsewhere in the world, modern travel can reintroduce them as serious public health problems. Other diseases are being held at low levels of incidence, but here too, watchfulness is required so that sporadic increases may be detected and curtailed. Still other diseases merit constant alertness to insure applications of new control measures as they are developed.

The need for continuing vigilance against communicable diseases led to the development of a surveillance program as part of the Center's activities. Originally developed for malaria this surveillance program has been expanded to include anthrax, influenza, encephalitis, murine typhus fever, poliomyelitis, diphtheria, rabies, psittacosis, leprosy, smallpox, and infectious hepatitis. The surveillance program maintains a constant evaluation of the incidence and trends of these and other diseases and disseminates pertinent information regarding diagnosis, origin, and possible interstate spread.

Studies are being conducted on a number of communicable diseases which are aimed at developing or improving diagnostic and control methods. Other studies are concerned with the bionomics and control of mosquitoes, and other insects of public health importance, the toxic hazards of economic poisons, and the resistance of insects to insecticides. Work on equipment is being carried on to aid in achieving more economical and effective control of vector-borne diseases. Studies are underway on new methods of disposal or conversion of organic wastes to eliminate disease vectors, which feed on such wastes.

Studies aimed at the improvement of laboratory techniques for diagnosis of certain communicable diseases have been an important part of CDC's program for many years. A major accomplishment in this field during 1957 concerns the development of flourescent antibody techniques. This method will reduce the time required for diagnosis of certain communicable diseases from several days with present methods to less than an hour. It has the added advantage that only small numbers of organisms, either living or dead, are needed for the test. The flourescent antibody technique shows promise as a rapid method for diagnosis of plague.

*Consultation*

Upon request, CDC's staff members work with state and local health agencies as consultants on the epidemiology and control of various communicable diseases. Consultants on vector control are available to conduct special surveys and assist state and local agencies in establishing or improving control activities. Such services are applicable to mosquito control, as well as fly control, rodent control and other vector control problems which may arise. Vector control consultation services for this Region are normally provided by Mr. Louis Ogden, who is assigned to the Logan Field Station.

Laboratory consultants are available to review the technical and administrative aspects of public health laboratory programs. Such laboratory reviews have been completed recently for three states in this Region: Colorado, Idaho and Wyoming. The Center provides reference diagnostic service whereby a State laboratory may submit for further study and identif- laboratory may submit for further study and identification any problem organism encountered and isolated in the course of its own work.

Consultation services are also available on public health training and on the development and utilization of training aids. Training consultants will assist states in the development of comprehensive training programs or in planning and conducting specific courses in vector control or other communicable disease control subjects.

*Demonstrations*

Community vector control demonstration projects are conducted by CDC in cooperation with state and local health departments to show the practical application of up-to-date vector control techniques. These projects can be established in cities having a high incidence of vector-borne diseases or unusual insect and rodent problems providing the city and state agree to take an active part in the project and to assume its direction when Federal participation is withdrawn. Federal participation in such projects consists primarily in the provision of a technical supervisor to direct the activities and the assignment of necessary vehicles and equipment for applying insecticides and rodenticides.

The community vector control demonstration projects cover all applicable phases of insect and rodent control including the elimination of privies, animal shelter cleanliness, drainage and refuse storage, collection and disposal. The principal objective of the program is to minimize the insect-rodent vector population through permanent elimination of their habitat or breeding sources. Insecticides and rodenticides are used as supplemental control measures where special problems exist and during the time sanitation improvements are being made.

Federal assistance for each demonstration is scheduled for two years and during the first year the supervisor devotes full time to evaluating the problem and getting the project underway. During the second year, when the sanitation improvement program is well underway the supervisor should have time to conduct seminars and furnish technical guidance to other locally sponsored programs within the State. After the two-year period, State and local officials are expected to continue the project with limited consultation and assistance from the Communicable Disease Center.

