PROCEEDINGS OF THE NINTH ANNUAL MEETING

OF THE

UTAH MOSQUITO ABATEMENT ASSOCIATION

held at

Midvale, Utah

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edited by

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OGDEN, UTAH

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UTAH MOSQUITO ABATEMENT ASSOCIATION

REMARKS FROM THE PRESIDENT

By DELORE NICHOLS

President, Utah Mosquito Abatement Association

Your officers and directors during the past year have had six main objectives in mind to benefit the organization:

1. To bring about closer working relationships between districts.

2. To bring about a correlated program between various agencies and departments interested in water usage.

3. To inform the public of mosquito control activities through more publicity.

4. Appoint a fact-finding committee and urge more activity by all committees.

5. Publish Constitution and By-Laws.

6. Prepare another good program for the next Association Annual Meeting.

1. The attempt to get closer working relationships has been carried over to the field workers and generally there were more personal contacts between the supervisors of the different districts. This was done especially to bring about closer cooperative work along the boundaries of the districts.

The one week training school held at Farmington, conducted by members of the U.S. Public Health Service and arranged for locally by Ward Warnock was a very successful school. Field workers from the six districts were in attendance and received valuable technical control information.

Two half-days were spent by the Davis County District field workers at a similar training meeting with the Salt Lake City District. Glen Collett led a discussion of much helpful information.

2. The Davis County District led out in a correlated program by working with various state and government departments in making a correlated study of the mosquito breeding areas along the lake shore. The Salt Lake City District representatives joined this study group.

3. Generally speaking there seemed to be more favorable publicity. An attempt was made to reach the public at least once through the three general methods, newspapers, radio, and television. The news articles were rather complete in the two Salt Lake newspapers and in the Ogden Standard in reporting the features of the last annual meeting. Pictures and stories of abatement activities were again published during the summer months in these papers. Stories were also published in county newspapers. At least two radio talks were broadcast giving mosquito control information.

4. Glen Collett was appointed as chairman of a fact finding committee. The objective here is to improve field working technical methods or develop new ones and thereby benefit the programs of all districts.

5. Frank Arnold and his committee followed up with the amendments of the Constitution and By-Laws and printed copies are now available to all members.

6. Jay Graham and his committee have prepared a splendid program for the 1956 annual convention meetings.

Other committee reports will be heard during the convention. Each committee has made an effort to bring about helpful recommendations and they have worked toward the betterment of the Association. As President, I wish to thank all chairmen and committee members for their services. I wish to express appreciation to all officers and directors for their splendid support. May this support and good will be extended to all new officers in 1956.

COOPERATIVE EFFORT IN MOSQUITO CONTROL AND AGRICULTURE

By WAYNE D. CRIDDLE

Irrigation Engineer, Soil and Water Conservation Research Branch, Agricultural Research Service, USDA, and Utah State Agricultural College

Some of my earliest recollections in the field of irrigated agriculture include carrying the old coal oil lantern down through the fields on warm summer nights. I recall that during the evening and early morning hours, hungry mosquitoes would rise in clouds. Large welts arose from their bites over all of my exposed skin.

These were the days before effective mosquito repellents were available. It was also before the days of mosquito abatement districts and spraying in Utah. At that time, I did not know that mosquitoes could be controlled. However, I did know that they were extremely disagreeable during night irrigation and under our conditions, night irrigation was essential. I did not realize that our irrigation practices could be contributing to the mosquito problem. I thought that perhaps mosquitoes were able to hatch out in the moist alfalfa fields and did not necessarily require free water.

My father and our farmer neighbors did not seem to worry too much about the mosquitoes. In fact, they used to tell me that I was just too tender. They said that with time my skin would toughen up so that I wouldn't notice such small matters. Their predictions have not come true. Mosquitoes annoy me as much now as they ever did. The only difference now is that I don't spend quite as much time with a shovel directing the irrigation stream as I once did.

The above is being told to you not because I believe my experiences were unique, but to emphasize the change in thinking that has taken place during the past 25 years. In the earlier days of irrigation, the thinking of the people was that man had to get "toughened" up to meet a natural condition. Today we think of changing the condition, not man.

Back in 1952, I first became associated with the Public Health Service and mosquito problems in the Milk River Valley of Montana. Any of you who have been in Chinook, Montana during the middle of the summer realize what a serious problem mosquitoes can be. Never have I been in an area where the mosquitoes are thicker, hungrier, or more ferocious.

After driving around the Milk River Valley for a day or so, the front of my car looked as if it had run through a mud bath. The windshield had to be cleaned often so that we could see where we were driving. For the first time, I then began to understand something about mosquito production on irrigated lands.

The soils in the Milk River Valley are fine glacial silt. They absorb water extremely slowly. In fact, after the initial wetting of the soil, the rate of water absorption is practically zero. Water on the surface of the soil must then leave either by evaporation or surface run-off. However, the slope of the land is extremely flat. The winding Milk River flows sluggishly. A considerable part of the surrounding valley land has a permanent high water table. There is little surface drainage.

Over the years, more or less primitive farming operations have developed on some of these lands. Natural vegetation called "blue-joint" grass is used for pasture or hay production. Single fields as large as 40 acres are surrounded by high dikes with little or no artificial land leveling within the diked area. Large streams of water are used to flood these fields. In order to get water over all of the surface of the ground, it is frequently necessary to pond water to a depth of several feet in some spots. Water often remains on part of the field several weeks after it was turned in at the head. There is no attempt to drain away the excess and allow the soil to dry. According to the entomologists, this provides an exceptionally good habitat for mosquitoes. It also provides the environment which limits agricultural production to low yielding blue-joint grass hay which has low nutritional value. Whenever this grass has been broken up and good varieties of either alfalfa or other grasses planted without land leveling and improved irrigation and drainage practices adopted, the improved planting soon goes out and mosquito production continues. If the land is treated right, it will produce much more forage than did the old native grass and mosquitoes can not develop.

Although the Milk River Valley of Montana is bad, conditions there are not too different from conditions in a number of areas in Utah. We have low-lying flat valley lands with tight soils that absorb water slowly. Often, little care is given in the application of water to these lands since they are considered as being marginal in agricultural production. Thus, we frequently have intermittent ponding of water on these areas. During the hotter part of the summer, not many days are required to hatch the eggs into mosquito larvae. The adult mosquito then flies off with a huge appetite and a desire to bite both humans and animals. Generally the lands which produce these mosquitoes produce low agricultural yields. Sometimes the soils are such that successful agriculture can not be obtained even under the best management practices. Under such conditions, it might be desirable for the land to be retired from any attempt at production. Public agencies such as mosquito abatement districts might well purchase the land and through surface drainage see that conditions favorable to mosquito production do not continue.

If the soils are suitable for agricultural production, the owners of the land should be encouraged to drain and properly operate the lands so that they do not produce mosquitoes. In many instances, this is an educational job. Few farmers want to allow conditions to exist that are favorable for mosquitoes, particularly when they understand that good agricultural production and good mosquito production are not compatible. In some few cases, legal action may be necessary from the standpoint of health and public nuisance before remedial action can be undertaken. This latter is particularly true of non-resident owners with tracts of land lying adjacent to some of our larger centers of population. These land owners often have no intention of ever farming the land but are merely holding for speculative purposes.

Draining all of our irrigated agricultural lands is a big job. It has been estimated by the Utah Water and Power Board that although 2,400,000 acres of arable land lies in Bonneville Basin, only about one-third of this arable land now receives water, and less than half of that receiving water or one-sixth of the total arable land, receives adequate water. Nevertheless, even with this tremendous water shortage, it has been further estimated that some 220,000 acres need drainage. Much of this land requiring drainage is actually consuming more water per acre than is consumed on an acre of land that is properly irrigated and drained. Thus, on the one hand, we have a tremendous shortage of water for the land which could be irrigated if we had water and on the other hand there is considerable wasting of land and water because of lack of drainage. Certainly as time goes on, we will find ways of salvaging this excess water for areas now receiving insufficient water for maximum crop production.

Pressures for more efficient use of water will allow no other course of action. If and when this excess water is salvaged and put to beneficial use and the land is farmed for maximum production, our mosquito problems will diminish considerably. Thus, increased use of our water resources means improvement in mosquito control. But this improvement in water use is not something which will take place overnight. Also, I do not wish to suggest that mosquito breeding places are the result only of our farming practices. Undoubtedly, there were plenty of mosquitoes around before the pioneers entered this valley 109 years ago. Natural periodic flooding of the low spots probably created many mosquitoes. Although I have not read of mosquitoes being any major problem in those early days, I am sure that they were with us. Perhaps one of the reasons I haven't heard about them is that "gnawing hunger" was more uncomfortable than the gnawing mosquitoes for a good many of our early pioneers. As with my own early experiences, the pioneers undoubtedly felt that this was a natural condition over which they had no control.

Again I want to emphasize that I do not think the farmer or the poor irrigator is the creator of all the mosquito problems in Utah. As I mentioned before, many conditions conducive to mosquito production were here before the advent of the white man. Also, paving of city streets, sidewalks, and parking lots and covering of land area with buildings has greatly changed run-off conditions from cities such as Salt Lake. Since the soil can not absorb the water, even small storms cause overflowing of the channels below town and flooding of the low lying lands. Obstructions are continuously being built across the natural drainage channels. Certainly, agriculture can not be blamed for these and many other problems resulting from our population increase.

To solve fully the mosquito problem will require joint effort of all people in the general area. Certainly the farmer is just as interested or more interested in eliminating the mosquito problem as is the city dweller. However, it would be unfair to assume that the farmers of Utah finance all of the costs of mosquito control even in the rural areas. True, decreasing the conditions which are favorable for mosquito production may greatly increase crop production; but decreasing mosquito production will also help the man who owns a tourist court. It is of value to the man who wishes to spend an evening in his garden in town. Since all of us are susceptible to being bitten by disease carrying mosquitoes, the public health aspect can not be overlooked. It thus becomes a joint operation to clean up the area from mosquito producing conditions.

Drainage is expensive. In the past, the farmer has been saddled with the entire bill. Can public health benefits pay part of the costs? Perhaps we should attempt to evaluate all the benefits accruing from drainage and proportion out the costs. We have found other benefits to help pay for water development projects and the public feels that such benefits should be assessed for part of the costs.

Those of us in soil and water conservation work welcome any legitimate excuse which will further work in our field and are therefore anxious to assist in directing irrigation and drainage practices towards mosquito control. I believe that agricultural production and mosquito production cannot both be high on the same land. We are interested in increasing crop production per unit of area and per unit of labor expended. We are also anxious to see that mosquito production is curbed as effectively as possible.

Many of us believe that this thinking is something new for many farmers. Undoubtedly, it is going to take an effective educational program on the part of you directly in charge of mosquito control with the help of all of us in the field of soil and water conservation. We must work together on eliminating this problem. But before we can effectively set up an educational program and carry it to our farmers, we still need more basic information on the problem. We must be sure of the effect that poor irrigation and drainage practices have on mosquito production in Utah. Studies to date have been extremely limited. We are attempting to interpret the meager data being gathered in such places as the Milk River Valley of Montana, the San Joaquin Valley of California, and the High Plains area of Texas to conditions along the Wasatch front here in Utah. Even in these distant places studies have been underway for such a short period of time that little is known on how to handle the agricultural problems associated with mosquito production. Such research work, if properly coordinated, can have a "double barrel" effect. Results from such studies can be used to control the mosquitoes and also to materially increase production from agricultural lands. Both of these are desirable goals for which we are all striving.

WILDLIFE PRODUCTION VS. MOSQUITO ABATEMENT

By A. R. Gaufin

Department of Zoology, University of Utah

There are at the present time, in this country, approximately 13,000,000 sportsmen. The annual expenditure of each sportsman is around $50, which makes the sportsmen's annual bill, $650,000,000. This enormous sum goes for equipment for hunting and fishing, including purchases of ammunition, firearms, and fishing tackle, as well as clothing, tents, canoes, and motor boats. These expenditures, and the industries they support, depend on the continuance of a crop of wild birds, mammals, and fish. Since many of these forms of life depend on lakes, streams, marshes, and swamps for their existence, any human activities which alter their habitats, may seriously affect wildlife production.

A number of practices employed in mosquito control operations may affect wildlife populations adversely, unless cooperative efforts are made to minimize the effects involved. Among the methods commonly used by mosquito control operators, drainage, alteration of water levels, and larvacidal spraying present the greatest threat to wildlife.

One way in which drainage militates against wildlife is by changing the vegetation. Under natural conditions there is little fluctuation of water in permanent ponds and swamps. Consequently, they support a wide variety of valuable plant life, ranging from misroscopic forms, such as the diatoms, to the higher seed plants. As a result of ditching, however, a large percentage of the water may disappear and the natural vegetation is destroyed or replaced by terrestrial plants.

In addition to changing the vegetation of the surface of a marsh, drainage, by dropping the water table will kill off millions of aquatic invertebrates found on the marsh surface. Careful studies by Drs. Cottam and Bourn of the U.S. Biological Survey, show the extent of this destruction of animal life. They found that six months after a marsh on the Atlantic Coast was drained for mosquito control, the ditched portion contained only one-seventh of the animal life of the unditched marsh. This widespread destruction of food and cover on which fish, waterfowl, and aquatic mammals depend must necessarily have a deleterious effect on their production.

Where the comfort of large numbers of people, over considerable periods, is concerned, and where no method besides drainage will serve, abating the mosquito nuisance should have priority over wildlife production. However, in many cases, drainage can be avoided by such methods as enlarging the water area, by impounding, or by introducing natural enemies of the mosquito larvae, such as top feeding minnows.

De-watering of the backwater areas of large lakes and reservoirs during the summer months for malaria and mosquito control purposes can seriously impair fish and waterfowl production if improperly handled. While this problem is practically nonexistent in Utah, at the present time, it is of major importance in some sections of the country as along the Tennessee Valley reservoirs of Southeastern U.S. The TVA authorities have solved the problem through the utmost cooperation between mosquito control workers and the fisheries and wildlife interests. High water levels are maintained in all reservoirs, if at all possible, during the spring and early summer as a mosquito control measure. This protects the fish during spawning and affords much additional food and desirable living space for the fry and young fingerlings. Many backwater areas are diked off from the main reservoir so they can be pumped dry during the summer drawdown. Primarily, a malaria control measure, diking makes large areas available for the production of waterfowl food.

Larvicidal sprays, such as nonvolatile oils, and even some of the newer organic insecticides, if applied in sufficient concentration, can kill fish and other wildlife, as well as destroy their food, and reduce the hatching success of waterfowl. Since most of the mosquito abatement work performed in Utah is being carried out in areas which do not produce game fish, larvaciding has produced few serious losses of fish. In other sections of the country, however, where warm water species of game and pan fish abound, serious fish kills have resulted from larvacides which were improperly applied.

The possible killing of waterfowl, or their food organisms, from the use of insecticides, constitutes a far more serious problem in Utah. In and near several waterfowl refuges, which are located along the eastern margins of the Great Salt Lake, mosquito breeding areas exist. Control of mosquitoes in such areas in such a way as to minimize or prevent losses of waterfowl involves the use of all available knowledge of the action of the insecticides being used as well as extreme care in its application.

