PROCEEDINGS OF THE
SIXTEENTH ANNUAL MEETING

OF THE

UTAH MOSQUITO ABATEMENT ASSOCIATION

held at the

Utah State University

Union Building

Logan, Utah

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Sixteenth Annual Meeting

PROCEEDINGS OF THE SIXTEENTH ANNUAL MEETING UTAH MOSQUITO ABATEMENT ASSOCIATION

The opening session of the Sixteenth Utah Mosquito Abatement Association convened at the Utah State University, Union Building, Logan, Utah, and was called to order at 9:30 a.m. by President George F. Knowlton, presiding. Welcoming address was given by Dr. Milton R. Merrill, Vice-president, Utah State University. Response for the Utah Mosquito Abatement Association was given by Dr. George F. Knowlton.

PUBLIC RELATIONS AS RELATED TO MOSQUITO ABATEMENT MANAGEMENT AND CONTROL

Morris F. Swapp, Manager

Davis County Mosquito Abatement District

Public relations should be classified as a science of its own. Millions of dollars are spent each year by business and industry on public relations. However, we who work with public funds must be prudent and watch all expenditures so as to avoid criticism. Since we have a limited budget for the purpose of public relations, I shall endeavor to point out some specific functions which can be carried on by the Board Members, Managers, and Abatement Workers, in various districts of this state.

BOARD MEMBERS

It should be the responsibility of the board members to acquaint themselves with the functions and operation of the program within their own district to the best of their ability; be abreast of as many technical procedures within the district as possible.

Board members are usually men of considerable influence within the community in which they live. Hence if they are acquainted with and sold on the program they can be a real asset to the public relations program. Board members should attend as many meetings of this type as possible. Funds should be made available for them each year for this purpose. It has been said that a well informed person is much easier to keep satisfied. Therefore I submit to you managers and abatement workers that a few hours time with your board members can be valuable moments well spent.

MANAGERS

The manager of any district is of necessity the administrator and must see that the work progresses in the most efficient manner.

However, I see the manager as the public relations expert of the entire district and without hesitation I think it is his duty to carry on a public relation program satisfactory to the district and to the board of directors.

The concepts which I shall present are certainly not all inclusive. There are many aspects of public relations which I shall not delve into today. Perhaps the first and foremost facet in any public relation program is communications.

I have found through past experience it has paid dividends not to build your public up for a big let down. In spite of Mr. Graham's recent forecast of no mosquitos in South Salt Lake, and I am aware that this is supposed to be the latter days, when all signs fail, I hesitate to tell the people of Davis County that the end of the pesky mosquito is in sight until I am sure the millennium is here. The general public is always ready to accept and devour stories of criticism when they are directed at a struggling minority group.

It is the responsibility of the manager to prepare and release articles to the press. To carry on an education program within his district by making himself available to Service Clubs, Women's Clubs, Fraternal Clubs, and other organizations. He should become acquainted with his school officials and be able to carry on an educational program through the schools.

One very important job of the manager of any public agency is to know the principal citizens of his area. This is a must. Never be too busy with your job that you cannot take time to make their acquaintance. It is one job which you cannot pass off to some other person in your organization. A good approach is to ask them if they have any questions about your district and its operation. This is an opening which can lead to further questions and conversation, in which you can get in some good mosquito control information. An invitation to take them on a personally conducted tour of the district will seldom be accepted by busy men, but the offer is well received.

There are many problem areas of mutual interest to both local health departments and mosquito abatement districts. The work of these two agencies pertaining to these mutual interest should be well coordinated.

Professional jealously between inter-agencies is a demoralizing factor for all concerned. Resulting in low morale and hence poor public relations.

The manager should be the sounding board for the abatement workers, the board of directors, the public or any agency connected with the abatement program. A good manager should be able to motivate his subordinates to excellent performance. An excellent performance is the ultimate in public relations. The worker who comes to his task each day with a feeling of resentment is the worker who will retard progress day by day. The manager should give credit where credit is due. This is especially true in connection with the abatement workers; conversely he should be equally as frank with a worker who is shirking his responsibilities. The manager who meets all issues head on whether they be pleasant or unpleasant will have respect of his co-workers, his board of directors and certainly the public at large. I see the public relations expert as the good manager and not necessarily the well trained manager as the public relations expert.

ABATEMENT WORKERS

These men can be a valuable asset to any district public relation program. Surely the best and foremost aspect of public relations is to abate the mosquito completely, but since this is practically impossible, let's look at what else can be done.

These are the men who are dealing directly with the farmers and the various water users where we find the mosquito producing areas. They should have some knowledge of water management which can be dispensed to those with whom they work.

A good example of this within our district is a drainage program in a large pasture area. After convincing one farmer that proper drainage would better his pasture it became very apparent to his neighbors, and the word spread rapidly. It wasn't long before we were swamped with requests for drainage. When it becomes a known fact that you have something to offer that will be of a help and money in their pockets the farmer will seek your help.

Like other government agencies it is well to be seen on the job, especially if you are following up a request. Just to have your men appear on the scene will often satisfy an annoyance call from an irate citizen.

It is true, we are called on many times by the public to perform some fuction which is time consuming and may not have too much relationship with abating mosquitoes, but let me remind you that we are serving the public from public funds and their whims must be satisfied to a certain degree at least.

The men on the job should have a rather thorough knowledge of the chemical being used, so as to answer inquires as to the toxicity etc.

Morale of the men must be kept at a high level through good working conditions, pay, etc. in order for them to reflect that feeling to the public.

These are just a few ideas. They are far from being all inclusive and I had no intention that they would be. Something must be left to your imaginations and initiative. But these things I do know from experience — there is no substitue for integrity — there is no substitute for respect. Only you can earn them.

INSPECTION AND GROUND SPRAYING PROCEDURES

J. Larry Nielsen, Manager
Magna Mosquito Abatement District, Magna, Utah

The general methods for inspecting and spraying are basically the same today as they were 15 or 20 years ago. There have been changes and improvements of course, but the control procedures are very much the same. The insecticides have changed and the equipment has been improved and made more dependable, however, the inspector still uses the same style dipper for sampling the water today, as was used 20 years ago. In the last few years some of the Districts in the state have started collecting larval specimens for identification purposes. The inspectors then must carry alcohol vials and a pipette as well as a dipper for collecting. A good pair of legs are also essential, because many of the areas are still inaccessible by vehicle and have to be covered on foot. Inspectors from most of the Districts also carry granules in their vehicles to treat small areas, such as wells or small drains, as they find them. This saves time by allowing the spray crews to concentrate on the larger areas. An inspector when looking for larvae, should take a sample of water every few steps, zig-zagging the area if it happens to be a pasture or grassy pond and making sure that the edges are inspected carefully. If the inspector is checking a drain, both sides of the water should be inspected. When inspecting a moquito producing area of any kind, the inspector should check the

entire area and not just part of it. If an inspector takes only 6 or 7 dips and finds a few larvae in a large area and without checking further, turns the entire swamp in to be sprayed, he may be wasting time and money. Possibly only a small part of this area has larvae in it. On the other hand, if the inspector does the same thing in another area and finds nothing in the first few dips and doesn't bother to check further, he may be missing many larvae on the other side of the pond. Generally, an inspector is extremly busy and at times may be tempted to pass something up. If he does miss an area producing larvae, he is hurting the entire mosquito control program in his District. In order to do an effective job, an inspector must know his area well, be thorough and use good judgment in inspecting any type of area. Also, the inspector or manager of the District should determine what type of spray or larvicide should be applied by the spray crew in the different areas where the larvae are found. Another thing that inspectors should carry, is red or yellow flags to place in the areas where they find the mosquito larvae. This makes it much easier for the spray crew to find these areas. A complete map of the District showing where most of the mosquito producing areas are located is very important, both to the inspector and the spray crew. A map makes it possible for the inspector to show the spray crew the exact location where the larvae have been found. Some of the Districts in the state use the colored pin system along with their maps.

This pinning system is very simple and extremely helpful in a mosquito control program. For example, after the inspector has completed his days inspecting and returns to the district office, he pins up on the map the locations where he found the larvae or pupae, the red pins representing pupae and the green pins larvae. After the spray crew has treated the areas they replace the red or green pin with yellow colored pins which indicate the areas have been sprayed. This system makes it possible for manager or the inspector to keep track of the areas that have been treated and to know the situation day by day, simply by glancing at the map. This system may sound complicated and time consuming, but it takes only a few minutes of ones time each day and it is well worth the effort.

Many of the spraying procedures are the same as they were several years ago although there have been major changes, particularly in regard to the chemicals used. Fuel oils which were so widely used before the war are rarely used now, having been replaced by the chlorinated hydrocarbons, organic phosphates and others. In the Magna District Parathion and DDT are the two main insecticides used and both can be applied by a power spray unit, a Buffalo turbine, or the Knap sack type spray can.

A sprayer should use every precaution in applying larvicide and use good judgment in spraying any particular area. Different areas can create different problems to a spray crew. The size of the area, the direction of the wind, and the thickness of the grass all influence the method of treatment. A spray crew can treat a pasture for mosquito larvae and obtain a very poor kill if a predesigned plan on how they are going to spray that particular area is not set up. A sprayer can very easily miss a spot completely by not concentrating on where he is going or where he has been with his last swath. He may not overlap his last swath or he may miss one altogether, allowing for a very spotty kill in that area. Keeping in line as straight as possible and allowing for an overlap on your last swath is very important in obtaining a good kill. There are also other factors to consider when spraying. The wind can either help or hinder you if it is not used to best advantage. We have found that by walking in the same direction the wind is blowing or by walking directly into the wind and keeping the spray nozzle low, we can do a much better job of keeping the spray where we want it. The wind can actually help you a great deal when power spraying by allowing the larvicide to travel a much greater distance if you work with the wind at your back.

Some districts in the state have a fogger, which is primarily used for adulticiding, but its effectiveness is often debatable and it is generally used as a last resort or for psychological effect. All districts have their own problems on inspection—spraying procedures and many have their own ideas on how to go about them, but I think we'll all agree that there is more to spraying and inspecting than just walking through a swamp with a spray or a dipper in hand.

SOURCE REDUCTION IN UTAH

Glen C. Collett, Manager
Salt Lake City Mosquito Abatement District

The term source reduction is one which has come into usage in mosquito control as applying to permanent control directed at eliminating or minimizing mosquito producing sources. Although the term itself is relatively new, being first used by Peters and Smith in California in 1952, this type of control, formerly called permanent control, which seeks to reduce or eliminate mosquito larval habitats is the earliest and still the most basic concept in mosquito control operations.

Source reduction measures should be given major emphasis in any control program. It is a means of more effectively and efficiently carrying out a program in a district. As a result of the elimination or reduction in size of major sources, efforts can then be directed to the finding of smaller sources which are continually being created by man in his varied activities. Thus, a high level of mosquito control can be provided at a relatively low cost.

The first mosquito control carried out in Utah by an organized district was in Salt Lake County. In the late twenties a great deal of this early abatement work involved the elimination of large mosquito producing areas by source reduction. This is pointed out in the following excerpt taken from the 1935 Annual Report of Salt Lake City Mosquito Abatement District: "Drainage has been along the same lines as laid out in previous years. Many new drains have been constructed and others cleaned. This is in direct correlation with the previous drainage plans as drawn up by the district, as its future program." At the close of the 1935 fiscal year more drains had already been finished than the district had anticipated in its ultimate plans and it was further noted:

"The value of this program will revert directly to Salt Lake County in several ways. First, the work of mosquito control will have been greatly furthered. Second, many acres of land heretofore not tillable will be rendered fit for agriculture. This will increase property values and automatically increase the revenue in form of taxes. Third, many hundreds of men that would have been out of work have been employed hereby increasing the payroll of the state. Fourth, a considerable amount of water that was going to waste has been developed that can be converted into irrigation and other purposes."

The above statements have been realized not only in Salt Lake County, but this is also true in the other counties of the state with organized mosquito control districts.

During this period of the early thirties, in addition to the work being carried out in Salt Lake County with E. R. A. and W. P. A. funds, mosquito abatement projects of a source reduction nature were being done in Utah, Davis, Weber, Box Elder, and Cache Counties with funds from the federal government. These projects were set up as state mosquito abatement projects. The work was under the supervision of Roscoe Boden, the present Salt Lake County Surveyor. All of the work in Salt Lake County was carried out with the Salt Lake City Mosquito Abatement District acting in an advisory capacity.