Communities chosen for vector control demonstration projects are usually in the population range of 20,000 to 100,000. The four projects which are currently in operation are at Pendleton, Oregon; Lawton, Oklahoma; Hammond, Indiana; and Jackson, Tennessee. Projects have previously operated at Boise, Idaho; Pueblo, Colorado; Laredo, Texas; Kansas City, Kansas; Cedar Rapids, Iowa; and Gadsden, Alabama.

*Training*

Training courses are offered in almost all fields of CDC activity. Those which might be of interest to this group are in vector control, environmental control of communicable diseases, epidemiology, and laboratory methods in the diagnosis of communicable diseases.

Vector control training has been a major activity of the Center since its inception. These courses are tied in closely with vector control research and demonstration programs of the Center and the epidemiologic surveillance activities on vector-borne diseases. Thus courses and training aids are kept up-to-date in this rapidly changing field.

Advanced courses in insect and rodent control and in the identification and biology of arthropods are given in Atlanta where the extensive collections and well-equipped laboratories permit advanced specialized training. Many of the vector control courses can be given at the Rocky Mountain Field Training Station in Denver or at field locations in the States. A concrete example of the latter is the mosquito control course which was held at Farmington, Utah, February 4-8, 1958.

The course in general environmental sanitation which is held annually at the Rocky Mountain Field Training Station is also of interest to vector control personnel. About two weeks of this 12-week course is concerned with insect and rodent control. A one week course entitled, "Public Health in Natural Disasters," is scheduled at the Logan Field Station, June 2-6, 1958. This course will include demonstrations and lectures on insect and rodent control under disaster conditions, including the use of power equipment.

A course in "Principles of Epidemiology" has been designated for all members of the public health team and may be given by individual discipline or on a multidiscipline basis. This course stresses fundamental epidemiology concepts applicable to communicable disease control, but is sufficiently flexible to permit selection of subject matter which will best meet the needs of a specific group. Thus major emphasis can be placed on vector borne disease if desired.

Several of the courses on laboratory methods in the diagnosis of communicable diseases have a bearing upon vector control activities. Such courses cover the diagnosis of malaria, encephalitis, murine typhus fever, tularemia, enteric diseases, leptospirosis, and plague, as well as many other communicable diseases. These specialized laboratory courses are offered at the CDC Laboratories at Chamblee, Georgia and Montgomery, Alabama.

The Center has produced many training aids related to vector control. These include simple pictorial keys for the identification of various arthropods, special training literature, slides, film strips and motion picture films. Small quantities of pictorial keys and training literature are available to state and local health workers upon request.

Film strips and motion picture films may be obtained on temporary loan from CDC Headquarters or the Rocky Mountain Field Training Station, 4200 E. Ninth Avenue, Denver, Colorado. Many of them can be purchased at print cost from United World Films, 1445 Park Avenue, New York 29, New York. A recent list indicates that 58 of our current motion pictures and film strips are on vector control subjects. They deal with vector-borne diseases, mosquitoes, flies, rodents, fleas, ticks, cockroaches, lice, and insecticides and equipment. A new release of particular interest to mosquito control workers of western United States is a color motion picture film entitled, "An Introduction to Arthropod-Borne Encephalitis."

In closing I would like to express my thanks for this opportunity to tell you something about CDC activities. CDC is now represented in all of the Public Health Service Regional Offices, and we are anxious to work closely with state and local health agencies and mosquito control organizations in the never-ending fight against insects and insect-borne disease.

## EDUCATION: ITS PLACE IN MOSQUITO CONTROL

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Our water supply, together with its intelligent use and conservation, is basic to life throughout the arid west. The presence of water is a necessity, but at the same time it creates problems.

Education is the starting point for both effective water use and mosquito control. First, we must have the engineering, biological and ecological information, and point of view, necessary to determine good usage of water. We must know whether or not any particular approach to water use, and to mosquito control, would be both feasible and practical. Closely estimated costs for all major operations must be carefully worked out. Then we must determine whether or not the resources of each area concerned could and would support the needed programs. Next, we must educate the populace to recognize the problem. This must be done before we can expect the people concerned to assume the costs and to give continuing support to the necessary programs.