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DDT AND FISH

By Oliver B. Cope

Chief, Rocky Mountain Investigations
U.S. Fish and Wildlife Service, Logan, Utah

The proceedings of numerous mosquito abatement meetings in recent years have included reports pertaining to the effects of insect toxicants on fish and fish food. Most of the reports have followed a rather stereotyped pattern featuring descriptions of field experiences or statements of toxicity levels and concluding with reminders that biologists and mosquito control operators must work together to make certain that no damage is done. Other insect control groups, such as the agricultural entomologists and the forest entomologists, have also sponsored studies and reports dealing with the consequences of the use of chemicals in the field. There has likewise been a uniformity of pattern in these reports. I feel that this repetition, together with the fact that few cases of mortality to fish have been shown to result from insecticide treatments in the field, has caused us to lose our caution. There seems to exist in some quarters a feeling that our knowledge of relationships between toxicants and fish is complete. It is quite understandable that this state of mind should develop, because the record for safe insecticide application is really quite good.

I would like to refer to two recent episodes which should serve to bring us back to the realization that we really understand very little about DDT and its effects on fish.

Kerswill and Elson (1955) describe the history of DDT airplane spraying for spruce budworm control in the coniferous forests of New Brunswick in Canada. Spraying of extensive areas began in 1952, and were continued in 1953 and 1954 at the rate of 0.5 pound of DDT per acre. The 1954 treatment involved a million acres and covered about one-third of the drainage of the Mirimichi River. The Mirimichi had been under investigation by fishery biologists since 1950, so considerable information on fish populations was available for two tributaries.

Careful studies of numbers of fingerling Atlantic salmon in these streams were made before and after the 1954 spraying, as well as studies on immature salmon held in live cars in the stream. After the DDT treatment no fish-of-the-year could be found in the Northwest Mirimichi, and virtually none in the Dungervon. Yearling fish were not quite so badly affected, but in one stream two-thirds of this size group were eliminated, and five-sixths of them were killed in the other stream. Among those held in live cars, the fish held in sprayed areas or downstream from sprayed areas suffered mortalities up to 91 per cent. Mortality among fish held in an untreated stream was 2 per cent. Dead and dying fish were found up to three months after the spraying.

The number of aquatic insects in these streams was seriously reduced. Dr. F. P. Ide, the entomologist who examined the insect populations after the DDT treatment, said, "At present there is virtually no suitable insect food in the streams examined. This scarcity is likely to persist for another summer at least, after which there may be large numbers of black flies and some other forms. But the insects normally associated with these fish, such as mayflies, stoneflies, and caddis flies, will probably re-establish slowly."

DDT spraying for spruce budworm in Montana and Wyoming in 1955 was done in a routine manner over thousands of acres and in several drainages. The standard rate of application was used, and, in conformity with previous experience on almost seven million acres sprayed in the United States, no damage to fish or fish food was observed in most of the drainage basins treated. In one stream system, however, DDT apparently contributed to a situation that resulted in some damage.[1]

The Yellowstone River area received an average of 0.22 pounds per acre of DDT on treated forests inside and outside of Yellowstone National Park in early July. Studies on fish and on aquatic invertebrates before and immediately after the spraying indicated that adult cutthroat trout were not directly affected by the toxicant. However, decided reductions in the aquatic insect fauna were evident in the sprayed areas a week after the treatment.

Reports from fishermen along the Yellowstone River downstream from the sprayed area began in October, and in November the complaints about dead and dying fish attracted considerable attention. Investigation by biologists revealed that there were indeed numbers of dead whitefish, suckers, and trout in the Yellowstone River, and that the affected section extended 100 miles downstream from the sprayed area. Studies on aquatic insects in the stream indicate a tremendous reduction in numbers both in and out of the sprayed section. The condition of the dying fish suggest that starvation may have been involved in the mortality on the Yellowstone.

The occurrences on the Mirimichi and on the Yellowstone should cause us to take stock of what we know about DDT and other insecticides. We know that the chlorinated hydrocarbons will kill fish and fish food, but we do not know under what conditions morbidity or mortality are caused. The treatments on these two large drainages were conducted according to standard practices, after experience elsewhere had indicated that these practices were safe. It is obvious now that we must learn more about the actions of toxicants under all physical and chemical conditions so that predictions of the consequences can be made with confidence. We shall then be in a position to use cooperative effort in insect control and achieve optimum results.

[1] Cope, O. B., and D. E. Parker, "Survey of conditions attending fish mortalities in Yellowstone River following spruce budworm spray project." Administrative Report to U.S. Fish and Wildlife Service and U.S. Forest Service, dated February 3, 1956, pp. 1-9.

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THE NEED FOR COOPERATIVE STUDIES IN MOSQUITO ABATEMENT ON WATERFOWL MARSHLANDS

By NOLAND F. NELSON

Supervisor of Waterfowl Management
Utah State Department of Fish and Game

Fish and game administrators are faced with an ever increasing number of people that are becoming interested and demanding an opportunity to participate in hunting and fishing. Part of this increase in interest is due to the 5-day work week which gives many people another day to find some form of recreation. With the tension and rapid pace of living that we now have, it is important that people pause to enjoy some form of recreation. Waterfowl hunting provides good recreation for large numbers of people throughout the nation.

In Utah during 1954, 30,398 hunters spent 179,652 days in the marshes and killed 395,375 ducks and 3,698 geese. In addition to the enjoyment they received while hunting, there is also the value of the large amount of meat. Perhaps this meat is not worth the hunter's average expenditure of over six dollars for each duck bagged, but it does show the value which the hunter places on an opportunity to spend a day in the field forgetting about the office or other daily grind.

The U.S. Fish and Wildlife Service recently completed a nationwide wetlands survey. One of the reasons for the survey was alarm over the rapid reduction in waterfowl habitat. Results of the survey show a need for restoration of several million acres of habitat plus preservation of existing levels.

Waterfowl habitat in Utah is also on the decline. Expansion of industry, cities, and agriculture destroys a little more wetland each year. Faced with the dilemma of trying to satisfy more sportsmen with less habitat each year, the Utah Fish and Game Department recognizes the importance of preserving as much habitat as possible and managing the areas for the best production and use by waterfowl.

Wetlands of value to waterfowl in Utah can be grouped into three categories. (1) The state and federal government have developed over 100,000 acres of marshlands for nesting, resting, and feeding of waterfowl. (2) Private clubs control and have developed nearly 50,000 acres of marshland. (3) There are also unmeasured areas of marshland on private and public lands where there is no management for waterfowl, but which are extremely important to the waterfowl picture in Utah.

It is unfortunate from a mosquito production standpoint that most of the marshlands of the state are located relatively close to centers of population. In an arid state such as Utah, agriculture and cities developed around the few water areas. Marshlands were found on the stream deltas and were created by the drainages from cities and agriculture. Thus we are faced with a problem of one agency creating and preserving marshlands that may produce pest and disease carrying mosquitoes, and another agency that could do their job better if these marshlands did not exist.

Certainly the Fish and Game Department does not want to manage their areas so they will produce mosquitoes. We are interested in managing the areas for a minimum production of mosquitoes. Likewise, the mosquito abatement districts do not want to pursue programs that will destroy or limit the production of waterfowl use of an area. In spite of our best intentions, mosquitoes are produced on even our most carefully managed marshlands; and some of the mosquito control practices limit waterfowl nesting and feeding. The only solution to this problem is cooperative studies that will lead to a program satisfactory to both agencies.

Studies now underway by the U.S. Public Health Service in Utah on mosquito production associated with various plant types could go a long way toward the solution of some of our problems. Perhaps certain vegetative types that are desirable for waterfowl nesting and feeding are undesirable to mosquito larvae. There also may be plants that have low value to waterfowl but which contribute to the heavy production of mosquitoes. If this were true, marshlands could be managed to limit vegetative types which are conducive to the production of mosquitoes.

This summer Dr. Don M. Rees of the University of Utah plans a cooperative study on water level management for the abatement of mosquitoes on one of our state marshlands. Results of this study should provide a guide to the best methods of water control on waterfowl marshes needed to limit mosquito production. With this guide private clubs and others contemplating marsh development work might alter their plans in order to limit mosquito production.

There are many other studies which are needed to make a compatible program for waterfowl and mosquito abatement. Our funds and personnel are limited, but we are willing to contribute what we can in our knowledge of marsh ecology and waterfowl needs. We are also willing as far as practical to alter our management program to fit any study that would help in the solution of our mutual problems.

ROLE OF INDUSTRY IN THE COOPERATIVE MOSQUITO ABATEMENT PROGRAM

By C. P. Starr

U.S. Smelting Refining & Mining Co., Salt Lake City, Utah

I am pleased with this opportunity to meet with you today and represent local Industry in this Cooperative Mosquito Abatement Conference. Although I represent specifically, only one industry, I presume I may speak in general terms for all industry on this matter.

Since cooperation appears to be the theme of this conference, I should like to refer to an observation, whose authorship is obscure at the moment, concerning this subject. Generally speaking, freckles are a source of annoyance to those who possess them. Yet, if these same freckles were to get together, what a wonderful coat of tan they would make.

So it is with the problem before us. Without full understanding and get-together between the parties concerned, much of the work done may be wasted. For example; if one land owner cooperates in draining his swamps and his neighbor does not, then we are still going to have mosquitoes. If this program is to be successfully carried out, then all of us must give our cooperative support, in time and effort, to bring it to its ultimate goal.

There are, of course, some problems associated with this matter of cooperation. No one cooperates to any greater degree than the extent of his understanding. What, then, are the motivating forces that result in cooperative activity? In my experience, cooperation generally results when there is a full understanding on everyones' part as to what the problem is and just what is required of each participating party. With reference to Industry then, I might inquire; just what is it we require of Industry in this mosquito abatement work? What is Industry's "stake" in this undertaking? Obviously, Industry must be adequately informed as to how it is involved, what is required of it, and how best it can discharge this responsibility.

Industry is, and wants to be, considered a part of the community. It wants to be a good neighbor. This implies then, a shouldering of certain specific responsibilities, compatible, of course, with industries' specific purposes. There will likely be no reluctance on the part of Industry to do this, providing others who have an interest in this program assume similar obligations.

The United States Smelting Refining and Mining Company has, for the past several years, participated in the mosquito abatement program in the South Salt Lake County Mosquito Abatement District. I am sure there are others who have likewise contributed materially to this effort. That there has been an increased interest generally in this program, there can be little doubt. This is largely due to a better appreciation of the mosquito problem. It is largely through the efforts and understanding of Mr. Jay Graham that the local public have acquired a knowledge of the problem before it and of its particular obligation to this program. In my opinion, Mr. Graham was effective because he tried to see and understand the other fellow's problem and viewpoint, preferring to jointly work the problem through with the people involved.

Over the past several years, the mosquito abatement district efforts have been fruitful. On our Company property, for example, considerable work has been done to abate the mosquito nuisance. Swamps and ponds have been drained or made uninhabitable to mosquito larvae. Part of this work was done by the Company. Other portions have been carried out by the mosquito abatement district. In still other instances, the work was accomplished jointly; the Company providing the dragline equipment, while the mosquito abatement district furnished the operator, the helpers and the fuel required for equipment operation. Also, through the payment of taxes, we have contributed substantially to the general financial support of the mosquito abatement program.

Referring again to local industries generally, I would suggest that we can expect the support of Industry to the fullest extent so long as it is conscious of the need for this work and providing we have a practical program which would invite Industry's participation. This is assuming, of course, that other groups and interests are similarly engaged in carrying on their part of the work. Industry should have no desire to be an individual freckle, or even the space between. It should want to be, and I am sure that my Company desires to be, a part of the overall tan coat.

CORRELATION OF MULTIPLE INTERESTS IN WATER RESOURCE DEVELOPMENTS

By J. William Funk

Chief of Reports Branch, Project Development Division, Region 4
Bureau of Reclamation, Salt Lake City, Utah

Water is perhaps the world's most important single resource. Without water no living thing, either plant or animal, can exist. Man requires it in abundance not only for drinking and culinary purposes but in vastly greater quantities to produce and process the food that he eats and other materials necessary to his welfare. In the arid west water is made more important by its scarcity. We have vast resources in land, fuels, oil, fertilizers, timber, metals, and recreational attractions, but water above all else is a key that will determine the extent to which these other resources can be pressed into the service of the Nation.

In writing recently to the Secretary of the Interior, President Eisenhower said, "The conservation and use which we make of the water resources of our Nation may in large measure determine our future progress and the standards of living of our citizens."

The first reclamation projects generally were planned and constructed with the sole objective of getting water onto the land. These no doubt were justified under conditions of the past. Now, however, with water constantly becoming more scarce and more valuable, attention must be given to possible multiple uses of the water before it is finally consumed or otherwise escapes. In planning water resource developments today we must consider such questions as these: Can the water enroute to the land or other place of use be used to generate electric energy? Can flood control features be incorporated into the development? Are there requirements for municipal or industrial water that should be satisfied? Can the plan be adapted to provide benefits in the way of recreation or fish and wildlife propagation? Not least in importance but perhaps the last to be fully considered is the matter of public health. What measures should be taken to prevent water pollution and to reduce or eliminate mosquito breeding areas?

Since enactment of the Water Pollution Control Act of June 30, 1948, the Bureau of Reclamation has cooperated with the Public Health Service and the State Health Department in formulating plans for all of its potential projects. The Public Health Service, together with other interested Federal Agencies are apprised of investigations of potential reclamation project investigations as the work is undertaken. The Service in turn confers with the State Health Department on the proposed plan and submits its report and recommendations which are bound with the Bureau of Reclamation report that is then sent to the President and Congress for their decision or authorization.

Fortunately measures recommended for mosquito abatement as a rule are also in the interest of conservation of water for irrigation or other purposes. The prevention of seepage from ditches, the leveling of irrigated areas, the drainage of swamp areas and the control and re-use of return flow from irrigated lands are all essential to both efficient water utilization and mosquito control. Not infrequently facilities for water control and distribution have in them inherent benefits to mosquito control. Perhaps the outstanding local example is Willard Reservoir of the Weber Basin Project which will inundate 11,000 acres of some of the most prolific mosquito producing area in this region.

On the other hand we do not close our eyes to the fact that irrigation has created many mosquito problems. The Public Health Service and the Utah State Department of Health have estimated that irrigation provides more than 50 per cent of the mosquito producing water in the Weber Basin. Much of this no doubt comes from projects that have been built in the past with little or no regard to the mosquito phase. The Weber Basin Project is creating some new problems but very likely its drains and its 80 wells that are intended jointly to produce useful water and at the same time lower the destructive water table will also eliminate some mosquito breeding areas. We are confident that the new problems can be solved or minimized through the continued cooperation of the agencies concerned. We have good reason to believe that henceforth the cooperation may be even closer and more effective than it has been in the past.

In May 1954 the President appointed what was then designated as the "Cabinet Committee on Water Resources Policy." It consisted of the Secretary of the Interior as Chairman with the Secretaries of Defense and Agriculture as full members. The Secretaries of Commerce, Health Education and Welfare; and the Director of the Bureau of the Budget were designated to participate on an ad hoc basis. The committee was later renamed the "Presidential Advisory Committee on Water Policy."

The committee's report was submitted to the President December 22, 1955. In submitting it to Congress on January 17, 1956 the President said, "I commend the fundamental purposes and objectives of this report, and I earnestly recommend that the Congress give prompt attention to its proposals."

In view of the high level origin and approval of this report it may be considered as particularly significant in indicating the policies that will guide future water resource development. Some of its provisions are therefore of particular interest as they apply to the question at hand.