Following this period of the early thirties when the major work on the drainage system of Salt Lake County was accomplished with E. R. A. and W. P. A. funds and continuing to the present, a major part of the mosquito abatement budgets have been expended on the maintenance of this drainage system. During the past several years, a good example of interagency cooperation has been shown with work of a Cooperative Drainage Committee, participated in by Salt Lake City Corporation, the Salt Lake County Commission, and the Salt Lake City Mosquito Abatement District. The function and accomplishment of this committee has been reported in various other papers.

Of major importance throughout the state is the mosquito production caused by poor irrigation and drainage practices. These same practices not only produce mosquitoes but also reduce crop yields, produce waste water, and damage agricultural lands. It has been stated many times by the Soil Conservation Service and others that none of the crops grown in Utah produce their highest yields if flooded for more than a few hours at a time — and this includes native hay and pasture. A classic example of this was shown in the study conducted by the U. S. Public Health Service in the Milk River Valley of Montana.

Good agriculture and effective mosquito control go hand in hand. There is no controversy between them. It is primarily a job of educating the water user. If water is placed on a field some means must be provided for taking off the excess water. It has been shown that agricultural benefits derived from good irrigation and drainage practices usually greatly exceed the cost of applying them.

Much of the ground used for pasture along the Wasatch Front is not managed properly simply because the farmers are not going to put money into ground that they cannot see is going to give them a high return. It is an area where waste irrigation is dumped on the ground and little effort is made to manage it. This practice not only creates mosquito sources, but also results in water logging, salt and alkali accumulations, leaching of plant nutrients, soil erosion, and produces very little feed for stock.

The common practice of flooding the ground to wash out high salt content leads to the excessive use of water and if it is not properly drained away leads to mosquito problems.

Seepage from unlined, elevated irrigation ditches is another problem which leads to the creation of mosquito sources.

Changes of cultural practices are slow and difficult. Although it is often frustrating to mosquito abatement personnel when unnecessary mosquito production occurs from irrigation waters, it requires a great deal of patience, generally, to bring about improve-

ment. It is encouraging to read reports from the Soil Conservation Service of the substantial progress being made in Utah towards conservation irrigation by lining or putting into pipeline many miles of ditches and canal, leveling of land, and installation of sprinkler systems.

Districts should enlist the help of various agencies and direct their efforts toward improving their source reduction program. This is the key to success. Some of the agencies which can be contacted for aid are:

1. Health departments for sewage and industrial waste.
2. Weed control districts.
3. Soil Conservation Service.
4. County Agents
5. Water Masters

Prevail upon water users to adopt the practices outlined by the American Society of Agricultural Engineers.

Once source reduction efforts are accomplished it is important not to let them be nullified by lack of maintenance.

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American Society of Agricultural Engineers 1958 Principles and practices for prevention and elimination of mosquito sources associated with irrigation. Agricultural Engineers Yearbook, pages 96-97.

Peters, R. F., and E. A. Smith, Chairman. 1952 Symposium on mosquito source reduction. Proceedings and Papers Twentieth Annual Conference Cal. Mosq. Cont. Assn., page 62.

EVALUATION OF MOSQUITO CONTROL PROGRAMS IN UTAH

By Jay E. Graham, Manager
South Salt Lake County Mosquito Abatement District

This paper will not provide answers to problems in evaluation which may develop in mosquito abatement districts, nor will any attempt be made to evaluate the mosquito abatement programs in Utah. Questions will be raised which, hopefully, will provoke some discussion and serious thought and eventually be helpful in developing more accurate techniques for evaluation of mosquito control programs.

Some problems encountered in evaluation of mosquito abatement programs can be approached by reviewing the appraisal of mosquito abatement agencies in Northern Utah made by Louis Ogden and James Smith (1958). After studying the districts for a short period of time, a report was made briefly reviewing problems and procedures of the districts. Recommendations were made to improve operations in all districts and some comments were made regarding the effectiveness of each district's program. Following is a comparison of areas and budgets for Utah districts in 1958 based on information from Ogden and Smith (op. cit.).

District	*Budget (Approx.)*	*Area in Sq. Miles*	
Box Elder	$40,000		461
Davis	35,000		165
Magna	20,000		45
Salt Lake City	70,000	(Urban)	40
		(Rural)	115
South Salt Lake County	32,000		217
Weber	74,000		230

Budgets and problems vary widely and no correlation exists between the two. Ogden and Smith recognized this and did not make an effort to evaluate the districts on a comparative basis. They also were aware that biting counts and light trap catches in districts, while valuable, are not strictly comparable for pupose of complete evaluation. For example, biting counts taken in an irrigated pasture east of Magna would be different than those taken on the campus of the University of Utah even if the districts involved were identical.

The above comments are included because there are some valuable lessons to be learned from a consideration of the appraisal by Ogden and Smith. Deficiencies noted in each of the districts could not be excused on the basis of budget in relation to problem as compared to other districts, since comparative evaluations of the districts were not made. The recommendations made should have received serious consideration and appropriate action in all districts.

Each mosquito abatement district must be evaluated in terms of its own problems, budget and objectives. Since no single program of evaluation will serve all districts, each district must develop its own objective evaluation program. Such a program involves many factors, not all of which can be considered here. Some important factors in evaluation are effectiveness, efficiency, and economy. These factors are interrelated but not necessarily dependent on each other. For example, a district with a small problem and a large budget might have effective control with an inefficient program and the reverse could be true for a district with a small

budget and a large problem, and either or both may have some economically wasteful procedures.

Estimates and measurements of the effectiveness of control can be obtained from many sources, including:

1. Evaluations of citizens.
2. Estimates by the manager and employees of the district based on:
   (a) Larval inspections before and after spraying.
   (b) Numbers of adults observed.
3. Light trap collections.
4. Biting counts.

All of these procedures are subject to significant errors, but if sufficient care is exercised in the collection and interpretation of data from these sources, fair approximations of the effectiveness of control can be made. Responses of residents to a particular level of mosquito populations vary greatly and must be evaluated carefully. Those in charge of mosquito control programs are afflicted with a disease which might be termed "managerial blindness". They find it difficult or impossible to see mosquitoes in residential areas until the numbers become extreme, at which point they are aware that a few mosquitoes have emerged. Because this bias may have many effects on evaluation, a competent source of evaluation not related to the district should be utilized whenever possible.

Collections made in New Jersey type light traps are the most commonly used objective measurement of control effectiveness in Utah. The traps are placed where, in the judgment of the operator, they will give the most valuable information. This "judgment" placing of light traps is as good as the judgment exercised. We might argue among ourselves as to whose judgment placing of traps is best, but cannot logically assume that our abilities to judge are identical. Therefore, it follows that the judgment placements of traps in different districts or even in the same district are not equally good. A possibility exists that some placements are not good at all. Light traps might be placed in residential areas to measure mosquito nuisances or they might be placed in rural areas to obtain more accurate data regarding mosquito production. They may be placed in areas where not many mosquitoes are found for the purpose of impressing the public or board members with the effectiveness of the program. To draw accurate conclusions regarding mosquito populations from light trap data is difficult even with a careful analysis of light trap sites and is impossible without such analysis.

Studies of light trap catches of *Culex tarsalis* in Salt Lake County show that the proportion of males taken is dependent on the nature of the light trap site. (Graham and Bradley, in press). See Figure 1 This factor can be significant since nuisance levels depend on the number of female mosquitoes.

Year	*% Male*	*Total Trapped*	*% Male*	*Total Trapped*	*% Male*	*Total Trapped*
	RIVERTON		MIDVALE		EAST MIDVALE	
1953	23	31	70	74	*	
1954	30	71	66	62	*	
1955	59	37	71	70	*	
1956	32	22	84	87	*	
1957	42	19	84	131	*	
1958	48	86	60	262	*	
1959	39	76	60	90	46	26
1960	38	74	81	113	22	26
1961	18	61	91	206	38	13
1962	15	34	91	179	45	129
Average	35%		74%		43%	

*Not operated

Figure 1: The Percentage of Males of *Culex tarsalis* Taken in Light Traps in Salt Lake County, Utah during the years 1953 to 1962 inclusive.

Difficulties encountered in selecting light trap sites that will accurately sample mosquito populations can be corrected by using a random system for the selection of sites, but such a system involves too much time, effort, and money to be practical for routine operations.

The effects of control on light trap catches are great, but not uniform, and catches do not always indicate what they may appear to indicate. Light traps can be compared to a squeaking wheel. They attract attention and demand a remedy. Because of this, catches may indicate control effectiveness in the immediate area and not be related to a general condition in a district. When control is very effective and light trap counts are low, a slight lapse in control will cause a percentage difference in light trap catches out of proportion to the event and can lead to unjustified assumptions regarding changes in populations. (Graham and Bradley, 1962)

In addition, light trap catches are not representative of the relative abundance of various species of mosquitoes.

This brief discussion of problems encountered in collecting and interpreting light trap data is obviously not complete. Many other factors can be involved and many different methods of analysis used.

Biting counts are used to supplement data obtained from light trap catches. They have the advantage of of detecting species that do not come readily to light traps but the problems of site selection apply equally to biting counts. To be most valuable biting counts must be standardized as to collection procedures, time, site, attractiveness to mosquitoes of the collector, etc., and these problems require considerable study in all districts.

Evaluating efficiency of a control program involves primarily evaluation of procedures used for control and this can lead into a jungle of complexities and unresolved questions. A relatively simple example is the question as to whether inspection for larvae should be conducted by individuals working separately and in advance of larviciding crews or whether inspection and larviciding should be assigned to the same crews. Considerable discussion can be, and has been generated on this issue. To some extent, the answer to this question will depend on the district's problem, but investigation shows both procedures are being used for the same type of problems in different areas. There are a number of other questions of the same nature where considerable disagreement exists as to the most efficient procedure. No attempt will be made here to resolve these questions, since such an effort would involve too much time and possibly would do more harm than good. However, all of us could adopt a more humble attitude regarding the efficiency of our control procedures and recognize that constant study and improvement is essential. None of us is perfect.

Economy of operation, like efficiency of operation, is difficult to evaluate. In one sense an effective, efficient program is economical, but there are a number of questions to be considered and problems to be evaluated. For example, as the percentage of mosquito reducation increases the cost for each additional percentage unit of reduction increases very rapidly. Ninety per cent control might be achieved for a modest sum but ninety-five per cent might require twice as much and ninety-eight per cent or ninety-nine per cent control might require ten to twenty times as much money as ninety-five per cent. Some sort of evaluation must be made of the level of desired control and budgets determined on this basis. Another aspect of operation is involved in ineffective control. When a district, either through lack of funds or some other factor, fails to obtain adequate control, all of the money spent on temporary control measures can be considered wasted. This is an important consideration in poor areas with large mosquito problems and should be considered before a district is organized.

Each district in Utah should continually be asking if the level of control obtained is the right level. Should taxes be raised to give ninety nine per cent control instead of ninety five per cent or ninety six per cent control? If twenty thousand dollars were cut from a district's budget would a significant change in the level of control occur? Answers given to these questions without careful thought might not be right.

One last comment should be made on economy of operation. All of us at the end of the year have, on occasion, some money unspent. We use this generally to purchase equipment that we feel we need, but we should determine by careful evaluation if this is really needed in the program or if we are spending money unwisely. All of us can and will defend such purchases strongly, but conversations with other managers indicate that some doubt exists about some purchases. Conclusions:

(1) Each mosquito abatement district must develop its own objective evaluation program that will consider its own problems, objectives, and budget. Competent sources from outside the district should be used for evaluation whenever possible.

(2) Collection and interpretation of data regarding the effectiveness of control must be done carefully to reach accurate conclusions.

(3) Mosquito abatement district could profitably adopt a more humble attitude regarding the effectiveness, efficiency and economy of their programs. None is perfect.

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SUMMARY OF ACTIVITIES OF THE ENCEPHALITIS SECTION DURING 1962

G. J. Love and D. Bruce Francy[1]

The Encephalitis Section of the Communicable Disease Center, located in Greeley, Colorado, conducts field and related laboratory studies on the ecology and control of arboviruses, with special emphasis on western (WE) and St. Louis (SLE) encephalitis. The objectives of these studies are:

1. To determine the vectors and reservoirs responsible for the summer and winter perpetuation in nature of WE, SLE, and related viruses.