Utah is a state of approximately 52,598,000 acres. Only small areas of this state are highly populated and have substantial enough resources to set up strong well organized and consistently workable mosquito abatement districts, as we think of them today. Most such areas are, or soon will be included in organized mosquito abatement districts.

44,500,000 acres, or nearly 85 percent of Utah's area, is range and other land used chiefly for grazing, forest, and for water storage purposes. Wherever fresh standing water occurs and people live, mosquito problems will probably develop. The more water, in general, the greater the problems. Just how are we going to meet the needs for mosquito control in the lightly populated rural areas, canyons, recreation areas, on range lands, and in scattered small communities throughout the state? This is my principal concern in this discussion.

Surely some effort at mosquito control is possible and justifiable wherever a mosquito problem occurs. The annoyance, and possible spread of disease by mosquitoes frequently endangers the health and well-being of man and livestock. The most important mosquito borne disease in Utah is western equine encephalitis. This to a large extent is spread through irrigation water mosquitoes. From 1940 through 1952, there were 22 recorded deaths of persons due to encephalitis in Utah. 4,000 human cases occurred in the ten western states during the 1941 epidemic.

In 1933 Utah had approximately 1,000,000 acre-feet of surface water storage capacity being used for irrigation purposes. This amount has since been increased. Water resource work now under way, and that in early prospect will add substantially to the water available for certain areas. Most of the water will be used for irrigating crops, for culinary purposes in the cities, towns, and small communities, and to permit industrial development. It is through storing water, moving it by means of engineering projects, distributing it to the distant fields, and applying it to the land that much of our irrigation water mosquito problem has arisen. Only through informed preplanning for all water developments, careful distribution to avoid making additional new mosquito breeding areas, and educating the users to apply the water carefully and intelligently, can we improve our mosquito situation, particularly in our less populated areas. Agricultural users especially must be educated to appreciate and adopt good cultural and conservation practices. They must realize that water used in excess of crop requirements will result in decreased crop production, and in increased farm cost. Excess use of water, beyond needs, involves the installation of costly drainage systems for water removal, it creates serious alkali conditions, and it reduces crop production. Poor water management practices reduce net farm and family income, thus resulting in lowered living standards.

Improper handling of water results in reduced property values. This occurs because of the breeding of hordes of nuisance mosquitoes, and because of the health hazards it creates from western equine encephalitis. It will take a stepped-up educational program, including cooperation from mosquito abatement personnel, to teach every farmer, orchardist, home gardener and resort owner that careful manipulation of available water is economically necessary and highly desirable.

Only when the undesirable effects of improper water handling are fully appreciated, and possible and desirable improvements generally recognized, will the improved practices be put into common use. Individual farmer manipulation of irrigation water alone, can eliminate many local mosquito buildup problems, which now are all too common in our irrigated areas. Only when the operator actually recognizes that the mosquito problem is serious, and undesirable, and he sees that his personal efforts will really help, will he put forth extra and timely effort to achieve the "bonus benefits" possible through well conducted irrigation and drainage practices.

Control of mosquitoes in areas of low human population and limited cash income constitutes a big program. Such will have to be developed and carried out over a long period of time. To accomplish mosquito control in rural parts of Utah will need the organizing help of the County Agricultural Agent. Help and cooperation must also be secured from the leaders of the water use boards, and also from the various agricultural agencies including the personnel of the Soil Conservation Service, the U.S. Forest Service, Bureau of Land Management, and other related agencies, as well as from County, State and Federal Public Health personnel. Information supplied by mosquito abatement personnel to people in non-organized nearby areas, will aid the progress toward control effort.

A sound program of engineering, worked out with the council of related scientists trained to recognize and avoid the development of new mosquito breeding waters, must be the forerunner of all future water developments. Up to now, man-made habitats have been responsible for a majority of our mosquito breeding waters. Then, based on the problems which actually do exist, an informed and interested public can be induced to appropriate funds, and to adopt farming and range management practices which will reduce mosquito annoyance and the probability of spreading mosquito-borne disease. In lightly populated areas where resources are not adequate, but where sound, urgently needed projects exist, co-operative county, state and/or federal help may at times be found to help solve some of the more serious problems.

