PROCEEDINGS OF THE
TWENTY-FIRST ANNUAL MEETING
of the
UTAH MOSQUITO ABATEMENT ASSOCIATION

held at

MUNICIPAL BUILDING

Layton, Utah

edited by

Glen C. Collett

Mary K. Benge

UTAH MOSQUITO ABATEMENT ASSOCIATION

P.O. BOX 307

MIDVALE, UTAH

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TWENTY-FIRST ANNUAL MEETING

Resolution

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

Whereas the speakers have provided an abundance of excellent and up-to-date information, many of them coming from California, Colorado, and Idaho to contribute to our meeting, and

Whereas the members of the Board of Directors, the employees of Davis County Mosquito Abatement District and the Community and County officials made adequate arrangements for our meetings, and

Whereas the members of our various committees performed their various duties well, for this our twenty-first meeting, and

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

Whereas Glen Collett rendered particular service with regard to program preparation, and

Whereas a fine tour of Antelope Island was arranged,

Therefore be it resolved that we, the members of the Utah Mosquito Abatement Association, go on record extending our thanks to the above persons and to all others who have served this Association in any capacity during the past year.

Resolutions Committee,

Lewis T. Nielsen
George F. Knowlton, Chairman

PROCEEDINGS OF THE TWENTY-FIRST ANNUAL MEETING UTAH MOSQUITO ABATEMENT ASSOCIATION

The opening session of the Twenty-first Utah Mosquito Abatement Association convened at the Municipal Building, Layton, Utah and was called to order at 9:30 a.m. by President Kendall Sedgwick, presiding. Welcoming address was given by Richard S. Stevenson, Mayor of Layton City and Richard Evans, Davis County Commissioner. Response for the Utah Mosquito Abatement Association was given by Kendall Sedgwick.

ACTIVITIES OF THE UTAH COMMUNITY PESTICIDE STUDY

STEPHEN L. WARNICK, *Ph.D.*
Utah State Division of Health
Salt Lake City, Utah

It is a privilege to meet with you again this year. I appreciated the opportunity last year of telling you about the Utah Community Pesticide Study and am happy for the chance to update that report.

I am impressed with the work of this group. The concern you have for your job is evident. I know it is your desire to wipe out mosquitoes as efficiently, thoroughly and safely as possible. When I say safely, I am referring to the use of pesticides. I am sure each of you feels good when you are able to control a mosquito problem with drainage or *Gambusia,* or some method other than pesticides. I am just as sure that we all recognize the fact that pesticides are a vital weapon in the battle against mosquitoes and the hordes of insect competitors for our food supply. The fact that even now 12,000 people starve to death each day, emphasizes that we cannot share our food supply with insects.

We all know the good pesticides have done. By controlling such diseases as malaria, typhus, and yellow fever, DDT has saved over five million lives — more than have been killed in all wars throughout history. Pesticides have contributed greatly to the abundant food supply we enjoy in this country and the President's Science Advisory Committee informs us that the world's food supply could be doubled by a five-fold increase in the use of pesticides.

On the other hand we must be concerned with a few facts:

1. There are now over 600 kinds of manmade chemicals available.
2. Many of these materials have high biological activity and are toxic to a wide variety of animals, including humans.
3. Some of them persist in the environment for years and have worldwide distribution.
4. Biological magnification occurs in nature in which concentrations may build up through levels of the foodchain to be a hazard to those animals at the top of the chain.
5. There have been incidents involving domestic animal and wildlife poisoning.
6. Humans have pesticides stored in their body fat.
7. There are many people poisoned each year, both occupationally and accidentally, and a chance that many more could be poisoned.

These problems should be faced with neither terror nor complacency, but with careful intelligent use of pesticides and continuing investigation and research. Doing this research is where the Community Pesticide Study comes in. It is our objective to answer the question: "Are pesticides affecting human health?"

The United States Public Health Service has recently renewed a $150,000 grant to the Utah State Division of Health for the second year of the Community Pesticide Study. The Utah Study is one of sixteen that have been established nationwide to see if pesticides are causing health problems.

The study has been organized into six work units. A brief description of the activities within each work unit follows:

WORK UNIT I — THE COMMUNITY PROFILE:

The study area has been carefully surveyed and the kinds and amounts of pesticides used by various groups has been determined. Over 376,000 lbs. of pesticides were used in Salt Lake County in 1967. Areas of heavy use were identified.

The subject population has been characterized and pertinent environmental, demographic, morbidity and mortality data have been obtained.

The profile is updated annually with special attention given to changing patterns of pesticide usage. For example, less chlorinated hydrocarbons and more organic phosphates are being used, and less spray is being used in orchards in an attempt to protect predator mites.

WORK UNIT II — EPIDEMIOLOGY OF EXPOSED AND CONTROL GROUPS:

We now have 70 exposed and 30 control people in the long-term study. They have been given extensive physical and neurological examinations, blood and urine analyses. They are checked every other month on a follow-up basis in a long range attempt to see if there are pesticide caused differences in the health of the two groups.

A preliminary examination of the data has not revealed obvious differences between the groups. The data is being subjected to computer analysis to look for statistically significant correlations or differences. An attempt is being made to relate dosage to certain symptoms and to body levels of pesticides.

WORK UNIT III — EPIDEMIOLOGY OF ACUTE POISONINGS AND ACCIDENTS:

One fatal poisoning and one fatal spray-plane crash have been investigated. Also invesigated were the Dugway sheep poisoning incident, two fish-kills, a spraying of a forest area, and several poisonings of wildlife and domestic animals.

The records of the Poison Control Center have been examined for poisoning cases within the past eight years. Communication has been established between the Community Pesticide Study, the medical profession and law enforcement agencies regarding poisoning cases and treatment.

Public relation work includes numerous letters to appropriate groups and professional people, articles in newspapers and medical bulletins, and seven talks to various organizations explaining the activities of the Utah Community Pesticide Study and emphasizing the safe use of pesticides.

WORK UNIT IV — PESTICIDE RESIDUES IN THE GENERAL POPULATION:

Five (5) tissues have been collected from each of fifty (50) autopsies and analyzed for pesticide residues. Average concentrations of total DDT derivatives were: fat - 7.45 ppm; liver - 0.34 ppm; kidney - 0.06 ppm; brain - 0.06 ppm; and gonad - 0.12 ppm. Traces of other chlorinated hydrocarbons were present.

The data show: a) pesticides increase slightly with age; b) there is no significant difference in rural and urban residents; and c) tissue levels are slightly higher in males than females.

A program of analyzing a large number of fat and blood samples from the general population is being undertaken to broaden the information on pesticide levels in the general population.

WORK UNIT V — DOSAGE FROM THE ENVIRONMENT:

A program has been set up to periodically collect samples of soil, housedust, foods, and water from the homes of participants in the exposed and control groups and analyze them for pesticides. Results show little difference in the samples from the exposed and control homes; however, there is some seasonal variation.

Representative levels of total DDT derivatives in some of the samples are: housedust - 14,000 ppb; meat - 13.0 ppb; bread - 15.0 ppb; lettuce - 3.4 ppb; fresh fruit - 1.6 ppb; irrigation water - 0.004 ppb.

Skin patches and air samples are also going to be used in an effort to more accurately measure the environmental dosage received by people so that this dosage can be related to symptoms and effects.

WORK UNIT VI — BIOCHEMICAL INVESTIGATIONS:

This work unit is being implemented to investigate the more subtle effects of pesticides on the biochemical, metabolic, and enzymatic functions of the human body. Emphasis will be placed on findings that can be correlated statistically to pesticide exposure and tissue levels. Abnormalities in amino acids, certain liver enzymes, and pesticide metabolites will be looked at. Also, such things as the relation of pesticide levels to the recovery time from anesthetics; the effects and interactions of drugs, stimulants, and other pesticides on the body functions; the effect of diet on pesticide storage and metabolism; the relationship of pesticide levels to certain diseases and their treatment will be studied carefully.

Results and Conclusions:

Data from all the projects are accumulating and are being analyzed statistically and otherwise for abnormalities related to exposure to pesticides. As abnormalities are identified by the projects, studies involving larger populations will be established for confirmation. Even if abnormalities are confirmed, it will still remain to be shown if they are indeed harmful to health or merely adaptations the body makes to compensate for the presence of pesticides.

In its first year of work, the Utah Study has not identified any obvious effects of pesticides on people, although some of the projects have indications of certain abnormalities. Work is being expanded in areas of special interest and we will energetically continue to seek the answers to the question: "Are pesticides affecting the health of humans?"

THE 1967 AMENDED UTAH ECONOMIC POISON APPLICATION ACT

RAY J. DOWNS

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Salt Lake City, Utah

Today we enjoy the highest standard of living, and the most abundant and varied food supplies ever known to man. This is due, in large measure, to advances in all phases of modern technology, among them pest control. Benefits from the use of pesticides have long been recognized in the field of public health. Pesticides are an important aid in the control of lice, mosquitoes, fleas, and other vectors and in the reduction of the incidence of many insect-born diseases.

To meet the growing demands for foods, feeds, fibers, and forest products and to maintain our standard of living and public health, we have to make better use of science and technology in our constant battle with those agents which compete for these products and affect the public health. Pesticide chemicals provide one method for accomplishing this. *But when we decide to use these chemicals we must accept the responsibility that goes along with their use.* These materials are poisonous to one or more forms of life, sometimes including our own. Only by proper and careful usage can we keep the various hazards associated with the chemicals to a minimum.

Today the public is vitally concerned over the possibility of misuse or indiscriminate use of pesticides, which can result in toxic effects to non-target plants and animals and to undue contamination of our environment. In the interest of the public, therefore, it has become necessary to establish and enforce laws and regulations governing the use of pesticides to provide effective control with the least amount of hazard to beneficial plants and animals.

The 1967 State Legislature amended the Economic Poison Application Act of 1951 in an attempt to protect the public from misuse of pesticides by unqualified applicators and to also protect those persons who are legitimately engaged in the business of pest control. Subsequently, the State Department of Agriculture established regulations by which the law is to be implemented and enforced. Following is a brief discussion of the more pertinent aspects of the amended law and the regulations established thereunder.

A. LICENSING

1. It shall be unlawful for any person to engage in the custom application of pesticides in excess of $50.00 per year in the State of Utah without a license issued by the Board of Agriculture.

2. Each person actually performing the physical act of applying economic poisons by aircraft or ground equipment for hire or compensation in excess of $50.00 per year is required to have a license. No longer can a company or governmental agency take out a license and then allow their employees to apply pesticides under that one license. *Each operator must be individually qualified and licensed.*

3. An applicant for license shall submit a completed application form to the State Board of Agriculture or its representatives, together with an annual license fee of $5.00. Each license shall expire on December 31st of the year of its issuance.

4. Persons applying economic poisons who are employed by a governmental agency must obtain an applicator's license annually, but such agency or its employees shall not be required to pay the license fee in performing the official duties of the agency.

5. It shall be the responsibility of the applicant for license to have adequate knowledge of pesticide application so as to protect persons, property, crops, and animals. Each applicant shall be required to take a written examination to evaluate such knowledge at the time that he first applies for a license beginning with the year 1968. Subsequent examinations may be required as the Board may direct. A handbook pertaining to the safe and effective application of economic poisons has been made available by the State Department of Agriculture as an aid in qualifying an applicant for a license.

6. The Board may suspend, revoke, or modify the provisions of any license if it finds that the licensee has violated any of the provisions of the Economic Poison Application Act or regulations made thereunder.

B. METHODS AND MATERIALS

1. No economic poison shall be applied under any circumstances or in any location where damage, illness or injury appears likely to result, through direct application, drift or residue, to persons, crops or animals other than the pest or vegetation which the material is intended to destroy.

2. No economic poisons shall be applied onto any property without the consent of the owner or person in possession thereof.

3. It shall be unlawful for any person applying economic poisons for hire to use an economic poison for any purpose *not specified on the label* of the container thereof or on supplemental printed directions delivered therewith nor used in a manner contrary to such label or directions. Behind every label are millions of dollars in research by private manufacturers, as well as exhaustive tests by university researchers to prove that the chemical formula will be useful in agriculture and that it will present a minimum hazard to human beings when properly used. Based on information contained on the label, all pesticides offered for sale in Utah must be registered annually with the State Department of Agriculture. Pesticide applicators should use only those pesticides that are satisfactorily proven and legally registered. If the validity of any chemical encountered is in question, the applicator should check with the State Chemist to verify the registration status of such chemical.

4. Persons engaged in the application of pesticides shall not dump or abandon pesticides, treated materials, or emptied pesticide containers in any place where they could endanger humans, plants or animals.

5. Before any employee engages in handling or applying economic poisons or is required to work in areas where residues of such poisons remain in injurious amounts, he shall be informed by his employer of the precautions recommended by the manufacturer

and shall be provided with adequate protective devices as specified in such recommendations.

6. Before any economic poison highly toxic to man is applied, the person responsible for making the application shall give adequate warning to all persons known to be on the property to be treated.

7. Before any economic poison known to be harmful to animals is applied, notice shall be given by the person responsible for making the application to the owners of any animals on the property to be treated.

8. Equipment used in the application of economic poisons shall be adjusted and so operated as to avoid drift which may cause injury to persons, animals or crops.

C. MAINTAIN RECORDS

Every licensee shall keep a complete record of each application of any economic poison. This record shall include such information as date and time material was applied; chemical, concentration, and rate applied; purpose of application; and name and address of property owner. These records will provide valuable reference information to aid in evaluating problems that may arise and provide protection to the public, as well as the operator, against unjust claims.

D. INSPECTION AND ENFORCEMENT

The Board of Agriculture or its representatives may enter upon any public or private premises at reasonable times in order to inspect supplies, records, animals, crops, pests, aircraft, ground equipment, or other property or persons subject to the law. All disputes, complaints, and enforcements will be handled by the Board of Agriculture after proper hearing, and any person aggrieved by any action of the Board may have recourse to court review as provided by law.

E. CONCLUSION

We now have a law which sets forth procedures for licensing pesticide applicators, methods and conditions under which pesticides shall be applied, and the enforcement procedures provided. It is essential that all persons applying economic poisons for hire in the State of Utah be familiar with the law and regulations. Copies of the law and regulations and handbook on safe and effective use of pesticides are available without charge at the Utah State Department of Agriculture, Room 412, State Capitol Building, Salt Lake City, Utah. It is hoped that those persons engaged in the pesticide application business throughout the state will study this information and become qualified to safely and effectively use these chemicals which have done so much to advance our society.

VECTOR BORNE DISEASES OF ANIMALS

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Some of the most interesting aspects of virus ecology concern those which are carried by arthropods. Most of these exist in a state of symptomless equilibrium with their natural hosts. Only when insects or ticks carry them to unusual hosts is there evidence of a disease.

An obvious example is afforded by the encephalitis viruses in North America which are carried from birds to horses and man, causing infections that are often fatal.

There is much circulating virus (Viremia) in certain birds, although the birds remain free from clinical signs. From them, the viruses reach horse or man by way of certain mosquitoes which are apt to bite hosts of different kinds. Viremia in horse and man is low and the infection is spread no further, so these infections are generally considered blind alleys from the point of view of the virus.

Outbreaks of disease can often be explained only when there is a full knowledge of the ecology of the vectors. When these are favored by certain climatic changes, there is a wider spreading of the virus among its normal hosts, and only then is there a spillover to abnormal ones. Occurrences of outbreaks of Eastern equine encephalomyelitis in seasons of wet weather is an example. An interesting instance is the "amplification" of Japanese B encephalitis when it multiplies to particularly high levels among nestling egrets and night herons and then spills over into other species. The ecological situation may be complex. When the monkeys raid banana plantations, *Aedes simpsoni* may take over the vector role and transfer infection to man.

Methods of transmission of parasites are doubtless subject to evolution and change. In particular, infections which are normally arthropod-transmitted may come to be passed by direct contact. Pheasants are birds not native to North America, and in them, in contrast to most native species, Eastern equine encephalomyelitis virus may cause fatal infection, and this may be spread when the birds peck each other. The virus of tick-borne encephalitis in central Europe may reach the udders and thus the milk of goats. Most striking of all, perhaps, is a rickettsial infection — Q fever — which was apparently originally an infection of certain mammals and carried by ticks. It is now, when it affects man, contracted by drinking milk from cattle or, more often, it may be inhaled in dust coming from infected cattle or sheep.

We are gradually coming to realize that as is the case with bacteria we carry around with us, there may be as many latent virus infections as clinical evidence presents. There may be a transient infection that is clinically inapparent, or the latent infection may be chronic or even lifelong. There is commonly a mutually convenient equilibrium between the hosts and their virus parasites. Apart from the unfortunate results of accidental transfer to an unnatural but susceptible host, disease is particularly likely to result when a balance is upset through exposure of hosts to unfavorable conditions.

The study of naturally occurring disease in wild animals is difficult. Despite these difficulties in observation, it is probably true that epidemic virus diseases are only troublesome when animals of one sort, including man, are herded together. A "pure culture" of one kind of an animal or plant is particularly susceptible to attack because of the ease with which parasitic viruses find fresh hosts and are perhaps exalted in virulence as a result of rapid passage. The outbreaks of psittacosis that occur among parrots as a result of bad husbandry afford a good example. An equilibrium may also be upset in individuals, such as when an attack of fever blisters is started off in a person carrying herpes virus as a result of a cold or other stimulus.

Dramatic examples of activation of latent viruses have come to light lately in cancer research laboratories. There seem to be many latent virus infections in stocks of laboratory mice. When grafted tumors are passed in series in such mice, virus diseases such as leukemia and hepatitis may be brought to light, although naturally occurring illness of such a kind were previously never observed. Many viruses find circumstances very favorable for their growth within tumors, and there they become exalted beyond anything that otherwise could occur. The appearance of such viruses has, not surprisingly, often confused cancer workers in the past.

The evolution of a virus disease may be supposed to follow a course such as this. A pathogenic virus and its host gradually reach an equilibrium so that the infection becomes inapparent and is perpetuated by vertical transmission or, more frequently, infection by some other means early in life. Accidentally, the infection is carried to a fresh host. Fatal disease may occur, but the virus is in a blind alley. Occasionally, however, the virus becomes adapted to its new host, and animal to animal transmission becomes possible with or without the aid of a vector. Once more the host-virus association leads to disease, and once again host and parasite gradually adapt themselves, and a state of toleration develops. All this need not take very long.

Viruses seem to evolve quite rapidly. We have fortunately been able to watch it happening in recent years in myxomatosis in rabbits. A benign disease in South American rabbits was transmitted among them by a mosquito vector. Accidental transmission to domestic rabbits occurred, probably from mosquito bites. In this instance, there was no blind-alley stage. The disease was infectious among domestic rabbits from the beginning provided that a vector was available. The disease was so fatal that men intervened and introduced the virus into Australia as a means of controlling plagues of rabbits on that continent. Success was dramatic, and the virus at first killed more than 99% of the rabbits infected. In the course of the next few years, the inevitable happened; both rabbit and virus evolved toward an equilibrium state. First, it was seen that the virus became less virulent, as rabbits infected with less virulent virus lived longer and remained infectious for mosquitoes for longer periods. This gave them an excellent chance of surplanting the more quickly killing original virus, since many more mosquitoes could pick up the modified strain. On the other hand, the original highly lethal virus exercised enormous evolutionary pressure on the rabbits, so that genetically resistant animals soon began to appear. The equilibrium now developing is a dynamic one; both host and virus continuing to offset changes in the other partner. Since mosquitoes only pick up virus by biting through the infectious myxomatosis lumps, the production of some lesions is necessary for the virus to survive and spread. In this instance, therefore, the end result seems likely to be, as in South America, a nonfatal disease, but not a wholly inapparent infection.

The arthropod vectors include the insects such as mosquitoes, fleas, lice, and biting flies and the arachnids such as ticks and mites. Nonbiting flies may transfer infections mechanically from the natural orifices, feces, urine, discharges to the eyes, nose, mouth, food and wounds.

Arthropod vectors are classified as either mechanical (those that transfer the virus without its multiplying in them), or propagative (in which it multiplies). In the former, the vector is infective immediately after it has had a meal from an infected animal and may become noninfective after a few days. In the latter, the vector does not become infective for several days after ingesting the virus. The virus multiplies and gains access to the salivary glands, and the arthropod remains infective for the rest of its life. In some instances in ticks, the infection is transmitted through the egg to the next generation. The period between ingesting the virus and becoming infective is known as the "extrinsic" incubation period, and its length is influenced by the temperature of the environment. It is usually between 3 and 12 days.

Example of mechanical transmission by arthropod vectors are mosquitoes and fleas in myxomatosis and mosquitoes in fowlpox. In these two diseases there are high titers of virus in the lesions on the more exposed areas of the skin, so the mouth parts of the mosquito become heavily contaminated with virus.

Mosquitoes in these diseases have been spoken of as "flying pins," which reflects their purely mechanical role. Pox diseases, in which there is a high concentration of virus on the skin and which can readily infect through the skin, are well suited to transmission in this way. In addition to the two examples just mentioned, lumpy skin disease of cattle is transmitted by biting insects and swinepox by lice. Another disease transmitted mechanically is equine infectious aneamia. In this case, the vectors are various blood sucking insects, especially gross feeders such as the *Stomoxys calcitrans.* The myxoma virus has been shown to survive for at least 3 months in the rabbit flea and then cause infection, and mosquitoes have transmitted fowlpox as long as 210 days after an infective meal, but commonly the survival of virus in the mechanically carrying vectors is much shorter.