2. To determine annual variations in enzootic activity levels of WE and SLE in specific study areas, and to relate these variations to environmental or climatic factors.

3. To determine the specific combinations of biotic and physical factors that precipitate human outbreaks of encephalitis.

4. To develop methods for preventing or controlling outbreaks of encephalitis.

Field studies during 1962 were related to each of these objectives. Additional serologic evidence of group A virus activity at high elevations was obtained. This evidence, based on HAI and neutralization antibody tests of sera from sentinel chickens located as high as 10,000 ft., has not yet been substantiated by the isolation of an agent. The study is significant, however, because *Culex tarsalis* has never been found at this elevation in the study area. Maximum elevation at which adult *C. tarsalis* has been collected in the area is 7,500 ft. However, *C. tarsalis* larvae have been collected at an elevation of 9,550 ft. near Red Hill Ranch in South Park, Colorado.

Laboratory tests of biting arthropods collected at higher elevations during 1961 were negative for group A virus; specimens taken during 1962 have not yet been tested.

Possible overwintering reservoirs of encephalitis viruses were studied at lower elevations during winter months, with major emphasis on small mammals. Ground squirrels and chipmunks collected in the fall were inoculated with WE virus just prior to being placed in laboratory hibernacula where they were held throughout the winter. These specimens will be tested in early spring for viremias and tissue infections. In Massachusetts, snakes and turtles inoculated with EE virus in the fall of 1961 did develop viremias in the spring of 1962 shortly after emerging from hibernation.

During each of the winter months a series of *Mus musculus* and of *Peromyscus*, as well as a series of English sparrows and of magpies, were collected and will be tested for virus infections in blood and tissues. These studies of possible overwintering reservoirs are designed to determine if virus does recirculate periodically in the hosts tested and the the length of time that tissue infections persist in them. If tissue infections persist for a sufficiently long time, future studies will be made to determine if alteration of particular physiological factors might lead to recurrent viremias.

Virus activity in vertebrate and invertebrate hosts varied widely from one area to another in 1962.

The infection rate with WE virus in *C. tarsalis* was estimated by using the formula of Chiang and Reeves (1962) to be approximately 14 per 1000 in the high plains region of the Texas panhandle where nearly 50 per cent of mosquito pools, each containing 50 *C. tarsalis*, were positive. This was the third consecutive year of high infections rates in this area. In other areas, infection rates were much lower. At Greeley, 8,264 mosquitos collected in 1961 were negative, indicating a year of low virus activity. Infection rates for Greeley during the past 10 years have varied between 0.3 and 6.+ per 1000 specimens.

Infection rates in chickens were generally lower than in preceding years. WE infection rates in chickens were less than 10 per cent in all Colorado study sites except Greeley, which had a rate of 21 per cent. The SLE infection rate for Greeley was 7.1 per cent, also higher than any other area of the State.

Infection rates in Utah chickens were low. Fifty sera from the Bothwell area were negative, and 55

1. From the Encephalitis Section, Technology Branch, Communicable Disease Center, Public Health Service, U.S. Dept. of Health, Education, and Welfare, Greeley, Colorado.

chickens from Salt Lake showed an infection rate of 3.6 per cent for WE and nothing for SLE (all positives were on one farm 13.3 per cent).

In an effort to determine factors responsible for differences in enzootic activity levels from year to year, infection rates in vector species and reservoir species are compared with climatic factors such as temperature, humidity, and precipitation, and with other environmental factors such as vector or reservoir density, to see if a given relationship between groups of data are consistently associated with high or low virus transmission rates. In this respect, data from Utah show an interesting relationship. Enzootic activity for the past several years has been related to the density of *Culiseta inornata* but not to the density of *C. tarsalis*. This is one of several observations made during the past few years which suggest that *C. inornata* might be more important in the epizootiology of WE than has been recognized formerly.

Data accumulated during the past 20 years indicates that human outbreaks of SLE usually have occurred at or below the 70° June isotherm in the United States, and that outbreaks of WE usually have occurred north of this line. This relationship to the June 70° isotherm suggested that temperature might be closely related to transmission potential during any given year, and that observations of temperatures during the spring and early summer months might indicate those years in which the risk of infection is higher or lower than usual.

Comparison of temperature and precipitation data from several areas of the United States show that WE outbreaks followed cool wet springs and the SLE outbreaks followed warm dry springs. The studies led, further, to the demonstration of a relationship between the occurrence of human cases and the temperatures and amount of precipitation during the spring and summer months. They are being continued in the hope that additional data or analyses will enable the more accurate prediction of conditions conducive to virus transmission.

Laboratory studies during 1962 gave support to the hypothesis that mammals might serve as overwintering reservoirs for arboviruses. Two isolations of western virus were obtained from rodent-brain tissue during the early spring (*Peromyscus* and *Microtus*). At this time of year no virus could be detected in birds or mosquitoes. California virus was isolated from a pool of *C. inornata* collected at 6,500 ft. in the mountain study area, and Modoc virus (a group B virus) was isolated from heart tissue from a *Peromyscus* collected in the permanent study area.

The possible occurrence of another agent in the area was suggested by HAI test results. Several chickens from Colorado and Utah gave positive HAI results to one strain of western antigen but not to several others. None of the positives could be confirmed by neutralization tests. Since similar results were not obtained on chickens from Texas, North Dakota, Oregon, Washington, or Massachusetts, the possibility of the occurrence of another agent related closely enough to confuse the HAI tests but not the neutralization tests is recognized. During the coming year, studies of this phenomenon will include intensive efforts to detect another agent.

Related to and associated with studies of encephalitis are continuing studies of the biology of mosquitoes, birds, and mammals. These involve the occurrence, abundance, and seasonal distribution of various species in relation to temperature, habitat, elevation, or photoperiod.

An interesting observation in this area has been that for the third consecutive year the first post-hibernation *C. tarsalis* female was found on almost the same date — on February 11, in 1961, and February 12, in both 1962 and 1963. For this same 3-year period, early activity of *C. tarsalis* was associated with mean and maximum temperatures. Specimens were collected from natural resting places during or immediately following the first week in which the mean temperature was 40°F. or above or as soon as daily maximum temperatures exceeded 60° for three or more consecutive days.

The ratio of *C. inornata* in light-trap and shed-trap collections has made an interesting observation. In the St. Vrain study area (elev. 4,600 ft.), light-trap collections of this species exceed those in shed traps by about 100 to 1. At the base of Lefthand Canyon (elev. 5,600 ft.), the ratio for *C. inornata* from light traps to those from shed traps was about 50 to 1. Further reduction in this ratio occurred with increases in elevation, until at 9,300 ft. the number of *C. inornata* in shed traps exceeded those in light traps.

In the Colorado study areas, mosquito populations were considerably lower in 1962 than in 1961. A light trap in the St. Vrain study area that averaged 86 *C. tarsalis* per trap night for the 1961 season collected only 38 per trap night in 1962. Similar reductions in catches occurred in other areas. At the 9,300 ft. site, only one-fifth as many *C. inornata* were collected in 1962 as in 1961 even though efforts were greatly intensified.

Experimental Encephalitis Control

1. *Wenatchee, Washington*

Studies were initiated in the Columbia Basin in the spring of 1961 to evaluate the effect of mosquito control through residual larviciding on encephalitis

transmission. An area of approximately 17 square miles providing a buffer zone of about 2 miles around rural sentinel flocks was treated with a pre-flood application of granular dieldrin. Sera from the sentinel chickens and mosquito pools collected from this area were tested for antibody and virus and the rates compared with those from three other areas.

The pre-flood dieldrin treatment failed to give effective control, and frequent retreatment of breeding areas with malathion and parathion was necessary.

Larval surveys indicated that approximately 85 per cent control of breeding within the area was achieved, but there was no significant reduction of *C. tarsalis* females in the treated area as compared with the untreated areas. Apparently considerable infiltration of *C. tarsalis* females from outside the treated area accounted for the failure to reduce the population.

Fall antibody rates in chicken sentinel flocks indicated that there was no reduction in WE transmission rates in the area.

In May and late July of 1962, three farmsteads in one of the areas were treated with 5 per cent DDT emulsion applied as an outdoor residual spray. Although mosquito populations overall were lower in 1962 than in 1961, the treated farmsteads showed a considerably greater decrease. It is believed that the residual premises spraying caused a significant reduction in the mosquito populations at the treated farmsteads.

Serologic tests on the blood sample obtained in the fall from the sentinel flocks in the treated area showed an 87 per cent reduction from the antibody levels of 1961. In one of the untreated areas, the HAI antibody rates increased 27 per cent over the 1961 levels, but the other untreated area the antibody rates showed a 90 per cent reduction from the 1961 levels.

2. *Texas*

Studies on WE and SLE virus transmission in the high plains area of the Texas panhandle were begun with a thorough survey of mosquito populations in 1954. Data on mosquito populations and encephalitis transmission rates have been collected in the vicinity of Plainview, Texas, for the past four seasons in anticipation of an experimental encephalitis control program designed to determine what effect mosquito control in a limited area around a town would have on transmission of WE and SLE virus, and to evaluate this as a means of providing protection for the residents of the town.

In the early spring of 1962, pre-flood application of granular dieldrin was made at the rate of one pound per acre to all known mosquito breeding sources in a 50-square-mile area. In the center of this treatment area was a small rural town of approximately 2,500 population. Sentinel flocks and light traps, located around the periphery of the town at the start of the study, were used to obtain indices of the mosquito populations virus infection rates in mosquitoes, and antibody levels in chicken sera. In addition, blood samples to be tested for antibody rates were obtained from the local residents. Two other areas similar to the treated area in agricultural practices, mosquito populations, and WE and SLE virus activity were used for comparison.

The granular dieldrin applied as a pre-flood treatment failed to provide the expected control, and it was then necessary to initiate a more conventional control program of larval inspection and treatment. Reapplication of granular dieldrin at rates up to one pound per acre to breeding sources repeatedly failed to yield acceptable levels of residual control. Reliance for the most part on DDT, malathion and parathion, and on Librom (Naled) and Bayer 29493 for special purposes, provided good control throughout most of the season.

Despite control efforts, the populations of *C. tarsalis* females within the treated area remained almost as high as those in the untreated comparison areas. Once again it is postulated that the high population of *C. tarsalis* within the treatment area was, for the most part, the result of mosquitoes infiltrating from outside the area.

Although there is some evidence that the population of *Culex quinquefasciatus* in the treatment area may have been reduced, the collections from previous seasons were not continued far enough into the early fall to make adequate comparisons.

Preliminary results from the 1962 sentinel flocks indicate that for the first time a reduction in transmission rates may have been accomplished through control of the mosquito vectors. Transmission rates in one untreated area were somewhat lower in 1962 than in 1961, but the reduction in the treated area was much more marked. SLE transmission rates were particularly low in the treated area with less than 2 per cent of the sentinels showing evidence of infection. This is much lower than any rates observed during the 5-year period in which the area has been under study. Final evaluation of results will be undertaken following completion of tests on sera from the second untreated area.

3. *Bakersfield, California, and Taunton, Massachusetts*

Experimental control studies in Kern County, California, also gave unsatisfactory results, and extensive infiltration of *C. tarsalis* into the treated area was demonstrated by releases of marked adult mosquitoes. Experimental control studies near Taunton, Massachusetts, were inconclusive because of the low activity of EE virus during the year of study. Results of the California and Massachusetts studies will be presented in separate papers.

Interagency Cooperative Studies

The Charter for a Subcommittee on Vector control was approved by the Interagency Committee on on Water Resources in 1961. The Departments of Agricluture, the Army, the Interior, and Health, Education, and Welfare, and the Tennessee Valley Authority are represented on the subcommittee. The mission of the subcommittee is the consideration, by the agencies concerned, of the major problems encountered in Federal water resources programs and to develop and coordinate policies dealing with vector control problems associated with the water resources development.

To meet the needs of the variety of problems, two task force groups were established: One for the preparation of a bulletin and other educational materials, and the other for cooperative research studies. There are eight regional projects throughout the country under the coordination of the Task Force with Dr. A. D. Hess as Chairman.