Many people who are annoyed by mosquitoes do not understand the biology, nor the ecology of mosquitoes. These persons seldom understand why mosquitoes can not all be killed off, right now, once and for all, and this "for free". Only a program of public understanding and education, beginning with the children in the grade and high schools, and reaching the parents in the homes, can fully overcome this situation. Living mosquito cultures, movies, field surveys, and control demonstrations, all are needed as a part of our educational program to put across the message of mosquito control. Comparatively few persons go through college, get a good founding in biology and medical entomology, then serve as community leaders on projects such as this.

## PROFIT OR LOSS

by

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Many of the papers on the program of these meetings deal with pesticides, activities from different field stations and districts, and the mosquito itself. I should like to talk about the same, but in a different light.

Mosquito Abatement Districts in California have been formed usually through the efforts of the local Service Clubs. The Districts themselves then operate by the Health and Safety Code or the Pest Abatement Act. I am not familiar with the laws of Utah in this respect, but directly or indirectly Utah and California Districts are basically the same and operate the same.

The primary need of these Districts to operate, is money. Monies that are obtained by taxes, from the Cities, County or State. To obtain this money a District has to present a budget to its Supervisors or Commissioners, who in turn approve it or request that it be adjusted for a lower tax rate.

Am I out of line in asking you if last year was a Profit or Loss for your District? Public employees come in for a lot of criticism for wasting the taxpayers money. What percentage of this is true? I leave that up to you.

But, I do ask you this, are you operating as efficiently as you can?

What about Records? In California most of the Districts are eligible for State Subvention money. Upon receiving this money they agree to submit certain information in a monthly report. Now it is a fact that many of these Districts never compiled any of this information until the Subvention program started. To them, one month had no connection with the next, and last year's work could certainly have no bearing on the present year.

Some Districts go to the extreme in regards to records; maps showing the district area, property owners, type of soil, type of crop, means of spraying, species of mosquito, etc. Then there are the reports that the operator keeps himself; species of mosquito found, means of spraying, time to spray, amount of material sprayed, type of material, property owner, location of property, etc.

In the District office you may find filing cabinets banking a solid wall, with complete records going back to the time the District was formed.

I have no complaints against supplying or keeping all this information, *if* there is a definite use for it. Is some of it just to impress their Board Members and other Districts?

Records should be kept, but keep them simple and only require that information which you know you need and can use.

Study these records, compare them and you'll be surprised at the results. Just for an example take an operators report and check over the places he has sprayed the past year. Here you see some places are sprayed more often than others. Look back at the year before. Same thing. Why?

He's a good operator, but maybe too good. For example, pretend this glass of water was a container, such as an automobile tire, old tub, flower pots and etc., you know the type. This operator never fails to spray it and always makes the proper notation in his report. Why not try Source Reduction (drink the glass of water). Source Reduction yes, and of course this example was a small one, but check around and see how often it would be more equitable to drain than to spray.

Some sources will stay sources. You and I can't change them. When the population increases so that the land is needed for agriculture or a place to live, these sources will be taken care of. If you read Gray's History of Malaria in California, you'll see what I mean and what happened to the mosquito, before Districts were formed in California.

Another form of records is Bookkeeping itself. Is there a difference between a Governmental Agency's Books and a Business? The basic principles of bookkeeping and cost accounting apply to both. Adequate records are becoming more and more essential to the small businessman. This is true for a number of reasons. For example, numerous studies by the Department of Commerce and other agencies have shown that most small business establishments that failed either had inadequate records or none at all. Business success and good record-keeping seem to go hand in hand. An adequate record-keeping system helps to reduce the probability of failure and increase the chances of survival.

Good records also help to increase profits. In a study of retail management practice, made by the Department of Commerce, it was found that among the stores surveyed most of the profitable ones had good records, whereas most of the unprofitable ones had poor records.