About 200 viruses are known to be transmitted by propagative vectors — those which play a biological role in the cycle of infection. These are the arboviruses. Most arboviruses are able to multiply in several different species of arthropod, and some even in arthropods belonging to different orders.

Arboviruses, unlike viruses carried mechanically by arthropods, do not spread among vertebrate hosts in the absence of the vector, except under unusual circumstances. Likewise, it is not thought that horizontal spread of these viruses occurs commonly, if at all, among arthropods in the absence of a vertebrate host. However, there is one report that sandflies became infected in their breeding grounds apparently as a result of the larvae ingesting the dejecta or dead remains of infected sandflies. Arboviruses do not cause any apparent ill effects in the vector.

Mosquitoes feed frequently but usually have a comparatively short life. Like other biting insects, they may travel many miles with the aid of wind. During hibernation mosquitoes may remain infective for some months. Bellamy (1958) showed that the virus of western equine encephalomyelitis and St. Louis encephalomyelitis survived in mosquitoes over 100 days in a cellar at 50° to 60° F.

Ticks fed on few occasions may live for several years, during which time they may retain any virus or rickettsiae with which they are infected. Nairobi sheep disease virus not only multiply in the invertebrate host, but is transmitted to the next generation of ticks transovarially, as are certain other viruses. It has been shown that this virus may survive in unfed larvae for 245 days, in unfed nymphs for 359 days, and in unfed adults as long as 871 days. Ticks and mites, since they cannot fly, do not travel except on their hosts. Fleas may travel a few meters.

It is recognized in several countries that the distribution of equine infectious aneamia is largely determined by topography and such features as woodlands and swamps which influence the insect population. In the United States the distribution of vesicular stomatitis of cattle is mainly along the natural waterways, such as the Mississippi River, since it is here that the reservoir hosts and mosquitoes abound.

The mere presence of vector, parasite, and host does not always lead to the spread of disease. For transmission to occur not only must the vector and the host be present in adequate numbers and concentration, but also the climatic conditions must be conducive to the vector feeding on the host.

The New Jersey vesicular stomatitis virus was isolated from a collection of eye gnats, trapped on a premise near Canon City, Colorado, on August 9, 1966. Clinical signs of vesicular stomatitis infection has been detected in the cattle on this farm. The gnats were collected by ANN field personnel employing the Tinkham cone type trap baited with decomposed eggs.

In addition to the isolation of vesicular stomatitis virus from eye gnats, 9 other isolations have been made. Those isolated have been identified as 5 strains of Flanders virus, 1 of Trivittatus virus (California encephalitis group), and 3 of western encephalitis virus. The viruses of the Flanders-Hart Park group have been found only in mosquitoes and birds and have not been incriminated in the cause of any diseases. The 3 western encephalitis virus strains were from insect collections or pools obtained in Colorado, New Mexico, and Iowa.

There is evidence that the vesicular stomatitis virus can persist in wildlife in areas where livestock are not present. Isolations of Indiana vesicular stomatitis virus were made from *Phlebotomus* sandflies by virologists working in the tropical forests of Panama and from mites found on terrestrial rice rats in Trinidad and Brazil.

One of the most serious vector borne diseases in livestock is Piroplasmosis or tick fever outbreaks that have occurred in the United States. At present a fullscale drive is under way by the U. S. Department of Agriculture and the Texas Animal Health Commission to eradicate 3 outbreaks of cattle fever ticks in Dimmit County, Texas.

These three outbreaks, southwest of San Antonio, are outside a longstanding quarantined area on the United States side of the Rio Grande River. The origin of the infestation is not known. Two of the infestations were reported on cattle by ranchers on September 1 and September 12 and the third infestation was found September 17, 1968, by a livestock inspector. The livestockmen are cooperating in the eradication effort.

A State quarantine has been placed on the infested areas and a program of inspection to determine the extent of the infestation and the dipping of infested and exposed cattle in a pesticide is being carried out by the Texas Animal Health Commission and the USDA's Animal Health Division.

Two of the infestations appear to have been in the area for sometime, although there is no connection established between them. The third infestation is on ranch property adjacent to the second infestation found.

All livestock shipped out of the infested areas are being traced and precautionary treatments given to the animals as they are located to assure that new infestations do not become established.

It has been reported just recently that the virus of hog cholera was isolated from mosquitoes. This may prove to account for some of the unusual outbreaks of hog cholera in certain areas.

In conclusion, let me say that vectors play an important role in the spread of diseases throughout the livestock industry. Since our Division, in cooperation with the various state governments, is responsible for the eradication of diseases in livestock, it is apparent that we will not succeed unless we control the vectors concerned. Therefore, we wish to take this opportunity of thanking the Utah Mosquito Abatement Association for their efforts in eradicating these vectors.

REFERENCES CITED

Bellamy, R. E., W. C. Reeves, R. P. Scrivani, 1958. Relationship of mosquito vectors to winter survival of encephalitis viruses. Am. Jour. Hyg., 67:90-100. In Betts, A. O. and York, C. J., 1967, Viral and rickettsial infections of animals, Vol. I, pg. 353-355.

MOSQUITO CONTROL IN COLORADO

TED DAVIS

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The organization and development of mosquito control programs in Colorado have proceeded in what we feel is the proper direction. The district concept as a solution to mosquito problems is gaining momentum. We now have a total of four districts organized with one more in the process. As of 1966 there was only one organized mosquito control district operating within the state.

Certain municipal programs are being operated in a progressive manner. In these instances the city councils have taken the initiative in allowing municipal employees to conduct control programs outside of the corporate limits of the city. In these programs a balance is being maintained between larval control as opposed to adulticiding. There still exist however, many programs operated by city administrations which are strictly an adulticiding operation and these are meeting with something less than satisfactory control.

Many programs which rely upon fogging have been receiving poor control because of the insecticide formulations used. They are using a prepared formulation purchased in large quantities on bid from different companies and the materials are of questionable quality. An example of one of these materials is that the concentrate was to have contained 44% malathion but upon analysis contained only 13% in one shipment and 17% in a replacement shipment. Action has been taken by the Colorado Department of Agriculture, the state regulating agency, to remove the product from the Colorado market. Gradually this problem will be resolved but those who use foggers are being advised to purchase concentrate insecticides and mix their own materials. Economy and effectiveness make this a must in any program. The regulating agency as well as the districts and municipalities should assume the responsibility of checking these materials upon receipt.

Local health departments have adopted control programs and are carrying these out within the confines of their jurisdiction. In such cases the programs are being operated within the cities, as well as the unincorporated areas of the county surrounding the larger municipalities. Funds do not permit a widespread approach to the problem. Progress has been made in directing the emphasis of these programs to larval control and in some cases, biological control. *Gambusia affinis* has been used in certain areas of El Paso county, in the vicinity of the Air Force Academy at Colorado Springs. This effort has met with some success, especially within the confines of the Air Force Academy. However, construction and changing of water courses have interfered with the propagation ponds. The Pueblo Health Department also imported *Gambusia* from the Weber County Mosquito Abatement District of Utah, and the fish program in Pueblo is now beginning to show progress and control is being realized by using this agent.

The over-wintering populations of the fish have not been too satisfactory. However, sufficient numbers do survive to insure a continuing population in spring. These recover very rapidly and in the case of the program at Pueblo, these fish are then transported to permanent water habitats throughout the county. This has significantly reduced the amount of chemical treatment in many of the areas where the fish have been introduced.

Altitude has a definite bearing on the operation of mosquito control programs whether they are district or non-district operations. Low elevation programs are operated in the same general outline that you are all familiar with here. The source of water creating the problem is irrigation. The species present, the general life span, and breeding habits are much the same as you experience in your programs here. The control agents are also similar. The insecticide most widely used is Baytex. In those areas where an intensive control program is carried out a 1% Baytex granule is used for larval control. In instances of aerial application, Baytex is again used, the formulation being 1/10 of a pound Baytex in one gallon of oil per acre. This formulation gives excellent control as an adulticide as well as providing approximately two weeks of residual for larval control. Malathion is frequently used in adulticiding programs. In instances where Malathion is used, the most commonly used formulation is that of L-V Malathion concentrate mixed at a rate of two gallons in 100 gallons of oil and applied at a rate of one gallon per acre. The adulticiding effect is excellent. The residual and larvicidal activity of this application is not as effective as that of Baytex and lasts approximately one week. Some Abate is being used as is D D V P in thermal fog applicators.

Programs being operated at higher elevations require some adjustment in technique as far as the non-district operation is concerned. There is very little difference in operation from the standpoint of the district operation or municipal programs which are more inclusive in their scope. The source of water in these high elevation problem areas is irrigation. However, the method of irrigation differs widely from that encountered in lower elevations. In the spring of the year water is flooded onto the large native meadows and continues to run into these meadows until late July or early August. While there is some fluctuation in the flow of water and the resulting amounts of water present in the meadows, there still remain areas within these habitats that are continuously flooded and pose a special problem in regard to treatment.

The variation in the high elevation programs is realized when one considers the species that are involved in the problems. There is a definite early season mosquito problem, caused principally by *Aedes idahoensis*. This species appears in the meadows shortly after flooding and will remain as larvae for two to three weeks, depending upon the temperatures. These, as they emerge, ordinarily will remain in the meadows, causing a problem only in those parts of incorporated areas that adjoin these meadows. There is not an apparent movement of this species over a wide area. As the *A. idahoensis* are emerging and beginning to cause annoyance to the ranchers and some tourists, the later species begin to appear as larvae. The number one species in these meadow habitats is *Aedes dorsalis* which will continue to be a problem until irrigation is curtailed. It is unfortunate that most of the programs that operate at these high elevations consist of one aerial application of insecticide. Funds are not available for more extensive treatment in the thousands of acres that are involved. The insecticide most widely used in these situations is Baytex applied at the concentrations listed above. In the higher elevations the cool temperature has an apparent effect on the residual of the Baytex. We are able to realize a three week residual of the insecticide.

Since only one application is possible in most of these locations, it then presents the problem of attempting to control the early species of mosquitoes or waiting until the later species begin to appear. The practice which has been meeting with the most success is that the *A. idahoensis* are allowed to emerge as adults. As the *A. dorsalis* larvae begin to appear, treatment is then instituted with the elimination of the adult *A. idahoensis* and a three week larval control over the *A. dorsalis*. This application is usually applied at the end of June or in the first 10 days of July. This provides a general freedom of annoyance until the end of July. At this time the populations of *A. dorsalis* begin to multiply rapidly. However, at this time irrigation begins to diminish in the meadows and the population of *A. dorsalis* is then controlled by the elimination of the habitat with the exception of those low areas within the meadows which remain wet. There are, of course, many variables which can affect control in this type of situation. The presence or absence of mosquitoes unfortunately is not uniform throughout a treated area and there is some invasion from non-treated areas to the municipalities as well as to the surrounding recreation and agricultural areas. Storm patterns are unpredictable at the higher elevations and this has a definite effect upon the success of these single treatment programs. The establishment of mosquito control ditsricts in these areas, while being highly desirable, is probably not too practical in that there is a limited tax base in small communities and the areas involved cover thousands of acres of agricultural land.

District programs being operated at high elevation are conducted much in the same manner as those at low elevations, the advantage being that life cycles are a bit slower to develop because of the lower temperatures and also the mosquito producing season is reduced.

Mosquito control in general has received much more attention throughout the state in recent years. There are two definite reasons for this interest:

1. Smaller communities, while the populations are remaining quite constant are realizing the importance of mosquito control as protection for tourist and recreation areas, as well as other economic values that can be derived from mosquito control.

2. The population of the more urban areas is increasing at a rapid rate, bringing about an increase in surburban housing developments. As the population moves from the older popu-

lation centers they are coming into much closer contact with mosquito breeding areas; therefore, the annoyance is going to be greater and this situation will continue. The governing bodies in these areas are becoming much more aware of mosquito annoyance and mosquito complaints, therefore they are much more interested in instituting some type of mosquito control to gain a measure of comfort. Every attempt is made to foster the mosquito control district concept in these areas. As additional districts are organized and their efficiency increases this concept of control districts will meet with much greater support and success.

ECOLOGY OF WESTERN EQUINE ENCEPHALITIS VIRUS IN NATURE[1]

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The agents causing the viral encephalitides are widespread; however in the U.S.A. there are only three that regularly produce serious clinical diseases in humans. These are St. Louis encephalitis (SLE); Eastern equine encephalitis (EE) and Western equine encephalitis (WE). These three viruses have caused epidemics in several states as well as in Canada, and are endemic in many areas of the U.S.A. Two other viruses of the encephalitides group, Venezuelan (VE) and the California complex account for a relatively small number of clinical human cases.

Because of the endemicity of the virus, a great deal of research has been done on their ecology in hopes of finding some reasonable overwintering mechanism of survival and possible methods for control.

Research prior to 1960 was centered on the vector mosquito (*Culex tarsalis* Coq.) (Hammon, *et. al.*, 1941, 1945), and birds as virus reservoirs (Reeves, *et. al.*, 1958; Kissling, *et. al.*, 1957; Bellamy, *et. al.*, 1958) as possible overwintering hosts. Mosquitoes, birds and certain mammals have been found to harbor the virus of WE during the mosquito season, but no plausible overwintering reservoir was suggested until Thomas, *et. al.* (1958, 1960), and Gebhardt, *et. al.* (1959, 1960) showed that certain snakes may harbor the WE virus for several months; the latter workers showed that the virus could be maintained in garter snakes from late fall to early spring. Further studies showed that WE virus could be isolated from snakes captured in nature (Gebhardt, *et. al.*, 1964; Burton, *et. al.*, 1966). Data from these studies further indicated that WE virus behaved cyclically in snakes.

Virus has also been isolated from frogs. In Korea, Japanese encephalitis virus has been isolated from snakes (personal communication, Dr. Lee).

Present Problems

Several problems have arisen from our research which we have attempted to solve:

1. The requisite conditions for the vector mosquito (*C. tarsalis*) to take a blood meal from snakes.

2. The reason why virus may be present in snake populations in one area and absent in snake populations in contiguous areas.

3. Probable reasons for the cyclic nature of the virus in snakes.

4. Possible methods of controlling virus spread in nature based on an overwintering survival mechanism involving mosquitoes and snakes.

Experimental Results

Studies carried out in a large insect-proof outdoor cage using captive mosquitoes showed that *C. tarsalis* will not feed on snakes during the hot summer months. Feeding did not begin until night time temperatures were from 60°F to 52°F. Above and below these temperature extremes little feeding occurred. The presence of rock and wood piles in the cage, which offer a close association between mosquitoes and snakes, definitely enhanced the biting activity of *C. tarsalis* on these reptiles. In another study, snakes were confined in a large cage to which wild mosquitoes had access. The results of this study showed that similar conditions were required for feeding to occur in the natural habitat of snakes and mosquitoes as was found using caged mosquitoes and snakes, namely the presence of rock and wood piles and a lowering night temperature of 52° to 60°F. This same phenomenon was confirmed using Cesium-137 tagged snakes.

In an area (Farmington Bay), where we had previously failed to isolate virus in snakes, we caught, bled, and lip tagged over 580 *Thamnophis* snakes. This work was started in the late spring of 1967 and continued until November of that year at which time the snakes began to hibernate. Some of these snakes were recaptured as many as five times prior to hibernation. These snakes were again recaptured in the spring and early summer of 1968. No significant antibody or virus activity was detected.

In the late spring of 1968 investigations were initiated in another area where we had previously isolated virus from snakes. This work is still in progress; however, the incidence of antibody in snakes against WE virus appears to be higher here than in the previously mentioned study area.

[1]Aided by a research grant Nonr 1288(07) Office of Naval Research and by the College of Medicine NIH General Research Support Grant FRO 5428.

So far these results suggest that there may be pockets or areas of infected snakes. Other studies on snakes captured in remote and isolated desert areas failed to show either antibody or blood virus.

Several explanations of the cyclic nature of WE virus in snakes are also being investigated. These are concerned with: 1. the presence or absence of antibody; 2. the presence or absence of interferon; and 3. the presence or absence of incomplete virus in snake tissue.

Preliminary data indicates that if neutralizing antibody is present in the snake blood, viremia does not develop. It was also found that hibernating infected snakes do not produce hemagglutinating inhibiting (HI) antibodies. Infected snakes kept at room temperature during the winter, however, do produce HI antibodies. Studies on development of neutralizing antibodies in hibernating infected snakes are in progress.

No definite data is available on the occurrence of incomplete virus in these poikilothermic animals, but studies using specific WE fluorescent antibody are in progress.

At a recent symposium in Tokyo, we (Gebhardt, *et. al.*, 1967) presented a possible role of poikilothermic animals in the epidemiology of WE virus.

1. Infected snakes hibernate and overwinter the virus.

2. As the snakes come out of hibernation in the spring the virus level in the snake blood increases.

3. If a female *C. tarsalis* mosquito takes a blood meal from a viremic snake at this time the normal chain of summertime infection can be started in about 10 to 14 days when this infected mosquito feeds on one or more birds.

4. More and more birds, including nestling birds become infected and likewise more mosquitoes become infected. Thus by mid-June we may have a high population of birds and mosquitoes infected and by the end of June (depending on accessability and climatic conditions) horses and humans may become infected.

5. During June and July and most of August, host preference for mosquitoes appear to be warm blooded animals and birds.

6. As the night temperature begins to cool (52°-60°F), mosquitoes will again use snakes as a blood meal host. If some of these mosquitoes are infected with WE virus, the susceptible snakes will become infected and serve as overwintering reservoirs for this virus.

From this data it seems sound to suggest the following procedures for preventing virus spread by the mosquitoes.

Begin spraying insecticide and larvicide in late March and early April to kill the early emerging larvae and mosquitoes in the Utah area. Continue the spraying every two weeks into the middle of June. Summer spraying may be required to reduce the pest effects of mosquitoes. Repeat sprayings at the end of August and continue through September or October depending on the temperature. If the temperature is regularly below 48°F in the evenings spraying could be discontinued.

If the mosquitoes present early in the year are prevented from becoming infected, the chances of a build-up of virus in mosquito and bird populations would be decreased. Spraying in the late summer and early fall would help prevent snakes from becoming infected, thus the overwintering cycle of the virus would be broken. A few years of such methodical spraying should completely break the chain.

REFERENCES CITED

Bellamy, R. G., W. C. Reeves, and R. P. Scrivani, 1958. Relationship of mosquito vectors to winter survival of encephalitis viruses. II Under experimental conditions. Am. J. Hyg. 67:90-100.

Burton, A. N., J. McLintock, and J. G. Rempel, 1966. Western Equine Encephalitis virus in Saskatchewan garter snakes and leopard frogs. Science, 154 (#3752), 1029-1031.

Gebhardt, L. P., and D. W. Hill, 1959. Preliminary report on over-wintering of Western Equine Encephalitis virus. Proc. International Northwest Conference on Diseases in Nature Transmittable to Man, 14th Annual Meeting Pullman, Wash., 26-28 Aug., p. 7-13.

Gebhardt, L. P., and D. W. Hill, 1960. Overwintering of Western Equine Encephalitis virus. Proc. Soc. Exp. Biol. and Med. 104:695.

Gebhardt, L. P., G. J. Stanton, D. W. Hill, and G. C. Collett, 1964. Natural overwintering hosts of the virus of Western Equine Encephalitis. New Engl. J. Med. 271:172.

Gebhardt, L. P., G. J. Stanton, and de St. Joer, 1966. Transmission of WEE virus to snakes by infected *Culex tarsalis* mosquito. Proc. Sci. Exp. Biol. and Med. 123:233-235.

Gebhardt, L. P., and G. J. Stanton, 1967. The Role of poikilothermic hosts as virus reservoirs. Symposium on Arbovirus Disease, Animal Vectors, and Reservoirs: 11th Pacific Science Congress, Tokyo. Japanese Journal. Med. Sci. Biol. 20:30-34.

Hammon, W. M., W. C. Reeves, B. Brookeman, and E. Izumi, 1941. Isolation of viruses of Western Equine and St. Louis Encephalitis from *Culex tarsalis* mosquitoes. Sci. 94:328-330.

Hammon, W. M., W. C. Reeves, and P. H. Galindo, 1945. Epidemicologic studies of Encephalitis in San Joaquin Valley of California, 1943, with isolation of viruses from mosquitoes. Am. J. Hyg. 42:299-306.

Kissling, R. E., R. W. Chamberlain, W. D. Sudia, and D. D. Stamm, 1957. Western Equine Encephalitis in wild birds. Am. J. Hyg. 66:48-55.

Reeves, W. C., G. A. Hutson, R. E. Bellamy, and R. P. Scrivani, 1958. Chronic latent infection of birds with Western Equine Encephalitis virus. Proc. Sci. Exper. Biol. and Med. 97:733-736.

Thomas, L. A., C. M. Eklund, and W. A. Rush, 1958. Susceptibility of garter snakes (*Thamnophis* spp.) to Western Equine Encephalomyelitis virus. Proc. Soc. Exper. Biol. and Med. 99:698-700.

Thomas, L. A., and C. M. Eklund, 1960. Overwintering of Western Equine Encephalitis virus in experimentally infected garter snakes and transmission to mosquitoes Proc. Soc. Exper., Biol. and Med. 105:52-55.

TULAREMIA IN SALT LAKE COUNTY, UTAH

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Tularemia is a plague-like disease which according to Gebhardt and Thorpe (1962) is prevalent primarily in lower animals. It has been demonstrated that the causitive organism, *Franciscella tularensis* may be transmitted to humans by either handling infected animals, through the bite of an infected arthropod, or by other agents such as water.