The Encephalitis Section is participating directly in several of the projects as a technical adviser.

Project V is in Utah and will be discussed by other participants of the conference in detail.

Project II was formed to design and evaluate modification methods for use on playa lakes in the southern high plains of the Texas panhandle. The purpose is to develop a practical modification that will serve the need for reduction or elimination of mosquito production, water conservation, reclamation of farm land, and waterfowl and fisheries development.

Observations of ten study lakes were made during the past season. Three of the lakes were modified this past winter, and studies will be continued to determine the effects of modification on the various biological and physical phenomena being studied.

Project IV, in the Columbia Basin in Washington State, is for the development and field-testing of vector control and sanitation measures that would be most practicable for use around waterside recreational areas of the northwest. These measures need to be compatible with multipurpose interests of public health, fish and wildlife conservation, overall recreational uses, and other uses of public lands. Activities pursued during the past year in connection with this project include mosquito bionomics, residual larviciding studies, an insect annoyance survey, observation as to the possible effects of insecticides on fish populations and a survey to determine the feasibility of permanent mosquito control measures.

Results of the first year's observations indicate that DDT emulsion sprays applied to trees, shrubs, and other vegetation in recreational areas offer promise for adult mosquito control.

Larviciding efforts with dieldrin as a pre-flood application failed to give adequate control.

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DEVELOPMENT AND USES OF WATER SUPPLY FORECASTS FOR UTAH

Elven H. McDonough[1]

Water is truly the Dr. Jekyl and Mr. Hyde in Mother Nature. Properly used it is one of man's greatest allies. On the other hand, water problems are as old as man himself. Even the Ancient Mariner had his own special problem. Today we are in danger of approaching a situation not too far removed from his. When we see the oceans, the rivers, the continuous flow of water through our taps and lawn sprinklers, it would appear that the supply was inexhaustible. The fact remains that the total amount of water on the earth and in its atmosphere remains constant. By a never-ending process, called the hydrologic cycle, water evaporates from the land and seas, falls back to earth as precipitation, and eventually returns to the seas in the huge river systems.

In modern times there has been an enormous increase in per capita consumption; approximately doubling with each successive generation. The accelerating population explosion diminishes even more each man's share of water, and the portion of good and usable water shrinks even farther as waste, pollution and poor conservation practices take their toll. Thus, the lament, "Water, water everywhere—" is nearer to reality than we think.

1. Water Supply Forecaster, U. S. Weather Bureau, Salt Lake City, Utah.

Obviously, there is a need for a better understanding of the complexities of the hydrologic cycle and its three major aspects: Evaporation-Precipitation-Runoff. Water supply forecasting concerns itself primarily with the latter two and most efforts are directed toward finding and developing relationships between precipitation and runoff.

Run-off, the end product of precipitation, is never coincident with the precipitation causing it. The time lag may vary from a few minutes or hours to several months as in the high mountain watersheds in Utah. Even longer periods of one or more seasons are in evidence in carry-over effects where underground water and storage plays a significant role in streamflow.

The economy of Utah and the Intermountain West is heavily dependent on the water accumulated in the winter snow pack which is later released during the snowmelt season. The western water user recognized early and exploited to his advantage this fortunate order of events. As a result, demands grew for a wide variety of water supply forecasts. Many operational forecasts are needed far in advance to plan for acreage to be cultivated, seed to be bought or disposition of hydro-electric power. Other purposes for which forecasts, some of a highly specialized nature, are needed, might include: (1) engineering design and planning of water-control structures; (2) navigational controls; (3) snow-melt floods; (4) culinary and metropolitan uses; (5) low stages, as affecting pollution problems or endangering marine life; (6) recreational pursuits, since nearly 50% of the people prefer water-based activities, such as swimming, skiing, boating and fishing. Other forms are more enjoyable near water such as camping, picnicking, hiking, canvas painting and many more; and finally, (7) special conditions and problems which are the concern of the mosquito control group assembled here today.

The first consideration in preparing a water supply forecast is the specific needs of the client. Some operations are a pure gamble and involve future use of water which may or may not become available. The operator should know what his odds are and how they change as the season advances.

A bulletin, "Water Supply Forecasts for the Western United States" is issued monthly by the Weather Bureau January 1 through May 1. In general, forecasts for the water year or some other seasonal period are prepared. If current flows can be obtained, or a reasonable estimate thereof, residual forecasts for the reminder of the season are included. All forecasts are based on the median of subsequent weather conditions.

In addition to the forecasts of the median value for which the chance of receiving more water is the same as getting less, four other forecast values are given, which assume that subsequent precipitation will be maximum, upper quartile, lower quartile, or minimum of record. The odds are 3 to 1 that the lower quartile of record will be equalled or exceeded, and, likewise, 1 to 3 for the upper quartile. The maximum and minimum forecasts are for occurrences which may be expected once in 30 or 40 years.

The success of any forecast depends on the data available; on the quantity and especially the quality of the data. Twenty years ago when the Weather Bureau recognized the need for an extensive and specialized water supply forecast program, a survey of data to develop precipitation-runoff relationships was not too rewarding. The number of precipitation stations in the important higher watersheds were too few or were too short of record. More than ten years of snow survey data was seldom available for any point. As such, any statistical approach to water supply forecasting had little chance for success.

Fortunately the Weather Bureau had maintained a fairly good network of precipitation stations with 25-30 years of record at low and intermediate elevations, supplemented by an occasional high altitude station. Surprisingly high correlations were found between stations, from low to intermediate to high elevations and even from one basin to another.

The first step in developing precipitation-runoff relations is to assemble all the basic data by months and seasons. Precipitation records dating back 100 years or more are found in various Weather Bureau publications. Streamflow records are available in water supply papers and summaries issued by the Geological Survey. The hydrologist can supplement these basic data with other meteorological elements such as temperature, wind, snow density, etc., in his research on water supply forecasting.

In conclusion, there may be various phases of the work pursued by this group for which a specific type of water supply forecast would be of some assistance either directly or indirectly. Potential insect breeding ponds are created by even small amounts of flooding or overland flow. On the other hand, during low stages, water becomes sluggish and isolated pools are formed in river beds. The high water yield of good years always encourages careless management of irrigation water.

I am sure we would be pleased to discuss any particular problem and investigate the possibility of arriving at a solution.

POPULATIONS OF AQUATIC INSECTS IN RELATION TO BOTULISM AT THE BEAR RIVER BIRD REFUGE, BOXELDER COUNTY, UTAH

Wayne I. Jensen[1]

Although outbreaks of "western duck sickness" or "alkali poisoning" had probably occurred in Great Salt Lake basin for many years earlier, it was not until 1910 that the malady was generally recognized as a serious threat to waterfowl. Another twenty years passed before scientists of the Bureau of Biological Survey and the Bureau of Animal Industry identified the disease as a form of botulism. It is impossible to estimate accurately the losses attributable to the disease, but it is safe to say that literally millions of aquatic birds have succumbed within this century.

Avian botulism is caused by a neurotoxin produced by a bacterium, *Clostridium botulinum* type C, as it multiplies somewhere in the marsh mud. The toxin is not uniformly distributed, and some birds will be exposed to larger doses than others in the course of their normal feeding activity. Accordingly, affected birds may exhibit symptoms varying from mild paralysis to complete prostration. Many of the severely intoxicated birds will die, particularly if they are not treated with injections of the specific antitoxin.

To summarize the results of much experimental work conducted at the Bear River Research Station and elsewhere, it is generally true that organic materials of animal orgin are more favorable media for toxin production that are those of plant origin. If for no other reason than their abundance there, the myriads of aquatic invertebrates that commonly inhabit botulism epizootic areas have been suspected of being an important source of the nutrients utilized by bacterium under natural conditions.

It has been demonstrated repeatedly in the laboratory that the carcasses of a number of species of invertebrates indigenous to the Bear River marshes serve as adequate media for toxin production by *Clostridium botulinum* type C. They both satisfy the nutrient requirements of the bacterium and provide the anaerobic environment that it needs for growth. Moreover, it has been shown that ducks consume these invertebrates, either by chance or by choice, in amounts varying with the species of bird, season of the year, abundance of the invertebrates, and probably other factors.

If invertebrate carcasses do indeed support toxin production at levels sufficiently high to precipitate a botulism outbreak, it may be hypothesized that a die-off of one or more species of invertebrates occurs a few days before the first sick birds are seen. To test this hypothesis, aquatic invertebrate population studies have been conducted at the Bear River Research Station each summer for the past eight years. One-hundredth square meter mud samples and ten liter water samples were collected at as many as sixty collecting stations in the marsh each week throughout the summer. Invertebrates were separated from the mud by washing the samples gently in a 42-mesh Tyler sieve. Organisms in the water were concentrated by passing the sample through a 173-mesh pond life dip net. The species in each sample were then counted and classified.

The numbers of organisms in the water taken at any particular station varied within wide limits from week to week, presumably because their distribution was not uniform and the foci of the several species were moved by wind action or, perhaps, their own activity. There was no apparent relationship between the occurrence of botulism outbreaks and the levels of these invertebrate populations, as determined by this study.

The counts of the macro-bottom fauna (largely dipterous larvae and oligochaetes), on the other hand, appeared to reflect true changes in population numbers. In 1955, 1957, and 1958, years in which botulism losses on the study area were moderate to severe, the numbers of these species reached a peak in early August, which was followed by a sharp decline. In each case, the beginning of a botulism outbreak coincided with the decline in the numbers of living invertebrates. In 1956, the macro-bottom fauna numbers remained at a very low level throughout the summer, and losses from botulism were the lowest in the history of Bear River Refuge. In the years 1959 to 1961, these species were more abundant than in 1956, but there were neither high population peaks nor sharp declines in numbers; waterfowl mortality was mild during this period.

Although outbreaks of botulism have been observed to follow natural die-offs of one or more species of aquatic invertebrates, a cause-and-effect relationship has not yet been proved. To do so, it will be necessary to induce outbreaks experimentally by artificially causing die-offs of invertebrates and, after a suitable incubation period, allowing susceptible birds to feed on the carcasses. Small-scale experiments of this kind have been carried out with limited success, and more effort will be devoted to them in the coming summer.

1. Fish and Wildlife Service, Bear River Refuge, Brigham City, Utah.

If the avian botulism-aquatic invertebrate relationship is eventually proved conclusively, the possibility of preventing or controlling the disease by way of limiting invertebrate numbers would seem to be worthy of investigation. The susceptibility of a few species to several chemical agents has been determined by laboratory and small-scale field tests. Much more work must be done, however, before the effectiveness and practicability of such methods can be evaluated.

FIELD TESTS OF RESIDUAL INSECTICIDES FOR CONTROL OF ADULT SNOW-WATER AND FLOOD-WATER MOSQUITOES AROUND A WATERSIDE RECREATIONAL AREA IN WASHINGTON

by

Louis J. Ogden[1] and Roy J. Myklebust[2]

These studies were made possible as a result of an interagency cooperative project entitled, "Development of Vector Control and Sanitation Measures for Waterside Recreational Areas in the Northwest." This project was initiated during 1961 by the Subcommittee on Vector Control, Interagency Committee on Water Resoures (Simmons, 1962). The Federal agencies participating in the planning and technical consultation pertaining to the project include the Forest Service, Fish and Wildlife Service, Public Health Service, and the Bureau of Reclamation. Washington State agencies, including the Department of Health, the Parks and Recreation Commission, the Game Department and the Fisheries Department, also collaborated in the project.

Beginning in June 1962, field studies were undertaken in the vicinity of Lake Wenatchee to evaluate DDT and BHC as residual adulticides against snow-water and flood-water mosquito species. Test were evaluated by two biological aides who made simultaneous biting collections, one in the treated area, and the other in an adjacent, untreated area. Three 15-minute biting collections were made each hour, with the biological aides changing positions every 15 minutes. Prior to each application of insecticide, pretreatment mosquito biting rates were established by collections for periods of approximately 8, 7, 6, and 3 hours, respectively, for the treated and untreated check sites at the Nason Creek Forest Camp, Glacier View Forest Camp, Cougar Inn and Fish Trap Area. Following application of the insecticide, mosquito collections were made during the peak mosquito biting periods; in the morning usually from 9:00 a. m. or 10:00 a. m. to 11:55 a. m. and in the evening from 7:00 to 8:55 p.m.