A Mosquito Abatement District depends upon its success, in the eyes of the public, in the abatement and control of the mosquito. But your Board of Trustees also considers your costs and disbursements, and if not they, then the County Grand Jury.

Consider your budget again. It is based upon what the District's needs will be financially for the coming fiscal year. Unless there is an unusual outbreak of mosquitoes during the year, the budget has proved to be adequate for the District. Consider the business man; that which he doesn't spend during a year is considered a profit and he is only human to wish that it were more. Could we as a District increase our Profits? I know we could if the law allowed us to put the profit into our own pockets. Actually we do put it back into our pockets indirectly; I believe we all pay our taxes.

Compare your records. Sometimes we can't see the forest for the trees. Remember the maintenance man who worked at one of the aircraft plants during the end of the war? About every other day just before quitting time, this man pushed a wheelbarrow of shavings thru the gate. Each time the guards inspected his wheelbarrow, but nothing was found in the shavings. After the war one of the guards met the man on the street. He stopped him and said, "We know you were stealing something from the plant, but we could never find it. Just what was it?" The former *maintenance man replied "I now sell wheelbarrows."* Have conditions changed so that changes in procedure and methods are advisable or necessary? From time to time we should review our operations and critically re-examine them. When your Auditor makes his examination of your cash accounts and records, ask for suggestions. You'll be surprised what some one who is outside of the forest can see. A good C. P. A. can help you turn a Loss into a Profit.

Hoping that my remarks have been accepted in the spirit that they were given, I thank you.

## SECOND SEASON EFFECTIVENESS OF MOSQUITO LARVICIDE RESIDUALS AND FURTHER TESTS OF GRANULAR DIELDRIN AS A RESIDUAL LARVICIDE*

V. I Miles and G. R. Shultz

In field trials of residual larvicides for the control of irrigation mosquitoes in the vicinity of Chinook, Montana, in 1956, the complete duration of effectiveness of several of the applications could not be determined because of limited floodings of test plots, or seasonal termination of mosquito production. Observations were therefore continued during the 1957 season on several of the plots treated in 1956. The details of plot treatments and mosquito evaluation methods, and the results during the first (1956) season are reported elsewhere (1).

*From the Communicable Disease Center, Bureau of State Services, Public Health Service, U. S. Department of Health, Education, and Welfare, Greeley, Colorado.