McDowell *et. al.* (1964) reports human cases in forty-three states. In Utah, during the period 1959-1963, there were 62 reported cases. The State of Utah, Division of Health, Morbidity Statistical Report, discloses the following cases of tularemia for the period of 1964 to September 22, 1968.

NUMBER OF CASES

Year	Utah	Salt Lake County		% of Cases in S. L. Co.
1964	24	8		33.0
1965	10	1		10.0
1966	3	0		0.0
1967	7	2		28.0
1968*	4	2		50.0
Totals:	48	13	5 year ave.	27.3

*Information for 1968 incomplete.

Although a common means of arthropod transmission in most areas is through the bite of ticks and fleas, in Utah the deer fly, *Chrysops discalis* Williston when infected is also an important mechanical vector.

In late July, 1968, an employee of the Salt Lake City Mosquito Abatement District, eighteen years of age, contracted tularemia as a result of a bite inflicted on his left forearm by the deer fly, *C. discalis*. The victim was bitten while working on the marshes west of Salt Lake City. The patient exhibited all the typical symptoms of ulceroglandular tularemia as described by McDowell *et. al.* (1964). The case was diagnosed and treated for tularemia by the attending physician without laboratory confirmation. The patient was hospitalized on August 3rd and released ten days later, returning to work apparently fully recovered five days after his release.

During the summer of 1968, a study was in progress on the deer flies and horse flies in the marshes bordering the southeastern shore of the Great Salt Lake, Utah.[3] This is in the general area where the bite occurred. As part of this study, a survey was conducted to determine if the disease organism, *F. tularensis* was present within the population of adult, female *C. discalis*.

A special trap was necessary to obtain sufficient numbers of these flies, and to maintain the viability of the disease organism. An acetate cone-trap was selected, utilizing CO_2 gas as an attractant and a chamber in which to freeze the flies on dry ice at the time of collection. The trap was modified from the type reported by Wright, *et. al.* (1968) (see Fig. 1).

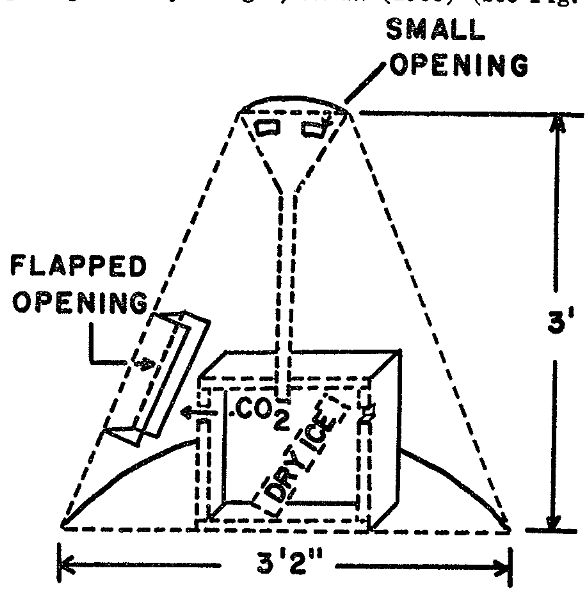

FIGURE 1. CUT-AWAY DRAWING OF ACETATE CONE TRAP.

The trap was approximately three feet high, with a diameter of 38 inches at the base and eight inches at the top. Around the sides four, wide rectangular flapped openings were cut at equal distances apart. A funnel, eight inches in diameter was attached at the top and inside the cone, with the narrow end

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down. The broad end of the funnel was closed. A plastic tube, 18 inches in length and one inch in diameter was sealed vertically to the lower end of the funnel.

The base of the cone was open to facilitate placement over the dry ice chamber. The chamber was 14 inches square and constructed of two inch thick styrofoam. The purpose of the container was to hold dry ice, slowly release the resultant CO_2 bait and to freeze the trapped flies. Single, one inch diameter holes cut near the top of each side of the chamber released the CO_2 attractant. The previously mentioned plastic tubing extended from the bottom of the funnel down through the top of the chamber to the dry ice in its interior.

The deer flies attracted by the escaping gas, enter the cone through the flapped openings and attempting to escape, fly to the funnel at the trap top. There they enter the funnel via the small openings and either return or fall inside the tubing into the dry ice chamber and are frozen.

The tularemia survey was conducted twice a week, on a twenty-four hour basis. Following each collection period the flies were transported in their frozen state to the laboratory. The amount of dry ice necessary to complete the daily survey ranged from eight to fifteen pounds, depending upon daily atmospheric temperatures.

For analysis in the laboratory, the flies were counted and placed into pools of 100. Later, the pool size was reduced to ten, to more specifically determine the presence of the disease organism. The flies were processed in the Zoonosis Laboratory, University of Utah, with standard procedures used to detect tularemia organisms.

During the 1968 season, a total of 1,248 *C. discalis* adult, female flies were collected in 13 samples during a two month period. Two pools consisting of 100 flies each from a total of 626 flies collected on July 8th were found to be positive for the organism. The tularemia strain was determined by the laboratory to be moderate in virulence.

SUMMARY

1. Since 1964, 27% of the 48 cases of tularemia reported in Utah by the State Division of Health, have occurred in Salt Lake County.
2. In July 1968, an employee of the Salt Lake City Mosquito Abatement District contracted Tularemia as a result of a bite from an infected deer fly, *Chrysops discalis*.
3. The disease organism, *Franciscella tularensis* was isolated from two pools of 100 flies taken from 626 *C. discalis* collected in Salt Lake County on July 8, 1968.

REFERENCES CITED

Gebhardt, L. P., and B. D. Thorpe, 1962. A review of Tularemia. Ecology and Epizoology. Series No. 78. Univ. of Utah, Salt Lake City, Utah. 51 pp.

McDowell, J. W., H. G. Scott, C. J. Stojanovich, and H. B. Weinburgh, 1964. Tularemia. U.S. Dept. of Health, Education and Welfare. Public Health Service. Atlanta, Georgia. 73 pp.

Wright, R. E., R. D. Anslow, G. R. DeFoliart, W. H. Thompson, and R. P Hanson, 1968. Isolation of another California group virus from Tabanidae in Wisconsin. In press. (Presented at the 24th Ann. Mtg. AMCA and 10th Ann. Mtg. LMCA. April 1968, for publication in Mosq. News.).

SALT LAKE COUNTY'S WATER RESOURCES[1]

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The task of providing adequate water supplies for Salt Lake City and County, within the framework of existing water law, has been a continuing struggle for more than a century. The low flow of streams containing water suitable for municipal use was fully appropriated soon after the original settlement of the county. The needs of the increasing population have been met by providing a small amount of surface storage, transferring water from irrigation to municipal use, exchanging saline or polluted water for better water, importing water from outside the county, and withdrawing substantial amounts of ground water. Despite these efforts to keep pace with the demand, large quantities of potable water still flow to Great Salt Lake and ground-water levels remain excessively high in parts of the county.

The principal sources of water within the county are the Jordan River (which generally is considered unfit for municipal use), six streams — Little Cottonwood, Big Cottonwood, Mill, Parleys, Emigration, and City Creeks — draining the Wasatch Range, and ground water in the valley fill. Water is now being imported from other basins, and current plans include additional imports of up to 50,000 acre-feet per year.

The Jordan River is the principal source of water for irrigation and industrial use. It is regulated by storage in Utah Lake at the cost of very high evaporation losses, which generally exceed the withdrawals for beneficial use.

The Wasatch streams are the primary source of water for municipal supply. However, monthly flows are highly variable — ranging from little more than 2,000 acre-feet to about 80,000 acre-feet. Obviously, the great need here is for effective storage capacity so that excess flow can be used to supplement deficient flow.

The average combined flow in these six streams for 1907-67 is 148,000 acre-feet per year (which is 12,300 acre-feet per month or about six times the minimum monthly flow). The dependable water supply available from any stream is always somewhat less than the long-term mean. By combining proba-

[1]Publication authorized by the Director, U.S. Geological Survey.

bility theory with the techniques of storage analysis, it has been determined that a supply of about 120,000 acre-feet per year could be maintained with a 2-percent chance of a deficiency if 200,000 acre-feet of storage could be provided to regulate the flow at the canyon mouths.

Present storage capacity of surface reservoirs is less than 5,000 acre-feet, but after completion of the proposed Little Dell project, the capacity will be about 50,000 acre-feet. This will provide much-needed regulation of most of the runoff from Mill, Parleys, and Emigration Creek basins but will leave the other three streams (including the two largest) unregulated. The development of storage on these Wasatch streams has been slow because of the relatively high cost per unit of capacity in the rugged topography.

Not all the water yield from the Wasatch Range occurs as stream-flow, however. Much of the precipitation is absorbed in the soils and fractured rocks of the stream basins and percolates downward to the ground-water reservoir. This ground water maintains the base flow of the streams after snowmelt ceases, and a large (but as yet undetermined) amount seeps directly from the mountain mass into the valley fill without appearing in a stream channel.

The role of the ground-water reservoir in the water-supply situation generally is complex and is determined, at least in part, by the prevailing social and legal system. In parts of the Southwest, for example, where there were few legal restrictions on pumping, at least during the early years of ground-water development, the rapid growth of the economy and population caused gross overdevelopment of the ground-water reservoirs. This in turn caused rapid and continuing declines of water level, greatly reduced streamflow, and even land subsidence.

The situation in Salt Lake County is just the opposite. Here, the courts hold that the owner of a discharging well that seriously interferes with a neighbor's well is liable for damages. Since effective use of the capacity of any reservoir depends on fluctuation of its contents through a considerable range, attempts to maintain water levels and artesian pressures near their natural state prevent full use of the ground-water reservoir. The experiences in the Southwest, however, show that simple removal of deterrents to pumping might intensify rather than solve water problems.

To be most effective in stabilizing the total water supply, ground-water storage should be used in the same manner as surface storage — drawn upon heavily when other supplies are deficient and replenished when other supplies are abundant. Some permanent lowering of water levels would reduce the waste of water by natural discharge and also would reduce other undesirable effects such as seepage into basements in low-lying residential areas. Surplus streamflow may be used for artificial recharge of parts of the ground-water reservoir if natural recharge is insufficient.

This simple mode of operation requires coordination of the use of water from different sources to a much greater degree than has been attempted in Salt Lake County. Here, as almost everywhere, surface water and ground water have been treated as though they were quite independent, both in the development of water supplies and in the evolution of water law. This works fairly well during the early stages of development, when only a small fraction of the available supply is used; but, as development approaches the ultimate, the need to recognize the interrelation and to provide unified management increases.

The capacity of the ground-water reservoir underlying the Jordan Valley is several times that required for regulation of the Wasatch streams. It would not be practical, however, to attempt to use all the capacity of the reservoir, because large declines of the ground-water levels in some areas would have undesirable effects. For example, a large decline in the northwestern part of the county might induce flows of brackish water from the marsh area or brine from Great Salt Lake into the reservoir. Similarly, a large decline along the Jordan River might induce flow from the river and leave an insufficient supply in that stream.

Such effects can be minimized by confining large-production wells to areas that are relatively remote from the river or lake. Also, additional control can be achieved by using a line of injection wells to maintain a fresh-water ridge between the production wells and the river or lake. The injection of small quantities of fresh water then enables the withdrawal of much larger quantities from the production wells.

We do not yet know whether such methods would be needed. To determine the probable effects of ground-water development by various plans, we have constructed an electric analog model of the ground-water reservoir in our Phoenix laboratory. Initial trials have been run and refinements of the model are being made. When complete, the model should respond to simulated historic changes of recharge and discharge in a manner that simulates the response of the ground-water reservoir to the actual changes. This will indicate that the hydrologic concepts used in constructing the model are correct. Then, we will be able to impose new conditions of recharge and discharge corresponding to probable future conditions affecting the reservoir, and the observed responses of the model should simulate those of the reservoir.

After this type of information is available, we will be able to evaluate the benefits of unified management of surface and ground-water resources of the county or of specific areas within the county. We will also be able to evaluate the perennial yield of the ground-water reservoir with no unified management and little or no use of the existing storage capacity.

Even now, it is obvious that from a strictly hydrologic viewpoint the most effective policy should permit substantial lowering of ground-water levels when and where necessary and insure their later recovery (by artificial recharge, if necessary) so that the ground-water system can make its maximum contribution to the total water supply. Such a policy, however, involves much more than hydrology, and the Geological Survey makes no recommendations concerning legal, political, or economic matters.

Many investigations provide useful information and also raise new problems or leave some old ones unsolved. This one is no exception in this respect. An important aspect of the artificial recharge previously mentioned is the rate at which surplus streamflow can be introduced into the reservoir. Some field experiments on this subject probably will be needed before satisfactory design of extensive recharge systems can be achieved. The present project was not set up or financed for such experiments, and even if it were, artificial recharge now would almost certainly cause cries of anguish from some low-lying residential areas, where the water level is already too high.

AQUATIC WEEDS AND THEIR CONTROL

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Concern and interest in controlling aquatic weeds by those involved in mosquito control programs are obvious. Any plant growth in streams, ponds, lakes, drainage channels and swamps, or along the banks or edges of these, usually enhance the environment for mosquito breeding and interferes with control operations.

Aquatic weeds are generally considered to be those that are actually growing in the water. There are many different kinds, each requiring a certain method of control.

A. Submerged aquatic weeds are rooted in the soil below the water and may extend to the surface but have most of their growth below the surface of the water. These include pondweed and water weed (often called moss) and can be controlled in canals and drains with emulsifiable aromatic solvents at the rate of 8 to 10 gallons for each cubic foot per second of water flow. Treat the stream as soon as the water weeds make enough growth to reduce the flow of water. This will usually be sometime in June depending upon the location and water temperature. Introduce the chemical into the stream at 100 to 400 pounds pressure with the spray nozzles under water. The specified amount should be introduced over a 30 to 60 minute period. This usually kills the water weeds for a distance of ¾ to 1 mile downstream depending on silt content of the water, amount of weed growth and velocity of the stream. Treated water is not harmful to crops or livestock but will kill fish.

B. Floating weeds such as algae (often called scums and moss) in ponds, lakes and slow moving streams can be controlled by copper sulfate (blue vitrol) at the rate of ¾ to 1½ ppm. This is 2 to 4 pounds per acre foot of water in the pond. Apply during early algae development. Treat by dragging a burlap bag containing the copper sulfate behind a boat. Use the lower rate if killing of fish is to be avoided. Keep livestock from drinking the water for a few days. Do not apply to water used for human consumption.

C. Emergent aquatic weeds are rooted in the soil below the water and have much of their stems and leaves above the water. Cattails and tules can be controlled with any one of the following:

1. An oil-water emulsion of 6 pounds of low volatile ester 2,4-D plus 10 gallons of diesel oil plus 1 quart emulsifier in 150 gallons of water. Spray when cattail heads first appear and repeat if re-growth occurs. Apply enough spray to thoroughly wet the foliage. Usually three applications over a two-year period is necessary for eradication. Take care to avoid injuring any crops that might be growing nearby.

2. Dalapon — 20 pounds plus 5 gallons of diesel oil plus 1 quart of emulsifier in 200 gallons of water. Spray when the cattails are fully headed out. Use enough spray to thoroughly wet the foliage. Repeat applications may be necessary for eradication.

3. Amitrol — 10 pounds per 100 gallons of water. Follow the timing and method of application given for Dalapon above.

Smartweed, water lilies and similar weeds having their leaves above the water can be controlled with 2,4-D, using 1-2 pounds plus 100 gallons of diesel oil and spray to wet the foliage.

Water Hyacinth, water lettuce and similar weeds having their leaves above the water can be controlled with Diquat. Follow the direction on the label for dosage. Treat after the weeds have made considerable growth. Spray onto the foliage until thoroughly wet. There should be no harm to fish when applied at recommended dosages. Follow cautions on the label regarding livestock. Do not use treated water for human or animal consumption, for spraying or for overhead irrigation within 10 days after treatment.

Watercress can be controlled with low volatile ester 2,4-D at 2 to 4 pounds per acre or Amitrol at 4 pounds per acre. Spray when the watercress is growing vigorously. It may be necessary to make repeat treatments. Do not use water from a stream treated with Amitrol for irrigating crops for 2 to 3 days after treatment.

D. Willows, wild rose and other undesirable woody plants are often objectionable when growing along the banks of streams, drains, lakes or ponds. These can be controlled by spraying with 2,4-D low volatile ester, 1 pound in 100 gallons of water, anytime after the plants are fully leafed out in the spring and a few weeks before leaves drop in the fall.

For further information and help on aquatic weed control, see Extension Circular 301 "Chemical Weed Control Guide for Utah" or contact your local Extension Agent or county weed supervisor.

FIELD EXPERIENCE WITH MLO FLIT AND DURSBAN

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History of Lavicide Oils

Oils have been used to control insect pests since the time of Pliny. Marco Polo in the thirteenth century wrote about the use of crude mineral oil for the treatment of mange on camels. As early as 1865, kerosene was recommended against scale insects on orange trees. One of the first recorded uses of oil for mosquito control was in Philadelphia where whale oil was used to kill mosquito larvae in rain barrels in 1793. In 1892, L. O. Howard pioneered experiments on the use of kerosene against mosquito larvae.

Diesel oil has been used as a mosquito larvicide for many years by mosquito abatement districts, public health agencies, and commercial pest control operators. The Southeast Mosquito Abatement District has been using larvicide oils since the District's inception in 1952. Weed oils, as well as diesel oil are presently being used by mosquito abatement districts as larvicides and pupacides. The weed oils most commonly employed as larvicides include Phillips Petroleum Company, Annalos 11, and Atlantic Richfield Company, Larvicide A. These oils are commonly used alone or in combination with diesel oil plus a surfactant. The addition of a spreader or surfactant increases the spreadibility of the oil by reducing the surface tension of the water and reduces the formation of oil droplets on the water. This facilitates the use of less oil to cover a given area.

Some of the qualities of a good larvicide oil are: high insecticidal activity, low mammalian toxicity, low cost, low phytotoxicity, good spreadability, low stainability, reasonably long residual action, low odoriferous qualities, and the inability of resistance to develop to the toxic action within a given insect population. Objectionable features of the present larvicide oils are phytotoxicity, burn hazards to skin, unpleasant odors, short residual life, and stain problems.

Flit (MLO)

Flit (MLO), a mosquito larvicidal oil developed by Humble Oil Company, first appeared on the market in 1967. Since little research had been done on the development of new mosquito larvicidal oils in recent years, Humble Oil Company took the initiative, in cooperation with the University of Texas, to develop a new larvicidal oil. In a study by Dr. D. W. Micks, *et. al.* (1967) at the University of Texas Medical Branch, 110 hydrocarbon compositions derived from petroleum were evaluated. From the materials screened emerged Flit (MLO), a mosquito larvicide with qualities considerably different from those of diesel and weed oils.

Flit (MLO) is a water-white liquid high in paraffinic hydrocarbons and low in aromatic hydrocarbons with little or no odor. It does not irritate the skin on contact and has superior spreading qualities without the addition of a surfactant. Studies have shown it to be non-phytotoxic when used at the recommended dosage, and it does not stain when applied, for example, to a swimming pool. It has a low order of toxicity for fish and wildlife and possesses a rather long residual life compared to other larvicidal oils.

Laboratory data as presented in the article by D. W. Micks, *et al.* (1967) is presented in Table 1 and is compared with diesel oil.

TABLE I

INITIAL EFFECTIVENESS MEASURED 24 HOURS AFTER APPLICATION ON ***Culex quinquefasciatus***

Percent Mortality

Application, ml	0.003	0.004	0.005	0.01*	0.02	0.04	0.08
Flit MLO	31	93	94	100	100	100	100
Diesel Fuel	—	—	—	30	44	55	75
Diesel Fuel +0.5 weight	—	—	—	15	55	—	—

% Triton X-45

*0.01 ml is equivalent to 2.5 gal. per acre.

For details concerning laboratory techniques, see Micks *et. al.* (1967).

Results of laboratory experiments carried out by the Southeast Mosquito Abatement District on Flit (MLO) using *Culex quinquefasciatus* larvae can be summarized as follows: In all tests carried out in the laboratory, mortality exceeded 80% and in most tests it exceeded 95%. However, in tests with application rates of 2.5 gal. per acre, 2% of the 4th instar mosquito larvae pupated and ultimately emerged as adults. At a dosage rate of 5.5 gal. per acre, essentially 100% mortality was recorded. The larvae used in these experiments were provided with food.

Extensive aerial and ground field tests have been conducted in Orleans Parish, La.; Harrison County, Miss.; Harris, Jefferson, and Galveston Counties in Texas; and other areas. In California, several mosquito abatement districts have been conducting ground tests; namely Southeast Mosquito Abatement District, Orange County Mosquito Abatement District, and Delta Mosquito Abatement District.

Results of tests by the Southeast Mosquito Abatement District have been favorable. In one extensive test in the Lakewood-Long Beach area (15 sq. miles), Flit (MLO) was used as the only mosquito larvicide. To date, "MLO Flit" at the rate of 5 gal. per acre, has been used to treat 892 miles of gutters, 10.6 miles of roadside ditches, 1017 catch basins, and 0.3 acre dairy waste representing an expenditure of 183 man hours. During this period of use of Flit (MLO), very few service requests have been received from the Lakewood-Long Beach area, indicating good control of mosquitoes. Advantages of use of Flit (MLO) in an urban area are its low phytotoxicity and no stain properties; gutters can be sprayed without fear of killing grass or plants along the streets. Flit has also been used in horse and cow water troughs effectively with no problem of deterring the animals from drinking the water due to an objectionable odor or taste.