In outlining the problems now faced in water development the Committee said:

> The basic elements of a sound policy relating to water are clear. That policy must look toward an adequate water supply for our people, prevent waste of water, provide for a greater re-use of water, reduce water pollution to the lowest practicable level, provide means for the useful and equitable distribution of available water supply, and take steps to check the destructive forces of water which threaten to injure or destroy land, property, and human life.
>
> The greatest single weakness in the Federal Government's activities in the field of water resources development is the lack of cooperation and coordination of the Federal agencies with each other and with the States and local interests. This has been occasioned by the fact that the Federal interest in water resources development has been expressed in different laws empowering different agencies to pursue particular programs for different purposes. There has been inadequate coordination of the program of one agency with that of another, and inadequate consultation with and consideration of the interests of the States, local communities, and individuals most vitally affected.

In developing proposed solutions to our present problems the report included this statement:

> Although some progress has been made toward coordination of effort, much remains to be done. The inadequacy of coordination in the field of water development stems largely from the fact that there are several Federal agencies engaged in various phases of water control and development programs, each operating under separate pieces of legislation and with differing objectives. Plans of the several agencies vary widely in detail and in purpose. Most of the planning done to date has been in the field of flood control, navigation, irrigation, soil conservation, watershed control, and hydroelectric power. There has not been sufficient planning, however, with respect to such functions as drainage, preservation and propagation of fish and wildlife, recreation, preservation of historic and scenic areas, abatement of pollution, and municipal and industrial water supplies.

The Committee proposed that an organization be set up to assure cooperation among the various Federal agencies and the States involved. Among the Federal agencies that were determined to have responsibilities in water resource development are the Departments of Agriculture; Army; Commerce; Health, Education and Welfare; Interior, Labor and State and the Federal Power Commission. The second of eight recommendations made by the Committee was this:

> That planning for water resources and related developments be conducted on a cooperative basis with representatives of all Federal, State, and local agencies involved; and that this joint participation be continuous from the beginning in order that plans and projects developed assure the best and most effective use and control of water to meet both the current and long-range needs of the people of a region, State, or locality, and of the Nation as a whole.

Opportunities for cooperation between reclamation and mosquito control interests in Utah appear to be far greater now than ever before. Not only is such cooperation being given renewed emphasis in National Policy but the stage is set for a construction program that dwarfs anything yet undertaken in this area. Although the Weber Basin Project has been under construction for more than three years the work so far has largely involved upstream facilities that are not closely related to the mosquito problems. As we get into the lower areas with our final plans for canals, laterals, drains, wells, and the Willard Reservoir, the help of mosquito control agencies will be most valuable. The Colorado River Storage Project with its 12 participating projects has been approved by both houses of Congress. Only yesterday a conference committee of the House and Senate agreed on the final provisions of the authorizing bill which now seems assured of passage and of Presidential approval. Let me emphasize that the Glen Canyon Dam and Reservoir are comparable in size and capacity to Hoover Dam and its Lake Mead that are located some distance downstream. In addition the Flaming Gorge Dam on the Green River and the Navajo Dam on the San Juan River would be constructed. The initial phase of Central Utah Project which would be assisted financially from power revenues from the main stem dams, is larger and more costly than the remaining 11 participating projects. It will cost more than $200,000,000. The Emery County Project, also a participating project, will cost almost $9,000,000. As the final planning for this vast program gets underway cooperation of all interested agencies will be required to assure the most beneficial development.

BASIC SCREENING FOR NEW INSECTICIDES

By A. O. Jensen

American Cyanamid Company

The development of a modern insecticide is far from a "hit and miss" affair. When a chemical company makes an insecticidal chemical available to today's public, there is behind it a well planned and carefully controlled series of steps which enable the scientist involved to know at any given stage in its development, exactly where the new chemical stands in relation to previously established insecticides.

This situation, however, has existed only for a very few years, actually in any highly organized way only since World War II.

Prior to the 1920's, the majority of effective insecticides came from mineral or plant sources and were actually "stumbled" upon. The ancient Greeks and Chinese first learned the toxic properties of arsenic. In the late seventeenth century it was discovered that a solution made by soaking tobacco leaves in water would kill certain pests. Eighteenth-century settlers in Malaya found the natives using rotenone bearing plants as fish poisons to make their fishing job easier. Using largely these natural compounds, early chemists produced various salts and extracts, some of which turned out to be useful insecticides.

It is only since the chemical industry has become highly developed, however, that much actual synthesis of insecticidal compounds has taken place.

Most chemical companies are engaged in the manufacture of many types of chemicals — pharmaceuticals, plastics, dyes, agricultural chemicals, etc. They employ many chemists who are constantly engaged in synthesizing compounds. This exploratory "making" of compounds results in literally hundreds of new chemicals being produced in the research laboratories of any one company in any one year. Each of these newly synthesized compounds is reviewed for possible usefulness in any of the fields in which the company is interested. Included in this is, of course, the possibility of the compound having insecticidal properties.

At the same time, groups of chemists are working on the specific problem of synthesizing insecticides. The first steps in this direction were to synthesize compounds which were related chemically to the known insecticides. As this work expanded, the chemists learned more and more about the kinds of chemical structures which would contribute to insecticidal effectiveness. From there came the exploration of families of chemicals related to a basic material. As an example of this we have the family of chlorine base insecticides starting with DDT and including methoxychlor, toxaphene, chlordane, dieldrin and many others.

Through the development of TEPP and parathion has come exploration of the phosporous family. American Cyanamid Company has done much of the basic development work with phosphorous base insecticides. Let's follow one of these compounds — one which was synthesized directly in the search for an insecticide — from the time it first took form in the chemist's retorts, until it finally went on the market. The compound's number was 4049.

4049

When 4049 was first born on a chemist's workbench at American Cyanamid's Stamford, Connecticut, laboratories, it consisted of only a few grams of brown liquid in a small bottle. It could be worthless or it could have great value. Only evaluation against insects themselves could tell.

After the chemist had analyzed the liquid to determine that the chemical was actually the compound he had set out to make, this small bottle of "known chemical with unknown worth" was sent to the entomological section of the laboratory. The first job here was to find out whether the compound would kill insects. Through experience, the entomologists have selected several typical insects for this preliminary evaluation of new compounds.

Basic Evaluation

In this first step they tested 4049 as a contact insecticide and as a stomach poison. Aphids were used to test contact killing since they are sucking insects only — they do not chew foliage. Thus, to get a kill the insecticide must be absorbed through the skin of the aphid. Nasturtium plants heavily infested with aphids were sprayed with 4049. It gave 100 per cent kill. Armyworms were used for the stomach poison test, since they are voracious foliage feeders. Lima bean leaves were dipped into prepared solutions and the worms placed on the leaves. Again 4049 gave kill.

As a third test, dust formulations of 4049 were prepared and this dust was applied evenly to glass dishes. Three insects were placed on the dusted dishes — confused flour beetles, German cockroaches, and milkweed bugs. Here the entomologists were getting an idea of the possible range of killing power of 4049, since these three bugs are of very different types. It killed all three.

At the end of these preliminary tests, 4049 had come through with flying colors. Of course 4049 was not the only compound undergoing these tests. Some fifty compounds a week are run through this primary evaluation. Many go no further than the tests described above — but 4049 looked promising so the testing moved into phase two.

Applied Evaluation

Here a new species was introduced — spider mites. Lima bean plants heavily infested with two-spotted spider mites were sprayed with 4049. There were all stages of mites on the plants — from eggs to adults. Mites also suck plant juices, so this test again showed contact action. In addition, however, it gave the first clue to the residual action of 4049. The unhatched mite eggs were watched closely to see whether they ever did hatch and if they did, whether the mites that hatched several days after spraying were killed. 4049 killed all the adult mites (contact) and continued to kill newly hatched mites for some days (fairly good residual) but did not prevent the eggs from hatching (it was not an ovicide).

As a final step in this series, 4049 was tested for possible systemic action. The roots of bean plants, the leaves of which were infested with mites, were dipped in a water solution of 4049. Since the mites were not killed, it showed that the material was not taken into the sap stream of the plant — at least not in sufficient quantities to kill the pests.

By now, quite a bit was known about this new compound. It was both a stomach and contact insecticide. It had a fair residual action. It did not injure the test plants used. It had a good range of killing power. It did not, however, appear to be an ovicide or a systemic. All this took about a month to determine.

It was too early to make flat statements (and scientists are always cautious), but at least 4049 looked promising.

Now the entomologists moved to more practical evaluations. 4049 was run in a careful series of tests comparing it directly with an insecticide whose performance was well known and charted. Since American Cyanamid had previously developed parathion, and 4049 was also a phosphate, parathion was used for the comparison. These tests determined the "potency ratio" of 4049, i.e., how much 4049 it took to kill the same number of insects as a known amount of parathion. These tests indicated that its potency against bugs was roughly one-third that of parathion.

The chemists were again back in the picture too — finding the best way of making the compound. Chemical reactions are touchy things. Making a compound in test tubes and on a production line are two different propositions.

Another group of chemists were working on other problems — formulation (how to make wettable powders, emulsions and dusts); compatibility (could 4049 be mixed with other commonly used spray materials); packaging (would 4049 react with metals, etc.).

Toxicologists were testing 4049 on warm blooded animals (mice, rats, guinea pigs, rabbits) to determine its potential hazard. Again these tests were run in direct comparison to already developed insecticides whose toxicity had been well established. Indications were that 4049 was much safer than parathion — maybe as much as 100 times as safe.

Arrangements were being made with state and federal entomologists to include 4049 in their field tests.

Finally, several months after 4049 was first synthesized, a small production line was set up in a miniature chemical plant (called a pilot plant) and the first few pounds of 4049 were actually manufactured.

Field Testing

As results began to come in from field tests, there was little doubt left that 4049 "had what it took" for a good insecticide. Its range of insect killing power was wide, almost as wide as parathion. It was safe on most plants and compatible with most other materials. At the same time, further toxicity tests continued to show that it had a low toxicity to warm blooded animals — roughly the same as DDT. This made the insect kill results doubly exciting, since this was the first phosphate material that was both effective and relatively safe to use. It was now time for 4049 to have a name of its own. The name chosen was malathon — later changed to malathion.

Many more months of both laboratory and field testing were to go into malathion before it was offered for sale. In order to obtain state and federal registration, data had to be presented showing not only its effectiveness against insects, but also its residual effects at given periods after application, presence or absence of off flavors in treated crops and whether or not it injured crops. This took time.

In fact it took almost three years from the time that malathion was first synthesized until the first pound was sold. Cost of this research? According to recent surveys, upwards of one million dollars goes into a modern insecticide *before any is sold.* With this kind of expense involved in putting a new insecticide on the market, the thorough evaluation described in this article is an absolute necessity.

The search for new insecticides goes on constantly, not only in the laboratories of American Cyanamid but in the laboratories of many other chemical companies as well. Not only does this careful testing of compounds protect the company involved, but at the same time it insures the consumer that before a new compound comes on the market it has behind it months and often years of careful evaluation. Poor insecticides just don't make the grade.

COOPERATIVE EFFORT INVOLVED IN FIELD OF TESTING NEW TOXICANTS

By Donald G. Denning

Velsicol Corporation

After a new toxicant is developed in the laboratory, as outlined by Art Jensen, and is ready for field testing, the next step is to have the Engineers build a Pilot Plant so enough material will be available. The ultimate object of field testing is to obtain recommendations and Federal registration so that the new toxicant can be sold to the public. No recommendation can be made until the data is backed by work of one or several approved research workers. No claims for insect control can appear on a label until it is cleared by the State Experiment Station, USDA and others. Practically all of this is accomplished by personal contact; the Entomological representative of the Company doing all the spade-work, before a product can be sold to the public.

In my case, for example, almost every recommendation for the use of Heptachlor in the Western States was made by personal contact with the research Entomologist. I contact USDA, PHS, Experiment Station workers and Entomologists with Industry, Extension personnel, State and County workers, independent consulting Entomologists and attempt to get them to carry on research work with our products, Chlordane, Heptachlor and Endrin. As Art Jensen has told you, we have a good idea on the kind of insect the new chemical is best suited for; something on dosage levels and something on toxicity. We adjust this information to the various field problems and try to fit the new chemical in the research program, especially if there is a chance for it to be competitive and if it looks better than existing products.

To get registration, a recommendation, label approval, etc., we have to secure flavor evaluation data, phytotoxicity data, time interval between applications, dosage level data, formulation data, effectiveness and residual control, residue data, toxicity data especially on pollinators and best method of application.

Our flavor data has to stand up under rigid, large panel tests such as those at the Food Technology Department at Corvallis, Oregon, or Davis, California. We set this up as a cooperative project between Entomology and Food Technology. Our phytotoxicity data is based on seed germination, seedlings, on growing plants. The tests are based on almost every crop grown at various dosage levels under laboratory, greenhouse and field conditions. Our ultimate recommendation is dependent upon what the residual control is, the degree of effectiveness and the amount of residue remaining. The past year or two, I have spent much time in obtaining residue data for Heptachlor; it would not be in 1956 recommendations had I not done so.

All of this and many more details go into the field development of our present day, and any new toxicant. Unless this is done, the toxicant would not be accepted. Because this is done, the toxicant is safe to use and can be used under the conditions stated on the label. As you can see, much time and effort goes into any new product before the public can ever purchase it.

An example of a large scale field testing program is that in which the California Bureau of Vector Control cooperated with a local Mosquito Abatement District and American Cyanamid in a test to determine the effectiveness of .5 Malathion per acre at Planata, California, in an area of resistant mosquitoes. Air samples were taken to determine how much Malathion got into homes after the entire town was treated. Effectiveness, degree of residual action, etc., were studied for 3 to 4 weeks.

Most of the existing organized Mosquito Abatement Districts have been very cooperative with us in field testing new insecticides. Several districts have continually been after formulations. Right now, some of our important field work on granular formulations is being done by districts in Utah and elsewhere. The Utah Districts have always been very cooperative in field testing and they have helped Velsicol and other companies work out problems on stability, correct formulations and methods of application.

COOPERATIVE EFFORTS OF THE SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT

By Glen C. Collett

Manager, Salt Lake City, Mosquito Abatement District

The elimination of mosquitoes is a complex problem which involves numerous agencies and individuals. It is, therefore, necessary that the personnel of the mosquito abatement district plan and cooperate with all those concerned to make mosquito control most effective.

In the very important field of cooperation the mosquito abatement districts are in an ideal position to assume leadership. In working with individuals, groups, or organized agencies, it is the responsibility of the districts to take the leadership in striving to reach a mutual agreement as to problems concerning mosquito elimination and its effect on other programs.

It has been the policy of the Salt Lake City Mosquito Abatement District since field operations began in 1925 to make individuals and the members of various agencies aware of mosquito problems and seek their aid and cooperation in an abatement program.

The first step taken, and one which has continued to the present, was an attempt to work with irrigation companies and water users in order to provide for proper disposal of their surplus water and thereby prevent mosquito production.

The history of the major drainage system in Salt Lake County is one which shows long range planning and cooperation. While constructed primarily for mosquito control, the drainage system has greatly improved property values in many sections of the county. During the late 1920's and early 1930's, recommendations were repeatedly made to Salt Lake City and Salt Lake County officials urging them to clean certain ditches to prevent flooding.