TABLE 1
SECOND-YEAR RESULTS OF RESIDUAL LARVICIDING EXPERIMENTS
CHINOOK, MONTANA, 1956-1957

| Insecticide | Formulation | Pre or Post Flood | Location of Plot | Date Treated 1956 | Lbs. Toxicant per Acre | No. of Floodings | | Average No. Mature Larvae & Pupae Per Dip in 1957 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1956 | 1957 | May | June | July | Aug. | Sept. |
| DDT | 1.5% Emulsion | Pre | Roadside Ditch | 5/3 | 2.9 | 2 | 2 | 0 | 0 | 8.0 | .. | .. |
| | | Post | Roadside Ditch | 5/4 | 2.8 | 2 | 2 | 0 | 0 | 0 | * | 0 |
| Dieldrin | 10% Granular | Pre | Alfalfa Field | 6/4 | 1.0 | 2 | 4 | 0 | 0 | 0 | 0 | Dry |
| | | Pre | Bluejoint Mead. | 6/7 | 1.0 | 1 | 1 | 1.9 | Dry | Dry | Dry | Dry |
| | | Post | Pasture | 6/6 | 1.0 | 1 | 2 | Dry | 0 | Dry | 0.1 | Dry |
| | 0.5% Emulsion | Pre | Roadside Ditch | 5/8 | 0.9 | 4 | 5 | 0 | 0 | 0 | 0 | Dry |
| | | Pre | Wasteland | 5/8 | 1.1 | 4 | 4 | 0 | 0 | 0 | 0 | Dry |
| | | Post | Wasteland | 6/1 | 1.0 | 3 | 5 | 0 | 0 | 0 | 0 | Dry |
| Heptachlor | 5% Granular | Pre | Bluejoint Mead. | 6/7 | 1.5 | 1 | 3 | 0.3 | 0 | Dry | 0.2 | Dry |
| | | Post | Pasture | 7/3 | 1.5 | 1 | 1 | 2.5 | .. | .. | .. | .. |
| | 0.75% Emulsion | Post | Roadside Ditch | 5/17 | 1.4 | 3 | 1 | * | 0 | 0 | 0.1 | 0 |
| EPN | 14.3% Granular | Post | Pasture | 6/8 | 1.0 | 2 | 1 | 4.0 | .. | .. | .. | .. |
| | | Pre | Bluejoint Mead. | 6/11 | 1.0 | 0 | 1 | 5.0 | .. | .. | .. | .. |
| Chlorthion | 14.3% Granular | Pre | Pasture | 6/8 | 1.0 | 0 | 1 | 15.0 | .. | .. | .. | .. |
| | | Pre | Bluejoint Mead. | 6/11 | 1.0 | 0 | 1 | 12.0 | .. | .. | .. | .. |
| Malathion | 10% Granular | Pre | Bluejoint Mead. | 6/11 | 1.0 | 0 | 1 | 6.0 | .. | .. | .. | .. |
| Check Plots | | | Pasture | .. | .. | .. | 2 | Dry | 10.0 | Dry | 9.2 | Dry |
| | | | Alfalfa Field | .. | .. | .. | 1 | Dry | Dry | 24.0 | Dry | Dry |
| | | | Bluejoint Mead. | .. | .. | .. | 3 | 7.0 | 0.8 | Dry | 0.7 | Dry |
| | | | Roadside Ditch | .. | .. | .. | 1 | 3.0 | 2.7 | 0.1 | 0.2 | * |
| | | | Wasteland | .. | .. | .. | 1 | 16.0 | Dry | Dry | Dry | Dry |

*Less than 0.05 per dip.

Treated and untreated plots, when flooded in 1957, were sampled for mosquito larvae twice each week as during the previous season. Sampling of treated plots was discontinued when the number of mature larvae and pupae present exceeded 0.1 per dip, indicating failure of the insecticidal treatments.

The second-year effectiveness of the larvicidal treatments of individual plots that produced no mosquitoes in the first year of treatment is shown in Table 1. All chlorthion and malathion plots and all except one of the EPN plots were dry throughout the 1956 season. The remaining plots were flooded from one to four times. All plots under observation in 1957 were flooded from one to five times throughout the season.

During the first flooding in 1957, large numbers of mature larvae and pupae were found on each of the plots that had been treated with EPN, chlorthion, and malathion in 1956 (Table 1).

The number of mature larvae and pupae exceeded 0.1 per dip on two granular heptachlor plots during the first flooding in 1957; these plots had received one temporary flooding in 1956. More effective results were obtained on an emulsion heptachlor plot located in a roadside ditch which was flooded throughout the 1957 season. On this plot, only three mature larvae were found during the entire season (one *Aedes vexans* and one *A. dorsalis* in May, and one *Culiseta inornata* in August).

No mature larvae or pupae were found throughout the 1957 season on four of six dieldrin plots. An average of 1.9 mature larvae per dip was recorded on a fifth plot during its first flooding in 1957, which was only the second flooding after treatment. It is noteworthy, however, that during the first 1957 flooding, dead and moribund mature larvae were observed on some portions of the plot. Only 2 mature *A. nigromaculis* larvae were found during the second flooding on a sixth plot. These two plots which showed some evidence of larvicidal failure were subject to having irrigation water flow through them, a fact which might account for more rapid dissipation of the dieldrin.

On one of the DDT plots, the number of mature larvae and pupae did not exceed 0.1 per dip during the entire season; on the other plot, however, large numbers were found in July.

Results during the 1956 and 1957 seasons indicated that, at the dosages applied, dieldrin was effective as a residual larvicide for longer periods than either DDT or heptachlor (Table 2).