The Orange County Mosquito Abatement District, Jack Kimball, Manager, has also had favorable results with Flit (MLO). In urban drainage ditches of approximately 18 square miles at a rate of 2 gal. per acre, approximately 95% control was recorded. These ditches were rather heavily overgrown with Bermuda grass. In normal gutter spraying at a rate of 3 gallons per acre, 100% control was achieved, spraying at ten-day intervals.

In summary, from the results reported, the future use of Flit (MLO) looks promising as it possesses many qualities absent in other mosquito larvicidal oils, while doing essentially the same job as these other oils. Currently, the cost of Flit (MLO) is high, $0.76 per gallon, which may preclude its use for very large acreage treatment. Urban use of Flit as described is economically feasible, since cost of insecticides is relatively low in relation to other costs.

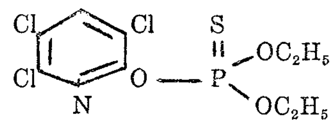
Field Experience With Dursban

As insects rapidly develop resistance to currently used chlorinated hydrocarbons and organophosphate insecticides, new materials are under development to replace the materials which have become ineffective.

A new material developed by the Dow Chemical Company is Dursban. This insecticide has been shown to be especially effective against mosquito larvae and adults as well as many household pests and turf grass pests. The development of Dursban was begun in 1965. Dow Chemical has just recently obtained a label for use in mosquito control at a recommended dosage of 0.025 pounds actual per acre.

Dursban belongs to a new class of organophosphates containing a pyridial ring. Its chemical name is 0,0 - diethyl 0,3,5,6 - trichloro - 2 - pyridyl phosphorothioate.

Structure:



empirical formula:
$C_9H_{11}Cl_3O_3NPS$

Its structure except for the pyridial ring and chlorine is the same as ethyl Parathion. Dursban is relatively insoluble in water 0.0002 gm./100 gm. of water and is readily soluble in many organic solvents such as acetone, carbon tetrachloride, chloroform, methylene chloride, 1, 1, 1, - trichlorethane, and xylene. Dursban is a very stable compound under normal conditions and is stable for several weeks in neutral or acidic aqueous formulations. The rate of chemical breakdown increases as the temperature and pH of the solution increase. Dursban is compatible with most insecticides except for the highly alkaline materials such as liquid lime sulfur and Bordeaux mixtures.

Dursban has shown high activity against mosquitoes, both susceptible and resistant to the chlorinated hydrocarbons and organophosphate insecticides. The LC_{90} for *C. quinquefasciatus* in the Cerritos area of the S.E.M.A.D. was approximately 0.001 ppm, LC_{50} being 0.0006 ppm. In *Culex peus*, the LC_{90} was 0.00046 ppm with an LC_{50} of 0.00025 ppm. Dow Chemical Company claims an LC_{95} of 0.0022 ppm for *Culex pipiens*, 0.004 ppm for *Aedes aegypti*, 0.002 ppm for *Culex fatigans* and 0.0025 ppm for *Anopheles albamanus*. Dursban granules applied to salt marshes subjected to repeated flooding at a rate of 0.025 pounds per acre gave complete control of *Aedes sollicitans* larvae for four weeks. A dosage of 0.05 pounds per acre gave effective control for six weeks.

The mammalian toxicity of Dursban is as follows: Acute oral LD_{50} for female rats - 135 mg./1 kg.; male rats - 163 mg./1 kg.; guinea pigs - 500 mg./1 kg.; Chicks - 32 mg./1 kg.; rabbits 1000 - 2000 mg./1 kg. of body weight. The mammalian toxicity is on a similar level to that of Fenthion.

The Southeast Mosquito Abatement District has done some field testing of Dursban in water spreading basins to determine its rate of percolation into potable water supplies and has also used it against mosquito populations in limited situations.

Preliminary results of percolation tests done in cooperation with the Los Angeles County Flood Control District indicate that Dursban due to its solubility and apparent affinity for organic materials could possibly contaminate potable water supplies in small quantities. We found that in a test basin simulating water percolating conditions with vegetation in the basin, Dursban was picked up at all levels sampled for over a four-week period with the samples being taken at weekly intervals and the basins being flooded 5 days a week. In a similar test with the vegetation removed from the test basin, Dursban was found to persist only a week and was not found below the four foot level. Apparently its affinity for organic matter increases its residual life. Our preliminary conclusions are that the solubility and affinity of Dursban for organic matter precludes its use in water spreading basins.

The Southeast M.A.D. has completed one field test of Dursban against a mosquito population with encouraging results. Approximately 12 acres of unimproved flood control channel were treated, using an intermittent dose technique at 0.05 pound actual per acre. This channel was heavily overgrown with tules and other vegetation. The mosquito population averaged approximately 25 larvae per dip using 50 dips as a standard. Twenty-four hours after treatment, 100% mortality was recorded and no mosquito larvae have been found in this channel for approximately five weeks since treatment.

REFERENCES

Flit MLO

Hammond, J. W., 1967. Those Durable Oils, Part II. Oil & The Farmer. Humble Oil & Refining Co. pp. 16-21.

Keenan, W. E., 1967. To Kill a Mosquito. Oilways 33(4):19-21.

Micks, D. W., G. Chambers, J. Jennings and A. Rehmet, 1967. Mosquito Control Agents Derived from Petroleum Hydrocarbons. I. Laboratory Effectiveness, Jour. Econ. Entomol. 60:426-429.

Sheppard, H. H., 1951. The Chemistry and Action of Insecticides. McGraw-Hill Co. Inc., New York.

Technigram 1967. Flit Mosquito Larvicidal Oil. Humble Oil & Refining Co.

Dursban

Gray, H. E., 1965. Dursban A New Organo-phosphorus Insecticide. Down to Earth 21(3):26-27.

THE AGE DETERMINATION TECHNIQUE — AN OPERATIONAL TOOL IN A CALIFORNIA MOSQUITO ABATEMENT DISTRICT

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ABSTRACT

ABSTRACT: A mystery story of the detection, incrimination, and eventual elimination of two major mosquito sources in a small California town.

During the summer of 1965, the Kings, California Mosquito Abatement District had a serious *Culex* problem. Sixteen light traps were operated throughout the county, and one, located in the town of Armona collected unusually large numbers of *Culex tarsalis* Coq., *Culex pipiens quinquefasciatus* Say, and *Culex peus* Speiser. Known breeding sites were under chemical control or had been previously corrected by the District. Numerous house to house surveys by MAD personnel failed to reveal any major source of the persistent mosquitoes.

Knowledge of the age of mosquitoes has been helpful in determining where they came from (Rosay 1960). McFarland and Magy (1962) successfully used aging methods to locate unknown breeding sites. It was hoped that the technique would solve the Armona problem.

Irreversible physiological changes occur in adult mosquitoes with time after emergence. The changes can be directly related to types of behavior. By dissecting female mosquitoes and looking for specific internal characteristics, important information can be obtained about their activities. For establishing proximity to origins, emphasis was placed on the newly-emerged, or teneral, stage. Three significant elements define the teneral female: the presence of the immature stage abdominal musculature, meconium in the midgut, and the very small reproductive system (Rosay 1961). During the time that these characters are present, the female is relatively inactive, she is incapable of sustained flight and remains near the breeding place. The finding of males generally indicates a nearby breeding site: male mosquitoes are not usually known to move far.

METHODS

Collecting stations for adult mosquitoes were established in four directions from the light trap in Armona to determine the most likely area of intensive breeding. These were: Bloyd, Mill, School, and Park, as shown in Fig. 1. Through the 1965 season, from mid-July to early September, five collections were made at each station for live adults. Recommendations for

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FIG. 1 Age Determination

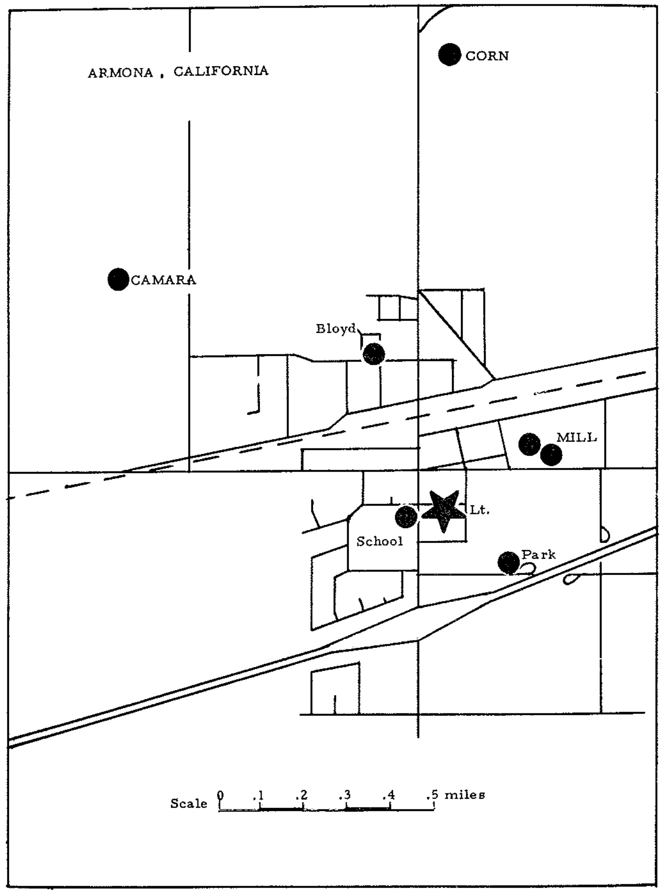

FIG. 1. *Map of Armona, Kings County, California, to show locations of light trap, collecting sites, and problem areas.*

FIG. 2 Age determination

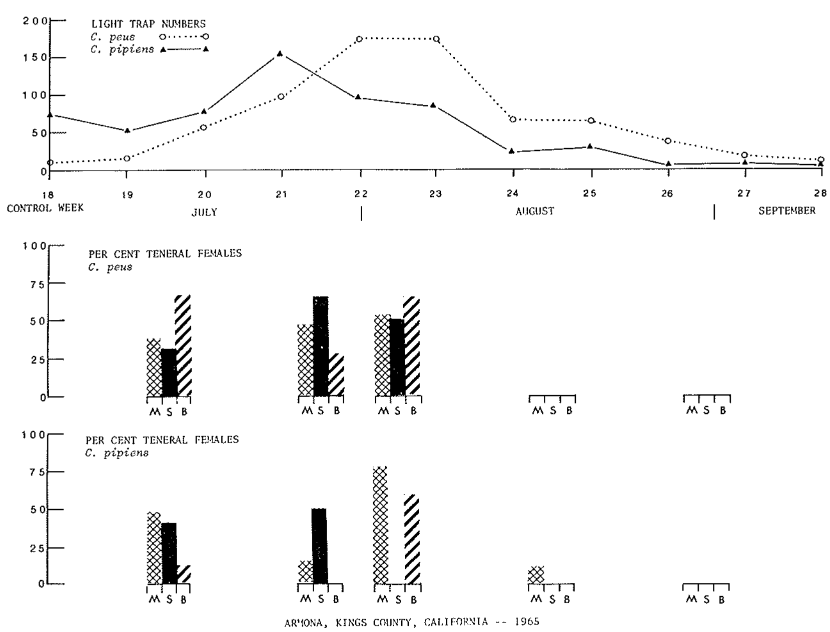

FIG. 2. *Weekly light trap totals for* C. pipiens *and* C. peus *through the season with results of dissections as per cent teneral females of each species at three locations. M=Mill; S=School; B=Bloyd.*

where to look for suspected breeding spots were based on dissections of as many females as could be collected and on the presence of males.

RESULTS

None of the mosquitoes collected in the Park were young, so this southeastern location was disregarded as a breeding place.

The *C. tarsalis* populations were old, low in total numbers, and were believed to be coming from a singular location. This proved to be correct, as intensive control in the irrigated corn field, 0.8 mile north of the Armona light trap eliminated the *C. tarsalis*.

At the two western stations, Bloyd and School, the dissections indicated dispersing populations of *C. pipiens* and *C. peus*. These mosquitoes were predominantly young, i.e. early post-teneral, and were accompanied by older males. A major source was suspected of being west of the town, and the search for it and treatment of known sources was intensified there. Locating the unknown locus was not immediate. After two and one-half weeks, an abandoned dairy drain was discovered at the Camara location, 0.75 mile northwest of the light trap. It was treated with insecticide and eventually permanently obliterated by a bulldozer.

After correction of Camara, the young mosquitoes disappeared from Bloyd and from the School. A minor source of *C. pipiens* in the School lavatories, unused during the summer, was also eliminated.

Meanwhile, inspection efforts at the Mill were progressing. One of the collecting sites was in an open corridor between buildings. The other, Mill Pit, was at the mouth of a buried water system. The first collections and dissections suggested that the mosquitoes at the Mill locations were part of the diffusing populations even though the Mill Pit was producing *C. pipiens* in small numbers. Subsequent collections of many young male *C. peus,* however, indicated that another major source was nearby. We discovered many. The entire complex of the sewer system at the Mill was a serious problem, and it required about a month to locate all the hidden water accumulations. This was, in former years, a cannery. Many small spots such as cisterns, leaky valves, underground drains, forgotten plumbing, had to each be found and individually corrected.

The magnitude of the numbers of mosquitoes examined from each location is shown in Table 1. Fig. 2 illustrates the light trap numbers through the season and the percent of teneral females from collecting stations. The effects of elimination of both species at their places of origin are obvious in the decline of light trap totals and in the absence of teneral females.

TABLE I
NUMBERS OF MOSQUITOES COLLECTED BY DATE AND LOCATION

	13 July			29 July			5 Aug.			19 Aug.			3 Sept.		
	♂	♀	T♀[1]	♂	♀	T♀	♂	♀	T♀	♂	♀	T♀	♂	♀	T♀
Culex peus															
Mill	18	19	(7)	32	15	(7)	63	24	(13)	6	1	(0)	0	0	—
School	9	13	(4)	16	12	(8)	4	4	(2)	0	1	(0)	0	0	—
Bloyd	19	9	(6)	9	7	(2)	28	3	(2)	7	0	—	0	0	—
TOTALS															
Males	46			57			95			13			0		
Females		41			34			31			2			0	
% Teneral			41.5			50.0			54.8			—			—
Culex pipiens															
Mill	17	17	(8)	2	7	(1)	17	4	(3)	0	8	(1)	0	2	(0)
School	4	8	(2)	2	4	(2)	5	0	—	0	1	(0)	0	3	(0)
Bloyd	4	9	(1)	0	1	(0)	7	5	(3)	0	0	—	1	4	(0)
TOTALS															
Males	25			4			29			0			1		
Females		34			12			9			9			9	
% Teneral			32.4			25.0			66.6			11.1			—

[1] ♂ = males; ♀ = females; T♀ = teneral females

CONCLUSIONS

1. By knowing the age of mosquitoes, unknown breeding sources, and especially obscure ones, can be located and permanently corrected.

2. In 1967, a new drain was constructed at the Camara location by MAD personnel; the owner of the property paid the costs.

3. Sources at the Mill were chemically treated weekly for four seasons. In 1968, an abatement notice was sent to the owners. Permission was given to the MAD to act as agent and hire the work done to permanently eliminate the mosquito breeding problems.

REFERENCES CITED

McFarland, G. C., and H. I. Magy, 1962. Use of age determination techniques to locate sources of *Culex quinquefasciatus*. Proc. Calif. Mosq. Cont. Assoc. 30:85-86.

Rosay, B., 1960. Advances in behavioral studies. Proc. Calif. Mosq. Cont. Assoc. 28:88-89.

Rosay, B., 1961. Anatomical indicators for assessing the age of mosquitoes: the teneral adult. Ann. Entomol. Soc. Amer. 54:526-529.

SOME OBSERVATIONS ON PUBLIC EMPLOYEES' UNIONS IN CALIFORNIA

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Public employees' unions are active and making news in California as well as elsewhere in the nation.

County Employees' Associations and other public employee organizations have been in existence for many years, but they have been relatively ineffective in obtaining better salaries and working conditions for their members. One union representative recently referred to them as "tea drinking social clubs."

In 1961 the State Legislature passed a law which gave public employees the right to join employee organizations as long as they were not subversive. The original bill also stipulated the right to strike and have collective bargaining and compulsory arbitration between the employee organization and the public agency, but these provisions were taken out.

In 1964 Assemblyman Gordon Winton from Merced County sponsored legislation which transferred teachers and other school district employees out of the Government Code and made similar provisions for them under the California Education Code.

As amended in 1964 the Government Code established the right of public employees to form, join, and participate in the activities of employee organizations of their own choosing and also gave them the right to refuse to join or participate. It established the right of employee organizations to represent their members in all matters relating to employment conditions and employer-employee relations, including but not limited to wages, hours, and other terms and conditions of employment. It also required the governing body, board, or administrative officer to meet and confer with representatives of employee organizations and to consider as fully as it deemed reasonable such presentations as were made. It stipulated that the public agency and the employee organization shall not interfere with, intimidate, restrain, or discriminate against an employee for exercising his right to join or not to join.

In August of this year (1968) the Governor approved Senate Bill No. 1228 which will become operative on January 1, 1969. This legislation amends the sections of the Government Code dealing with public employee organizations to clarify and strengthen the rights established in 1961. Added provisions include that the public agency shall give reasonable written notice to each recognized employee organization affected, of any ordinance, rule, resolution, or regulation proposed to be adopted and shall give the employee organization an opportunity to meet with the governing body. The words "confer in good faith" have been added to the requirement to meet with the employee organization. The meaning of this term is spelled out. In cases where agreement cannot be reached, a Mediator may be selected and the cost shared equally by the public agency and the employee organization.

Whether or not public employees have a right to strike is still debatable. The statutes make no provision either for or against it. There have been quite a number of strikes in recent years, including our own county employees in August of this year. In some cases where the public agency has submitted sufficient proof that the public's health and safety are jeopardized, the courts have granted temporary injunctions against the strike. There has been considerable reference to a Superior Court decision that public employees do not have the right to strike. This case has not come before the State Supreme Court, and therefore serves only as a precedent which could be cited in any case where all of the circumstances are quite similar.

The sections of the California Labor Code dealing with labor unions specifically exclude governmental employees, and the unions operate at the present time as public employee organizations.

In October 1959, the Contra Costa Mosquito Abatement District's employes joined the County Employees' Association. March 1961 is the earliest record of this organization's affiliation with the union. Since that time their letterhead has carried the name "Contra Costa County Employees' Association, Local 1675, American Federation of State, County, and Municipal Employees, AFL-CIO."

At the Board of Trustees meeting on October 13, 1959 the district manager recommended that the Board adopt a personnel policy, and the Board directed him to compile data and make a specific proposal for their consideration.

On April 10, 1961 the Board adopted the first written personnel policy. It was very general, but did provide for the drawing up of three additional documents: (1) a "Salary Schedule"; (2) "Job Classifications"; and (3) a code of "Regulations" covering vacations, sick leave, overtime pay and other matters. There was a section on disciplinary action with the right of appeal to the Board, and a provision for arbitration if the employee was dissatisfied with the Board's decision. It further provided that in the event of lay-off, employees would be laid-off and recalled by seniority.

In April 1963 a professional union representative appeared at the Board meeting and presented a proposed "Agreement" by which the district would recognize the union as the bargaining agent for all employees and would require all employees except the district manager to join the union. During the balance of that calendar year the union representative attended every Board meeting and pleaded for a union contract agreement.

At the January Board meeting in 1964 the Board appointed a personnel policy committee. On May 11, 1964 the Board adopted the committee's proposal for revision of the Personnel Policy. This new policy was considerably more comprehensive than the old policy of 1961. The most outstanding provisions were: (1) Recognition of the union and establishment of an Agency Shop; (2) Required the Board to give 10 days notice of any proposed alteration, amendment, or repeal of the policy or any other matter affecting conditions of employment; (3) Promotion by seniority; (4) Appointments by the district manager were subject to confirmation by the Board; (5) New employees could be dismissed during their probationary period without appeal or recourse; and (6) Prohibited discrimination because of membership or lack of membership in the union.

In March 1966 the district manager presented a request to retire due to health and age, and the Board accepted the request with the stipulation that said retirement was granted for no reasons other than those stated.

Following the employment of a new manager and some relatively minor operational and personnel changes, there were quite a number of minor skirmishes with the union, but these were resolved in a manner which continued to maintain friendly relations with most of the district's personnel. Some troublemakers left by mutual agreement during this period. During the winter of 1967 internal problems developed within the union ranks and in January, 1968 a majority of the employees voted to expel the district's three supervisory personnel from "rank and file" meetings and set them aside in a separate unit. In retaliation the supervisors withdrew their permission to have union dues deducted from their wages. This problem together with the need for revising some obsolete portions of the Personnel Policy prompted the Board to appoint a committee to study the policy and make recommendations to the Board. The committee's proposal for revision of the policy with some minor changes was adopted at the July 1968 Board meeting, except for one paragraph affecting promotion of employees. This paragraph was held over for further study. In addition to bringing the "Salary Schedule," "Personnel Classification and Job Descriptions," and the "Rules and Regulations" together in one document, an effort was made to sectionalize each part of the policy and to clarify and broaden its provisions. Notable departures from the 1964 policy were: (1) Abolished the Agency Shop; (2) Abolished arbitration of employee grievances; and (3) Provided for administrative rules of conduct to be formulated and revised by the district manager.