During the thirties mosquito abatement projects were carried out in many of the counties in the state with the aid of the W.P.A., C.W.A., and E.R.A. administration. In Salt Lake County the bulk of this work was carried on west and south of Salt Lake City and east of Murray. At this time 400 to 1,600 men were employed in extending and improving the drainage system of the county. This work was carried out in cooperation with City and County Commissions, with the Salt Lake City Mosquito Abatement District serving in a planning and supervisory capacity.

With the completion of the major drainage program with W.P.A. labor during 1937, the principal concern of the Board of Trustees of the district was the future maintenance of these drains. The following is a statement prepared by Dr. Don M. Rees contained in the 1937 Annual Report of the Salt Lake City Mosquito Abatement District which urges cooperative efforts; I quote:

> The future drainage program should provide for the repair, cleaning and upkeep of all drains now installed. This is the important problem confronting the administrators of the district, and immediate provisions should be made for this work while the drains are still functioning properly. The future maintenance of the mosquito abatement drainage system will require the expenditure of considerable funds each year, in fact more money than the Salt Lake City Mosquito Abatement District can possibly spend for this purpose under its present tax levy.
>
> The future maintenance of the drainage system should become a cooperative enterprise, financed by those benefited by the system. The drainage system while outlined primarily for mosquito control, has greatly improved property values in many sections of the county, and the removal of surface waters has aided in the construction and upkeep of roads and railroads. Mosquito control has encouraged and stimulated the building of homes west of the city in an area previously abandoned on account of the presence of pest mosquitoes during the summer months. Residents of Salt Lake County outside the city limits, the official boundary of the mosquito abatement district, are receiving these benefits from drainage and mosquito control work while the residents of Salt Lake City are assessed for all the local funds used in this work.

It was through the efforts of the Board of Trustees of the Salt Lake City district in 1949 that a cooperative agreement between the district and Salt Lake City and Salt Lake County was realized. Each now contributes $10,000 a year to a fund to be used for the maintenance and extension of the installed drainage system, the funds to be expended by a committee composed of representatives from each of these agencies. This cooperative effort has continued for the past six years with substantial direct benefits to all the agencies participating.

Although the Salt Lake City District functioned for twenty years as the only organized district in the state, numerous mosquito control projects were conducted in the state. In 1950 recommendations were made by the Zoology Department of the University of Utah that mosquito work in Salt Lake County should be expanded. The Salt Lake City Mosquito Abatement District Board of Trustees, before the organization of the Magna Mosquito Abatement District, succeeded in organizing Magna Mills, Arthur Mills, and the Garfield Improvement Company to put forth a united effort to eradicate the mosquitoes in that locality. The same year Davis County Commissioners agreed to take measures in preventing excessive flooding of land in that county.

With the development of mosquito control in Utah the past few years the Utah Mosquito Abatement Association created in 1948 has promoted better mosquito control in the state.

At the present time an agreement has been entered into with the University of Utah, United States Public Health Service, State Fish and Game Department, and the Salt Lake

City Mosquito Abatement District to make a study of two of the gun clubs in the area. A report on this will be given by Dr. Rees.

In order to assure cooperation among other agencies the mosquito abatement district must expend efforts to insure being included in the water policies which are being made in the various areas.

Numerous other agencies and individuals have cooperated with and assisted the Salt Lake City mosquito abatement program each year since its inception. Some of the principal contributors have been South Salt Lake County, Magna and Davis County Mosquito Abatement Districts; Utah State Road Commission; gun clubs; irrigation companies; railroads; industrial companies; and numerous property owners. The assistance given by these agencies have materially aided the control of mosquitoes by the Salt Lake City District.

OBSERVATIONS ON THE OVERWINTERING OF *CULEX TARSALIS* IN NORTHERN UTAH[1]

RICHARD P. DOW, G. ALLEN MAIL, and C. S. RICHARDS[2]

It is commonly stated that *Culex tarsalis* Coq. hibernates as an adult female, but there are only a few observations on overwintering populations in the northern part of its range (Keener 1952, Smith 1955). In order to study the winter behavior of this mosquito and the factors which determine the end of hibernation in the spring, routine observations were made in 1954-55 in two abandoned mines in northern Utah. One mine was located near Providence, Cache County, and the other, near Farmington in Davis County. The study produced unexpected results in that the *C. tarsalis* in these mines did not appear to represent a successful overwintering population. The data obtained, however, are presented at this time because of their possible use to others working on the same problems.

Observations at Providence. The mine near Providence, Utah, is located about 800 feet above the floor of Cache Valley at an elevation of about 5300 feet. It consists of two connecting chambers followed by a long, narrow tunnel. The outer chamber is constricted at the entrance of the mine and narrows where it joins the inner chamber. The floor of each chamber measures about 5 by 10 feet. The tunnel, 75 feet long, 5 feet wide, and about 5½ feet high, opens off a dark, low corner of the inner chamber.

To obtain information on the activity of the mosquitoes within the mine, especially at the end of hibernation, the outer chamber was so equipped with wire screening and baffles that it would trap any specimens moving toward the entrance. First, the opening of the mine was screened and provided with a small door, and then a partition was constructed between the outer and inner chambers. Besides a doorway, this partition consisted mostly of two vertical rows of pyramidal baffles made of wire screening. The baffles of one row were directed into the outer chamber and allowed free passage to mosquitoes moving in that direction. In the other row they were directed into the inner chamber but were inclosed in screened cages which would catch any mosquitoes moving back into the mine. Double curtains of unbleached cotton cloth which were hung in the doorway of this partition and also in front of the outer screen door permitted the observers to pass through the outer chamber without danger of taking any mosquitoes with them. The walls and ceiling of the outer chamber were painted white so that all mosquitoes trapped there might be seen more easily.

At the entrance of the tunnel there was a demonstrable exchange of air, colder air entering at the bottom and warmer air leaving at the top, but in spite of this circulation, the air temperature a foot above the ground and 25 feet from the end of the tunnel varied only 5° F. (43–48°) from January 13 to April 13. Even in the outer chamber just a few feet from the screened entrance, the air temperature ranged only 23° F. (28–51°) during the same period.

When the mine was first visited on October 14, 1954, approximately 25 *C. tarsalis* were seen, also a few *Anopheles freeborni* Aitken. On January 17 and 19, after the baffles were in place, the maximum count of *C. tarsalis* was 4, and of *A. freeborni,* 7. Because of the small number of *C. tarsalis,* it was decided to introduce more specimens, but only 2 females were ever found. These were collected on January 26 in another mine on the same hillside and were transferred immediately to the study mine. It happened that 5 female *C. tarsalis* had been counted in the outer chamber the same morning and so the maximum number of *C. tarsalis* known to have been under observation was 7. In looking for additional *C. tarsalis,* 67 female *A. freeborni* were found in mines and fruit cellars, and 47 of these specimens (3 torpid, the rest apparently in good condition) were released in the study mine from January 26 to February 8. Including the 7 specimens of *A. freeborni* counted on January 19, the known maximum under observation was 54.

In late December and early January, while the mine was being prepared for study, a few mosquitoes had been observed near the entrance. Less than a week after the partition between the two chambers was completed on January 13, females of *C. tarsalis* began to appear in the outer chamber. These specimens and all other mosquitoes caught there were subsequently released either in the inner chamber (up to January 21) or at the far end of the tunnel. The factor or factors that caused the movement into the outer chamber are unknown, but the numbers of mosquitoes collected there appear to serve as a measure of activity within the mine. *C. tarsalis* was the only species of mosquito found in the outer chamber for over two weeks (table 1). When *A. freeborni* did appear, the total number of captures was much smaller. *C. tarsalis,* with a maximum count of 7, was observed in the outer chamber 34 times, but *A. freeborni* with a maximum count of 54 was observed there only 20 times. Disproportionate rates of activity are thus indicated for the

[1] A contribution from the Technology Branch, Communicable Disease Center, Public Health Service, U.S. Department of Health, Education, and Welfare, Logan, Utah.

[2] Scientist, Medical Entomologist, and Scientist (R), respectively, Logan Field Station Section, Logan, Utah.

TABLE 1. NUMBER OF MOSQUITOES FOUND WEEKLY IN OUTER CHAMBER OF PROVIDENCE MINE

Week ending	Number of inspections	*Culex tarsalis**		*Anopheles freeborni**	
January 22	4	3	(3)	0	(0)
January 29	3	10	(13)	0	(0)
February 5	3	4	(17)	2	(2)
February 12	3	4	(21)	0	(2)
February 19	3	6	(27)	3	(5)
February 26	3	0	(27)	2	(7)
March 5	3	4	(31)	6	(13)
March 12	3	1	(32)	5	(18)
March 19	3	1	(33)	1	(19)
March 26	3	0	(33)	0	(19)
April 2	1	1	(34)	0	(19)
April 9	1	0	(34)	1	(20)
April 16	1	0	(34)	0	(20)

* The numbers in parentheses represent the cumulative totals.

two species even if one assumes that all of the introduced mosquitoes had promptly died. As a matter of fact, March 4 was the last day 2 *C. tarsalis* were seen and March 9, the last day for 2 *A. freeborni*. The last *C. tarsalis* was seen on March 30 and except for one dead *A. freeborni* found in a spider web on May 11, the last specimen of this species was seen on April 6.

Upon analysis, the activity of *C. tarsalis*, as indicated by the numbers trapped in the outer chamber, is found to be correlated with the temperature and the relative humidity, at least during the first half of the observations (table 2). The temperature readings used for the analysis were those made by a hygrothermograph in the outer chamber. Another hygrothermograph in the tunnel showed similar fluctuations but the changes were very slight and very gradual. With regard to relative humidity, which followed very similar trends at both ends of the mine, the record of the tunnel hygrothermograph was chosen because, having lower humidities to measure, it operated more accurately.

To learn if *C. tarsalis* would feed on blood during the winter, one to three roosters were kept in a cage in the outer chamber from January 13 to March 30. Of all the mosquitoes caught there, none was ever found engorged. Perhaps this was due to the low temperatures of the outer chamber, where the maximum during this period exceeded 50° F. only twice.

TABLE 2. ACTIVITY OF *Culex tarsalis* IN RELATION TO TEMPERATURE AND RELATIVE HUMIDITY, PROVIDENCE MINE

No. of *C. tarsalis* in outer chamber	January 13 to February 18: No. of obs.	Av. max. temp. (°F.) in outer chamber*	Av. max. rel. hum. (per cent) in tunnel*	February 21 to April 13: No. of obs.	Av. max. temp. (°F.) in outer chamber*	Av. max. rel. hum. (per cent) in tunnel*
0	4	39.5	67.8	12	45.2	73.6
1	8	40.6	74.1	5	46.8	78.6
2	2	40.0	76.0	1	50.0	71.0
3	2	42.0	75.5	0	——	——
4	1	42.0	83.0	0	——	——
5	1	44.0	82.0	0	——	——

* Since previous inspection.

Observations at Farmington. On December 21, 1954, the second abandoned mine was found to harbor 98 *C. tarsalis*, 143 *Culex pipiens* L., and 10 *A. freeborni*. It was inspected routinely because it offered an unusual opportunity to observe winter populations of these species, two of which seemed to occur at characteristic depths. The mine consists of a single, straight, horizontal tunnel, 250 feet long, which enters the slope on the north side of Farmington Canyon. Diffused light penetrates the whole length of the mine but, because the south side of the canyon is quite high, direct sunlight never extends more than a few feet beyond the entrance. This mine was much damper than the one near Providence and often contained puddles of water. At every inspection, the mosquitoes were identified when and where they were found. There were no baffles or curtains to interfere with their movement.

Throughout January and February the air temperatures of the mine tunnel increased rapidly in the first 50 feet from the entrance and then more gradually to the far end. In spite of wide fluctuations at the entrance, the air temperature at waist height at the far end of the tunnel varied only 3 degrees (55–58° F.) from January 6 to March 28. Even at a depth of 100 feet, it varied only 6 degrees (46–52° F.) in the same period. Thus, the air temperature in the tunnel is influenced more strongly by that of the surrounding rock than by that of air coming from the outside.

C. tarsalis and *C. pipiens* occurred in distinctive zones along the tunnel. The mode of distribution for *C. tarsalis* occurred first in the section 100 to 150 feet from the entrance and then, retrogressing only once, moved closer to the entrance at each successive inspection. *C. pipiens* showed less change in its distribution. Until February it remained mostly at a depth greater than 150 feet. It then began to occur also in the section 50 to 100 feet from the entrance, and finally was fairly evenly spread the whole length of the tunnel.

To study the relation of these distribution patterns to air temperature, a mean temperature of occurrence was calculated by averaging the temperatures taken at each end of the zone in which each mosquito was counted (table 3). Similarly, a mean depth of occurrence was computed by averaging the depths of each end of the zone in which each mosquito was counted. From these figures, it is clear that *C. tarsalis* chose, as it were, a much lower temperature than *C. pipiens* or *A. freeborni*. Moreover, there was little or no change in these "preferred" temperatures during the season. This fact is particularly interesting with respect to *C. tarsalis* because an examination of the temperature curves shows that 47° F. occurred in a zone which moved progressively toward the entrance. Finally, in March, when only 2 *C. tarsalis* were counted, no temperature lower than 48° F. was recorded in the mine. When this information is considered in relation to the average depth of occurrence, it appears

TABLE 3. DISTRIBUTION OF MOSQUITOES ACCORDING TO DEPTH AND AIR TEMPERATURE, FARMINGTON MINE

Dates	Av. temp. (°F.) at entrance	*Culex tarsalis* Total no.	*Culex tarsalis* Av. depth*	*Culex tarsalis* Av. temp.**	*Culex pipiens* Total no.	*Culex pipiens* Av. depth*	*Culex pipiens* Av. temp.**	*Anopheles freeborni* Total no.	*Anopheles freeborni* Av. depth*	*Anopheles freeborni* Av. temp.**
January 6, 13	29	88	101	46.5	248	184	52.5	16	168	51.4
January 21, 28	32	52	63	46.5	198	186	53.2	12	112	48.5
February 4, 8	38	18	66	47.2	169	151	52.1	11	121	50.9
February 17, March 1	52	8	45	48.2	102	138	51.6	4	115	53.5
March 10, 28	54	0	—	—	40	90	51.8	5	89	52.8

* Average depth in feet of zones where specimens were counted (based on mean depth of zone in which each specimen was found).
** Average temperature in °F. of zones where specimens were counted (based on mean of temperatures taken at waist height at each end of zone).

that increasing outdoor temperatures might have so increased the temperatures in the tunnel that *C. tarsalis* was "forced" out of its shelter.

Although *C. pipiens* disappeared very abruptly from the mine during a period when the temperature near the town of Farmington varied from 14 to 60° F., and the last *C. tarsalis* left when the temperature ranged from 12 to 55° F., the numbers of both species had been diminishing since the first complete inspection of the mine on December 21 (figure 1). A point of great interest, however, is the more rapid disappearance of *C. tarsalis* which decreased by 50 per cent about every 2 weeks. *C. pipiens* disappeared very gradually and took 6 or 7 weeks to decrease once by 50 per cent. *A. freeborni* seemed to diminish like *C. pipiens* but this comparison is not reliable because the initial count of *A. freeborni* was only 10.