DDT water-emulsion was applied to a 6-acre section of the Nason Creek Forest Camp by means of a hydraulic, orchard-type power sprayer equipped with 200 feet of hose and an orchard-type spray gun. Shrubs, trees, and other vegetation were sprayed to the point of run-off. Trees were sprayed to a height of approximately 15 feet. The mosquito collecting station for evaluating this insecticidal treatment was located 100 feet inside the nearest boundary of the sprayed area.

A Buffalo Turbine[3] was used to apply a DDT mist to a 7-acre section of the Glacier View Forest Camp.

Trees, shrubs, and other vegetation were thoroughly wet with emulsion. The mosquito collecting station for evaluating this insecticidal treatment was located 75 feet inside the nearest boundary of the sprayed area.

A similar procedure, using the Buffalo Turbine, was used to apply DDT emulsion to camp ground and other parts of the premises at the Cougar Inn. The mosquito collecting station within this camp ground was located about 30 feet inside the nearest boundary of the sprayed area. Lack of an access road prevented application of DDT to a wider area around this camp ground. Eleven days after the application of DDT., BHC dust was applied in the same manner to the camp ground and other parts of the premises at the Cougar Inn.

A 2-acre strip of rather dense woodland adjacent to the experimental study area (Fish Trap Site) of the U.S. Fish and Wildlife Service on the White River was treated with BHC dust applied by means of a Buffalo Turbine. The mosquito collection station used to evaluate this treatment was located about 30 feet inside the nearest boundary of the treated zone. Again, lack of access roads prevented application of dust to a wider area.

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1. From the State Aids Section, Technology Branch, Communicable Disease Center, Public Health Service, U. S. Departent of Health, Education and Welfare, Wenatchee, Washington.
2. From the Washington State Department of Health, Olympia, Washington.
3. The use of the trade name for this equipment is for identification purposes only and does not constitute endorsement by the Public Health Service or the Washington State Department of Health.

The estimated reduction in mosquito biting rates resulting from the pesticide treatments tested are shown in table 1. Although the interpretation of the insecticide studies are complicated by low mosquito populations, it appears that in two tests DDT emulsion, applied either with an orchard-type power sprayer or with a Buffalo Turbine, at rates of 7 or more pounds of technical DDT per acre gave significant reductions of adult mosquitoes for periods up to three weeks.

In three other tests, DDT emulsion applied with a mist blower at the rate of 13 pounds of technical material per acre and BHC dust applied with a power duster at the rates of 1.2 and 2.3 pounds of gamma isomer per acre did not give satisfactory control. Failure of these tests may be attributed to presence of dense vegetation and lack of access roads, preventing establishment of an adequate barrier strip — 50 feet wide or wider.

Mosquito species against which these measures were directed include: *Aedes aboriginis, A. cinereus, A. communis, A. fitchii, A. hexodontus, A. increpitus, A. intrudens, A. punctor, A. sticticus,* and *A. vexans.* Of these, *A aboriginis, A. communis, A. increpitus,* and *A. sticticus* were the most common species.

Analysis of mosquito biting collections made during the hours of 8:00 a.m. to 9:00 p.m. showed that the peak biting period occurred during the evening hours with a lesser rate of biting during the morning hours. Mosquitoes exhibited little biting activity before 8:00 a.m.

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TABLE 1: RESULTS OF APPLICATION OF DDT AND BHC TO CONTROL ADULT MOSQUITOES AROUND FOUR RECREATIONAL AREAS, LAKE WENATCHEE, WASHINGTON 1962

AREA	TREATMENT	ESTIMATED PERCENT REDUCTION IN MOSQUITO BITING RATES																	
		Days After Treatment																	
		1	2	3	4	5	6	7	8	9	11	13	16	17	18	19	20	23	25
Nason Creek Forest Camp	2½% DDT Emul. Power Sprayer	100	100				100		96			100	100	88			84		
Glacier View Forest Camp	2½% DDT Emul. Buffalo Turbine		*			99				*			96					97	
Cougar Inn	2½% DDT Emul. Buffalo Turbine	78		92			1												
Cougar Inn	BHC dust, 3% gamma isomer Buffalo Turbine		41		28						99					91			
Fish Trap Site White River	BHC dust, 3% gamma isomer Buffalo Turbine	82				85			66		33				50		48		28

*Zero counts in both treated and comparison sites.

UTAH MOSQUITOES - THEIR PUBLISHED HISTORY[1]

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The published history of Utah mosquitoes covers a period of 46 years, from 1917 to the present. The first significant publication was by Dyar and Knab (1917) who described a new species of mosquito, *Aedes niphadopis* D. & K. from Salt Lake County. Few additional publications appeared until D. M. Rees of the University of Utah actively undertook the study of the Utah mosquito fauna in 1928. The first comprehensive publication on Utah mosquitoes was a bulletin by Rees (1943) which included a taxonomic, ecological and control study of the known species. From that time to the present numerous publications on the Utah mosquito fauna have appeared. The most recent major publication has been the "Identification Guide to the Mosquitoes of Utah" by Nielsen and Rees (1961).

The establishment of mosquito control in Utah and particularly the organization of the Utah Mosquito Abatement Association has been a major factor in stimulating publications on Utah mosquitoes. The annual proceedings of the Utah association has been one of the most important sources of information on the local mosquito fauna.

The present bibliography includes a list of publications whch are either devoted entirely to Utah mosquitoes or contain significant references to the Utah fauna. There are 245 titles representing 30 different periodicals included. This represents nearly 700 published pages and approximately 250 mimeographed pages. Also included are the titles of 24 unpublished theses representing graduate degrees awarded for studies on Utah mosquitoes at Utah universities.

Most of the mosquito abatement districts in Utah prepare mimeographed annual reports of their activities which are not available as publications. The Salt Lake City Mosquito Abatement District however, has published and distributed an annual report of activities each year since 1930 and a yearly summary of these reports each year since 1945. These publications have been edited by D. M. Rees and authored by D. M. Rees, the managers of the district and contributors from the Department of Zoology and Entomology, University of Utah. They contain in addition to control activities much valuable information on mosquito research projects conducted in the district. A detailed list of these reports and summaries has not been included, but information on their availability may be obtained from the manager of the Salt Lake City District.

1. This study was supported by a PHS research grant, A1 04121 from the National Institutes of Health, Public Health Service.

Abbreviations used are as follows:

AMCA—American Mosquito Control Association

CMCA—California Mosquito Control Association

NJMA—New Jersey Mosquito Extermination Assn.

UAS—Utah Academy of Sciences, Arts and Letters

UMAA—Utah Mosquito Abatement Association

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A COMPARATIVE GROWTH RATE STUDY BETWEEN THE LARVAE OF *AEDES DORSALIS* MEIGEN AND *AEDES NIGROMACULIS* (LUDLOW)

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This study was conducted to obtain more exact data pertaining to the relationship between the temperature and the growth rate of two mosquito species, *Aedes dorsalis* and *Aedes nigromaculis,* and to determine the differences in growth rate between these two species.

Procedure

Growth sequences were run by first selecting irrigated locations which were known to produce large numbers of both *A. dorsalis* and *A. nigromaculis* and were known to hold water long enough to complete aquatic development of these two species.

As soon after irrigaton as possible, the areas were checked for larval populations, and the most productive sections were marked off with red flags. Random larval samples were collected in these sections at 7:00 A. M. and 4:00 P. M. daily. Water and air temperatures were taken at each collection. The immature stages were then brought into the laboratory for identification and determination of instar.

Discussion

The first of the two growth sequences was conducted from May 7 though May 18, 1962 in a lightly grazed pasture irrigated by water from the Jordan River. The mean air temperature for the ten day period was 57.7°F. with a mean water temperature of about 60°F. At these temperatures, about two and one half days were required to complete the first larval instar development in both species, two days for the second instar in *A. nigromaculis* and slightly longer with *A. dorsalis. Aedes nigromaculis* required about one and one half days to complete the third instar as compared with two and one half days for *A. dorsalis.* Fourth instar and pupal development rates were incomplete due to the loss of surface water. Thurman, in California, reported that *A. nigromaculis* required 16 days at 54°F to complete its aquatic stages, with three days in the first instar, two in the second, two in the third, six in the fourth and three in the pupal stage. (See table 1, page 25)

The second sequence was conducted from July 6 through July 11, 1962 in an ungrazed irrigated pasture which was flooded on July 6 and 7th. The mean air temperature for the five day period was 80°F with a mean water temperature of 76.5°F. At these temperatures, *A. nigromaculis required* about 18 hours for the first instar, about 18 hours for the second instar, one day for the third instar, one and one half days for the fourth instar and one for the pupal stage, for a total of five to five and one half days to complete the aquatic stages, as compared with *A. dorsalis* which required one day each for the first and second instars, one and one half days for the third instar, one and one half to two days for the fourth instar, and about one day for the pupal stage, for a total of six to six and one-half days. (See table 2, page 25)

Summary and Conclusions

During this study, at a mean temperature of 57°F, *A. nigromaculis* required about 14 days to complete the aquatic development as compared to only five days at 80°F. *Aedes dorsalis* required about 16 days at the former temperature, and six to six and one half days at the latter temperature.

The rapid development of *A. nigromaculis* at July and August temperatures in Utah allows only about four days from the time eggs hatch until pupation begins. If effected control is to be realized it is necessary to inspect areas where this species occurs at least twice weekly during the seasons of the year when the warmest temperatures prevail.

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UTAH'S STATE-OWNED MARSH LANDS THEIR ROLE IN THE PERPETUATION AND USE OF A RESOURCE

By
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Waterfowl is a resource of international significance - one, which like many other natural resources is showing the effect of an encroaching civilization. The Soil Conservation Service estimates there were 127 million acres of wetland habitat scattered throughout our borders at the time the country was settled. Today there are less than 70 million acres and losses continue to occur.

No one knowns what our waterfowl popluations were during the early years of our settlement but some observers estimate there were some 145 million ducks, geese, swan and coots on the continent at the

TABLE 1

GROWTH RATE OF *AEDES NIGROMACULIS & AEDES DORSALIS*

		Aedes nigromaculis					*Aedes dorsalis*					Water Temperature				Air Temperature**		
Date	Time	1	2	3	4	p	1	2	3	4	p	Pres.	Max.	Min.	Mean	Max.	Min.	Mean
5/9	0830	5					7					....	....	....	....	82	62	72
5/10	1030		14					13				62	69	....	....	86	58	72
5/11	0800		24					43				53						
5/11	1600		10				2	36				70	74	53	63.5	80	50	65
5/12	0900		1	25				20	23			60						
5/12	1600			34					4			66	71	44	57.5	75	39	57
5/13	0800			67	5			2	77			50	....	47	....	63	46	55
5/14	0800			10	113				35	5		*						
5/14	1600			4	109				53	6		*	....	....	....	61	41	51
5/15	0800			3	86				31	13		*	....	....	....	63	36	50
5/18	1500				11					2		*	....	....	....	73	42	50

Note: The study area, a lightly grazed pasture, is located along the west side of the Jordan River at 2500 North. This was the first irrigation of the year and occurred on May 7 and 8.

*Surface water had dissipated with larvae being recovered by addition of water, no pupae were observed.

**Air temperatures obtained from U. S. Weather Bureau, Salt Lake Municipal Airport.

TABLE 2

GROWTH RATE OF *AEDES NIGROMACULIS & AEDES DORSALIS*

		Aedes nigromaculis					*Aedes dorsalis*					Water Temperature				Air Temperature		
Date	Time	1	2	3	4	p	1	2	3	4	p	Pres.	Max.	Min.	Mean	Max.	Min.	Mean
7/7	0930	6	8				4					76						
7/7	1600		27					3				91	92	....	....	93	60	77
7/8	0700		5	28				5				65						
7/8	1600			32					4			86	89	64	77	99	65	82
7/9	0730			7	33				13			61						
7/9	1600				37				2	8		91	93	59	76	97	62	80
7/10	0700				38					9		63						
7/10	1600				11	22*				13		94	95	61	78	96	63	80
7/11	0800				6	24*				6		63						
7/11	1630					2*					1*	**						
7/12	0800					***							....	59	....	99	61	80

Note: The study area, an ungrazed pasture, is located on the northeast corner of 1700 North and 2450 West. It was inspected twice on July 5 and found to be dry; irrigation occurred some time on July 6 and water was still entering the field on July 7.