The union expressed displeasure with these revisions and threatened to go on strike if the Board did not reconsider its actions. Following the adoption of the new policy three more employees became disgusted with the internal strife in the union and elected to withdraw. After considerable prodding by the professional union representative, thirteen employees established an informational picket line, after work each day, during the week of July 29 through August 2, 1968. There was obvious lack of enthusiasm, and it was equally obvious that their efforts were futile, that the Board did not intend to reconsider short of actual strike negotiations and perhaps not then since the union lacked support and the summer season was rapidly drawing to a close.

On August 9th a meeting of all personnel was called by the district's union Shop Steward and the matter of withdrawing from the union and forming an employees' association was discussed. On August 12th at an open meeting of both union and non-union employees, members of the union voted to withdraw their membership and all employees then voted to form a new organization to be known as the Mosquito Abatement District Employees' Association. Later in the month approximately 700 county employees who were members of the same local were on strike for 9 days in an effort to obtain greater salaries for the current fiscal year.

What does all this mean to you? Well, perhaps you have already encountered similar problems; if not it seems quite likely that you may in the future for we are living in a period of great change in the field of human rights and human relations. The "good old days" are gone. In those days the principle requirement for a personnel supervisor was the ability to lick any man working under him. His problems were easily solved by shouting, "You're fired!" Today the personnel supervisor must be a leader — not a pusher! Morale is one of his most important functions — he must satisfactorily solve the employee's problem.

In meeting after meeting we discuss insecticides, application methods, mosquito biology and ecology, source reduction techniques and many other technical subjects which are indeed important but we continue to ignore that item which is probably the most important element for the success of any mosquito control program. That item is *personnel!* It accounts for more than half of the Budget expenditures in most mosquito abatement programs!

The best time to solve personnel problems is before they happen.

The average worker wants: (1) A job that interests him; (2) Reasonable job security; (3) Satisfactory working conditions; (4) A fair wage; and (5) Some opportunity for advancement — usually in that order. We may not be able to completely satisfy all of these requirements but by diligent effort we can usually find a satisfactory answer for most of them.

All employees like to know precisely what is expected of them and in turn what they can expect from the employer. A consistent policy, in written form, using clear, concise language that all employees can understand is a vital necessity in maintaining good personnel relations. This Personnel Policy should include: (1) Policy statements setting forth the employees' rights but also including statements of the district's objectives and rights; (2) Procedures for selecting and hiring new employees; (3) Method of awarding promotions; (4) Classification of employees and job descriptions; (5) Employee benefits provided by the district; (6) A salary schedule with an explanation of the application of steps if a step plan is involved; (7) Disciplinary action — how administered and for what causes; (8) An employee grievance procedure which includes the right of appeal to the Board of Trustees; and (9) General rules and regulations.

I believe that the Board and the Management of mosquito abatement programs have a moral obligation to maintain a constant awareness of the ever-changing economic conditions within their area and to see to it that salary schedules and fringe benefits of the district's employees maintain a favorable position by comparison with those of other workers in both industry and government.

Attention to the matters that I have just enumerated will go a long way toward maintaining good personnel relations. Most assuredly it will place the district in a very favorable position to deal with the labor unions if they should move in on you.

YEAR-ROUND CONTROL OPERATIONS IN THE KINGS MOSQUITO ABATEMENT DISTRICT, CALIFORNIA

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Kings Mosquito Abatement District is located in the southern part of the San Joaquin Valley of California. It encompasses 553 square miles in portions of Kings and Tulare Counties and serves a population of 70,000 people. There are six population centers in the district: Hanford, Corcoran, Lemoore, Armona, Stratford, and the Lemoore Naval Air Station inclusive.

THE SOILS & CROPS

Mosquito productivity in the San Joaquin Valley is related to the soils found there, their impermeability to water and the crops which they support. An understanding of the four common soils found in Kings M.A.D. is important to spray and source reduction personnel.

1. The Grangeville soils produce the best crops and contribute the least to mosquito production. They are very low in alkali content. Water penetration is good and subsurface water deep, making them an ideal soil for fruit trees and vineyards. These soils are located in the northern part of Kings County along the Kings River.
2. The Foster soils are found in the central area of the district and general cropping is practiced on them. Alfalfa, corn, cotton, and permanent pasture are the major crops. These crops are large producers of *Aedes* and *Culex* species when water managment is poor.
   To the west of this area is a wide belt of perched water extending south to the Tulare Lake Basin, causing many seepage and natural type mosquito problems in the area.
3. The Lethent soils are located along the west side of Kings County and are farmed by corporate concerns. For many years they were principally dry farmed. Today they are sprinkler irrigated and grow cotton, grain, tomatoes, and cantaloupes. They cause very little mosquito problem.
4. The Traver soils extend along the east and south side of the county and are the worst of our soils. Cotton, corn, sugar beets, large acreages of irrigated pasture and alfalfa are grown in this area. The soils are highly alkaline which causes slow water percolation. This type of condition may result in a real problem by producing *Aedes nigromaculis*. Our greatest insecticide resistance problems exist in this area.

THE MOSQUITOES

Aedes nigromaculis is the most common mosquito in the San Joaquin Valley. This is due to the extensive irrigated agriculture which takes place there. They breed in irrigated pasture and alfalfa fields. The local population of this pasture mosquito is the most chemically resistant strain in the world and very costly to kill.

There are other troublesome *Aedes* in our district. *Aedes vexans* is found in many of the sloughs and seepage areas along the Kings River. *Aedes melanimon* develops in alkaline ponds of native pasture. These two species present a problem in the spring of the year.

Many of the irrigated pastures, corn, and sloughs produce *Culex tarsalis* and *Culiseta inornata* during the spring and fall.

Weedy dairy drains or sumps produce great numbers of *Culex peus* and *Culex quinquefasciatus*. Street catch basins, gutters, drains, and faulty septic systems are among the producers of the *Culex* species.

The spray season begins with *A. nigromaculis* and *A. melanimon* control late in March and continues to mid-October. *C. tarsalis* begins breeding in late February, but no control is begun until late March. No attempt is made to control *C. inornata*, which breed through the cooler months and are not considered biting pests in our area.

The aerial spray program used two Pawnee 235's and a 150 Super Cub. The aircraft are district owned. During the 1968 season, 147,279 acres were treated. The pilots treat 75-100 sources in any given day during the spray season. No field or problem is considered too small to air spray. Only safety and accessibility determine whether aircraft is to be used. At Kings M.A.D., 99.5% of all spraying is done by aircraft.

Each aircraft is equipped with a dual-spray system. The conventional spray system applies ½ gallon liquid spray per acre of methyl parathion or EPN. The other is a ULV system which applies 4 ounces of Baytex per acre. The ULV system was installed and used initially for *C. tarsalis* control in corn fields during the 1967 season. Now, it is used for all species in all types of habitat (Frolli, *et. al.*, 1967).

SOURCE REDUCTION

A most important phase of our control operations is source reduction. The district owns an International TD-9 tractor with a dozer and a 4½ yard speed-haul scraper. Drain sumps and reservoirs are constructed and maintained by the district with the landowners sharing the cost of operations.

Since there are over 100 dairies in Kings M.A.D., source reduction personnel have been concentrating mostly on dairy waste problems. The construction of sumps greatly reduces mosquito breeding when kept weed free. This is done with soil sterilants and wild ducks which maintain them. Mosquito breeding is thus discouraged or confined to an area which can be treated rapidly and effectively by hand or by aircraft. This water loaded with nitrogen is frequently pumped into irrigation systems and utilized to improve soils and crops.

In the fall and winter source reduction projects include filling seepage holes and cleaning sloughs of undesirable brush without disturbing the natural cover for wildlife. Many of our *A. vexans* and *C. tarsalis* sources were eliminated or reduced by our source reduction personnel.

Another phase of source reduction in our district is urban and domestic programs which are directed at the control of *C. quinquefasciatus*. Household problems include cesspool and septic systems which are faulty, open, or poorly constructed. The approach is strictly a legal one. The district encourages property owners to correct their own problems or face the abatement notice.

The Kings M.A.D. accomplishes its year-round operations with 18 full-time employees. The area is divided into 9 control zones, each with a steady full-time operator working as an inspector-source reductionist. The $240,000.00 program is supported through a 17¢ tax rate, U.S. Navy and farmer contracts. Killing mosquitoes around the calendar has gained the district popular acceptance.

REFERENCES CITED

Frolli, R. F., E. O. Lewis, and G. Martinez, 1967. "Low Volume Trials in Kings Mosquito Abatement District." Proc. Utah Mosquito Abatement Assoc., 20:20.

A PROCEDURE TO REDUCE CONTROL FAILURES

J. LARRY NIELSEN[1] and JAY E. GRAHAM[2]

In 1968 the South Salt Lake County Mosquito Abatement District and the Magna Mosquito Abatement District initiated a program wherein both inspectors and sprayers were required to fill in a form explaining control failures in their areas. This technique is not new to mosquito control but was employed with more emphasis and completeness in 1968 than in other years. At times it seems appropriate to report on basic techniques developed years ago because such techniques are often forgotten or neglected and can be of great value.

Control in each district is a larviciding program involving inspection of all known sources using maps to locate and identify sources. Small sources are treated at the time of inspection and larger sources are reported to headquarters for treatment by spray crews.

After inspectors and sprayers finish an area control failure inspections were conducted by the manager or other supervisory personnel. Whenever larvae are found in a treated area this is recorded on a form termed a breeding report. The person responsible for control failure is required to explain why adequate control was not obtained.

BREEDING REPORT
(CONTROL FAILURES)

Date Location Instar Adult Number/dip Area (Size)

Explanation of spraymen:

Explanation of inspector:

Approximately 300 control failures were reported in the two districts in 1968. They were generally of two types, either an inspection failure where small sources were missed or a spraying failure where some kill was obtained but spraying procedures were inadequate. In the South Salt Lake County District about 5% of the sources were reported as control failures but since these sources were either small or partially controlled, control effectiveness without

[1]Manager, Magna Mosquito Abatement District, Magna, Utah.
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breeding reports would be about 97 or 98%. With breeding reports control improved to a level above that. At these higher levels improvement in control is difficult.

Some of the reasons given by inspectors and sprayers give valuable information for improving control. Some examples of reasons are:

1. Too long between inspections
2. New source not on maps or known to inspectors
3. Source checked but no larvae found
4. Fast area for mosquito development: no water or no larvae when inspected but pupae present less than a week later
5. Area sprayed but water moving and apparently diluting insecticide
6. Didn't spray far enough
7. Perhaps sprayers too far apart
8. Some areas not accessible
9. Inspector indicated wrong source
10. Area treated but no kill; perhaps bad granules.

This list could go on almost indefinitely but these examples show the types of excuses that were used. It should be obvious to all that some of the reasons point ways to improving techniques of control, while other reasons are not acceptable since they indicate that the workers didn't follow established procedures.

The benefits of more complete checking on their work should be obvious. Workers who were not inclined to do their job properly could be detected. Conscientious workers welcomed the extra checking and accepted the checking as a challenge. Soon we had a game going where checkers tried to find missed sources and workers tried to prevent misses.

The final winning score should be nothing to nothing and this is our goal.

A PRELIMINARY REPORT ON AQUATIC INVERTEBRATES IN MOSQUITO LARVAL HABITATS

MARY K. BENGE,[1] KEITH H. WAGSTAFF,[1] and RUSSELL D. ANDERSON[2]

The Board of Trustees of the South Salt Lake County Mosquito Abatement District has enunciated a policy that the district as a responsible public agency should know as much as possible about the impact of their control operation on the aquatic ecosystem. To implement this policy the district has developed an ecological research program which has become an integral part of the total control program.

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[2]College of Southern Utah, Cedar City, Utah.

Richard F. Peters, Chief, Bureau of Vector Control and Solid Waste Management, California State Department of Public Health, during a recent evaluation of our district stated in regard to this: "Perhaps the outstanding feature of the program is the series of ecological activities underway and planned which are providing physical-chemical-biological documentation of the year-by-year impact of the various aspects of your program as they relate to the total environment. This unique undertaking provides both justification for choosing specific courses of action and basis for guiding future program emphasis. The records obtained even provide management with basis for analyzing inspector-operator performance."

In 1967 a survey was initiated to ascertain what macroinvertebrates are in the district. This is necessary before any extensive study can be undertaken.

This paper is concerned with a preliminary phase of our study of aquatic invertebrates in mosquito larval habitats.

PROCEDURES

In 1967, inspectors collected the macroinvertebrates found during routine checking for mosquito larvae. In 1968, collections have emphasized the aquatic Diptera, Coleoptera, and Hemiptera.

No attempt has been made as yet to exhaustively collect all species in an area, nor to make collections from all the approximately 1700 known mosquito producing sites in the county. This phase of the study has been qualitative, not quantitative.

Collections were preserved in an alcohol solution (70%) and were identified using R. L. Usinger's *Aquatic Insects of California* with assistance from Ward & Whipple's *Fresh Water Biology*. In most cases, identification was to family or genus only as available keys were not applicable to all the immature forms. Dr. Russell D. Anderson spent two weeks with our staff during the summer of 1968 collecting and identifying the adult Coleoptera. Our knowledge of the beetles in the district is at present more complete than for other invertebrates as Dr. Anderson collected aquatic beetles for his Ph.D. thesis and has studied the collections at the University of Utah and Brigham Young University.

Macroinvertebrates included in this study to date are those organisms that could be identified with a 40X binocular dissecting microscope.

RESULTS

Table I is a listing of all macroinvertbrates collected to date. In summary, these include:

Four phyla
- Aschelminthes with one class, Nemata
- Annelida with two classes, Oligochaeta and Hirudinea
- Mollusca

Arthropoda with 3 classes
  Arachnoidea with 1 order
  Crustacea with 5 orders, 1 suborder, 8 families and 8 genera
  Insecta with 7 orders, 1 suborder, 1 superfamily, 28 families, and 75 genera

The collections made to date are not a representative sample of the organisms in the district nor do they indicate a seasonal distribution.

FUTURE WORK AND GOALS

The most important work is yet to be done: the continuation of the survey with the objective of collecting organisms from the district more extensively. Until this is accomplished, we cannot present an accurate cross-section of the macroinvertebrates in the district.

A random selection of 100 pools will be made and macroinvertebrates will be collected from these throughout the year in order to determine a seasonal distribution of the organisms. Quantitative studies must also be made in the future.

When the organisms that occur in the district are known, the next step will be to determine their interrelationships with each other and with mosquito larvae. Methods must yet be devised to determine if our larviciding program alters the aquatic environment, if it is detrimental and if it interferes with the local invertebrate/animal population, and to what extent.

A literature review must be undertaken to determine what organisms occur in stagnant ponds. As of yet this hasn't been done as we wish first to determine those macroinvertebrates associated with the mosquitoes as reference to this is often omitted or not known.

It will be some time before any final conclusions are reached, but we are aware of the importance of knowing the effects the district's program has on the environment.

TABLE I

LIST OF MACROINVERTEBRATES COLLECTED IN SALT LAKE COUNTY

Nemata
Oligochaeta
Hirudinea
Mollusca
Anostraca
  Branchionectidae
    Branchinecta
Cladocera
  Daphnidae
    Ceriodaphnia
    Daphnia pulex Leydig
    ?*D. laevis* Birge
    Simocephalus sp.
    S. vetulus Shodler
  Macrothricidae
    Wlassicsia kinistensis **Birge**
Ostracoda
  Cypridae
Copepoda
  Cyclopidae
  Harpacticoida
Malacostraca
  Asellidae
    Asellus
  Gammaridae
    Gammarus
  Talitridae
    Hyalella azteca (Saussure)
Acari
Collembola
  Symphepleona
    Smynthuridae
  Entomobryoidea
    Hypogastruridae
      Xenyella
Ephemeroptera
  Baetidae
    Callibaetis
Odonata
  Aeshnidae
    Aeshna
    Anax
  Coenagrionidae
    Anomalagrion
    Amphiagron
    Enallagma
    Ischnura
  Lestidae
    Lestes congener Hagen
  Libellulidae
    Erythemis
    ?*Leucorrhina*
    Sympetrum
Hemiptera
  Corixidae
    Corisella
    Hesperocorixa sp.
    H. vulgaris (Hungerford)
  Belostomatidae
    Lethocerus americanus Leidy
  Gerridae
    Gerris remigis Say
    G. gilletei Lethierry & Severin
  Naucoridae
    Ambrysus bohartorum Usinger
  Notonectidae
    Notonecta sp.
    N. unifasciata Guerin
    N. undulata Say
    ?*N. shooterii* Uhler

Lepidoptera
- ?Pyralidae (if aquatic)

Coleoptera
- Haliplidae
  - *Haliplus subguttatus* Roberts
  - *H. robertsi* Zimmerman
  - *H. dorsomaculatus* Zimmerman
  - *H. mimeticus* Matheson
  - *Peltodytes callosus* (LeConte)
- Dytiscidae
  - *Laccophilus atristernalis* Crotch
  - *L. decipiens* LeConte
  - *Bidessus affinis* (Say)
  - *Hygrotus sayi* Balfour-Browne
  - *H. bruesi* (Fall)
  - *H. nigrescens* (Fall)
  - *H. medialis* LeConte = *lutescens* (LeC) ?
  - *H. tumidiventris* (Fall)
  - *H. impressopunctatus* (Schaller)
  - *H. unguicularis* (Crotch)
  - *Hydroporus notabilis* (LeConte)
  - *H. despectus* Sharp
  - *H. occidentalis* Sharp
  - *Deronectes striatellus* (LeConte)
  - *Agabus cordatus* (LeConte)
  - *A. disintegratus* (Crotch)
  - *A. approximatus* Fall
  - *A. obliteratus* LeConte
  - *A. lugens* LeConte
  - *A. seriatus intersectus* (Crotch)
  - *A. griseipennis* LeConte
  - *Rhantus binotatus* (Harris)
  - *R. hoppingi* (Wallis)
  - *Hydaticus modestus* (Sharp)
  - *Dytiscus marginicollis* LeConte
  - *D. dauricus* Gebler
  - *Ilybius fraterculus* (LeConte)
  - *Colymbetes sculptilis* (Harris)
  - *Thermonectus basillaris* (Harris)
  - *Cybister explanatus* LeConte
  - *Graphoderus occidentalis* Horn
- Gyrinidae
  - *Gyrinus consobrinus* LeConte
- Dryopidae
  - *Helichus immsi* Hinton
- Hydrophilidae
  - *Tropisternus lateralis* (Fabricus)
  - *T. sublaevis* (LeConte)
  - *T. columbianus* Brown
  - *Enochrus perplexus* (LeConte)
  - *Heleophorus lineatus* Say
  - *Hydrobius fuscipes* (Linnaeus)
  - *Cymbiodyta dorsalis* (Motschulsky)
  - *Ametor scabrosus* (Horn)
  - *Berosus infuscatus* LeConte
  - *Hydrophilus* sp.
  - *Hydrochara* sp.
  - *Helochares* sp.
  - *Laccobius* sp.

Diptera
- Chironomidae
  - *Hydrobaenus*
  - *Cricotopus*
  - *Metriocnemus*
  - *Pelopia*
  - *Cryptochironomus*
  - *Chironomus*
  - *Pentaneura*
  - *Corynoneura*
  - *Tendipes*
  - *Calypsectra*
- Dixidae
  - *Dixa*
- Ephydridae
  - *Ephydra*
  - *Scatella*
- Ceratopogonidae
  - *Atrichopogon*
  - *Palpomyia*
  - *Forcipomyia*
  - *Dasyhelia*
  - *Culicoides*
  - *Alluaudomyia*
- Psychodidae
  - *Psychoda* sp.
  - *P. alternata* Say
- Sciomyzidae
  - *Sepedon*
- Stratiomyidae
  - *Euparyphus*
  - *?Nemotelus*
  - *Hermiones*
- Syrphidae
  - *Tubifera*
  - *?Helophilus*
- Tabanidae
- Tipulidae
  - *Tipula*
  - *Helius*

CONTROL OF MOSQUITO LARVAE IN A FRESHWATER MARSH WITH FISH:

GAMBUSIA AFFINIS AFFINIS AND *LUCANIA PARVA*[1]

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An invesigation was conducted during 1966-67 to determine the effectiveness of *Gambusia affinis affinis* (Baird and Girard) and the killifish *Lucania parva* (Baird and Girard) in controlling mosquito larvae in experimental units on the Farmington Bay Waterfowl Management Area.

In June, 1966, five units were constructed ranging in size from .27 to .80 of an acre. The units were enclosed by dikes and, except for their relatively small size, were ecologically typical of the freshwater marshes at Farmington Bay. An attempt was made to determine the preferences of these fish for water depth and chemistry; type of vegetation; and their effectiveness in controlling mosquito larvae in the different habitats in the two units in which they were introduced.

The water used in the experimental units was obtained from the Jordan River via the State Canal. Dissolved oxygen concentrations fluctuated between 0.0 ppm and 5.0 ppm while pH remained between 7.5 and 7.9. Water temperatuers ranged from a low of 53°F in May to 75°F in July, moderating in September to 63°F.