DISCUSSION

In the observations made by Keener (1952) in western Nebraska, *C. tarsalis* was found during the winter in several food storage cellars. Although periodic observations were

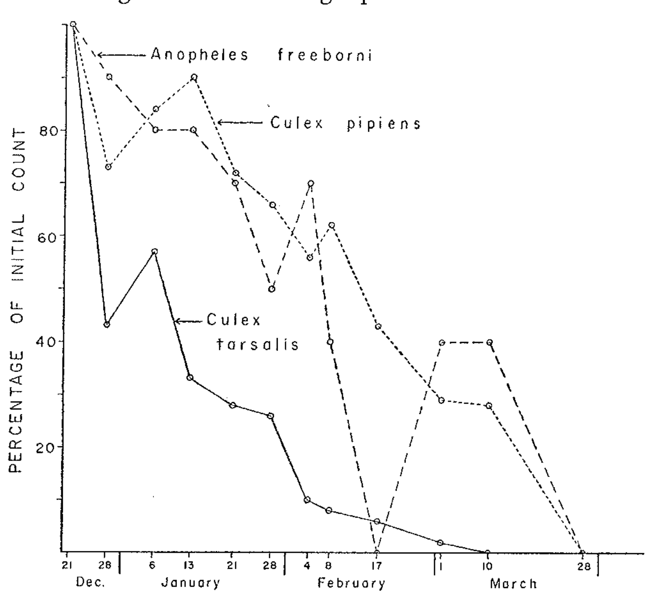

FIGURE 1. Population counts of three mosquito species in Farmington mine. Successive counts are shown as percentages of the numbers observed during the first complete inspection on December 21, 1954. The mine then contained 98 *Culex tarsalis*, 143 *Culex pipiens*, and 10 *Anopheles freeborni*.

made in 2 cellars near Minatare, the figures cannot be taken as successive population counts because, up to March 1, specimens were caught and put in cages. It is interesting to note, however, that although 8 *C. tarsalis* were counted the week ending March 17, no more than one *C. tarsalis* was found in any week in April.

In unpublished observations made by Smith (1955) at Chinook, Montana, 3 outdoor fruit storage cellars were observed weekly throughout the winter. In 2 which were left open, the maximum counts of *C. tarsalis* were 18 and 21, and after January 3 no more specimens were seen until the end of April. In the third storage cellar, which was kept closed all winter, the maximum count of *C. tarsalis* was 25, 3 specimens were observed 6 times from December 27 to February 21, and none was found thereafter until May 6. The following remarks are quoted from Mr. Smith's report: "In general, fewer mosquitoes were recorded each week until January 17, at which time no *C. tarsalis* were found in the general interior of the cellars. Cracks between the ceiling boards allowed access to numerous holes in the straw and earth cover over the cellars. As the winter progressed, the mosquitoes were observed to enter these holes to depths of 3 to 18 inches."

In attempting to evaluate the various studies on the overwintering of *C. tarsalis* it is necessary to bear in mind that in spite of strong evidence that it is fertilized females which successfully outlast the winter, there is no satisfactory information on where this population exists.

If it is assumed that mines or other deep holes serve as the winter habitats, then the population will apparently be subject to a very high mortality, presumably because of activity stimulated by the air warmed by the earth's crust. The data from the Providence mine are not convincing because of the small population of mosquitoes and the dryness of the shelter, but these objections do not apply to the Farmington mine where the activity was equally great and the mortality was, apparently, equally high.

The question of mortality must be approached with care because the observed decrease in population counts can be explained in at least two other ways. First, there is the possibility that many *C. tarsalis* creep into places where they cannot be counted. What Smith observed in storage cellars was not found in the mines in Utah. Cracks with any patent air space are practically absent in the Farmington mine, and furthermore, no tendency to rest in crevices was noted by any of the observers.

The second way in which mine populations can diminish without excessive mortality is by dispersal to the outdoors and failure to return to the same shelter. This argument is not readily acceptable because it is difficult for man to understand why mosquitoes should leave a winter shelter before conditions became favorable for breeding outside. Nevertheless, the last *C. tarsalis* disappeared from the Farmington mine in a period when the outdoor temperature ranged from 12 to 55° F., and if overwintering females can survive these conditions, possibly they can endure others more severe.

If these explanations of the apparent mortality do not apply, and if undue activity caused by unusual warmth is the principal obstacle to successful overwintering in mines, then a colder type of shelter would seem to be more favorable. *C. tarsalis,* regardless of its physiologic state during the coldest weather, must need energy for the late fall and early spring. If the source of this energy is food stored in the body and if this supply must last through the winter, the species should survive best in natural shelters where it would be inactivated by cold, and not trapped by heat, as in mines.

Summary

During the winter of 1954-55, observations were made on the behavior of mosquitoes in 2 abandoned mines in northern Utah. *Culex tarsalis,* represented by females only, was found to be active in both mines at temperatures below 50° F. and in the second mine seemed to favor resting sites with an average air temperature of about 47° F. In the first mine, its activity, as measured by the numbers which were trapped in a chamber at the entrance, was correlated with higher air temperature and higher relative humidity. It was more active than *A. freeborni* under the same conditions. Toward the end of the winter, the numbers of *C. tarsalis* diminished to zero in both mines, possibly because of high mortality resulting from the relatively high temperatures. In the second mine, the mosquito disappeared at a time when the coolest zone near the entrance had become warmer than the "preferred" temperature.

If *Culex tarsalis* overwinters successfully in mine tunnels, it survives in spite of excessively high mortality. It seems more likely that the normal winter habitat is still unknown.

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TESTS OF RESIDUAL LARVICIDING FOR MOSQUITO CONTROL

J. V. Smith and G. R. Shultz[1]

During the summer of 1955, field tests were made in the Milk River Valley in northern Montana to determine the effectiveness of residual larviciding with chlorinated hydrocarbons for controlling mosquito production in major habitats associated with irrigation.

Detailed studies made in 1952 and 1953 at Chinook showed that the chief sources of mosquitoes were: depressions, irrigation laterals, and drains on bluejoint meadows, pastures, and alfalfa fields; depressions on wasteland areas; roadside ditches; abandoned irrigation laterals; and sloughs. These habitats produced large numbers of *Culex tarsalis,* the common encephalitis mosquito, and various *Aedes* species such as *A. dorsalis, A. idahoensis, A. nigromaculis,* and *A. vexans.*

In May and June, plots located in typical mosquito producing areas near Chinook were given preflood and postflood residual larviciding treatments with water emulsions and granular formulations of dieldrin and heptachlor. The plots which ranged in size from 0.1 to 3.7 acres were selected on the basis of mosquito production during previous years. For preflood treatments, dieldrin and heptachlor emulsions were applied to depressions on bluejoint meadows, and granular dieldrin to depressions on irrigated pastures and to an abandoned irrigation lateral. For postflood treatments, granular dieldrin was applied to depressions on irrigated pastures, to roadside ditches, and to a slough; granular heptachlor was applied to depressions on wasteland.

The finished dieldrin emulsion (0.6 per cent) was formulated from a 15 per cent dieldrin emulsifiable concentrate and applied with a 3-gallon compression hand sprayer equipped with an 8002 "teejet" nozzle. With the operator holding the nozzle approximately 2 feet above the ground and walking at about 2 mph, the finished spray was applied at the rate of about 26 gallons per acre using an average pressure of 30 p.s.i. The finished heptachlor emulsion (0.5 per cent) was formulated from a 23.4 per cent heptachlor emulsifiable concentrate and applied with a boom-type power sprayer mounted on the rear of a pickup truck. The spray boom, which covered a swath 8 feet wide, was equipped with five 8004 "teejet" nozzles spaced 20 inches apart and was adjusted so that the discharge tips of the nozzles were about 18 inches above the ground. With the pickup traveling at 5 mph, the finished spray was applied at the rate of about 24 gallons per acre using a nozzle pressure of 40 p.s.i. The discharge rates of the finished sprays were sufficiently high to assure good coverage of the ground surface and of vegetation. The granular dieldrin (10 per cent) and the granular heptachlor (5 per cent) were broadcast with a crank-type hand seeder at rates of 10 pounds and 30 pounds per acre, respectively. Plots treated by this method were staked off to aid the operator in obtaining

[1] S. A. Sanitarian and Sanitary Engineer, respectively, Logan Field Station Section, Technology Branch, Communicable Disease Center, U.S. Public Health Service.

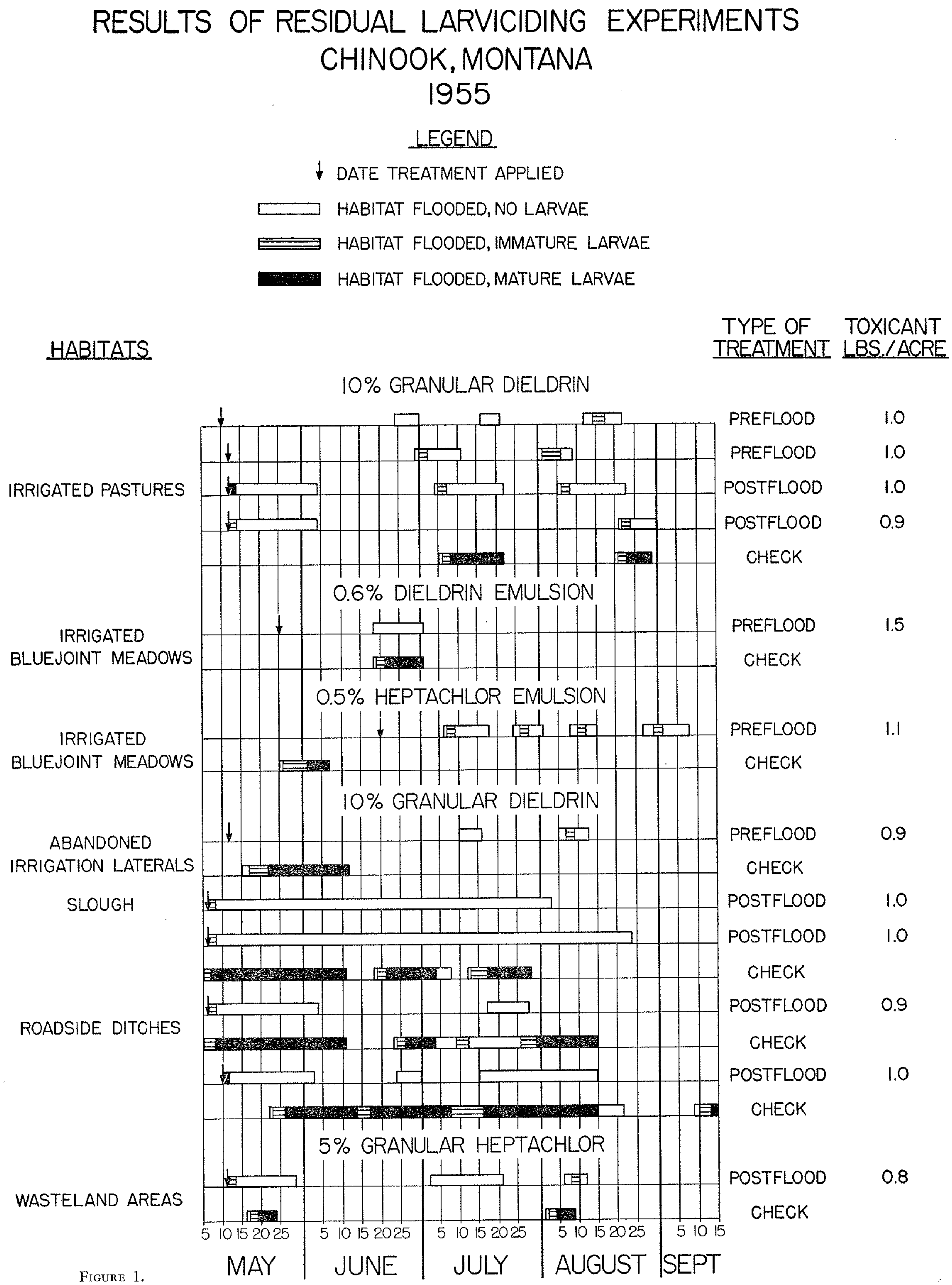
RESULTS OF RESIDUAL LARVICIDING EXPERIMENTS
CHINOOK, MONTANA
1955
LEGEND
DATE TREATMENT APPLIED
HABITAT FLOODED, NO LARVAE
HABITAT FLOODED, IMMATURE LARVAE
HABITAT FLOODED, MATURE LARVAE
HABITATS
TYPE OF TREATMENT
TOXICANT LBS./ACRE
10% GRANULAR DIELDRIN
IRRIGATED PASTURES
PREFLOOD 1.0
PREFLOOD 1.0
POSTFLOOD 1.0
POSTFLOOD 0.9
CHECK
0.6% DIELDRIN EMULSION
IRRIGATED BLUEJOINT MEADOWS
PREFLOOD 1.5
CHECK
0.5% HEPTACHLOR EMULSION
IRRIGATED BLUEJOINT MEADOWS
PREFLOOD 1.1
CHECK
10% GRANULAR DIELDRIN
ABANDONED IRRIGATION LATERALS
PREFLOOD 0.9
CHECK
SLOUGH
POSTFLOOD 1.0
POSTFLOOD 1.0
CHECK
ROADSIDE DITCHES
POSTFLOOD 0.9
CHECK
POSTFLOOD 1.0
CHECK
5% GRANULAR HEPTACHLOR
WASTELAND AREAS
POSTFLOOD 0.8
CHECK
5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15
MAY JUNE JULY AUGUST SEPT

FIGURE 1.

uniform distribution of the granular materials. Actual rates of application on each plot (amount of toxicant used to number of acres treated) varied from 0.9 to 1.5 lbs./acre for dieldrin granules and emulsions and from 0.8 to 1.1 lbs./acre for heptachlor granules and emulsions (see figure 1).

The entire area below the expected high-water line was treated on plots in roadside ditches, the abandoned irrigation lateral, and the slough. Most of these plots were subject to inflow and outflow at the higher water levels. For the plots on irrigated pastures, bluejoint meadows, and wasteland, the lowest areas where ponded water most likely would occur were treated.

At the time of treatment, dead vegetation from the previous season was present and new growths were just beginning to appear on the plots. The predominant plants on treated plots in irrigated pastures and bluejoint meadows were foxtail (*Hordeum jubatum*), sedges (*Carex* sp.), wire rush (*Eleocharis leptos*), and sour dock (*Rumex venosus*). In the roadside ditch plots, cattail (*Typha* sp.) and Western wheatgrass (*Agropyron smithii*) were the dominant species. Cattail (*Typha* sp.) and bulrush (*Scirpus* sp.) were the principal plants on the slough and wasteland plots. Willow (*Salix* sp.) and Western wheatgrass (*A. smithii*) predominated on the abandoned irrigation lateral plot.

Both the treated and the untreated check plots were sampled for mosquito larvae throughout the season in order to evaluate the effectiveness and duration of the various treatments. Where flooding was intermittent, the plots were sampled daily for larvae until the water disappeared; where it was semipermanent and permanent, the plots were sampled on a weekly basis. A pint-size, white enamel dipper was used in sampling for larvae along permanent transects on each plot. When mature larvae were present, samples were collected for identification. The average number of larvae per dip was based only on the sampling in areas which appeared to be suitable for mosquito breeding.

An evaluation of the species composition of mature larvae collected from all check plots indicated that *A. dorsalis* and *A. vexans* were the principal species on most of the checks, making up 85 per cent of the total specimens collected during the season. Other species which were found in significant numbers on untreated check plots included *Aedes spencerii* (6 per cent) and *A. nigromaculis* (3 per cent).