Additional trials were made in 1957 at Chinook, Montana, and Logan, Utah, to evaluate the effectiveness of preflood and postflood applications of granular dieldrin at 0.5 pound of toxicant per acre. At Chinook, plots ranging in size from 0.1 to 0.5 acre and representing both "on-field" and "off-field" sources were treated during the latter part of May. At Logan, a

TABLE 2

COMPARATIVE PERIODS OF EFFECTIVENESS DURING 1957 FOR DDT, DIELDRIN, AND HEPTACHLOR APPLIED AS RESIDUAL LARVICIDES IN 1956, AT CHINOOK, MONTANA

| Insecticide and Dosage | Formulation | Pre or Post Flood | Location of Plot | Date Treated 1956 | 1956 Floodings: Date of First | 1956 Floodings: Total No. | 1957 Floodings: Date of First | 1957 Floodings: Total No. | Periods Effec. From May 1 to October 1, 1957 |
|---|---|---|---|---|---|---|---|---|---|
| DDT 3 lbs./acre | 1.5% Emulsion | Pre | Roadside Ditch | 5/3 | May | 2 | 5/17 | 2 | 12 Weeks |
| | | Post | Roadside Ditch | 5/4 | May | 2 | 5/14 | 2 | Entire Period |
| Dieldrin 1 lb./acre | 10% Granular | Pre | Alfalfa Field | 6/4 | July | 2 | 5/15 | 4 | Entire Period |
| | | Pre | Bluejoint Mead. | 6/7 | July | 1 | 5/12 | 1 | None |
| | | Post | Pasture | 6/6 | July | 1 | 6/10 | 2 | Entire Period |
| | 0.5% Emulsion | Pre | Roadside Ditch | 5/8 | May | 4 | 5/22 | 5 | Entire Period |
| | | Pre | Wasteland | 5/8 | May | 4 | 5/22 | 4 | Entire Period |
| | | Post | Wasteland | 6/1 | June | 3 | 5/15 | 5 | Entire Period |
| Heptachlor 1.5 lbs./acre | 5% Granular | Pre | Bluejoint Mead. | 6/7 | July | 1 | 5/12 | 3 | None |
| | | Post | Pasture | 7/3 | July | 1 | 5/22 | 1 | None |
| | 0.75% Emulsion | Post | Roadside Ditch | 5/17 | May | 3 | 5/11 | 1 | Entire Period |

TABLE 3

RESULTS OF 1957 RESIDUAL LARVICIDING EXPERIMENTS WITH GRANULAR DIELDRIN APPLIED AT 0.5 POUND OF TOXICANT PER ACRE (PLOTS NUMBER 5 AND 15 LOCATED AT LOGAN, UTAH; ALL OTHERS AT CHINOOK, MONTANA)

| Pre or Post Flood | Plot No. | Location of Plot | Date Treated | Actual Dosage: lbs./acre | No. of Floodings | Average Number of Mature Larvae and Pupae per Dip | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | May | June | July | Aug. | Sept. |
| Pre | 1 | Bluejoint Mead. | 5/10 | 0.5 | 2 | 0 | 0 | Dry | Dry | Dry |
| | 2 | Bluejoint Mead. | 5/14 | 0.5 | 1 | 0 | Dry | Dry | Dry | Dry |
| | 3 | Pasture | 5/13 | 0.6 | 1 | 0 | Dry | Dry | Dry | Dry |
| | 4 | Pasture | 5/13 | 0.5 | 2 | Dry | 0 | Dry | 0 | Dry |
| | 5 | Pasture | 6/14 | 0.4 | 2 | -- | Dry | 0 | 0 | 0 |
| | 6 | Wasteland | 5/14 | 0.5 | 1 | 0 | Dry | Dry | Dry | Dry |
| Post | 7 | Bluejoint Mead. | 5/23 | 0.5 | 2 | 0 | 0 | Dry | Dry | Dry |
| | 8 | Pasture | 5/18 | 0.5 | 3 | 0 | 0 | 0 | 0 | Dry |
| | 9 | Roadside Ditch | 5/18 | 0.5 | 3 | 0 | 0 | 0 | 0 | Dry |
| | 10 | Roadside Ditch | 5/24 | 0.5 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 11 | Wasteland | 5/24 | 0.5 | 1 | Dry | Dry | Dry | 0 | Dry |
| Check Areas | 12 | Bluejoint Mead. | -- | -- | 1 | 12.0 | Dry | Dry | Dry | Dry |
| | 13 | Pasture | -- | -- | 1 | 17.0 | Dry | Dry | Dry | Dry |
| | 14 | Pasture | -- | -- | 3 | 4.0 | 40.0 | 2.3 | 0.1 | Dry |
| | 15 | Pasture | -- | -- | 2 | -- | Dry | 0.5 | 0.2 | 0 |
| | 16 | Roadside Ditch | -- | -- | 1 | 3.0 | 2.7 | 0.1 | 0.2 | * |
| | 17 | Wasteland | -- | -- | 1 | Dry | Dry | Dry | 2.2 | Dry |