The water is high in organic content and other pollutants and has a saline content of 0.4%, thus limiting the type of vegetation inhabiting these marshes. The major emergent vegetation types are: Olney's bulrush (*Scirpus olneyi* Gray); alkali bulrush (*Scirpus paludosus* A. Nels); hardstem bulrush (*Scirpus acutus* Muhl.); saltgrass (*Distichlis stricta* Torr. Rydb.); cattail (*Typha* spp. L.).

No fish were stocked in the experimental units during 1966. Sampling of the mosquito larvae present, *Aedes dorsalis* (Meigen), *Culex tarsalis* (Coquillett) and *Culiseta inornata* (Williston), was started that year during the second week of July and continued through September. Larval production reached a maximum in both units during August and September of ten larvae per dip.

In 1967 units 2 and 3 were stocked with fish. Unit 2, containing .42 of an acre, was stocked with *Gambusia* as follows: 2000 on May 10, and 1000 on July 14. These fish were collected from warm water springs with water temperatures ranging from 90°-100°F. Unit 3 was stocked with *Lucania* as follows: 630 May 3, 1000 May 16 and 2000 June 16. The *Lucania* were collected from Timpie Springs Waterfowl Management Area located in Tooele County. During the study, standard wire minnow traps were used to sample the fish populations in the units.

According to the vegetation, unit 2 was divided into 6 plots of about equal size: 3 of saltgrass; 1 bulrush; 1 cattail; and 1 covered mostly by *Lemna*, a floating plant. Water depth varied between 5 and 13 inches in different parts of the unit. During August and September gravid female *Gambusia* were collected most abundantly in the bulrush and cattail plots, with averages of 43% and 33% respectively of the total catch. Immature *Gambusia* were most abundant in the saltgrass, comprising more than 44% of the total *Gambusia* taken. Male and small female *Gambusia* fluctuated in number in the samples taken in all vegetative plots.

Numbers of *Gambusia* increased with increased water depths in all vegetative plots of unit 2, although fewer gravid females were collected in the saltgrass regardless of water depths.

Unit 3 containing .27 of an acre was divided, according to the vegetation, into 7 plots similar in size to unit 2; 2 saltgrass and 5 bulrush plots. Mixed populations of *Gambusia* and *Lucania* occurred in unit 3 since the young of *Gambusia* were able to enter through the screens into unit 3 from unit 2.

In unit 3 *Gambusia* and *Lucania* fluctuated in numbers in both types of vegetation. During the course of the season, *Gambusia* were more commonly collected than *Lucania*. *Gambusia* have a higher reproductive ratio over *Lucania* by a factor of about 2.5 to 1. During July and August, *Gambusia* comprised 68% and 74% respectively of all fish collected in this unit.

Water depths in unit 3 varied between 5 and 13 inches. In the saltgrass, samples of *Lucania* increased with higher water levels while increased water depth had little effect upon the *Gambusia*. Increased water depths in the bulrush resulted in an increase in the numbers of *Gambusia* and *Lucania* present.

In unit 2 during May and June of 1967 mosquito larvae production ranged between 1 and 12 larvae per dip. This number decreased to 0.0 larvae per dip beginning in late July and no larvae were present during the remainder of the season.

In unit 3 maximum mosquito larvae production occurred in 1967 during May and June with fluctuations of 1 to 10 larvae per dip. Mosquito larvae production decreased to 0.0 larvae per dip by late June and continued thus through the remainder of the season.

[1]This study is part of a research program now in progress financed in part by the National Communicable Disease Center research grant CC 00171.

Mosquito production in the experimental units and in the adjacent marsh, where fish were not present, was about the same in 1966 and 1967.

Conclusions to Date:

Unit 2

1. Gravid female *Gambusia* appear to show a preference for bulrush and cattails. Immature *Gambusia* were dominant in numbers in the saltgrass and largely avoided the cattails.
2. It appears that *Gambusia* prefer deeper water in vegetative plots except saltgrass where they decreased in numbers as water depth increased above 9 inches.
3. As temperatures increased during mid summer, a wider distribution of *Gambusia* was observed. Gravid females seem to prefer shade and cooler water temperatures present in bulrush and cattail plots.
4. Dissolved oxygen concentrations evidently are of little importance in determining *Gambusia* distribution in these units.
5. During August and September of 1967, *Gambusia* were completely effective in controlling all mosquito larvae in all vegetative plots and at all water depths.

Unit 3

1. *Lucania* appeared to show a slight preference for saltgrass over bulrush plots.
2. *Lucania* appear to prefer deeper water in bulrush plots without obvious preference in other vegetation.
3. Mixed populations of *Gambusia* and *Lucania* are effective in the control of mosquito larvae in bulrush and saltgrass habitats. A reduction of mosquito larvae occurred earlier in unit 3 where bulrush were dominant.
4. *Lucania,* where present, are effective competitors with *Gambusia* and other aquatic predators of mosquito larvae.
5. How effective *Lucania* alone are in controlling mosquito larvae could not be determined in this experiment. This study was continued in 1968 in an attempt to determine the effectiveness of *Lucania* in controlling mosquito larvae in an experimental unit. Results to date are incomplete.

REFERENCES

Rees, D. M., 1962. Development of techniques for multi-purpose management of reuseable water before it enters the Great Salt Lake. Proc., Utah Mosquito Abatement Assoc., 15:1-2.

MOSQUITO CONTROL IS NOT A STRAIGHT LINE FROM INSECTICIDE CAN TO INFESTED LAND[1]

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A straight line is hardly ever the shortest distance betwen two points. In mosquito control it's more like going in circles — "life cycle circles" — where the concept of breaking the life cycle is of prime importance. The A. B. C.'s of mosquito control are:

A. Permanent water management to prevent breeding areas,

B. Temporary control by treating larvae on a survey basis, and

C. Adult control as a last ditch stand.

As a result of considering and employing the various control techniques, we usually adapt those methods which have been easiest and most economical to use and yet provide optimum results. Few of us, however, have stopped to examine the development of each method or to evaluate previously proven techniques. That is my topic for today, especially in reference to the development of ground Ultra-Low-Volume techniques of application.

LARVICIDES

All early chemicals were larvicides. Oils have been used since the 17th Century. The famous Panama Canal larvicide was comprised of crude carbolic wood resin, water and sodium hydroxide. This was replaced by Paris Green which is still being used today. The age of larvicides lasted well into the mid-1940's when we experienced the era of DDT. Larvicides were generally quite bulky and required large volumes of liquid diluents or, as in the case of Paris Green, large quantities per acre for effective control. In the early days chemicals were not as easily handled as they are now. Despite disadvantages, DDT larvicide solved many problems.

ADULTICIDES

DDT was also found to be an effective tool for adults, a portion of the life cycle that had not previously been attacked. The further economy of adult control placed an almost complete emphasis on development of adulticide techniques.

MISTERS

For some time sprays were employed to great advantage. Misters could cover 1.7 acres with a mere gallon of finished spray with an effective swath width

[1]Illustrated with slides.

of 350 feet. Continued improvements refined the conventional aircraft applications so that the previous volume of five gallons per acre shrank to two quarts per acre.

AEROSOLS

The next great advancement in adult control came with the development of thermal aerosol. Fogging units such as the TIFA flourished, and soon even more economical foggers like the Dyna-Fog machine were found in almost every municipality interested in mosquito control. The need for easier operation and less maintenance was realized with the introduction of the Leco. These are only the "big three"; many others have been and are still being introduced. Not only was it possible to cover 5⅓ acres per gallon of finished fogging oil but improvements made it possible to use 1/5 less insecticide or even 1/10 as much with compounds like Baytex.

Why have foggers been used in such large numbers? Is it because we miss too many larvae and strike out at the resulting adults? Frankly, I believe it is due to a matter of economics. Most communities feel it is the least expensive method and requires less specialized personnel — a theory I can't condone.

FOGGING OILS VS. STANDARD OILS

The next area of concern was improvement of the oil carrier. Does a specially refined oil provide control that is superior to diesel or fuel oil? Mount *et. al.* (1966) and Taylor and Schoof (1968) claimed that there was no difference.

AIRCRAFT U.L.V.

While things were moving on the ground, the aerial application didn't stand still. Aircraft which previously left white streamers in the clouds now seemed to fly without purpose. The 0.8 oz. Baytex or 3 to 4 oz. Malathion could only be seen on windshields of cars or be felt as tingling sensations in the peering eyes. The distribution of droplets of chemicals became all important. How do you spread a small amount of fluid over an entire acre? We looked at Mini-Spins, Micron Air Nozzles, and even plain nozzles at 45° angles to the air stream. Conventional sprays gave way to many conversions for ULV on fixed wing aircraft and even on helicopters. Today, Baytex, Malathion, and Dibrom are cleared for ULV applications. Both Malathion and Baytex can be used for larval as well as adult control.

GROUND DISTRIBUTION OF INSECTICIDES

Dispersion through the air was reconsidered for ground applications. Why not combine the elements of thermal aerosol with the distribution principles of a mister? So, inside a mister we placed a Leco fogger. The advantage in dense foliage was obvious, but the overall aspect has not been favorable.

THERMAL AEROSOL VS. NON-THERMAL AEROSOL

Since aerosols were so successful, we tried to modify them for use without heat and without oil. The important thing was to obtain a particle size of less than 50 microns. We started with a Dyna-Fog "4000" with a multi-orifice nozzle because the insecticide could be distributed directly to the primary head. A heat source was not required to break up the particles because this was accomplished by the air stream surrounding the insecticide in the dispersal nozzles. The results of the work done by Dr. G. A. Mount (U.S.D.A.), Dr. R. T. Taylor (C.D.C.) and Dr. A. Rogers (Florida State Entomological Research Center) have not only shown that fogging oils are equal to standard oils but that a non-thermal aerosol can control mosquitoes as effectively as a thermal fogger if the same chemicals and dosage rates are used.

GROUND ULV

If the particle size could be mastered, why not reduce the dosage? This was done by G. A. Thompson of the Jefferson County M.A.D., Nederland, Texas. He used one gallon for approximately 16 acres which was ⅓ less than the standard fog application or 1/10 less than the standard mist rate (Thompson 1968). Similarly, Dr. A. W. Buzicky of the Metropolitan M.C.D., St. Paul, Minnesota, has worked with ground ULV. He has developed a method for converting a back-pack sprayer into a mist blower (Buzicky 1967).

SUMMARY

Why should we be so enthusiastic about the ground ULV? Some of the many reasons are:

1. Less pesticide is needed.
2. Economy is greater than for a thermal fog.
3. There is much less equipment maintenance.
4. Swath width is greater under most conditions.
5. There is no visible fog hazard.

REFERENCES CITED

Buzicky, A. W., 1967. Pest Control Magazine (June).

Mount, G. A., C. S. Lofgren, J. B. Gahan, and N. W. Pierce, 1966. Comparisons of thermal and non-thermal aerosols of Malathion, Fenthion and Naled for control of stable flies and salt marsh mosquitoes, Mosq. News 26:132-138.

Taylor, R. T., and H. F. Schoof, 1968. Evaluation of thermal and nonthermal fogs against four species of mosquitoes, Mosq. News 28:8-11.

Thompson, G. A., 1968. Pest Control Magazine (Feb.).

PROBLEMS WITH QUALITY IN SPRAY EQUIPMENT

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We did not realize the quality we had been enjoying and receiving from our old fly spraying equipment until we purchased some replacement units this year. For a number of years we had been using "Oliver-Iron-Age" pumps we had installed on old "Dobbins" tanks. Under the heavy usage they received we had very little trouble.

This spring we purchased three new spray units to augment our old sprayers and eventually phase out the old ones. We usually use seven sprayers in our fly spraying season so we prepared five of the old ones for use. With these and the three new ones we figured a relatively trouble-free fly season.

We called for bids on three new 100 gallon 5 gpm sprayers and one 200 gallon 10 gpm sprayer for borrow pit spraying. A representative of the one company represented in the bidding came up and checked what we had been using and said his sprayers would give comparable service. A Utah firm representing this nationally known pump company was low bidder, so after considering all information available, our Board awarded the bid to this firm.

We also purchased six 150 foot hoses for our sprayers. Our fly spraying season started with a bang! That is, all at once. We started the three new sprayers and four old sprayers and concentrated on mosquito control. After three weeks, all three new sprayers were out of service, two with a fifty cent valve seat and one with a broken pressure valve. We also had problems with the larger 10 gpm sprayer but managed to keep it in use until parts were received.

We made one new sprayer out of the three and used two more of the older sprayers. I immediately called the factory representative and he made an emergency order for spare parts. They came after ten days! In the meantime, three of the six spray resistant hoses completely closed up on us and new ones were ordered. Then diaphragms on the new sprayers went haywire and we replaced them with everything from sheet plastic to pieces of heavy duty innertubes. During the season all of the six original new hoses stopped working and had to be replaced. In order to keep the new sprayers operating, when we had parts to fit them, we had to wash them out every night with clear water. The older sprayers would only need an occasional cleaning, no new parts and very few repairs.

We were being billed for the replacement parts for the new sprayers and nothing had been done by the factory about the sprayers. I wrote a letter to the company president with copies to the factory representative and to the firm that sold us the sprayers. In a few days we had a visit from the local factory man and another man direct from Chicago! They went all over all three sprayers and found spare parts still needed.

After comparing the new sprayers to the old Iron-Age sprayers, the Chicago man said, "You can't expect these new sprayers to do the job your old sprayers do!" They left with a promise to send the necessary parts that were still missing, and after about a month we received some of the parts and are still waiting for the balance of the parts.

We are contemplating the purchase of new tanks for our old Iron-Age sprayers and using the "new" sprayers as emergency units.

I don't believe there are any "problems with quality in spray equipment," but the problem is *finding* quality in new spray equipment. In other words, "you just can't hardly get quality any more."

A CURRENT LIST OF MOSQUITOES KNOWN TO OCCUR IN UTAH WITH A REPORT OF NEW RECORDS

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In 1961, Nielsen and Rees reported the occurrence in Utah of 40 species of mosquitoes belonging to six genera. This paper presents a current list which includes six additional records, one of which represents a new generic record for the state. In addition, one formerly reported species is now believed to be of doubtful status and has been removed from the state list.

The following list of 45 species belonging to 7 genera represents the species now known to occur in Utah. A brief distributional note is included after each species name.

Names preceded by an asterisk were not included in the Identification Guide to Utah Mosquitoes (Nielsen and Rees, 1961).

Aedes atropalpus (Coquillett) — Common rock hole mosquito — Desert regions of southern Utah

A. campestris Dyar and Knab — Widespread in valleys of state

A. cataphylla Dyar — Widespread in mountains and mountain valleys

A. cinereus Meigen — Mountain valleys of northern Utah

A. communis (De Geer) — Mountains, northern Utah to La Sal Mtns. in S.E.

A. dorsalis (Meigen) — Dominant mosquito in valleys of state

A. excrucians (Walker) — Uinta Mountains

A. fitchii (Felt and Young) — Mountains and valleys of entire state

A. flavescens (Muller) — Valleys of northern Utah

A. hexodontus Dyar — Mountains throughout state

A. implicatus Vockeroth — Mountains throughout state

A. impiger (Walker) — Uinta Mountains and extreme northern Wasatch Mountains

A. increpitus Dyar — Common throughout state along streams and in southern mountains

A. intrudens Dyar — Uinta Mountains

A. melanimon Dyar — Common in valleys and along streams in eastern Utah, uncommon elsewhere

A. nigromaculis (Ludlow) — Common in valleys throughout state

A. niphadopsis Dyar and Knab — Common in Great Basin area of Utah

A. pullatus (Coquillett) — Common in mountains throughout state

A. schizopinax Dyar — Widespread, but rare in mountain valleys of state

**A. sierrensis* (Ludlow) — Tree hole mosquito. Known only from Weber Co.

A. spencerii idahoensis (Theobald) — Floodwater species, chiefly along rivers of northern and central Utah

A. sticticus (Meigen)—Floodwater mosquito along streams of northern Utah

**A. trivittatus* (Coq.) — Known only from Bluff area, San Juan Co.

A. varipalpus (Coquillett) — Tree hole mosquito, southern Utah and Utah County

**A. ventrovittis* Dyar — Known only from Logan Canyon summit area

A. vexans (Meigen) — Abundant along valleys and streams throughout state

Anopheles earlei Vargas — Known only from Juab, Rich and Summit Counties

A. franciscanus McCracken—Widespread in southern half of state

A. freeborni Aitken—Widespread throughout state

Culex apicalis Adams — Known only from southern Utah

C. erythrothorax Dyar — Widespread in state

C. pipiens Linnaeus — House mosquito — widespread in state

C. quinquefasciatus Say — Southern house mosquito. Known only from Salt Lake and Washington Counties

C. restuans (Theobald) — Known only from Duchesne Co.

C. tarsalis Coquillett — Abundant throughout state

C. territans (Walker) — Known only from mountain valleys of northern Utah

**C. thriambus* Dyar — Known only from Washington Co., southern Utah

Culiseta impatiens (Walker) — Mountains of entire state

C. incidens Thomson — Mountains and valleys of entire state

C. inornata Williston — Mountains and valleys of entire state

**C. morsitans dyari* Coq. — Known only from Weber Canyon

C. silvestris minnesotae Barr — Known only from Morgan and Weber Counties

Mansonia perturbans (Walker) — Valleys of northern Utah

**Orthopodomyia signifera* (Coq.) — Known only from San Juan Co. Tree hole species

Psorophora signipennis (Coquillett) — Widespread throughout desert valleys of state

NEW RECORDS

Aedes sierrensis (Ludlow)

The occurrence of this tree hole species in northern Utah was reported by Nielsen, Arnell and Linam (1967). The species has been collected in cottonwood tree holes along the Weber River in Weber County. It is not considered to be an important pest species in Utah. *A. sierrensis* is very similar to *Aedes varipalpus* which occurs in southern Utah and Utah County. However, there are reliable differences in all stages. *Adult female: A. varipalpus* has several light bristles arising among the scales of the subspiracular patch; *A. sierrensis* lacks these bristles. In *A. sierrensis* there is a broad basal white ring on the fourth tarsal segment which covers one-third to one-half of the segment; in *A. varipalpus* this basal white ring covers only one-fifth of the segment or less. *Larvae:* The most conspicuous difference is the shape of the siphon. In

A. varipalpus the siphonal index is 3.0 (length divided by basal diameter) or less. The siphon is expanded mesally and tapers to become much narrower distally; in *A. sierrensis* the siphonal index is about 3.5 and the siphon lacks the distinct mesal expansion and is more parallel sided. Another reliable difference is prothoracic hair no. 5, which is double in *A. varipalpus* and usually single in *A. sierrensis*. *Male terminalia:* The most conspicuous difference is the basal lobe which in *A. varipalpus* bears one long single spine and several shorter spines and setae and in *A. sierrensis* bears a large brush-like cluster of long stout spines.

Aedes trivittatus (Coq.)

This valley species is known only from Bluff, Utah, in San Juan County, where biting females were collected by G. C. Collett on August 19, 1968. *Adult female:* Females are not likely to be confused with other Utah species: Tarsi without bands; Wings dark brown scaled; Mesonotum with a pair of broad stripes of white scales separated by a median brown stripe of equal width, anterior margins of mesonotum dark brown scaled; Scale patch on sternopleuron does not extend to upper anterior border; Mesepimeron lacking scales on ventral third; Abdominal tergites dark brown scaled with white scales occurring on lateral basal margins and often in very small median basal patches. *Larvae:* The larvae of *A. trivittatus* have single head hairs and the anal plate completely encircles the anal segment. The larvae may be confused only with *Aedes nigromaculis*. In *A. trivittatus* the comb scales are not spine-like and the pecten teeth are evenly spaced; in *A. nigromaculis* the comb scales are distinctly spined and the last 2-4 pecten teeth are more widely spaced. *Male terminalia:* This structure in *A. trivittatus* is unlike any other Utah species. See Carpenter and La Casse (1955:249).

Aedes ventrovittis Dyar

This mountain species is known only from the summit area of Logan Canyon, Cache County, where it was collected in a roadside pool on May 23, 1964, by L. T. Nielsen at an elevation of 7500 ft. Females are severe biters of man, but the species is too rare in Utah to be of pest importance. *Adult females:* Tarsi unbanded; Wings dark scaled usually intermixed with a few to many white scales along the anterior wing veins; Post coxal scale patch present; Scales on sternopleuron extending to or near the anterior margin; Lower one-third of mesepimeron bare, lower mesepimeral bristles absent; Abdomen with narrow basal white bands which widen laterally. On some segments mesal portions may lack basal white scales. *Larvae:* Upper and lower head hairs single; Siphonal index 2.5 to 3.0; pecten usually extending past middle of siphon with 1-4 detached teeth; Comb scales 8-12, each scale slender and spinelike, anal plate extending to near mid ventral line. *Male terminalia:* The male terminalia is very similar to *A. spencerii idahoensis*, and cannot be reliably separated from that species. The two are not likely to be confused as *A. spencerii idahoensis* is a valley species.