The plots that received preflood residual larviciding treatments were flooded from 1 to 4 times during the season. Each of these floodings resulted in conditions which appeared to be favorable for mosquito breeding. All of the plots that were flooded at the time of treatment (postflood) already contained larvae; and on one of the plots, a few pupae were present. Subsequent sampling showed that the larvae were killed but that some of the pupae survived. Although first and second instar larvae were often noted on the treated plots, no mature larvae were found on either of the preflood or postflood plots during the entire season. Mature larvae and pupae were found on the untreated check plots throughout the season, about three-fourths of the total inspections being positive. The weekly average number of mature larvae and pupae per dip for the various check plots ranged from 0 to 91, with an average for the season of about 4. The results of the studies are summarized graphically in the accompanying figure. The results of these studies indicate that all preflood and postflood residual larviciding treatments were completely effective in preventing mosquito production for an entire season in habitats associated with irrigation.

Similar experiments with DDT and dieldrin were carried out during 1955 on the irrigated Southern High Plains in the vicinity of Plainview, Texas. These experiments showed that preflood larviciding treatments in playas and roadside ditches were effective during the first floodings which occurred 4 to 5 weeks after the treatments were applied. Unusually heavy rains in May and June completely inundated all plots in playas and associated roadside ditches and made further evaluations impossible.

Summary

Preflood and postflood residual larviciding applications of dieldrin granules and emulsions at 0.9 to 1.5 pounds of toxicant per acre, and of heptachlor granules and emulsions at 0.8 to 1.1 pounds of toxicant per acre gave effective control of irrigation mosquitoes (mostly *A. dorsalis* and *A. vexans*) for an entire season in experimental plots located near Chinook, Montana.

BARRIER ZONE SPRAYING FOR MOSQUITO CONTROL ON INDIVIDUAL FARMSTEADS

G. Allen Mail

Medical Entomologist[1]

Barrier zone spraying of individual premises has been found to be an effective means of protection against several species of mosquitoes. In the southeast coastal region of the United States, outdoor residual spraying of premises with DDT at the rate of 5 to 10 pounds per acre has prevented daytime biting of salt marsh mosquitoes (*Aedes taeniorhynchus and A. sollicitans*) for periods of 4 to 9 weeks; dieldrin and BHC proved to be relatively ineffective (Bidlingmayer and Schoof 1956). In the Pacific Northwest, DDT sprays applied to foliage and shrubbery around picnic grounds gave protection from the annoyance of pest mosquitoes (mostly *Aedes*) for a period of 10 days or more (Yates, Lindquist, and Mote 1951). In the Cascade Mountain area of Oregon applications of 2 to 3 pounds of DDT per acre gave good control against daytime biting mountain *Aedes* for from 10 to 45 days. Lindane at the rate of 1½ pounds per acre gave about the same control as 2 pounds of DDT (Hoffman and Lindquist 1952). The tests in both the southeast coastal region and in the Cascade Mountain area of the United States gave daytime control only, but little or no control against nighttime biting. In the Missis-

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sippi Delta region, airplane applications of a DDT spray over a barrier zone was ineffective in protecting a small town from ricefield mosquitoes, *Psorophora confinnis,* and *P. discolor* (Quarterman, Jensen, Mathis, and Smith 1955).

In the present investigation, an attempt was made to determine whether barrier zone spraying with DDT or dieldrin would protect residents of rural dwellings after sunset from attack by *Culex tarsalis,* the primary vector of encephalitis in the Western States.

Two pairs of adjacent farmsteads were selected in an irrigated area within Cache Valley where there was a high population of *C. tarsalis.* One farmstead of each pair was treated while the other served as an untreated check. One pair of farmsteads was located on the same side of a highway with not more than a quarter of a mile separating the farm buildings. The other two farmsteads were across the highway from each other about 200 yards apart.

Biting rates were used for pre-spray and post-spray evaluations of mosquito density. Beginning at mid-June, weekly mosquito biting collections on human hosts (actually landing-rate collections) were made on each of the farmsteads. Observations on the man-biting habits of this species have shown that at the latitude of Cache Valley the peak of feeding occurs during the fourth 15-minute period after sunset (Beadle 1955). Accordingly, in order to determine when the *C. tarsalis* population was approaching its seasonal peak, which would be the most advantageous time to spray the farmsteads, biting collections were made from the third to sixth periods after sunset. In all cases, collections were made near the farm dwelling and in close proximity to

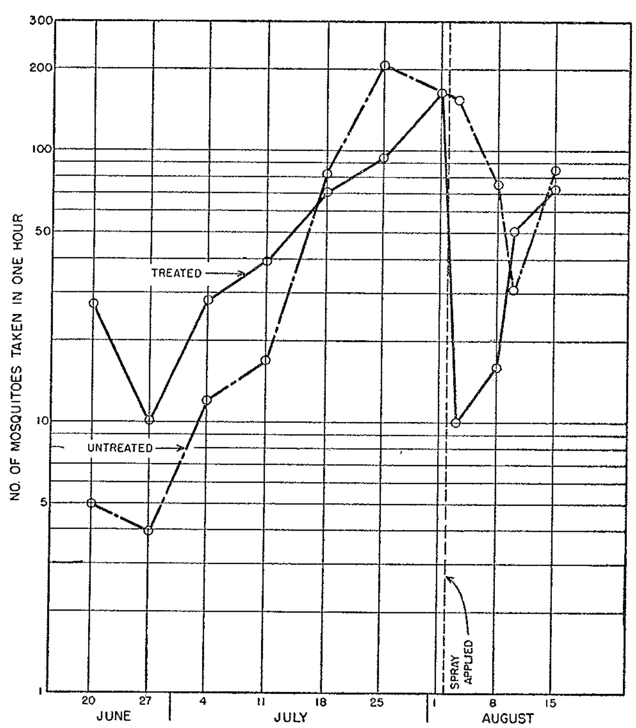

FIGURE 1. Number of *Culex tarsalis* in biting collections (on human host) on farmstead with DDT Barrier-Zone Residual Spraying and untreated check farmstead

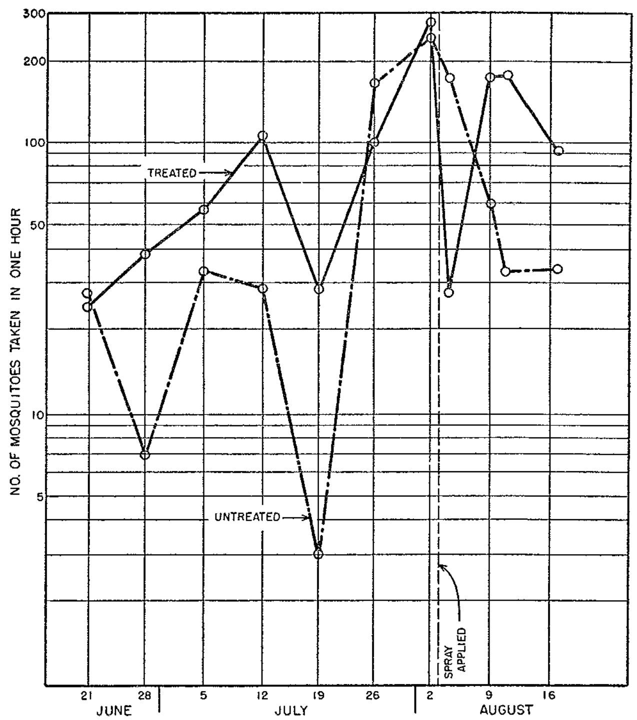

FIGURE 2. Number of *Culex tarsalis* in biting collections (on human host) on farmstead with Dieldrin Barrier-Zone Residual Spraying and untreated check farmstead

shrubbery. With the exception of nine collections made in June, all the collections were made by the same two individuals who evaluated the same premises during the entire course of the experiment.

During the pretreatment period, June 20 to August 2, a total of 2,919 mosquitoes was taken in 28 biting collections on the four farmsteads. *C. tarsalis* constituted 71 per cent of the total specimens. By late July, collections indicated that the *C. tarsalis* population was reaching its peak. On August 2, one of the farmsteads was sprayed with 125 gallons of 5 per cent DDT water suspension. On August 3, a farmstead in the second pair was treated similarly with 125 gallons of 2.5 per cent dieldrin water suspension. The spray was applied at a pressure of 100 p.s.i. by a power sprayer equipped with an orchard-type gun. All potential resting places for mosquitoes were treated on both farmsteads. At the farmstead where DDT was applied, the vegetation, trees, and buildings were concentrated in an area approximately 250 by 200 feet surrounding the dwelling. At the dieldrin treated farmstead, the buildings and shrubbery were scattered over an area of approximately 200 by 800 feet, although the surface area sprayed was about the same. All vegetation on each farmstead such as shrubbery, trees, weeds, corn, berry patch, and flowers was well covered. In addition, the eaves of all buildings, the porches of the dwellings, the inside of the garages, calfsheds, cowbarns, pigpens, and chicken houses were thoroughly sprayed. Wettable powder formulations were used in preference to xylene emulsions in order to avoid the hazard of injury to vegetation.

Biting collections were continued at both treated and check farmsteads on the 1st, 5th, 7th, and 12th nights after spraying; by this time, it was evident that the treatment had ceased to have any effect. The results are shown in figures 1 and 2. The DDT treatment apparently was effective for 5 or 6 days and the dieldrin treatment for less than 5 days. This relative ineffectiveness of dieldrin as a barrier zone spray is similar to the results obtained with salt marsh mosquitoes.

Post-treatment declines in the untreated checks lessened the significance of the results, but the fact that the DDT check remained high immediately after spraying whereas the treated farmstead dropped abruptly makes it fairly conclusive that the spray did greatly reduce biting rates for a short period. The protection period under the test conditions was too short to make the barrier zone method of any practical value in protecting farm personnel against *C. tarsalis.*

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RESISTANCE STUDIES WITH *CULEX TARSALIS* COQ.

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Abstract

The development of insecticide resistance in mosquitoes is reviewed. As early as 1949 salt-marsh mosquitoes showed considerable resistance to DDT in Florida and reports by 1955 indicated poor or unsatisfactory control with materials such as DDT, BHC, and dieldrin. Resistance of mosquitoes was also reported in Arkansas and Mississippi. Published data showed *Culex tarsalis* in California to be highly resistant to DDT by 1950 and at the present time the use of chlorinated hydrocarbon insecticides against this species has been all but abandoned.

In laboratory studies *tarsalis* larvae reared from females collected in California were shown to be approximately 40 times as resistant to DDT as a laboratory colony, and crosses between these groups were intermediate in resistance. No mosquito resistance problem has been found or reported in Oregon.[1]

NOTES ON LOG POND MOSQUITOES AND THEIR CONTROL IN WESTERN OREGON

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Abstract

A marked increase in breeding situations has evolved in western Oregon as a result of the increased number of log ponds required in the expansion of the lumber industry. Predominating species appear to be *Culex tarsalis* Coq., *Culex stigmatosoma* Dyar, and *Culiseta incidens* (Thompson). Lesser number of *Culex pipiens* (L), *Culex territans* (Walk.) and *Anopheles punctipennis* (Say) are also found.

Results of larval control tests using DDT indicate a high initial reduction of larvae with DDT emulsions at rates of 0.04 to 0.2 p.p.m. and practical control through approximately 30 days at rates of 0.1 and 0.2 p.p.m. Wettable powders of DDT were less effective than emulsions. Surface oils gave good initial mortalities but did not result in extended control.

On a surface application basis, complete control of larvae was obtained with emulsions of DDT or EPN at rates as low as 0.25 pound per acre, but rates of approximately 1 pound per acre were necessary for extended control.

Field results with EPN did not appear to be as effective as expected. Therefore, laboratory tests comparing the effectiveness of EPN and DDT relative to the effect of suspended matter and temperature on the toxicities were tried. The results demonstrated a negative temperature coefficient for DDT and a neutral to slight positive coefficient for EPN. Also, there was a reduction of toxicity in pond water as compared to tap water, probably as a result of the quantity of suspended matter in the former.

MIST BLOWERS CUSTOM MADE FOR MOSQUITO CONTROL

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During the past two years, a considerable number of new mist blowers have been built completely, or adapted from commercial models in order to meet the specific needs of

[1] Since this presentation, Dr. Eddy has informed us that DDT resistance in *Culex tarsalis* larvae reared from log pond specimens brought to the laboratory by Eugene, Oregon Vector Control workers was shown to be greater than in the California strain.

several of the mosquito control agencies in California for efficient, low-cost machines for the application of larvicides and adulticides.

The specific advantages of the mist-blower type of spray machine were recognized long ago by some mosquito workers, but most of the commercially produced machines had been developed for agricultural pest control, and did not satisfy the requirements of mosquito control as it is practiced in California. More than seven years ago, Mr. Ernest Campbell, then manager of the Northern San Joaquin Abatement District, built the first of a number of custom-made mist blowers, permanently mounted on the back of a jeep for one-man operation, and known locally as the "wind wagon."

Various modifications in the original basic design have been incorporated in similar machines built more recently by the same District (now managed by Mr. Robert Peters), by the Diablo Valley district (presently managed by Mr. Campbell), and by the San Joaquin, the Merced, the East Side, the Marin, and the Shasta Mosquito Abatement Districts. Commercially built machines have also been adapted for mosquito control use by the Alameda, South East, Orange County, and Merced Mosquito Abatement Districts.

During October and November of 1955, seven machines, fairly representing all of the modifications that had been incorporated in the various units, were submitted for critical analysis in a testing program organized by the Bureau of Vector Control, with the cooperation of the various organizations which had built the machines. Some of the significant findings were as follows:

(a) The best particle size spectra for adulticiding were produced by machines which used a number of small nozzles, set outside the throat or "discharge cannon" of the blower rather than inside.

(b) A superior particle size spectra for larviciding was produced by the machines which employed a smaller number of larger sized nozzles, similarly located.

(c) The particle spectrum was impaired when the nozzles were placed within the "discharge cannon," or where impingement of the spray particles against any part of the machine could occur.

(d) The velocity of the air blast produced by the various machines ranged from about 60 mph to 120 mph, measured at the discharge orifice, but little advantage could be attributed to the higher velocities, for at distances of 50 feet or more from the machines, the differences in velocity of the air column were hardly significant. The tests appeared to indicate that horsepower might be wasted in attempting to develop the higher discharge velocities, and that the most efficient use of the available power occurred in the machines which produced discharge rates of slightly more than 60 mph, through relatively large diameter discharge "cannons."

Conclusions

The developments so far accomplished have produced very effective mist blowers for both larviciding and adulticiding. Other machines presently under construction will utilize somewhat larger and more efficient blowers, in an effort to still further reduce the horsepower requirements. At least one District has equipped each of its operator's jeeps with a mist-blower, and it appears likely that many more machines of this type will be in service in California in the future.

It is perhaps appropriate to report at this time that Mr. Ted G. Raley, and his associates at the Consolidated Mosquito Abatement District, have made a great improvement in the California Thermal Exhaust Generator, by substituting a venturi fog head for the original "plumbers nightmare" fog unit. The resultant adulticiding particle spectrum is nearly ideal, with a mass median diameter of 30 to 40 microns, when operated at 700 degrees Fahrenheit and 12 g.p.h.