* Less than 0.05 per dip.

0.5 acre plot located on a waterlogged irrigation pasture, was treated on June 14. Dieldrin impregnated granules (8/20 mesh containing 2.5 percent toxicant) were used at both locations. The granules were broadcast on the Chinook plots with a crank-type seeder, and at Logan they were applied with a small modified lawn fertilizer spreader.

The treated plots were flooded from 1 to 3 times during the season. When flooded, both treated and untreated check plots were sampled for mosquito larvae twice each week as in previous residual larviciding experiments.

The results for plots that were treated with granular dieldrin at 1/2 pound per acre are shown in Table 3. No mature larvae or pupae were found on any of the plots after dieldrin had been applied. Large numbers of mature larvae were found on the check plots (Table 3.).

The species composition of larvae collected from the check plots (Tables 1 and 3) is shown in Table 4. It will be noted that *A. dorsalis* was the principal species on most of the plots.

The results of the 1957 trials at Chinook and Logan indicate that granular dieldrin applied at the rate of 0.5 pound toxicant per acre will provide effective control of irrigation mosquitoes for an entire season. Additional studies are needed to determine the minimum dosage of dieldrin that will provide effective control for an entire season.

## REFERENCE CITED


(1) Shultz, G. R., and V. I. Miles.
1959. Larviciding Experiments in the Milk River Valley, 1956. Proceedings 10th and 11th Annual Meetings Utah Mosquito Abatement Association, Pages 1-4.

TABLE 4

SPECIES COMPOSITION OF MATURE LARVAE COLLECTED FROM CHECK PLOTS FOR RESIDUAL LARVICIDING EXPERIMENTS, LOGAN, UTAH, AND CHINOOK, MONTANA, 1957

| Location of Plot | Number of Plots | Total No. Mature Larvae Identified | Percentage of Each Species by Plot Location | | | | |
|---|---|---|---|---|---|---|---|
| | | | *Aedes dorsalis* | *Aedes vexans* | *Aedes nigromaculis* | *Culex tarsalis* | Other Species** |
| Pasture[1] | 1 | 133 | 94 | 0 | 0 | 4 | 2 |
| Pasture | 3 | 126 | 61 | 1 | 18 | 21 | * |
| Alfalfa Field | 1 | 21 | 24 | 28 | 0 | 0 | 48 |
| Bluejoint Meadow | 2 | 73 | 54 | 10 | 19 | * | 16 |
| Roadside Ditch | 1 | 65 | 37 | 28 | 0 | 25 | 10 |
| Wasteland | 2 | 19 | 25 | 5 | 0 | 0 | 70 |
| TOTAL | 10 | 437 | 63 | 8 | 8 | 11 | 10 |

[1] Plot located at Logan, Utah.

* Less than 0.5 percent.

** Other species include *Aedes campestris, A. cinereus, A. idahoensis, Anopheles earlei, A. freeborni,* and *Culiseta inornata.*