*Pupae reared in laboratory for positive identification.

**Surface water had dissipated with three pupae being recovered by addition of water; one larvae was observed but was not taken.

***No larvae or pupae were recovered by the addition of water. A few biting *Aedes nigromaculis* females were observed but apparently were not from this brood.

turn of the century. Present-day calculations indicate that these early numbers have dwindled to between 35-40 million birds. It is inconceivable these populations will ever again be as prosperous as they once were, but it is just as difficult to think they should be further decimated.

While our habitat and waterfowl numbers have been plummeting, our duck hunters have been skyrocketing. In 1934, the first year of the duck stamp, there were 635,000 waterfowl hunters in the United Sates. Interest reached an all-time high in 1955 when approximately 2,370,000 persons participated in this sport. Thus, in a span of some 22 years the numbers of duck and goose hunters over our Nation increased an almost incredible 273 per cent. This population has now leveled off - no doubt due to a supply and demand relationship with the resource. As you are aware, the supply hasn't been too good lately.

These few statistics are given to emphasize the need for good managed waterfowl habitat and to reveal some of the important motivating factors in the Department's wetland acquisition and development program. Other factors have also been considered such as the acquisition of better marsh habitat by gun clubs and the incidence of disease. Botulism, which in one year alone took an estimated 300,000 ducks on the delta of the Bear River was a primary consideration in the development of Bear River Refuge. Our concern regarding these trends and factors was climaxed in 1923 by initial development on the Public Shooting Grounds. This was the first area in the United States to be developed for the primary purpose of waterfowl shooting. Since 1923, the Department has acquired and in most cases developed, 13 additional waterfowl areas of sizes varying from 2 to 13,700 acres.

We now own and operate nine developed marshes totaling 61,178 acres and five undeveloped areas totaling 5,191 acres. Thus, state-owned marshes comprise a grand total of 66,369 acres of diversified habitat. This habitat has been acquired and developed at an expense of well over $2,000,000. The value of any commodity is what it can be bought and sold for. Based on a recent sale of hunting rights in California for $800.00 per acre, these lands take on a tremendous value — something over $50,000,000. I don't believe we have reached this point yet, but experience shows it can happen.

These marsh areas play host to hundreds of thousands of waterfowl each year. In addition to local birds we provide for multitudes of migrating birds both during their spring and fall movements. Birds banded on our marsh have been recovered in no less than 28 states and 5 foreign countries.

We estimate that between 200,000-225,000 ducks and from 2,500-3,000 geese are produced in Utah each year. This represents approximately two per cent of the waterfowl produced in the Pacific Flyway of which Utah is a member. Approximately 45,000-50,000 of these ducks and over 800 geese are produced on Department-owned marshes. Thus, on approximately 11.5 per cent of the total wetland habitat in Utah we are obtaining approximately 22 per cent of the State's waterfowl production. Certainly this emphasizes the value of managed habitat as opposed to marginal natural wetland area. The more common nesting species on our marshes are mallard, redhead, cinnamon teal, pintail, gadwall and shoveller in addition to Canada geese.

Waterfowl hunting has been one of the primary purposes of our developments. During an average year there are approximately 31,000 people who hunt ducks and geese in Utah. These people will average six days of hunting each and reportedly kill about 13 ducks each during the season. Thus, between 175,000-200,000 days afield are enjoyed each year in pursuit of waterfowl and a reported total of some 400,000 ducks and geese are killed. About 30 per cent of these trips are made on Department-owned marshes and they account for approximately 30 per cent of the waterfowl killed in the state. This is a significant quantity of recreation.

Other recreational opportunities also exist and are enjoyed on our marshes. Pheasant hunters are becoming more abundant on our developments each year. Good waterfowl habitat is also excellent pheasant habitat. An estimated 1,200 hunter trips were made on waterfowl management areas in 1962 during which about 1,500 pheasants were harvested. As expressed earlier, this use is increasing at a tremendous pace.

Muskrats, although a nuisance in some instances, are an important element in a marsh complex. Their houses provide nesting sites for waterfowl and their material gathering activities open vegetative stands and increase the quantity of shoreline which improves marsh composition. Their runs provide avenues of escape for young and flightless adult waterfowl through dense vegetation. These animals must, however, be kept in balance with other factors in the marsh. The Department of Fish and Game allows controlled public trapping on management areas and each year over 20,000 muskrats are taken. With fur prices as they are this year, the total income to trappers will be nearly $25,000.

In 1962 approximately 3,000 visitor days were recorded on Ogden Bay and Farmington Bay Waterfowl Management areas. These people came from all walks of life and their purposes were many-fold.

Students, scouts, teachers, bird-watchers and people with no specific design, toured these areas and obtained historical and biological information from lectures provided by Department technicians.

Valuable research programs are conducted on our marshes. Such studies have included the interrelationship of carp and waterfowl food plants, food habit investigations, life histories of various species, marsh succession, waterfowl productivity, habitat requirements, disease research, hunting mortality, migration patterns, water requirements for marsh management, and mosquito-waterfowl relationship. Such investigations improve our knowledge and increase our ability to manage a valuable resource with a minimum of conflict.

To place a strict monetary value on our public marshes or to fully evaluate their contributions to the State and Nation would be a difficult task. I doubt that such calculations are necessary as I believe their relative importance can be realized from an analysis of the foregoing statistics. I hope these few facts have been enlightening to you.

PROGRESS REPORT FOR 1962 ON COOPERATIVE RESEARCH PROGRAM IN UTAH PERTAINING TO MULTIPURPOSE USE AND MANAGEMENT OF REUSABLE WATER[1]

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At the fifteenth annual meetings of the Utah Mosquito Abatement Association held in March, 1962, I presented a report on a multipurpose water use and management study that is being made in Utah for "The Development of Techniques for Multipurpose Management of Reusable Water Before It Enters the Great Salt Lake." The study has, as collaborators, appointed representatives of several federal, state, and county agencies. This report is published in the proceedings of the 1962 UMAA meetings.

Today I have been requested by the program committee to: (1) outline the major events that have taken place in this cooperative study of multipurpose water management during the past year, some of which will be reported on in greater detail by other speakers during this session; (2) report on the "Conference for Co-ordinated Program on Wildlife Management and Mosquito Suppression" held at Yosemite National Park, California, October 15-18, 1962, which included an inspection tour of some of the wildlife areas in California; and (3) enumerate some of the related events that have taken place in Utah since this conference was held in California. These topics will be presented in the above order.

The work on the program to develop techniques for multipurpose management of reusable water before it enters the Great Salt Lake was generally conducted according to the plans presented in the 1962 meetings of this association. In addition to the collaborating agencies that were named as participating in this program at that time, the Soil Conservation Agency during the past year has accepted an invitation to join us as a collaborator and has appointed its representative. The marshes of the Lake Front Gun, Fur and Reclamation Club were selected, with the consent and full cooperation of the officers of the club, as one of the study and test sites of the program. Farmington Bay Bird Refuge with the full cooperation of the State Fish and Game Department is being used as the second study area. In addition, an unexpected opportunity for study, experimentation and testing, to develop techniques for more beneficial multipurpose water management practices, was made available during the year by the Wheeler Machinery Company. This company is in the process of developing a 750 acre tract of land involving multipurpose use of water that formerly discharged into marshes on or near Farmington Bay Bird Refuge and eventually into the Great Salt Lake. At these meetings Dean M. Andersen will report on the work that was accomplished on the Lake Front and Farmington Bay marshes during 1962. Frank D. Arnold will explain the cooperative water management program that has been established with representatives of the Wheeler Machinery Company for the tract of land this company is developing on the shores of the Great Salt Lake.

Glen C. Collett, manager of the Salt Lake City Mosquito Abatement District, will present some results of mosquito production in this district by comparing mosquito production on the Lake Front Club where some water management is in operation, with adjacent areas where water management has not been attempted.

The "Wildlife Management — Mosquito Suppression" conference held in California in October of this year was very successful in attaining the stated objec-

1. This research project is being supported in part by funds provided by the Research and Training Grants Branch, Division of Water Supply and Pollution Control, Public Health Service, Research Grant WP-00027-02.

tive of promoting cooperation between those individuals and agencies engaged in wildlife development and management and those individuals and agencies engaged in mosquito suppression. This is the first conference of its kind to be held in western United States. Approximately one hundred people registered for the conference and others attended some of the sessions. It was attended by representatives of many federal and state agencies located in different parts of the country who are interested in this problem, but the majority in attendance were from western states. Six people were present from Utah: Donald A. Smith of the State Fish and Game Department who is in charge of waterfowl management for this department, the managers of Salt Lake City and Salt Lake County mosquito abatement districts in Utah, and three from the University of Utah who are working on the water management research program. Four of the contingent from Utah were scheduled on the program of the conference and all participated in the discussions.

The members attending the conference met at noon, October 15, at Berkeley from where a conducted motor tour was made of the reclaimed salt marsh in Solano County north of San Francisco Bay which contains some 100,000 acres, On Tuesday a tour was made through wetland areas in western Merced County beginning at Gustine and ending at Los Banos. This area comprises some 200,000 acres part of which is natural marsh watered by overflow from the San Joaquin River and its tributary streams and the remainder is intermittent marshland created by irrigation drainage water. Frequent stops were made during these tours to explain problems of concern to wildlife and mosquito control agencies. The scheduled meetings of the conference were held at Yosemite National Park on October 17-18.

This conference will undoubtedly be followed by other similar conferences. It was generally agreed by those attending the conference that the principle of cooperation should be included in developing the programs of wildlife management and mosquito suppression but to many of those attending this was the first time they had officially met to consider this possibility. In this respect, Utah is far ahead of most states. We have not only accepted the principal of cooperatin, we have put it into operation in some areas among those engaged in multipurpose use and management of water on our marshes and found it is workable and mutually beneficial to wildlife and mosquito abatement programs. In addition it has been found, in some instances, to be beneficial to other water users who are attempting to increase productivity of pastureland.

Since the California conference, the officers of the Utah Mosquito Abatement Association, after consultation with personnel of the State Fish and Game Department, appointed "The Utah Mosquito Control-Fish and Wildlife Management Coordination Committee". Dr. Jessop B. Low, wildlife biologist, Fish and Wildlife Service, was appointed chairman with Donald A. Smith, Supervisor of Waterfowl, of the Utah State Department of Fish and Game, and Dr. Don M. Rees, chairman, Division of Biological Sciences, University of Utah, as members of this committee. The committee has prepared a plan and list of objectives to be achieved in developing this cooperative program. The plan and objectives will be presented at the business meeting of this association for consideration, amendments if desirable, and we hope adoption by this association.

Officers of the UMAA have been informed by the officers of the National Mosquito Control — Fish and Wildlife Management Coordination Committee that Utah has organized the first state committee of this kind in the country and congratulated them on the leadership Utah has demonstrated in developing this cooperative program for multipurpose use and management of reusable water. We are all very pleased in the accomplishments that have been made in this cooperative program during the past year and in the prospects for continued development of the program in the future.

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A REPORT OF THE FIRST YEAR STUDY ON DEVELOPMENT OF TECHNIQUES FOR MULTIPURPOSE MANAGEMENT OF REUSABLE WATER[1]

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Introduction: It is recognized that some current water management practices, or lack of water management, along the eastern shores of the Great Salt Lake have resulted in the production of mosquitoes in a variety of situations. The development of waterfowl refuges and shooting areas has at times resulted in the production of mosquitoes which could have been prevented had mosquito abatement measures been included in the development plans. The mismanagement of water used for irrigation, particularly on pastures, has created prolific mosquito production in certain parts of this area and, in some instances, with detrimental effects to the pastures.

It is recognized that there is a need for more information demonstrating the relationships between mosquito production and planned water management practices, which includes the necessary requirements for waterfowl propagation, agriculture, public health, and the development of other economic values derived from the land and water involved.

Since September 1, 1961, an investigation has been under way to determine the effect of the use of water, which eventually runs into the Great Salt Lake, upon mosquito production, waterfowl propagation and management, agriculture, and other operations which are connected with the use of this water.