REPORT FROM CALIFORNIA

By G. Edwin Washburn

Manager Turlock MAD

Secretary-Treasurer, California Mosquito Control Association

Several others on the program of this conference have very ably covered the field of cooperative efforts in mosquito abatement and since I appear to be the sole California mosquito control man in attendance at this meeting I am going to take the liberty of changing my talk and tell about some of the things we are doing in California and of our future plans.

First of all I wish to bring you greetings from W. Donald Murray, President of the California Mosquito Control Association, Inc., who was unable to attend this year. We enjoy coming to the Utah meetings as we always welcome you to our meetings in California. The exchange of friendships and knowledge is good for both organizations.

The CMCA is presently made up of some 54 mosquito control agencies. The greater number of these are mosquito abatement districts; the remainder are pest abatement districts and local health departments doing mosquito control. In all, about 36,000 square miles of California enjoys mosquito abatement. The annual expenditure of both local and state funds toward mosquito control is close to $4,000,000; by far the greater amount of these funds are local tax funds.

The Association maintains a group of very active standing committees that are always working to better our local programs and consequently the program throughout the state. Among these several committees are a few I think have done an extra good job this past year. The Records, Forms and Statistics committee has prepared a "Yearbook." This booklet contains much valuable information to mosquito control workers. It lists all state mosquito control associations, meeting dates, constitution, etc., of the CMCA, and other information which has been gathered together in one handy place. This committee surveys annually the salary status of all district personnel as well as their classifications. This information is sent to all the member agencies to help plan their annual salary plans and other budget matters.

It is always a great help to know what the others are doing about such matters.

One of the committees, the Insecticide Committee is presently preparing a booklet entitled "A Guide and Recommendation for the Use of Insecticides for California Mosquito Control." This should be highly valuable to many for it not only gives the common procedures but, in detail, the practices and procedures we have found necessary when using certain of the phosphate insecticides. It is our hope that this publication will be ready for distribution by the time the active spray programs are under way this year. This booklet deals with the several chlorinated hydrocarbon insecticides and the phosphate pesticides used for mosquito control, since these two groups of pesticides are affected by the "Miller Amendment."

I believe that many mosquito control workers, not only in California but elsewhere, have no or very little knowledge of the effect of the "Miller Amendment" to mosquito control. It behooves all of us to know these facts and prevent any serious problem in our work. It may be that the phenomenon of mosquito resistance to the chlorinated hydrocarbon insecticides was a "Life-Saver" as far as we are concerned. Certainly with the "Miller Amendment" now in effect we are in a position to "live" with it far better than we were two years ago. It seems to me that no district can safely apply DDT or some of the other chlorinates on pasture areas without incurring trouble with the dairy farmer and beef cattle men since there is a zero tolerance for DDT in milk. Careful attention to the "Miller Amendment" will go far to prevent any serious trouble with insecticide residues.

We in California have been signally honored this past year by having our own R. F. (Dick) Peters as President of the American Mosquito Control Association. We think he has done a fine job, not only in that high place but as Chief of the Bureau of Vector Control, California State Department of Public Health. The BVC, as we call the Bureau has a very active section engaged in several phases of mosquito work. A program of surveying and reporting the *Culex tarsalis* populations in the state has been carried on for several years in cooperation with the mosquito control agencies. This entails weekly larval and adult mosquito reports to the BVC. Eventually, some of us hope, an "index" of dangerous population levels may be devised in order to prevent any serious outbreak of encephalitis.

The BVC has, at its Fresno, California Field Station, an intensive research program relating to the biology and control of mosquitoes. Some of the programs of study being carried on here have to do with:

1. Basic biology and life-history of:
    (a) Pasture mosquito species
    (b) Rice field mosquitoes

This Association in cooperation with the BVC and other agencies has been doing research along several lines. One study, with the USDA, has been an intensive study of the "Resistance" problem in California as well as testing of certain insecticides as aerosols and mists for mosquito control. Mr. C. M. Gjullin, of Corvallis Oregon has been doing this work in our state. His reports are available.

A cooperative project with the Agricultural Research Service is being made relative to irrigation efficiency, land leveling and irrigation structure problems. Much good has and will come of these joint efforts, since the bulk of mosquito control work in California is related to irrigation.

Other studies and research have to do with evaluations of various types of mosquito control equipment such as the aerosol machines and mist machines. These evaluation tests have shown that careful engineering and planning must be done to build and properly use much of this equipment. Equipment of doubtful value can thus be eliminated early in a program to prevent expenditures of funds for equipment not suited to the job requirements.

An insecticide testing and evaluation program has been inaugurated under the direction of Lewis Isaak at the Fresno Field Station of the BVC. This has been of real value to the districts for the many products offered for sale to mosquito control agencies are either proven satisfactory or not. We depend a good deal upon his findings for our insecticide purchases.

Of course the long-range program of "Source Reduction" is being carried out by more and more agencies. Many agencies started the program with one specialist or consultant in charge of the work but have found it necessary to employ an additional man. Although often the results of this progressive reduction of mosquito sources are not immediate the long-range effect has been good. Much mosquito source area has been eliminated and reduced. One of the side effects has been the change in attitude of ranchers, irrigators and water users. Since they have realized the nature of the problem and relation of water management to mosquito control they have, in general, been very helpful and cooperative. A phase of source reduction which is being emphasized more and more in California has to do with weed control. Several districts carry on an intensive weed control program while others are doing the same in varying degrees. Much has to be learned about this phase of the work both as to chemical control or cultural methods of weed control.

WATER MANAGEMENT FOR MOSQUITO ABATEMENT ON THE WATERFOWL MARSHES IN UTAH NEAR THE GREAT SALT LAKE

By Don M. Rees, Ph.D.

Zoology Department, University of Utah

Water management is considered an extremely precious privilege in the semi-arid west where water is a most valuable possession. Water management is, therefore, acquired or assumed by many individuals or groups, each frequently with different objectives and ideas as to what constitutes the most beneficial use of water. Ownership of water rights and the resulting privilege of management has produced some of the most bitter feuds and court battles in the western United States, many of which are still in progress.

The problem of water management for mosquito abatement on the waterfowl marshes in Utah near the Great Salt Lake is a complex problem involving multiple interests and diverse opinions. This problem is continuously assuming increasing importance as more of these waterfowl marshes are acquired by federal, state and private agencies. These agencies are primarily interested in producing and maintaining waterfowl habitats and to some extent the production of fur bearing animals. To date very little attention has been directed by any of these agencies towards the effects of their programs on mosquito production. They all seem to operate: first, on the principle that the success of their program is dependent on the amount of water they can accumulate on their property; and second, that this acquisition should be accomplished with the very minimum of expenditure and without long range planning or consideration of other programs. Improvements on these properties frequently consist of the construction of a high dike on the lower or drainage end of the property; usually the outlet gates or culverts in the dikes are inadequate. Nothing is generally done to limit the area flooded by the construction of dikes at the upper end of the property nor are there any provisions made to regulate the amount of inflow of water.

The extensive fresh water marshes along the shores of the Great Salt Lake are situated on the old lake bed where the drainage water from the surrounding country enters the lake. In these marshes the gradient towards the lake is on an average about one foot per mile. Obviously under these conditions when the dikes raise the water level at the lower end of these marshes, considerable areas of the level dry ground at the upper end of these properties become covered with water when enclosing dikes are not consrtucted to prevent this limitless flooding. Minor fluctuations are constantly occurring in the amount of water entering the marshes on all of these properties, but at times, during the spring and summer following high water from melting snow or heavy storms and the accompanying release of excess irrigation water, great tracts of thousands of acres are flooded because of the presence of dikes which impounds this water and prevents it from entering the Great Salt Lake by the regular water channels.

The dry ground in the marshes may be relatively free from vegetation but areas which border the more permanent waters and are only periodically flooded are usually covered with salt grass, *Distichlis stricta* (Torr.) Rydb. These grassy areas are usually heavily seeded with the eggs of *Aedes dorsalis* (Meigen). At each flooding during the mosquito season great numbers of these eggs hatch. The water generally remains long enough, six or more days, to produce a brood of these mosquitoes. *Aedes dorsalis* is the most abundant and important mosquito produced on these marshes and practically all of them are produced as a result of the flooding of these marginal areas which were previously dry.

It is true that other species of mosquitoes, principally *Culex tarsalis* Coq. and *Culiseta inornata* (Will.), are produced on the marshes in the more permanent waters but these species do not attain the plague-like numbers or pestiferous importance of *A. dorsalis* nor do they have its long range migratory habits.

After considering this problem of increased mosquito production on these fresh-water marshes that are being developed for waterfowl and fur farming, it is apparent that with more cooperative and effective planning and development all interests can be better served than at present. Obviously, at present, the wildfowl interests are not doing the best job possible by attempting to produce and attract wildfowl on areas where water is improperly stored and managed. It is essential to maintain water on wildfowl marshes at fairly constant levels especially during the nesting season. The same uncontrolled floodings that produce *A. dorsalis* mosquitoes are responsible for the destruction of numerous waterfowl nests each year. It is also desirable to keep water fresh by permitting it to flow through an area and it is absolutely essential that the first area receiving water be managed in a way to allow a fairly uniform flow to continue to the next property in order to maintain suitable waterfowl habitats. This cannot be accomplished under the prevalent concept in which each agency believes it should accumulate all of the water possible on its property whenever it is available. It is obvious what the application of such a philosophy does to waterfowl, as well as to mosquito production.

An attempt is being made in Davis County at the present time to bring together representatives of all governmental and private agencies interested in water management in that county. A committee known as the Davis County Correlation Committee was established by DeLore Nichols, a former County Agricultural Agent. Practically all agencies concerned with water management in Davis County are participating in this program and the results, thus far, are encouraging.

Another step in this direction was instigated last October when representatives of the Salt Lake City Mosquito Abatement District, the University of Utah, the State Fish and Game Department, the Logan Field Station of CDC, USPHS and the U.S. Fish and Wildlife Service established a committee to consider this problem. At the first meeting it was agreed to conduct a study of one governmental and one privately owned and operated waterfowl marsh. As the governmental unit, Farmington Bay Bird Refuge, owned and operated by the State Fish and Game Department, was selected for study. Later the Officers of Lake Front Fur and Reclamation Company, a privately owned company, agreed to work with this committee using their property as a study area. It is proposed to make a study of water conditions on these properties and as a result make recommendations for water management that will be most beneficial for all interests concerned. If successful, we hope to use these areas to introduce similar programs on adjacent areas.

As a result of observations and existing information I am of the opinion that if the following principles and practices were adopted in the water management program on these marshes they would be greatly beneficial to all interests concerned:

1. Establish ownership and the proportional amount of water available for each property.

2. Establish the responsibility for the distribution and constant policing of this water in one agency such as the Office of the State Engineer.

3. Construct dikes on all sides of a marsh where water is impounded to prevent shallow flooding of adjacent dry ground when there is a controlled or unpredictable rise in water levels.

4. Install wide weirs in the dikes instead of culverts; removable boards should be placed in the weirs thus making it possible to establish constant water levels by providing adequate spillways to compensate for variations in the amount of water entering the diked unit.

5. Make an extended and intensive study of the marshes by qualified representatives of all agencies interested in the water management program.

6. Disseminate the information obtained as a result of this study and insist on its application.

SOME UNUSUAL MOSQUITO BREEDING AREAS IN SALT LAKE COUNTY

By Russell D. Anderson

South Salt Lake County Mosquito Abatement District

The mosquito control program in the South Salt Lake County Mosquito Abatement District has two basic problems. The control of Aedes mosquitoes which occur chiefly in temporary pools along the Jordan River and in irrigated pastures, and the Culex and Culiseta mosquitoes which can be found breeding in a wide variety of more permanent situations throughout the county. This paper will be confined to the latter problem.

In the period from May to the middle of July, the Murray Park light trap was consistently low in mosquito collections, but on July 21 a notable increase in the collection of *Culex tarsalis* occurred. After an extensive inspection of the area the breeding source was found to be in the now razed Murray Smelter. The steam tunnels, flues, catch basins, and underground passage ways were, even though partially filled with debris and tumble weeds, found to contain enough water to provide for ideal Culex breeding. One of the catch basins was especially interesting as the larvae were found concentrated within the confines of an old tire partially emersed in the water. There may have been some unknown toxicant in the water as numerous dead larvae were found before control measures were applied. After treatment of this area the mosquito population in the Murray Park area immediately dropped and remained low for a period of a week. The average again rose on July 28. This time, however, the gutters and catch basins of Murray city were found to be the cause of the increase and were successfully treated.

In Midvale the now unused tailings ponds of the United States Smelting Refining and Mining Company situated along Sixth West between 80th and 83rd South were found to be prolific producers of Culex and Culiseta mosquitoes for the first time since the organization of the district. This breeding area was found after a rise in the light trap catch in Midvale indicated the presence of a mosquito producing area in the vicinity of the trap. The area is a series of five ponds partially covered with sedges, rushes and grasses. A nearby slaughter house dumps part of its waste material into the first pond adding ample organic matter to the water. The control of this area is quite difficult because the ponds can not be waded and the dikes are too soft to support the larviciding truck. As the tailings deposited in the ponds are finely ground ore wastes they are easily blown about by the wind which causes a dust problem in Midvale. To prevent this the owner wishes to keep the ponds wet until the plant cover is sufficient to stabilize the soil thus preventing the dust. As the ponds can not be permanently drained the control of mosquito breeding in the area presents a problem. The best control appears to be complete drainage with regular flooding of the ponds each week to keep the plant cover alive.

The numerous farms in the district often present some interesting problems, mostly man made. On many farms and dairies the watering troughs were found to contain egg rafts and larvae. As chemical control is not desirable in these situations the best solution was found to be the drainage of the troughs at regular intervals. If this is not possible, Gambusia fish can be planted. On one occasion, a watering trough in West Jordan raised the light trap catch by thirty Culex mosquitoes in one night.

Another breeding source found last August was a plastic wading pool which was producing *Culex pipiens* and *Culex tarsalis* mosquitoes. If the water remained in the pool for a week or more, a brood of mosquitoes was produced. As the number of such pools in the district is great, they may prove to be a real problem. The logical control procedure would be to empty the pools each week, thus eliminating the eggs or larvae. This can best be done by educating the owners of such wading ponds.

PROGRESS REPORT ON THE FIELD TESTING IN UTAH OF SOME ORGANIC PHOSPHORUS INSECTICIDES FOR MOSQUITO CONTROL

By Jay E. Graham

Manager, South Salt Lake County Mosquito Abatement District

and

Don M. Rees

Zoology Department, University of Utah

During the summer of 1955 EPN, Parathion and Malathion were tested in Salt Lake County for the control of mosquito larvae and adults. The tests were conducted for two purposes: (1) To determine the desirability of substituting one of the tested compounds for the insecticides now used for mosquito control in Utah and (2) to obtain information regarding these insecticides in the event that resistance to the chlorinated hydrocarbons develops in the mosquito population in this area.