Culex thriambus Dyar

This species was first reported for Utah by Nielsen, Linam and Rees (1963). It is a southern species and has been collected only in Washington County in the vicinity of St. George. Females do not feed on man. *Adult female:* Females of this species are very similar to *Culex tarsalis* and easily confused with that species. *C. thriambus* lacks the distinctive longitudinal line of white scales present on the femora and tibiae of *C. tarsalis*, as well as the characteristic V-shaped dark patch of scales present on the venter of each abdominal segment in *C. tarsalis*. The broad white ring present on the proboscis of *C. tarsalis* is incomplete in *C. thriambus*, being present ventrally and around the sides, but never conspicuous on the dorsal surface. *Larvae:* The siphon of *C. thriambus* has the siphonal tufts present as three pairs of long single (rarely double) irregularly placed hairs. In this character *C. thriambus* is distinct from all other Utah *Culex* except *C. restuans*. However, the siphonal index in *C. thriambus* is usually at least 6.0 as compared to 4.0 to 4.5 in *C. restuans*. In addition the antennae of *C. thriambus* are greatly constricted beyond the antennal tuft which is situated near the outer third of the antennal shaft; in *C. restuans* the antennae are nearly uniform in shape and the antennal tuft is situated near the middle of the antennae. *Male terminalia:* The terminalia of *C. thriambus* is similar to *C. tarsalis*. The most conspicuous differences occur in the leaf-like filament of the subapical lobe, which is broad in *C. thriambus*, narrow and clublike in *C. tarsalis* and in the crown of the tenth sternite which in *C. thriambus* has the spines all pointed, while in *C. tarsalis* the outer spines are blunt.

Culiseta morsitans dyari Coq.

This species was first collected in Utah at Trout Springs near the mouth of Weber Canyon by L. T. Nielsen on May 23, 1968. Females do not normally attack man. *Adult female:* The female is very similar to *Culiseta silvestris minnesotae*, but differs in the abdominal tergite markings. In *C. s. minnesotae* both basal and apical bands of white scales are present; in *C. m. dyari* only narrow basal white bands are present. *Larvae:* The larvae of *C. m. dyari* are very similar to *C. s. minnesotae* and cannot always be separated with certainty. In the former species the upper frontal head hairs are 3-7 branched, and the pre-antennal hair is 5-9 branched. In the latter species the upper head hairs are 6-11 branched, and the pre-antennal hair is 8-14 branched. The number of tufts in the ventral brush is 19-22 in *C. m. dyari* and 16-19 in *C. s. minnesotae*. *Male terminalia:* The terminalia of *C. m. dyari* are very similar to *C. s. minnesotae*. However, in the former species, the phallosome tapers to a point at the apex; in the lattter species the apex of the phallosome is blunt and broadly rounded.

Orthopodomyia signifera (Coq.)

This species was reported from southeastern Utah by Nielsen *et al.* (1968). It has been collected in tree holes in San Juan County along the San Juan River near Bluff, and along Salt Creek in Canyonlands National Park. Females do not feed on man. *Adult female:* Females are characterized by the presence of three pairs of narrow longitudinal lines of silvery white scales on the mesonotum; Pleuron with narrow white lines and patches of white scales; Tarsal segments conspicuously white banded; Wing scales broad, intermixed brown and white. *Larvae:* Larvae can easily be recognized by the absence of pecten on the siphon, and the presence of large sclerotized dorsal plates on segments VIII and often on segments VI and VII. Anal segment is completely ringed by the anal plate. Head hairs are multiple. *Male terminalia:* The terminalia are distinctive and unlike any other Utah genus. See Carpenter and La Casse (1955).

Culex salinarius Coq.

This species has been reported as occurring in Utah (Nielsen and Rees, 1961). A study of existing material reveals that no valid record of this species exist. All specimens identified as this species are actually *Culex erythrothorax* or *Culex pipiens.* The presence of this species in Utah is, therefore, considered questionable and it has been removed from the state list.

REFERENCES CITED

Carpenter, S. J., and W. J. La Casse, 1955. Mosquitoes of North America North of Mexico. Univ. of California Press. 360 pp.

Nielsen, L. T., J. H. Arnell and J. H. Linam, 1967. A report on the distribution and biology of tree hole mosquitoes in the western United States. Proc. and Papers of the 35th Ann. Conf. of the Calif. Mosquito Control Assoc. and the American Mosquito Control Assoc., pp. 72-76.

Nielsen, L. T., J. H. Linam and D. M. Rees, 1963. New distribution records for mosquitoes in the Rocky Mountain States. Proc. of the 50th Ann. Meeting of the New Jersey Mosquito Extermination Assoc., pp. 424-428.

Nielsen, L. T., J. H. Linam, J. H. Arnell and T. J. Zavortink, 1968. Distributional and biological notes on the tree hole mosquitoes of the western United States. Mosquito News, 28:361-365.

Nielsen, L. T., and D. M. Rees, 1961. An Identification Guide to the Mosquitoes of Utah, Univ. of Utah Biol. Series, 12(3): 58 pp.

AN ECOLOGICAL STUDY OF *AEDES* MOSQUITOES IN UNCONTROLLED AREAS IN TOOELE COUNTY, UTAH

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An extensive investigation of the biology and ecology of four species of *Aedes* mosquitoes, *Aedes campestris* Dyar and Knab, *Aedes dorsalis* (Meigen), *Aedes fitchii* (Felt and Young) and *Aedes niphadopsis* Dyar and Knab, was conducted in Tooele county, Utah during the period of January, 1967 to April, 1968. Two isolated study sites were chosen. These areas had never been subjected to mosquito control practices. One study area is located one mile west of Mills Junction (state highway 36 and U.S. highway 40) and the other, 3.5 miles north of Grantsville. A distance of 13 miles separates the two sites. Both areas are at elevations of 4250 feet above sea level.

The Mills Junction habitat is a pasture type, flooded by spring and early summer precipitation with the level of accumulated floodwater being maintaind for more extended periods of time by an elevated water table produced by an adjacent pond of permanently impounded water. The maximum length attained by the flooded area was 375 feet. The greatest width was 65 feet. The average pool depth when the greatest volume of water had accumulated was six to eight inches. The Grantsville study site is situated along the marginal area of the southern shoreline of the Great Salt Lake. The habitat investigated consisted of two temporary pools, A and B, plus adjacent scattered patches of temporarily flooded saltgrass. These pools are filled by early vernal precipitation and are maintained indefinitely by a naturally high water table. The larger Grantsville pool, A, was at maximum capacity 40 feet long by 18 feet wide. The greatest depth of the pool was 15 inches. The second pool, B, was separated from pool A by a distance of 250 feet. When flooding occurred, the vegetation submerged in the Grantsville pools was mainly saltgrass. The peripheral vegetation of the pools was composed of a mixture of saltgrass, glasswort and pickleweed.

The two study sites were visited on the average of three to four times weekly during the entire period of the investigation. All aedine species (four at Mills Junction and three at Grantsville) were under constant surveillance from the initial hatching of the respective broods, throughout the entire natural developmental sequence and then terminated with the death of the adults.

DEVELOPMENTAL RATES

The data in Figure 1 was drawn from collections made throughout the period from early February 1967 to May 1968 and encompasses the simultaneous developmental sequences of the four *Aedes* mosquitoes found at the Mills Junction site of investigation. The species are treated separately, the developmental rates of each being traced from the first hatching of the larvae to the time of major emergence of the adult populations. Included are the dates on which each particular developmental stage first appeared, the period of greatest abundance of that stage, and when that developmental stage was last taken in significant quantity. Also included is the number of total elapsed days for each of the four successive larval instars and the pupal stage. The respective species are presented in order of consecutive calendar emergence of the adult broods. In the treatment of adults of the four species, dates are supplied which represent the first appearance of the given species and the period over which the greatest adult emergence occurred. First broods only are treated.

FIG. 1. *Developmental rates of the immature stages of mosquito species collected at Mills Junction during* 1967.

Aedes niphadopsis:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/4	2/6 -2/8	2/25	21
II	2/9	2/14-2/25	3/22	42
III	2/18	2/28-3/22	4/5	48
IV	3/8	3/22-4/9	5/7	61
Pupae	3/22	4/5 -4/25	5/14	54

First Adult Emergence	Period of Greatest Adult Emergence
4/16	4/23-5/9

Aedes campestris:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/11	2/28-3/14	4/14	63
II	2/21	3/5 -3/22	4/19	58
III	2/28	3/11-4/2	5/2	64
IV	3/11	3/27-4/23	5/16	67
Pupae	3/27	4/19-4/29	5/23	58

First Adult Emergence	Period of Greatest Adult Emergence
4/23	4/29-5/14

Aedes dorsalis:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/21	3/11-4/2	5/9	78
II	2/25	3/25-4/16	5/14	84
III	3/5	4/9 -5/7	5/16	73
IV	3/22	4/16-5/14	5/25	65
Pupae	4/5	4/25-5/19	5/31	57

First Adult Emergence	Period of Greatest Adult Emergence
4/25	5/4-5/23

Aedes fitchii:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/7	3/5 -3/11	3/14	36
II	2/21	3/8 -3/14	3/25	33
III	2/28	3/22-4/2	4/5	37
IV	3/22	3/27-5/2	5/14	54
Pupae	4/9	4/29-5/13	5/23	45

First Adult Emergence	Period of Greatest Adult Emergence
5/7	5/12-5/19

A. niphadopsis was the first species to hatch at Mills Junction. The minimum water temperatures required to stimulate hatching of *A. niphadopsis* was determined to be between 40° and 45°F. The first collection of this species was taken from water encrusted with one-fourth inch of ice. An overall progressive elevation in water temperature of approximately 18°F. occurred within the developmental interval between the first larval instar and the first recorded emergence of adults. Water temperatures consistently averaging above 55°F. were not recorded until the approximate time of the first appearance of fourth instar larvae of this species. The initial hatching of the larval population of *A. niphadopsis* was of a massive, all-inclusive nature with comparatively few first instar larvae appearing at dates more than five or six days subsequent to the initial February 4th hatch. This phenomenon demonstrates a great propensity of *A. niphadopsis* for ready, mass-hatching at very low water temperatures. The first events in the course of the basic developmental process of *A. campestris*, *A. dorsalis* and *A. fitchii* were distinctly different. When these species were first taken during the month of February as first instar larvae, their relative abundance was limited and often each species was represented by only a small number of individuals, rather than as a large sample indicative of a large, well-established population. At these times water temperatures in excess of 45°F. were not recorded. Their general initial hatching process was extended, with the major respective hatches of these species occurring from two to four weeks after their first appearance. This was especially true of *A. dorsalis* and *A. fitchii.* These observations indicate that the eggs of these *Aedes* of Mills Junction hatch at a significantly higher temperature than *A. niphadopsis,* probably at least 45°-50°F., and require a far more extended exposure to that critical minimal temperature before hatching of a significant percentage of an entire given brood will occur. It is probable then, that the few *A. campestris, A. dorsalis* and *A. fitchii* consistently taken throughout the month of February were the product of the exposure of a few eggs to a minimum critical hatching temperature, though of insufficient duration to effect a substantial larval hatch. For example, a lapse of approximately three weeks was noted between that time when larval *A. dorsalis* were first taken and when first instar larvae of that species suddenly appeared again in collections in numbers indicative of the occurrence of a major hatch.

A. niphadopsis was the first species to emerge as adults at Mills Junction. The emergence of adult *A. niphadopsis,* in pure culture, preceded that of other aedine species by approximately one week. Similarly, the major emergence of *A. campestris* (the second species to emerge) preceded that of *A. dorsalis* by approximately one week. This first significant emergence of *A. campestris* was even upon its initial onset not a pure culture but contained occasional *A. dorsalis.* Within three weeks after the first emergence of *A. campestris,* the emergence of the coexisting population of *A. dorsalis* had numerically equalled and then overwhelmingly surpassed that of *A. campestris. A. fitchii* was the last first-brood aedine species to emerge from the flooded area at Mills Junction. There was an approximate one week lapse between the initial periods of greatest adult emergence of *A. dorsalis* and *A. fitchii.* In contrast with the relatively extended emergence of *A. dorsalis,* that of *A. fitchii* was, at its peak, marked in intensity but brief in duration. The emergence of this single brooded species was completed by May 27th.

Comparatively, the average minimum developmental spans (from the first substantial hatch of each larval brood to adult) of each of the four Mills Junction aedine species were: 71 days for *A. niphadopsis,* 54 days for *A. campestris,* 45 days for *A. dorsalis,* and for *A. fitchii,* 68 days.

The comparatively small spatial character of the pools at the Grantsville sites facilitated detailed observation of the progressive development of the mosquito populations which they supported. This application was especially true of the smaller pool, B, which supported moderately large populations of *A. niphadopsis, A. dorsalis* and *A. campestris. A. fitchii,* a relatively common species at Mills Junction, did not breed within any Grantsville pool. The data contained in Figure 2 are that pertaining to individual species developmental rates at Grantsville obtained from the smaller pool B.

FIG. 2. *Developmental rates of the immature stages of mosquito species collected at Grantsville, pool B, during* 1967.

Aedes dorsalis:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/14	3/5 -3/27	4/16	55
II	2/21	3/11-3/25	4/25	60
III	2/28	3/22-4/9	5/2	64
IV	3/14	4/5 -5/9	5/27	75
Pupae	4/5	4/25-5/12	5/31	57

First Adult Emergence	Period of Greatest Adult Emergence
4/19	4/25-5/12

Aedes campestris:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/14	2/25-3/14	4/9	55
II	2/21	3/5 -3/25	4/16	55
III	2/28	3/14-4/5	4/25	57
IV	3/14	3/27-5/2	5/21	75
Pupae	4/2	4/19-5/7	5/29	63

First Adult Emergence	Period of Greatest Adult Emergence
4/19	4/23-5/7

Aedes niphadopsis:

Larval Instar	First Collected	Peak Population	Last Collected	Total Days Elapsed
I	2/2	2/4 -2/6	2/25	24
II	2/6	2/7 -2/11	3/5	28
III	2/11	2/14-2/25	3/11	29
IV	2/21	3/5 -3/22	4/25	64
Pupae	3/25	4/5 -4/19	5/13	50

First Adult Emergence	Period of Greatest Adult Emergence
4/16	4/25-5/4

Throughout the extended period of simultaneous investigation of the Grantsville pools A and B there was discovered to be a continuous average difference in water temperature of those habitats of at least 1¾°F. At times the two pools differed in temperature by as much as 4°F. The larger pool, A, was invariably the warmer. The effect of this discrepancy in water temperatures was manifested in the rates of development of the larvae in each pool. This temperature-regulated developmental difference in two adjacent (separated by a distance of less than 250 feet) larval populations was noted with accuracy in the two respective populations of *A. niphadopsis.* After the observation for one season of the simultaneous development of the *A. niphadopsis* populations of the two pools, it was concluded that a difference of at least one week in the developmental rates of the two populations was induced by the effects of an average 1¾° F. dissimilarity in temperature of the two habitats. By way of comparison, the major emergence of *A. niphadopsis* from the Grantsville pool A, preceded that of the Mills Junction site by approximately one week. The water temperature of the Grantsville pool A, was consistently higher than that of the Mills Junction location by at least 1½°F. It is possible that other ecological factors could have been responsible for some of the differences in developmental rates. However, the study revealed no significant differences in other environmental or nutritional factors between the study sites.

RELATIVE ABUNDANCE OF THE SPECIES

In the determination of relative abundance, a cumulative sample of 8,800 first-brood *Aedes* larvae were identified to species. Of this larval sample, about 4,400 represented those collected from the more central portion of the Mills Junction pool which was flooded initially in February and remained relatively stabilized in volume until mid-March. At this time additional floodings which extended into early April raised the water level, and new areas around the margins of the pool were flooded for the first time. An additional 4,400 newly hatched larvae were collected from this newly flooded periphery of the pool. The following data, expressed as a percentage of the total first-brood population, represent the approximate relative abundance for the year 1967 for each of the four aedine species indigenous to the site of investigation at Mills Junction. Table I is representative of the relative abundance of those *Aedes* hatched upon the initial flooding of the central portion of the study area. Table II indicates the relative abundance of those *Aedes* having hatched as a result of subsequent progressive flooding of the periphery of the pool.

TABLE I

Aedes dorsalis	35%
Aedes niphadopsis	25%
Aedes campestris	25%
Aedes fitchii	15%

TABLE II

Aedes campestris	60%
Aedes dorsalis	35%
Aedes niphadopsis	5%
Aedes fitchii	0%

OVIPOSITION SITE PREFERENCES

A comparison of the proportions of the species produced by the two floodings (Tables I and II) reveals some significant oviposition preferences. Four species were present in the collections from the central flooding. Only three species were present in the collections from the subsequent flooding of the periphery. *A. niphadopsis*, which made up 25% of the collections in the first floodings represented only five per cent of the total larvae collected during the second flooding. *A. dorsalis* comprised about one third (35%) of the total larval count of both floodings. *A. campestris*, in collections from the main pool during the earlier, lower volume floodings represented 25% of the larvae collected, but in the second peripheral floodings this species represented 60% of all larvae collected. *A. fitchii* made up 15% of the larvae taken in the initial collections but were not encountered in larval samples resulting from the later floodings. It is emphasized that extensive collections of larvae from the flooded periphery were taken at random from various locations surrounding the entire perimeter of the pool. It would appear that *A. campestris* females had a distinct preference for oviposition along the densely vegetated margins of the pool whereas females of both *A. fitchii* and *A. niphadopsis* apparently preferred the more central regions of the pool as sites to lay their eggs. *A. dorsalis* larvae hatched with equal frequency in both areas indicating that females of this species were ubiquitous in the selection of oviposition sites.

LARVAL DIET

Gut analysis of fourth instar larvae of the four aedine mosquito species developing at Mills Junction revealed a representative section of the primary larval diet. All four species were found to have ingested filamentous algae, diatoms, larval exuviae and fragmented crustaceans. One *Aedes* species demonstrated a marked nutritional preference. Of the various genera of filamentous algae by all mosquito species, *Oscillatoria* proved to be the form most often taken by *A. fitchii.* Dissections of *A. fitchii* consistently revealed large quantities of *Oscillatoria,* sometimes to the extent of constituting as much as 50% of the gut content. Also special note was made of an apparent affinity of *A. fitchii* for the oil-rich oogonia of *Oedogonium.* Approximately half of the diet of the Mills Junction *Aedes* larvae consisted of a mixture of filamentous algae of the genera *Oedogonium, Oscillatoria* and *Tribonema.* No preference for a particular algal form was demonstrated by *A. dorsalis, A. campestris* or *A. niphadopsis.* Diatoms were ingested in great numbers by all species and represented an important part of the larval diet. Larval exuviae and fragmented crustaceans were regular but minor constituents of the total diet. Encountered also in gut dissections were the algae *Chlamydomonas, Euglena* and rarely, filamentous *Ulothrix.*

At the Grantsville site *Oscillatoria* was the filamentous alga found to be eaten with regularity by all *Aedes* species. Also present in the gut contents were large numbers of diatoms, the most common form of which was *Navicula.* In general, Grantsville larvae ingested higher proportions of diatoms than those of the Mills Junction site. It is believed this was due to a greater availability of diatoms at Grantsville, rather than larval preference for that algal form.

MOSQUITO PARASITES

About 5% of thos Mills Junction mosquito larvae examined microscopically were found in a state of being actively parasitized by one or more immature hydracarinid mites, probably of the genus *Piona* Koch. Parasitized fourth instar mosquito larvae of all aedine species, with some individuals bearing as many as four larval mites were taken in collections. Portions of the larval mosquito anatomy on which the mites were found were the neck and the abdominal region in the area of the intersegmental membranes. All eight intersegmental regions of the abdomen were commonly attacked. When two mites were found attached in the neck region of a larva, the mites were often situated in opposition to each other. Attachment of the mite was very secure, requiring with preserved specimens, considerable tension in order to remove the parasite from the larval host. At no time were the immature hydracarinid mites observed to produce mortality in the mosquito larvae that were parasitized.

At the Mills Junction site, blood-seeking adult females of *Aedes*, *Culex* and *Culiseta* species were captured and found to harbor immature hydracarinid mites. Three of the four Mills Junction *Aedes* species, *A. dorsalis*, *A. niphadopsis* and *A. campestris* were found to harbor these mites. Very few adult *A. fitchii* were collected and none had mites attached. However, it is considered doubtful that this species escapes this type of parasitism. The maximum number of mites observed on any given adult was two. The preferred site of attachment was in the region near the juncture of the thorax and abdomen. If two mites were present, the positions assumed were usually ventrolateral, with the mites situated on each side, and in opposition to each other. Hydracarinid mites did not occur in Grantsville pools, possibly due to the higher alkalinity of those pools.

MATING SWARMS

At the Mills Junction and Grantsville site several adult mating swarms were discovered, and their physical and environmental characteristics were observed from initial association to the actual termination of the swarming phenomenon. Swarms in all stages of development were encountered most frequently at Mills Junction.

In all swarms only two mosquito species, *A. dorsalis* and *A. campestris* were involved. Swarms usually consisted of pure cultures of *A. dorsalis* males. *A. campestris* was on occasion found associated with *A. dorsalis* swarms, but was represented by one or two males rather than by being inter-mixed in any abundance. Swarming of *A. fitchii* or *A. niphadopsis* within the immediate area of original adult emergence was at no time in evidence throughout the course of the study. Mating swarms representing the first brood of *A. dorsalis* were discovered and studied from May 20th through June 2nd of 1967. First-brood mating swarms after June 2nd ceased to occur.

The population of swarms was extremely variable, ranging from a minimum of approximately 50 individuals to a maximum of approximately 175. Swarm formation began with the loose aggregation of eight or ten males with additional individuals progressively entering the group until generally within 10 or 12 minutes a maximum population was reached. Upon entrance into the swarm each mosquito would become oriented in a position facing up-wind and remain in this attitude throughout the duration of the association. The volume of a given swarm and the distance separating each unit of the swarm were variable. The heights of all swarms above a surface were varied with extremes ranging from a maximum height of 12-13 feet to a minimum height of 1½ feet. Swarms in general demonstrated no obvious preference for a surface type or object over which to form.