When the effects of the current use of water in the study area have been determined, physical facilities and techniques will be developed and tested in an attempt to improve multi-purpose water management practices in this area. This should eventually result in the formulation of a number of basic recommendations for improved water management practices that would be beneficial to all water users concerned.

Procedures: The name "reusable water" is proposed to identify what is commonly called "waste water." This water has its immediate orgin in run-off irrigation, storm gutters and sewers, seepage from canals, discharge from industrial and municipal sewage treatment plants, water from streams originating in the mountains and other sources. If not checked in its course, this water would flow by most natural route into the Great Salt Lake where at the present, the water is no longer usable.

The reusable water with which this study is concerned is present in an area between the shores of the Great Salt Lake on the west and Highway 89-91 on the east and forms an irregular strip of land varying from 3 to 8 miles in width and about 45 miles in length, extending from Willard Bay Reservoir on the north to Salt Lake City on the south. This area covers approximately 400 square miles.

Included within this area are productive agricultural lands, high and low quality pasture lands, thousands of acres of managed and unmanaged marsh lands, and large tracts of barren alkali and mud flats.

Two specific marsh and one pasture area were initially selected from the general area for detailed investigation. Only the results of the marsh studies will be presented in this paper.

The Lake Front Gun, Fur and Reclamation Club, one of the marsh areas selected for study, has a total of approximattely 6,000 acres of which 1,500 acres are covered by water during the mosquito season when water is available. This is a private gun club with a membership of 60 shares.

The Farmington Bay Waterfowl Management Area, the other of the marshes selected for study, is a state-owned refuge covering approximately 10,000 acres.

Fourteen larval sampling stations were selected in the Lake Front Club and sixteen stations in Farmington Bay. Each station was sampled weekly from the first of April to the end of September, 1962. A pint dipper was used to collect larvae and larval densities were measured in average number per dip. The adult mosquito population was sampled by means of light traps and bite counts.

Each larval sampling station was evaluated as very high, high, medium, or low in mosquito production. This evaluation was based upon the number of times larvae were found, the densities in which they were present and the number of times larviciding was required for control. These stationss were also evaluated on their value as a habitat for waterfowl by two experienced waterfowl managers of the Utah State Fish and Game Department. The stations were rated as excellent, good, fair, or poor, based upon food, nesting, and cover available for waterfowl.

Results: Six species of mosquitoes were collected in the larval stage. These were, in order of numbers taken, *Culiseta inornata* (Williston), *Culex tarsalis* Coquillet, *Aedes dorsalis* (Meigen), *Culex salinarius* Coquillet, *Culex erythrothorax* Dyar, and *Culex pipiens* Linnaeus. The above species, with the exception of *C. salinarius*, were also taken in adult samples. In

1. This research project is being supported by funds provided by the Research and Training Grants Branch, Division of Water Supply and Pollution Control, Public Health Service, Research Grant WP-00027-02.

addition, a single *Anopheles freeborni* Aitken specimen was taken in a light trap sample. *Culex tarsalis* was the most abundant adult mosquito taken.

The evaluation of the 30 larval sampling stations in the two study areas as to their suitabliity as a waterfowl habitat and for mosquito production was made in four general groups, those in which: 1) mosquito production is high and suitability as a habitat for waterfowl is poor; 2) mosquito production is low and suitability as a waterfowl habitat is good; 3) mosquito production is medium to high and suitability as a habitat for waterfowl is fair to good; 4) mosquito production is low and suitability as a habitat for waterfowl is poor. Those habitats which received the highest rating for waterfowl propagation were rated as low mosquito producers, however some mosquito production was found in all sampling stations.

Discussion: The mosquito larvae of the three major species present in the study area were found associated with all types of emergent vegetation and with most of the moist soil plants which were flooded. The areas which were most prolific in mosquito production were generally those in which there were dense stands of salt grass (*Distichlis stricta (Torr.) Rybd.*) which were either intermittently flooded or more permanently flooded with six or less inches of water. Generally, those areas which supported rather sparse emergent type vegetations such as alkali bulrush (*Scirpus paludosus* A. Nels.) and other similar plants were not prolific mosquito producers. However, as the water depth decreased in these areas the mosquito production increased. The density of the vegetation also plays an important part in mosquito production. Generally, the greater the density of the vegetation, both emergent and moist soil types, the more prolific the mosquito production in the marsh areas.

According to Nelson (1962) "An ideal Utah marsh would have constant water levels. Large lakes, ponds, and streams would be filled with sago pondweed, and these would be interspersed among alkali bulrush, hardstem bulrush, and wild millet. . . ."

Nothing in the above requirements for a good waterfowl marsh, as described by Nelson, is ideal for the production of the species of mosquitoes that are present on these marshes. In fact, the above described marsh would contribute greatly to mosquito suppression on these marshes when compared with existing conditions.

Recommendations for Water Management: General recommendations for water management in the marsh areas for 1963 are: 1) confinement of the water through adequate diking and or alteration of topography; and 2) provide adequate water control structures necessary for a flexible water management program to meet the needs of a fluctuating water supply.

The confinement and stabilization of water level will greatly reduce the production of *A. dorsalis*, the temporary pond or flood water mosquito. It will also help provide the constant water level required for optimum growth of marsh plants and prevent the destruction of the nests of waterfowl by flooding. With a flexible water management program, areas can be permanently flooded or kept dry during the mosquito season, according to the water supply. The water depth can be maintained above the optimum for mosquito production and yet not too deep for proper waterfowl propagation.

Specific recommendations, following the principles of the above general recommendations, have been formulated and will be carried out in certain areas of the Lake Front Club and Farmington Bay.

THE WHEELER MACHINERY COMPANY LAND DEVELOPMENT PROJECT AND MULTIPURPOSE WATER MANAGEMENT PROGRAM[1]

Frank D. Arnold, M. S.
Department of Zoology and Entomology, University of Utah

The Wheeler Machinery Company of Salt Lake City has purchased 750 acres of land which borders Farmington Bay on the south and the Great Salt Lake on the west. The land was procured primarily for the purpose of testing heavy construction equipment which is sold and reconditioned by this company. A benefit derived incidental to the testing is land improvement by grading, leveling, drainage, and construction of water management and control facilities.

Of the total acreage, 445 acres are to be developed for agricultural use, primarily high quality pasture, and 285 acres are planned for wildlife wetland development.

Considerable progress has already been made during the past summer on the actual development of the project. Roads have been constructed, fences installed, water holding reservoirs built, land leveled, and some water managememt devices established. In the wetland area considerable acreage is now under

1. This research project is being supported by funds provided by the Research and Training Grants Branch, Division of Water Supply and Pollution Control, Public Health Service, Research Grant WP-00027-02.

water. The project probably will not be completed for several years.

Because of its proximity to Farmington Bay, the Wheeler Machinery Company development is ideally suited for extensive study of the wildlife wetland-mosquito relationship. It also presents the opportunity for further investigation of the irrigated pastureland mosquito situation. Both involve multi-purpose water management within the scope of the research project now underway.

Mr. J. K. Wheeler and several of his assistants have been contacted. They have indicated a willingness to cooperate. The extent of their cooperation could include the use of heavy construction equipment in the development of water management structures, shore alignment, and control of vegetation, where mutual benefits can be derived.

The Soil Conservation Service has been the planning agency for much of the land development project. A detailed plan has been established showing sizes of fields, location of waterways, details of planting, water management concepts, and other information. The Soil Conservation Service has expressed their willingness to cooperate also, and they have provided much useful information.

Of particular interest is the Soil Conservation Service plan for wildlife wetland development and water management. In Field 10, which consists of 285 acres, the habitat for game birds will be improved by construction of a large waterway on a level grade extending from Farmington Creek to the northeast corner of the field. A series of smaller waterways will be constructed generally in a north-south direction as the need arises and water is available. The bottom widths of the waterways will be detemined by field examination. Dikes will have top widths of 24 feet and will be seeded with a mixture of 8 pounds tall wheat grass and 4 pounds yellow blossom sweet clover. Seeding will be done in early spring on a firm weed-free seedbed. The waterway bottoms will be drilled in early spring with about 25 pounds per acre of duck millet. This will be irrigated during the summer and flooded to a depth of 6 to 12 inches during the fall hunting season. A master control dam will be placed in Farmington Creek. Control structures will be installed at each diversion along the main waterway and where needed in each of the smaller waterways to allow flooding of the canal bottoms and to control the depth of the water. It is estimated that 50 control structures will be needed.

It can be readily determined that the SCS plan is comprehensive and that it does not conflict with anti-mosquito concepts in wildlife wetland environments.

In addition to the extension of research activities into the Wheeler Machinery Company land development project, it is contemplated that investigations will be extended into agricultural areas where poor pasture lands, with high mosquito production, are being converted into improved agricultural lands by water management practices with consequent mosquito reduction.

This land development and water management program of the Wheeler Machinery Company provides an excellent opportunity for cooperative efforts in developing techniques for multi-purpose management of reusable water for greatest mutual benefits to agriculture, fish and wildlife, public health and related interests.

THE CHALLENGE FOR MOSQUITO CONTROL IN CACHE COUNTY

By
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Introduction

Public health personnel, entomologists, sanitarians and other interested persons have been trying to promote mosquito control in Cache County, Utah, for many years. Since 1950, the subject of mosquito control has been discussed before nearly all of the major civic clubs and several related organizations. The local press has frequently carried articles on this subject in recent years.

Progress towards a mosquito control program in Cache County has been very slow, however, both the Cache County Commission and the Logan City Commission now have modest mosquito control programs in operation. The next goal should be an integrated county-wide mosquito abatement district.

The Mosquito Problem in Cache County

The Breeding Areas

There are approximately 22,139 acres of waterlogged lowlands in the central part of the Valley which constitutes the "Mosquito Belt." These lowlands are fed millions of gallons of polluted water daily from the mountain streams which pick up industrial and community wastes as they enter the valley.

Irrigation canals follow the edges of the Valley and spread out into the farm lands where they provide the crop lands and pastures with water. In past years residual waste water, flooded pastures and marshlands have provided the mosquito with ample breeding areas.

The Mosquitoes

Studies by the U. S. Public Health Service and others have shown that there are at least 16 different species of mosquitoes present in Cache County. These 16 species are representatives of the following five genera; *Culex Aedes, Anopheles, Culiseta* and *Mansonia.* The 1958 Public Health Service study showed that five species of mosquitoes accounted for 97 percent of all adult mosquitoes collected. The big five were: *Culex tarsalis, Aedes vexans, Aedes dorsalis, Culiseta inornata and Aedes nigromaculis.*

The encephalitis vector, *Culex tarsalis* accounted for over 60% of both the larval and adult mosquitoes collected by a U. S. Public Health Service Survey team in 1958.

Public Health Aspects

It is common practice to associate mosquitoes with malaria and oftentimes the concept exists that if there is no malaria in an area then the mosquitoes are of only minor importance. Public health personnel and entomologists have long recognized the inadequacy of this concept.

While malaria is a significant mosquito-borne disease in many parts of the would, it is not a problem in Utah. The most important known mosquito-borne disease in Cache Valley are the viral encephalidities. These diseases have been reported in both man and horses from this area.

Certain mosquito species in Cache Valley have been found positive for both the Western encephalitis virus and the St. Louis encephalitis virus. Of considerable interest to those of us living here is the recent discovery by the personnel of the U. S. Public Health Service of a virus isolated from *Culiseta inornata* mosquitoes collected near Wellsville. This new virus was named the "Cache Valley Virus" (CVV) and CVV antibodies have been found in horse sera collected in Cache Valley.

While mosquito-borne diseases rate our attention, it must not be forgotten that pest mosquitoes can rightfully be classified as public health nuisances.

In 1958 the Cache Valley Medical Society went on record as favoring mosquito abatement and stated that it would support legislation necessary to establish such a program.

Economic Aspects

While we may lack the facts and figures as to the nuisance value of mosquito bites by mere observation we can conclude that it is significant. That mosquitoes plague our livestock during the warmer months is well known; to what extent this constant feeding on the dairy cattle results in lower milk production and retarded gain in weight among beef is not known. There is reason to believe that this loss could be substantial in our $7,370,000 (1962) beef and dairy industry. If this loss were only 1% it would amount to approximately $73,700 a year.