Although none of these compounds have been used for mosquito control in Utah, they have been used extensively in California and to a lesser degree in Florida. Issac (1952) reported that EPN was the most effective of several insecticides tested by the Kern County Mosquito Abatement District of California. Gjullin, Issac and Smith (1953) obtained 97 per cent mortality of *Culex tarsalis* larvae with 0.01 lbs. per acre. Malathion was not as effective but 99 per cent control of *Aedes nigromaculis* was obtained with 0.4 lbs. per acre. Lighter concentrations lowered the percentage of mortality but a 67 per cent kill of *Culex tarsalis* larvae was obtained with 0.1 lbs. per acre. They stated that Malathion is one-tenth as effective as EPN. Geib (1955) reported the minimum effective field application rates of EPN, Parathion and Malathion as 0.04 lbs., 0.05 lbs. and 0.4 lbs. per acre respectively. Stivers (1956), at the 12th annual conference of the American Mosquito Control Association in Beaumont, Texas, reported that large quantities of Parathion were used effectively for mosquito control in California in 1955 at rates at or below 0.1 lbs. per acre.

Malathion was used for the control of adult mosquitoes in Florida in 1955 and some observations were made as to the effect of this insecticide on larvae (Gahan, et. al. 1956).

Although they are very toxic to mammals, Parathion and EPN can be safely used in mosquito control work as experience in California has shown. A variety of test animals have been used in determining the toxicity of these compounds to mammals but mosquito control workers are more directly concerned with the minimum dose that will show toxic effects or cause death to farm animals. Radeleff (1955) found that calves were the most susceptible to insecticide poisoning. The minimum doses, expressed as milligrams per kilogram of body weight, given orally that would cause death in calves 1-2 weeks of age were 0.5 for Parathion, 1.0 for EPN and 20 for Malathion. Comparative values for Heptachlor and DDT were 25 and 250. Minimum lethal doses for sheep and cattle were much higher per kilogram of body weight.

If Parathion is applied for the control of mosquito larvae at the rate of 0.05 lbs. per acre on water with an average depth of 6 inches, the most susceptible calf would have to drink more than 10 times its weight in treated water to get a lethal dose of insecticide.

The tests in Salt Lake County were conducted under field conditions and the materials were applied with Champion knapsack sprayers. Both wettable powders and emulsifiable concentrates were used. Caution was taken in handling the insecticides but neither a respirator or gloves were worn. The toxicants were tested against larvae of *Aedes dorsalis, Culex tarsalis, Culiseta inornata* and, in one case, *Anopheles freeborni*.

Malathion was applied at rates varying from 0.05 to 0.5 lbs. per acre and EPN and Parathion were applied at rates varying from 0.02 to 0.1 lbs. per acre. Inspection of the treated area was made before application of the insecticide and the larvae per dip counted. An inspection 24 hours after treatment was made and the larvae per dip counted and compared to the pre-treatment numbers.

The results of these tests revealed no differences between Parathion and EPN. Both toxicants gave good control at 0.02 lbs. per acre in most trials but at times both failed to give good control at this concentration. At 0.03 lbs. per acre both materials apparently killed all the larvae. Malathion did not provide any control at 0.05 lbs. per acre except in one case mentioned below. At concentrations of 0.1 lbs. per acre kills varied from 10 to 50 per cent. Malathion did not give satisfactory control in all trials until it was applied at the rate of 0.4 lbs. per acre although in some trials at 0.3 lbs. per acre apparently all of the larvae were killed.

No differences between species were noted except in one trial where Malathion was applied at 0.05 lbs. per acre. The area was an unusual breeding area in which *Aedes dorsalis, Culex tarsalis* and *Culiseta inornata* were found in the pre-treatment inspection. When the post-treatment inspection was made a few dead larvae of *Anopheles freeborni* were found but no dead larvae of the other species were observed. Further tests with larvae of *A. freeborni* are planned for 1956.

One test for the control of adults of *Aedes dorsalis* with EPN was conducted. The material was applied at approximately 0.075 lbs. per acre in an area where the adults were very numerous. The area was inspected 12 hours later and no adults could be found although adjacent, untreated areas still had large numbers of adults. Frogs that were in the area before and after treatment showed no visible effects.

Conclusions

Parathion and EPN are both effective against mosquito larvae in Salt Lake County at concentrations of 0.03 lbs. per acre and all higher concentrations. Both toxicants are safe if properly used for the control of mosquito larvae. Malathion is effective against mosquito larvae in Salt Lake County at 0.4 lbs. per acre and all higher concentrations. EPN is effective against adults of *Aedes dorsalis* at 0.075 lbs. per acre and may be effective at lower concentrations.

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FURTHER INVESTIGATION OF THE EFFECT OF MOSQUITO FOG ON VARIOUS INSECTS

By Earl A. Jenne

Supervisor, Weber County Mosquito Abatement District

In 1955 this study was not expanded as had been planned in 1954. The 1955 season was a rather bad year for mosquito abatement, and the time could not be spared from routine duties to expand the research. The project however, was continued on a small scale and certain techniques in method were improved. The 1955 tests were limited to the use of fog of six per cent DDT and five-hundredths to one-tenth per cent pyrethrum. The three major improvements in techniques were as follows:

1. Control specimens were used with each test. Each time specimens were collected an effort was put forth to collect at least two insects of each type to be used. One insect was put in a screen wire cage and exposed to the fog, and the other was placed in a similar cage and carefully withheld from the fog, but kept in the test area. In this manner each insect was exposed to the same climatic conditions and same amount of handling. The only major variable in their environment was the fog.

With these preparations there were two factors which affected the longevity of the specimens. One factor was the effect of the fog, and the other was the individual resistance of the insect. We could not measure or control the strength of the specimens used, so we could not concern ourselves with this factor beyond being aware of its existence.

2. In measuring the distance the traps were placed from the fogger a rapid method was desirable, so that the specimens could be removed quickly from the fogged area after treatment. Using canvas belts or a tape measure proved involved, but the distance could be quickly paced off so this method was adopted and proved to be surprisingly accurate.

3. The screen wire cages were cleaned and carried in a clean paper bag to prevent contamination with insecticides while not in use.

During the hot summer weather there was an increased mortality of the insects due to confinement. Some tests could not be carried out due to this factor, even though care was taken to keep the insects in the shade. Those insects which were hardy enough to withstand the effects of the hot weather also appeared to be more resistant to the fog.

In October 1954 house flies were kept in confinement for periods up to forty-three and one-half hours without mortality, but on September 3, 1955 due probably to higher temperatures four flies died within five hours and two more died nine hours after capture. None of these flies were subjected to fogging.

The more active the insects were in the cages the quicker they died apparently due to the effects of confinement. Seven very active honey bees were confined and in four and one-half hours all but one had died. Four and one-half hours after capture the remaining bee was fogged, but was still alive two and one-half hours after being fogged.

The insects which were killed by the fog followed a behavior pattern which was similar in all specimens observed. The insects seem to lose the ability to coordinate their body movements and have difficulty walking. The cages are too small for the insects to fly in them, but they seem to retain the ability to move their wings longer than their legs. This loss of coordination increased until they could not walk without falling. Finally they could no longer even stand. This appeared to be due to a loss of strength, as well as a loss of coordination. At this stage they frequently still buzz their wings. After this there is a continued loss of strength until death occurs.

As a result of the 1955 tests the following tentative conclusions were reached: Honey bees are apparently not as susceptible to the fog as previously thought. Ant lions and dragon flies are not killed by the fog concentrations used in these tests. All beetles tested were resistant to the fog.

THE DUTIES OF A MEMBER OF A BOARD OF TRUSTEES OF A MOSQUITO ABATEMENT DISTRICT

By Arthur Gentry

Board of Trustees, South Salt Lake M.A.D.

I do not intend to instruct other trustees in their duties but I would like to explain the basic philosophy that guides me in the performance of my duties as a member of the Board of Trustees of the South Salt Lake County Mosquito Abatement District.

The trustee is a representative of the taxpayers of his community and he must do everything possible to see that the money paid by the citizens that he represents goes, without waste or excessive expenditure, into effective mosquito control. It seems to me that a board of trustees, such as mosquito abatement districts have, is the best device yet discovered for spending public funds without waste because every expenditure is approved by a number of taxpayers who in turn must justify their actions to the taxpayers of their community. I am certain that no person or group of persons is more tax conscious and no unit of government more effective in keeping expenditures at a reasonable level than the boards of trustees of mosquito abatement districts. Since a trustee receives no compensation for his time and has no partisan political objective to advance, his only reward is the personal satisfaction he receives from knowing that his community has asked him to do a job and he has done it well.

It is much easier to be for economy in a public work than to take the responsibility for it. A trustee, to properly perform his duties, must devote considerable time to learning the various complexities of mosquito control work. Most trustees do not have the time nor the inclination to become experts in this type of work but they should at least attend board meetings regularly and conferences, when possible, so that they will have some information on which to base their decisions.

The trustees of a district in addition to keeping a close check on expenditures must also set the overall policies of the district. To implement their policies they must employ some one to manage the program of the district and report to them regularly on the progress of the program. This manager is subordinate to the board of trustees but authority is delegated to him to enable him to properly discharge his duties. It is obvious that the trustees then work through the manager rather than trying to direct control operations in detail themselves.

It is presumed that all trustees will have some experience in the expenditure of money and will therefore know that economy is not always achieved by purchasing cheap equipment. This is often the most wasteful method. They must devote some time to determining which equipment is best for the work and then select what is needed with their best judgment based on the best information they can obtain.

Trustees must devise some method of evaluating the work of the abatement district. It is easy to form opinions based on favorable or unfavorable comments from the residents of the district, but such opinions often may be in error. No matter how capable or objective the manager of the district is, his opinion of the work is of necessity, biased. Whenever practical the board of trustees should have competent people make an evaluation of the program using mechanical measuring devices. The people making such an evaluation should not be regular employees of the district.

Mosquito control work is a very complex and highly technical field. Entomology, chemistry, engineering and other sciences are involved. Research from all parts of the world is advancing techniques in mosquito abatement and making for more effective control at lower costs. Each board of trustees is obligated to take all reasonable measures to obtain and use the latest and best in control procedures. The trustees of the district should insist that the manager of the district be aware of current research throughout the country. We are aware that this is a time consuming task and that we are not, as yet, able to offer a salary equal to that offered in other states, but we still insist the man who accepts the job must do the best he can. The board of trustees should provide reasonable assistance to the manager in keeping up with the latest developments. The purchase of pertinent literature and attendance at mosquito control conventions by a conscientious manager will pay rich dividends to the district. The South Salt Lake County Mosquito Abatement District has saved several thousands of dollars in the past two years because of its research program.

In closing I would like to say that Salt Lake County is a better and healthier place to live because of mosquito control and I am happy to have had a part in the mosquito abatement work in our district.

MOSQUITO ACTIVITIES IN BOXELDER COUNTY FOR THE YEAR 1955

By Karl L. Josephson, *Supervisor*

We started our mosquito control work in the first part of April. This was the first year we had four trained men to start the season out with and results were very gratifying. We had an extremely wet Spring and Summer, yet our mosquito control was very good.

We had heavy rains in May and right after the water was in the canals we had more rain and the excess water was turned out of the canals on to submarginal areas, producing millions of mosquito larvae. We found larvae in abundance all over our territory. We put all available equipment to work including some fly sprayers. Along with the wet season, we had a lot of wind, complicating our air spray program. Because of this, we had about one thousand acres of larvae get away from us two different times. This necessitated the early use of our foggers.

The wind quieted down some in June giving us a better chance to use our control methods. We plan to put a duster on our air boat to help in case we have a similar wind condition another year.

July gave us more of the same, as rain and wind was again the rule. August came with its extreme heat and along with the extra rain that again fell, we really had our hands full. Our inspector-treatment method was very effective. The men worked long hours spraying-inspecting and then would take the foggers into their territory at night treating the areas known to be infested with adults.

Our mosquito activities finished up the middle of October and we felt we had a very successful year.

We planted several barrels of Gambusia fish again this season, finding some areas where the fish had survived the winter, but much replanting was necessary.

Our airboat will play a more active part in our control work in the future as with its use we gain experience as to the best methods of its use.

REPORT OF DAVIS COUNTY MOSQUITO ABATEMENT DISTRICT 1955 WORK

By Ward Warnock, *Manager*

The Davis County Mosquito Abatement District is still an infant in age and experience in this work, as we have operated for only one year as an official district on a budget of one-half mill tax. We hire only part time men (six school teachers), who work part time in the spring and late fall, and full time during summer months. These men have all shown great interest in the work by taking extra study work on Mosquito Abatement wherever it is given. They are doing a very good job for us. We do hope to sometime get into a position to have more help to conduct intensive studies and compile our statistics.

Our big problem in Davis County is still the lake shore of Great Salt Lake which is so flat between the pasture lands and salt water (a distance of one to six miles) that waste water ponds and creates extensive mosquito breeding areas. This will no doubt be aggravated by increased irrigation waters on the higher land by the Weber Basin Project. We have tried to plan ahead for part of this by forming a Correlation Committee consisting of a representative from all agencies concerned, and a sub-lake shore committee of part of the Correlation Committee with members from the Soil Conservation Service, Reclamation Bureau, Davis County Planning Department, Davis County Health Department, Mosquito Abatement District, Fish & Wildlife Federation, Water Users Association and State Fish & Game Department.

Two trips were made last summer by this group along the lake shore to study the problem and determine what could be done to benefit most everyone. We feel that through such cooperative effort good results can be worked out for better control of the waste water to benefit Mosquito Abatement District, Fish & Game, and water users groups. The Reclamation Bureau is installing drains which will eliminate several mosquito producing marshes in the vicinity of the Farmington Bay Bird Refuge.

In closing we want to thank our neighbors to the south and north of us. Both the Salt Lake City Mosquito Abatement District and the Weber County Mosquito Abatement District have assisted us greatly. Without their aid in control of some of our lower lake shore areas we could not have been so successful last year.

REPORT OF THE RESOLUTIONS COMMITTEE

Resolutions Committee Members:

Dr. George F. Edmunds
Dr. George Knowlton
Leslie Kidman
Reed S. Roberts, *Chairman*

Whereas the program committee and officers have provided us with an excellent program of outstanding speakers, and

Whereas the speakers have gone to much effort to bring us helpful and up-to-date information; and in many cases, have come long distances to participate in our program, and

Whereas the Midvale City officials have provided us with places of meeting, eating and arranged for other necessary facilities, and

Whereas the members of the various committees have performed their duties well with this, our Ninth Annual Meeting, and

Whereas the officers of the Association have performed their duties well and faithfully throughout the year, and for this meeting

Therefore, it is resolved that we extend to everyone who has aided in any way to make this Ninth Annual Meeting of the Utah Mosquito Association a success (this March 16 and 17, 1956) our sincere thanks. We wish to extend our thanks to the following for their generous donations used for printing the program of the Ninth Annual Meeting:

1. California Spray Chemical Company
2. E. C. Olsen Company
3. Trans-Air Inc.
4. Wasatch Chemical Company
5. Wheeler Kershaw Company

REPORT OF LEGISLATIVE COMMITTEE

The legislative committee, following last year's meeting, enlisted the aid of the Utah State Attorney General for development of a legislative bill embodying the changes to the mosquito abatement district law voted on by the Utah Mosquito Abatement Association. The job of writing the bill has been delegated successively to three different deputies in the attorney general's office, because the first two left their positions before completing their assignment. The result is no bill at the present time, but a continuing promise that it will be prepared.

Since the legislature will meet prior to this association's 1957 meeting date, it would appear wise to give the Board of Directors authority to approve and present for adoption the anticipated legislative bill after it has been prepared in harmony with the changes to the law recommended by this association.

Lynn M. Thatcher
Chairman