Hundreds of Cache citizens have built out-door patios and have landscaped their backyards so that they might enjoy outdoor living during the warm summer evenings. How much value one can put on this form of recreation is not known. With an estimated cost of only $500.00 per patio, the investment for 1,000 patios would be $500,000. If mosquitoes depreciated the use of these patios by only 10%, their cost would be $50,000.

The Property Tax in Cache County

A conventional mosquito abatement district is financed by means of a property tax levy. The limit in Utah which can be established for mosquito control is 1 mill. The assessed valuation of property in Cache County for 1962 was $35,953,045.00. The present mill levy for the County is 56.32 of which only 10.80 is used directly for County programs, the remainder being a school tax. The population of Cache County is estimated at approximately 35,788. A one mill property tax levy would raise approximately $35,953 in revenue. Pro-rated on a basis of population this would mean about $1.00 per person per year for mosquito control. Thus, while the issue may be money, the question is one of values. How much is it worth to the average citizen in Cache to get relief from mosquitoes and minimize the danger from encephalitis? that is the question which must be answered.

In many northern Utah communities the west side of town borders the mosquito breeding areas and has a much lower assessed valuation than the east side of town which is more removed from the sources of mosquitoes. The depreciation of real estate on the west side of our communities is substantial. Again we may not know how much, but it may be a safer guess to say that the difference between building lots of the same size on the east side of town as compared to those on the west side would be in the neighborhood of $2,000 each. Thus, assuming only 500 lots were involved, this could amount to at least $1,000,000 difference. The loss here in tax money is quite evident. Obviously we would not credit mosquitoes for all of this difference in prop-

erty values, but likewise, we should not fail to recognize their contributions to the difference.

There is little question but what a well operated professionally managed, county-wide mosquito abatement program would be in the best interests of the people of Cache County both healthwise and economicwise. The lament of the past that we cannot afford mosquito control must be answered by a much more pertinent question. How much longer can we afford not to have control?

Thus, the challange for mosquito control in Cache County rests with the people. They must decide between the present cost of mosquitoes and what it would cost to control them.

Acknowledgements:

Much of the information contained in this report was obtained by reference to previous reports on mosquito control in Cache County and from telephone conversations with informed people here in Cache County. Acknowledgements for assistance are gratefully extended to the following: The U. S. Public Health Service; The Utah State Department of Public Health; The Cache County Surveyors Office; The Cache County Agricultural Agents Office; The Cache County Assessors Office; The U. S. Forest Service; The Cache Chamber of Commerce; The Cache Valley Medical Society and The Department of Agricultural Economics, Utah State University.

LOGAN'S MOSQUITO CONTROL PROGRAM TO DATE

By
Roger L. Stephens, Chief Sanitarian
Logan, Utah

Good afternoon Ladies and Gentlemen, this has indeed been an interesting day. Never in my work with public health have I found as much cooperation and sincere assistance as with personnel associated with the mosquito program. I would like to publicly thank Dr. Knowlton, Dr. Davis, Dr. Hawes, Lewis Fronk, Glen Collett and Lou Ogden just to name a few who have been most helpful and cooperative whenever assistance was requested.

We in the Logan Health Department have long recognized a need for mosquito control and for a good many years have beeen working for an effective program. In 1958 the need for a program was brought home very forcefully when the Public Health Service conducted a sanitary survey of Cache County and found that 66% of their light trap catches were *Culex tarsalis*, the primary vector of encephalitis.

Unfortunately, to date, efforts to organize a Cache County Mosquito Abatement district have not been too successful. We hope to find a way to accomplish this objective. There are many communities in the U. S. which have established their own program and then let it spread into a county program.

Finally in July of last year, through the assistance of Mayor Bishop and Commissioners Covington and Chambers, we were appropriated $14,876 to initiate a mosquito control program for Logan.

We feel that we accomplished a great deal last year by getting a program started, although we have not yet accumulated much of the information necessary for effective control. After July 1st we hired personnel, purchased equipment, and did some mapping and survey work. We ran some light traps and with these we found some interesting data.

As might be expected our light traps showed that most of the mosquitoes were concentrated in those parts of town adjacent to irrigated and pasture areas. Very few adults were taken in light traps in the foothill or bench areas. Most of the adults were collected in the northwest part of town. Catches there were running between 150 to 180, and I'm sure the bite counts were much higher. Our light trap catch totals were 46% *Culex tarsalis*, 43% *Culiseta inornata*, and 11% other species.

Our equipment at the present time consists of 1 jeep, 2 spraying rigs, 4 light traps, and miscellaneous equipment. We have 1 full time entomologist for the mosquito work, however, he is also trained so that in the winter time he can work as a registered sanitarian. We also have 2 part time men.

Our goal is the same as yours. We realize our program can't be as effective as if it was county wide but at least we feel we can make it livable for a person to use his patio and more important lessen the chances of an encephalitis epidemic. Also, we hope that we can have an effective enough program to interest other Cache County towns and thereby establish a county wide program whereby everyone can enjoy its benefits. We hope to prove that hordes of mosquitoes do not necessarily need to be part of our way of life in the Cache County.

REPORT OF THE UTAH MOSQUITO CONTROL-FISH AND WILDLIFE MANAGEMENT COORDINATION COMMITTEE

Members of the Committee

Don M. Rees, *Division of Biological Sciences, University of Utah;*

Donald A. Smith, *Waterfowl Supervisor, Utah Department of Fish and Game;*

Jessop B. Low, *Leader, Utah Cooperative Wildlife Research Unit, Chairman.*

Associated Agencies

1. Utah Mosquito Abatement Association
2. Utah Department of Fish and Game
3. Bureau of Sport Fisheries and Wildlife
4. Utah Wildlife Federation
5. Wildlife Society (Utah Chapter)
6. University of Utah
7. Utah State University
8. Utah Department of Health
9. Various city and county health departments

Objectives of the Committee

1. To work with the National Committee in further serving the aims and objectives of the National Committee on the state and local level.
2. Coordinate mosquito control and fish and wildlife management programs and policies on state and local levels.
3. Gather and disseminate relevant information and suggest standards on mosquito control, techniques consistent with sound fish and wildlife management objectives.
4. Gather and disseminate relevant information and suggest standards on fish and wildlife management techniques consistent with sound mosquito control objectives.
5. Stimulate needed research and demonstration projects relating to mosquito control and fish and wildlife management practices.
6. Sponsor suitable meetings and cooperate with agencies, organizations, and all others whose activities and interests may relate to those of this committee.

Areas of Coordination

Cordinated control between the two groups—mosquito control and wildlife management interests—is highly desirable to achieve mutual benefits.

1. Promote mutual understanding of the problems and methods involved in mosquito control and in wildlife conservation. Mosquito control and fish and wildlife conservation share the same goal—the public benefit.

2. Standardize procedures in the fields of both mosquito control and wildlife conservation.
   New chemical insecticides are being developed yearly. They must be tested thoroughly before use. Additional research for standardization must be sought in other mosquito control possibilities, such as fish which feed on mosquito larvae, insect predators, algae, and parasites.
   Wildlife and fisheries biologists need further research toward standardization in the manipulation of water levels on controlled marshes, location and sizes of developments, and growth of desirable vegetation, all of which undoubtedly have a bearing on mosquito production.

3. Cooperate on legislative and administrative matters which may include right-of-way, ownership responsibilities, and legal decisions.

4. Share the responsibility of educating and disseminating facts to the public.
   Modern-day living causes numerous stresses. The need for more rest and relaxation is greater than in the past. Outdoor recreation in mosquito-free scenic areas is becoming more popular, even a necessity. Mosquitoes discourage millions of people from enjoying outdoor recreation. Many public recreation areas are not used because of mosquitoes. Furthermore, these pests transmit several important diseases of man and animals. These pests have been responsible for depressing land values in resort areas. They also adversely affect residential and industrial development as well as agriculture and forestry in some areas. Most of the current mosquito control operations are designed to protect urban and park and recreation areas.

5. Mutually work out plans to hold and further develop public confidence in and support of joint mosquito control and fish and wildlife management projects.
   Nobody really loves mosquitoes! Abatement workers, whether striving to control these insects for reasons of health or because they are just plain nuisances, have a big job to do. Every year new impoundments are created for fishing, irrigation supply, sewage disposal, drinking water, wildlife development, electric power, navigation, and flood control. Road building, residential and industrial development, and farm irrigation may also create new breeding areas. It is no wonder then that mosquitoes have little trouble finding new places to breed!
   The heart of the matter is man-to-man cooperation and agency-to-agency coordination.

6. Cooperatively encourage demonstration areas for control of mosquitoes by methods not detrimental to fish and wildlife resources. And, to manage fish and wildlife by methods not conducive to mosquito production.
   Sometimes carelessness in the use of measures to control mosquitoes has been harmful to fish and wildlife. Fish and wildlife have been killed

with insecticides. Wildlife water areas have vanished wherever drainage and earth fills were held more important. The food of fish and wildlife has sometimes been destroyed by chemical sprays.

When chemicals are used, water levels are damaged, or the breeding places of mosquitoes are manipulated, the environment of fish, birds, and beneficial insects is endangered.

Some methods of managing water for irrigation or wildlife development may result in more mosquitoes and consequent damage to the health and well-being of man.

7. Encourage management agencies concerned with developing either mosquito control or wildlife development projects to seek the advice of the other prior to project initiation for suggestions and ideas advantageous to wildlife and disadvantageous to mosquito production.

Proposed Program of the Committee for 1963

1. Complete the committee assignments including area or district organizations that may be deemed necessary.
2. Prepare a list of agencies and groups interested in the subject of mosquito control-wildlife management programs and problems.
3. Establish a calendar of meetings of the committee and related group meetings that may be brought to the attention of the membership.
4. Conduct one or more field days on areas of problems or on demonstration programs showing progress toward solution of problems.
5. Establish a calendar of associated events and meetings where the subject might be introduced, entertained, or brought to the attention of those present.
6. Serve as a clearing house for problems of this nature and serve as a source of information dissemination to those wishing mosquito control and wildlife management information.
7. Promote a research program that will assist in closer understanding of the mosquito and wildlife management programs.
8. To prepare information and maps showing the mosquito abatement districts as presently constituted and the areas of developed and natural wildlife interests.

Adopted unanimously by members of the Utah Mosquito Abatement Association, March 9, 1963.

REPORT OF THE EDUCATION AND PUBLICITY COMMITTEE

Education and Publicity Committee Members

Don Rees
George Knowlton
Edwin Cannon
Frank Arnold
Jay Graham, Chairman

The Educational and Publicity Committee of the U. M. A. A. was instructed by President Knowlton to prepare recommendations for governmental units planning to initiate mosquito abatement programs.

Discussion:

Before a mosquito abatement district is organized, an initial survey should be conducted to determine if an adequate program can be developed with available financial resources. Once the district is organized and a trained man employed, problems of surveys, inspection, spraying, water management, and other procedures should be delegated to him.

Mosquito abatement is based on the application of scientific knowledge obtained both in formal education and practical field experience.

It differs from most pest control activities in that it is an area-wide program rather than a program to remove a pest in a limited location. Involved are hazards relating to the application of highly toxic chemicals over a wide area. This work is done safely only by specialists. Inexperienced people might endanger humans, farm animals, fish, and wildlife or food chain organism utilized by other animals. Knowledge of water management in relation to mosquito control is also necessary. Several species of mosquitoes can be found in any area and each requires slightly different procedures to be controlled economically.

Following are recommendations for establishment of a mosquito abatement program:

(1) That the program be established on a permanent basis. The best and most economical mosquito abatement programs develop over a period of years with each year's program based on previous experience. Temporary or emergency control procedures are expensive, uneconomical, and ineffective. Spraying occurs too late and generally at the wrong place. It sometimes appears to be effective because the problem is decreasing naturally.

(2) That a suitable budget be planned and provided for in advance of each year's program. Orderly growth and improvement requires reasonable stability in the budget.

(3) That the person assigned to manage the program be intensively trained in the technology of mosquito control and employed on a full-time basis.

(4) That the best way to accomplish the above objectives is to establish a mosquito abatement district under the provisions of the present state law. Experience in Utah and other states has shown that mosquito abatement does not function properly when it is part of another county or city agency.