The population of all swarms consisted of sexually mature males. Copulation was effected with the random entrance into the swarm by females. A female would enter the swarm and immediately become attached venter to venter with a male. Usually pairs *in copula* would leave the swarm, fly a short distance, tumble into vegetation, and quickly terminate the act. Throughout the duration of a given swarm, the maximum number of females observed successfully entering the swarm, pairing, and exiting with males was five. With a maximum number of five male-female couplings for any given swarm, a question arises as to whether the function of male mosquito swarms is purely to attract females into the swarm for mating purposes. In view of the immense numbers of recently emerged biting females (most females actively seek a blood meal only after copulation) in the vicinity, coupled with the knowledge that comparatively few swarms escaped observation by the author, it appears that mating probably occurs commonly in isolated male-female encounters, possibly completely divorced from a swarming situation. It must be noted, however, that no such isolated matings were observed during this study.

The *Aedes* mosquitoes studied demonstrated marked requirements in type and degree of physical stimuli necessary for conditions conducive to swarm formation. Foot candles of illumination, relative humidity, temperature and wind velocity proved to be of primary importance. Swarming invariably began shortly after sunset.

Swarm association commenced at a maximum light intensity of 450 foot candles. Minimum intensity at swarm initiation was 280 foot candles. Greatest swarm activity was reached at light intensities ranging from 40 to 150 foot candles. Swarm population and activity dwindled with progressive decrease in illumination below 40 foot candles. Swarm dispersal was abrupt, beginning rapidly at a point when, or slightly after, light was no longer measurable. The maximum duration of any swarm observed from beginning to end was 28 minutes. Minimum was 17 minutes. The average longevity of all swarms observed from formation to dispersal was 22 minutes.

Mating swarms were discovered only at temperatures of from 60°-70° F. The average temperature during the early stages of all swarming activity was 66°F. The minimum average temperature at the dispersal of all swarms studied was 64.7°F. The role of temperature was of apparent importance in supplying a threshold for swarm activity. Under otherwise favorable conditions, with a ready abundance of adult males in the immediate vicinity, swarms failed to occur when temperatures below 55°F. were in effect.

The average relative humidity recorded during the early stages of swarm formation was 64.5%. At the beginning of swarms, extremes from a minimum of 40% to a maximum of 83% relative humidity were noted. Although other physical factors often favored swarm formation, mating swarms were never observed when relative humidities in excess of 83% or below 40% were in effect.

OVARIAN CYCLES

In ovarian dissections treating the gonotrophic cycles and longevities of the *Aedes* in this study, the basic principles of the technique developed by Detinova (1962) were employed. This is the most accepted, recent method for the examination of ovarioles for dilatations and stage of ovarian development.

It is known that eggs normally form in each of the multiple ovarioles which constitute each ovary. Development occurs in an enlarged region known as the follicle. After oviposition there remains a small permanent dilatation at the follicular site of the formation of the original egg. In the event of further ovipositions, additional eggs will develop in new follicles which always form anteriorly to the dilatations representing the most recent ovipositon and when released will leave a new dilatation. Therefore, in a given individual, each completed gonotrophic cycle is evidenced by a dilitation, the most posterior representing the first oviposition, the furthest anterior, the most recent. Each dilitation indicates one cycle of ovarian development. The total number of dilatations represents the number of ovipositions and if the time required to complete a gonotrophic cycle is known it is possible also to obtain an accurate estimate of the age of the mosquito.

Figure 3 represents 1967 data obtained from ovarian dissections throughout the life spans of biting females of the four Mills Junction aedine species. Each species is treated separately. Listed is that date when biting females last appeared within the study area and the total cumulative days through which that species was represented by biting females. Included is the date of each collection, the number of individuals dissected, and the number of dilatations discovered. Figure 4 also lists the biting periods and the maximum number of dilatations discovered for each species studied.

FIG. 3. *Ovarian Dissection Data* 1967

Mills Junction Site

Species and Date	Number of Dissections	Number of Dilatations 0	1	2	3	4	5
Aedes niphadopsis:							
5/19	6	6					
5/23	6	6					
5/27	4	3	1				
5/29	3	3					
6/2	5	3	2				
6/8	4		4				
6/11	4	2	2				
6/17	6	2	4				
6/23	5	1	4				
6/28	4		4				
Totals	47	26	21				

Species and Date	Number of Dissections	Number of Dilatations 0	1	2	3	4	5
Aedes campestris:							
5/4	6	6					
5/9	7	7					
5/14	10	8	2				
5/20	8	7	1				
5/23	3	3					
5/27	7	5	2				
5/29	4	3	1				
6/2	8	6	2				
6/8	4	3	1				
6/11	5	1	4				
6/17	6	2	4				
6/23	6		6				
6/26	3		3				
6/30	3	1	2				
7/3	4	1	2	1			
7/5	2		2				
7/7	5	1	4				
7/10	1			1			
7/16	5		2	1	2		
7/23	2				2		
Totals	99	54	38	3	4		
Aedes dorsalis:							
5/4	6	6					
5/9	8	8					
5/14	10	10					
5/20	7	7					
5/23	7	6	1				
5/27	10	8	8				
5/29	7	7					
6/2	7	5	2				
6/8	6	4	2				
6/11	4		4				
6/17	8	6	2				
6/23	6	2	4				
6/26	6	3	3				
6/30	6	5	1				
7/3	4		4				
7/5	4	2	2				
7/7	9	8	1				
7/10	9	7	1	1			
7/17	4		4				
7/20	4		4				
7/21	7	2	4		1		
7/23	12		10	1	1		
7/26	3	1	2				
8/3	11	4	4	1	1	1	
8/9	9	2	4	3			
8/11	6	1	4	1			
8/13	5		4				1
8/15	3		2	1			
8/18	8	2	3	3			
8/23	11	5	6				
8/28	3	3					
9/2	3		2	1			
9/22	9	1	6	1	1		
10/13	8	1	7				
10/16	3		2		1		
Totals	233	116	97	13	5	1	1

Species and Date	Number of Dissections	Number of Dilatations 0	1	2	3	4	5
Aedes fitchii:							
6/21	2	2					
6/23	5	5					
6/26	4	4					
6/28	4		4				
Totals	15	11	4				

FIG. 4. *Biting and ovarian dissection data for four Mills Junction species.*

Date first biting females collected	Date last biting females collected	Maximum biting period	Maximum number of dilatations
Aedes niphadopsis			
5/19/67	6/28/67	41 days	1
Aedes campestris			
5/4/67	7/26/67	84 days	3
Aedes dorsalis			
5/4/67	10/20/67	170 days	5
Aedes fitchii			
6/21/67	6/28/67	8 days	1

The data for *A. niphadopsis* raises doubt that this species is capable of completing more than two gonotrophic cycles throughout the normal life span of the adult. Of a total of 47 dissections of biting female *A. niphadopsis,* 21 or 44.5% had a single dilatation and 27 or 55.5% had no dilatations and were thus just beginning the first cycle. As all the females collected were actively attempting to bite, it is assumed that, had those which had oviposited once (one dilatation) successfully completed their second blood feeding they would have been capable of completing a second oviposition. However, despite intensive collecting throughout the entire summer, no biting *A. niphadopsis* were collected after June 28th and none were taken with more than a single dilatation during the period of May 27th to June 28th. This certainly would appear to be an adequate period for an additional ovarian cycle to occur. The factors contributing to this apparent restriction to a single or double cycle are not known with certainty. Possible conditions responsible for this behavioral pattern might be found in a relatively short natural longevity or in genetic factors inhibiting multiple ovipositions. Also potentially instrumental may be the flight habits of this species, typified by mass, post-emergent adult migrations to adjacent foothill regions where the search for a blood meal occurs and perhaps mating takes place. The authors have taken biting female *A. niphadopsis* in areas several miles removed from the nearest possible source of larval development and have also observed male swarms of *A. niphadopsis* in such areas. It is assumed that this widespread dispersal of adults is due to a scarcity of suitable hosts within the immediate area of emergence and/or a mating urge. These activities probably result in a prolonged delay in the return of females to sites suitable for oviposition. Also of great significance is the direct weakening effect of the ovipository act on the female mosquito. A study of the ovarian dissection data of *A. dorsalis* and *A. campestris* reveals that only an extremely small fraction (3.16% for *A. campestris* and 5.75% for *A. dorsalis*) of the total number of females dissected had survived two separate acts of oviposition and had thereafter sought a third blood feeding. Thus in *A. dorsalis* and *A. campestris* a high percentage of oviposition-induced mortality had occurred. The most likely explanation then, for the consistent failure of *A. niphadopsis* females to survive a second oviposition would be found in a high mortality due to the weakening effects of oviposition in combination with factors such as a short natural longevity and a prolonged geographic separation of females from oviposition sites. It is probable that some female *A. niphadopsis* oviposit a second time, but, as the data indicate, die during or shortly after that act.

A period of 33 days elapsed between the first adult emergence of *A. niphadopsis* and the appearance of biting females of that species at the Mills Junction site. Adult *A. niphadopsis* first began to emerge on April 16th. Recently emerged adults were common in the area, but biting females were not encountered until May 19th. From the period of May 19th through June 28th, biting females were encountered in relative abundance upon every visit to the Mills Junction site. Most of those females seeking a blood feeding from May 19th to May 29th were, upon dissection, found to have no dilatations. The majority of those biting females taken through the month of June had one dilatation each. It would appear that those biting females with no dilatations, taken during the latter part of May, represented individuals which had emerged in April or early May. They left the immediate area of development, mated, and then returned to the Mills Junction area in the random search for a blood meal. It is uncertain though, whether those females with one dilatation taken in June had oviposited and then remained in the area to seek a second blood feeding or had oviposited, left the region for an undetermined time, and then returned to seek another blood feeding. No females were discovered with the ovariolar sheaths and pedicels still in the form of loose distended sacs, having not yet contracted to form the smaller more distinctive, nodular dilatation. This condition is positively indicative of oviposition having occurred within 48 hours. It would then appear that at least two to three days had elapsed before the females with one dilatation commenced feeding again in the study area.

The disappearance (June 28th was the last day of collection of this species at both Mills Junction and Grantsville) of *A. niphadopsis* was sudden, suggesting that the last remaining females had died during or shortly after a first or second oviposition. The possibility, though, that some gravid females dispersed to oviposition sites other than those at Mills Junction and Grantsville must not be dismissed.

A. campestris demonstrated the capacity for the completion of at least three gonotrophic cycles. Unlike *A. niphadopsis* the post-emergent Mills Junction population of *A. campestris* tended as a whole to remain within the immediate vicinity of the breeding area. Gradual dispersal rather than mass migration was the behavioral pattern for this species. A lapse of approximately six days separated the first large emergence of adult *A. campestris* and the initial encounter of biting females of that species. The calendar difference (10 days) between the first May 4th discovery of biting females and the May 14th discovery of the first dilatations may be considered to be the approximate length of the first gonotrophic cycle of *A. campestris.* About 20% of the biting females were discovered with the ovariolar sheaths and pedicels still heavily distended from very recent ovipositions. It was therefore determined that for this species a period of no more than 48 hours is required between the oviposition of the first batch of eggs and the renewed search of the female for a second blood feeding.

A. dorsalis, the only true multivoltine aedine species to breed at Mills Junction or Grantsville and numerically dominant throughout the entire breeding season, proved most fecund in terms of brood number and individual female capacity for multiple acts of oviposition. Due to the multi-brooded capacity of *A. dorsalis,* this species persisted at the Mills Junction site 86 days longer than did any of the other three species of that genus. Slow dispersion rather than mass migration was the general post-emergent behavior of this species. The basic gonotrophic pattern observed for *A. dorsalis* was very similar to the earlier stages of that pattern established by *A. campestris.* The dominant physiological difference between *A. campestris* and *A. dorsalis* is that marked increase in capacity of the latter to survive ovipositions in excess of one. One biting female *A. dorsalis* was found to bear five distinct dilatations, thus demonstrating the capacity of at least some females of that species to survive at least five separate acts of oviposition.

The post-emergent habits of adult *A. fitchii* were similar to those of *A. niphadopsis.* As in the observations of *A. niphadopsis,* adult *A. fitchii* made no immediate post-emergent attempts to seek blood. This species emerged from the Mills Junction breeding pool in relative abundance through the period of May 12-19th. By June 8th adults were no longer taken in any of numerous, regular systematic net-sweeps of the entire vegetative periphery of the pool. *A. fitchii* females did not reappear at the Mills Junction site until the fourth week of June. During that period, including June 21-28th fifteen biting females were encountered. Ovarian dissections of these females collected through June 28th revealed one dilatation in four individuals and no dilatations in eleven. No collections of *A. fitchii* were made after June 28th. Due to the few females examined no significant conclusions can be drawn nor can an explanation be made of the scarcity of females in the area where larvae of this species were relatively abundant.

LITERATURE CITED

Detinova, T. S., 1962. Age grouping methods of Diptera of medical importance, World Health Organization, Geneva, Switzerland. 216 pp.

COMPARISON OF WESTERN ENCEPHALITIS VIRUS INFECTION RATES AMONG ***CULEX TARSALIS*** COLLECTED BY DIFFERENT TRAPPING TECHNIQUES

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ABSTRACT

In the western United States several diseases of man are caused by arthropod-borne viruses (arboviruses) and are transmitted by the mosquito, *Culex tarsalis* Coquillett. Epidemiologic studies of these diseases include the collecting and testing of the mosquitoes for the presence of arboviruses, so there is a good reason to evaluate the relative sensitivity of the various collecting techniques with respect to determining mosquito virus infection rates. The purpose of this study was to review data obtained on western encephalitis (WE) virus infection rates among *C. tarsalis* collected by different techniques to determine if the method of collection affected the results obtained.

The data analyzed and compared were obtained from studies in Weld County, Colorado and Hale County, Texas during 1965, 1966, and 1967. The mosquitoes collected in shed traps, New Jersey light traps, or natural shelters were used to obtain weekly population indices and were tested for the presence of virus using previously described testing procedures. The mosquitoes collected in 1965 were tested in lots of 50, and those obtained in 1966 and 1967 were tested in lots of 25 specimens. Only specimens collected by a single technique at a single collecting site were used for purposes of this report, and only deplete or gravid female specimens were tested. The Chi-square test

at the 5 percent level was used to evaluate the significance of differences observed for the *C. tarsalis* virus infection rates among specimens collected by different techniques. Analysis of the data is not complete at this time (October 1968), and it is the preliminary results that are herewith presented.

The test results of *C. tarsalis* collected by aspirator in natural shelters or by shed traps at one site, and by light trap or shed trap at another site in Colorado during 1965 revealed no significant difference of WE virus infection rates among the specimens collected by either of the collecting techniques. The virus infection rates among *C. tarsalis* collected in shed traps or light traps at three sites in Texas during 1966 also were similar. However, at one of these sites during 1967, there was a significant difference between the proportion of positive pools collected in light traps and those from shed traps.

Further study is needed to determine the conditions under which a given mosquito collecting technique is the most sensitive for estimating arbovirus infection rates. It is hoped that additional analyses of the available data can provide insight regarding the factors that might influence such estimations; factors such as the month of collection, the proportion of newly emerged and unfed females in the collection and interference with collecting efficiency due to various types of competition. These preliminary data do not provide the amount of information needed to make recommendations regarding the most sensitive method for determining WE virus infection rates among *C. tarsalis*. However, the data do indicate that the proportion of virus positive specimens may be influenced by the method of collection, and arbovirus investigators should be cognizant of this possibility.

BIOLOGY AND BEHAVIOR OF THE GNAT *TENDIPES UTAHENSIS* ON THE SOUTHEAST SHORES OF THE GREAT SALT LAKE, UTAH[1]

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In the marshes and adjacent land bordering the shores of the Great Salt Lake, the large non-biting gnat, *Tendipes utahensis* Malloch, is present and, at times during the year, extremely abundant. When most abundant, swarms of these gnats extend for miles along the shore of the lake and resemble spiraling smoke clouds. When this occurs, these gnats alight and crawl over everything in the areas, creating considerable annoyance to man and other animals.

Because of the nuisance created by their presence and abundance, this gnat was included as part of a cooperative study of annoying and/or potential insect vectors of disease organisms that is being conducted in this area. This particular study was conducted during 1966-67, on the property of the Lake Front Gun, Fur and Reclamation Club and on five small experimental plots on the Farmington Bay Waterfowl Management Area.

From March until October, weekly collections of larvae and adults of these gnats were made on these study areas. Periodic collections were taken during other months of the year when specimens were available.

Adults were collected with floating emergence traps, light and car traps, and with aerial and sweeping nets. Larvae were collected with square-foot bottom samplers designed for the purpose. Pupae and pupal skins were collected with dip nets. Eggs were collected at oviposition sites and by dissecting gravid females.

Careful observations were made during the study on the biology, life history, and habits of these gnats in the study and adjacent areas. This was accompanied by laboratory rearing studies under controlled conditions.

RESULTS OF STUDY

The following species of gnats of the genus *Tendipes* were collected on the study area: *T. utahensis* Malloch, *Tendipes plumosus* Linn., *Tendipes tentans* Fabr., *Tendipes decorus* Johan., and *Tendipes fumidus* Johan. Six other related genera of gnats were collected, each represented by one species in each genus.

T. utahensis was the most abundant and annoying of the eleven species collected. Adults of this gnat are among the first to appear in the spring, some years as early as February, and are present until the first severe low temperatures in the fall which may be as late as December. Population peaks were attained in May and June and again in September and October with a minor peak in late July and early August.

The females deposit their eggs in greatest numbers during the morning and evening hours. During egg laying the females were observed skimming above the surface of the water near shore line and emergent vegetation. At frequent intervals they would dip down and touch the water surface for a brief interval. This continued until an egg mass was deposited. The eggs remained on the surface for several minutes while water was absorbed, then the mass or sac settled to the bottom. Egg masses deposited in the laboratory and dissected from gravid females averaged approximately 700 eggs at the height of egg laying periods. Other investigators report as many as 1200 eggs per female. The peaks of egg laying occurred in June and October with relatively few eggs being deposited in July and August. The eggs were observed to hatch in three to five days after oviposition.

[1]This study was supported in part by USPHS, National Communicable Disease Center, Atlanta, Georgia, Research Grant CC-00171-3.

The larvae pass through four instars. Under favorable conditions the development, from egg hatching to adult, can be completed in 14-23 days. The pupal stage requires 2-4 days. The period required for each larval instar is increased by a decline in water temperature. As the eggs hatch the larvae burrow into the bottom mud where they remain during development.

During spring and early summer, larvae were most frequently found in coarse bottom sand near matted saltgrass vegetation. Summer showed a larval concentration occurring in areas where the bottom consisted mainly of a silty to clay type of soil among various types of marsh vegetation. In late summer and fall the larvae were found in greatest numbers where the bottom consisted of sludge and very black mud containing high amounts of decaying vegetation. Late fall and winter populations were highest near the shore under dense vegetation mats and in greater water depths than at other times during the year.

Tendipedid larvae are most numerous in stagnant water at a distance of one to three feet from shore, with a water depth of one foot or less. If this approximate water depth is the same over a large area, larvae are present in equal numbers throughout the impoundment.

When water depth steadily increased, larvae were found to decrease in numbers to a depth of about three feet and a distance of about six feet from shore. At greater depths larvae were rarely present.

The pupae may form and remain in the fourth instar larval burow. At 75° F, pupation is completed in about one day. In this study, it was observed that the surface floating pupae do not necessarily emerge immediately after pupation. In most instances they float, sometimes more than 24 hours, before the adults emerge. At adult emergence the integument of the pupa splits medio-dorsally in the region of the thorax. Newly emerged adults have a reddish brown coat, which darkens to black when fully dry. As they emerge the adults climb onto the exuviae and water film. In a few seconds emerged adults fly to nearby vegetation. First flights are generally short, not more than 20 yards, and rests are frequent.

Laboratory studies showed a life span of seven days for *T. utahensis* adults. In the field the life span for adults was three to six days.

The adult males swarm during day light hours soon after emergence and at temperatures about 40° F. The larger swarms contain thousands of males moving rhythmically in a forward and back movement. The swarms generally form over some object such as greasewood or shadscale bushes. The swarms take a variety of shapes, the most common is the pillar formation about 20 feet high and 4-6 feet in diameter. The swarms may locate within three feet of each other but are generally a greater distance apart. The swarms are disrupted temporarily by loud noises such as shouting, hand clapping or shot gun blasts but rapidly reform if not further disturbed.

Winds of 4 to 6 miles per hour drop the height of the swarm to near ground level and winds above six miles per hour cause adults to alight in available vegetation or on the ground.

Mating takes place while the males are swarming. Females were observed flying into a swarm and copulating with a male. The attached pair leave the swarm alighting on the ground or shrubbery where copulation is completed in 5-10 seconds and the pair separate, the male re-entering the swarm.

After fertilization the females begin egg laying. As the complete life cycle can be completed in less than 30 days, there are several generations per year.

The life history and ecology of Tendipedid gnats is an interesting and complex phenomenon. The reduction in numbers of this annoying pest, *T. utahensis*, on the marshlands in Utah may possibly be accomplished by a water management program. This conclusion is based on information obtained from this and other studies on *T. utahensis* and related species.

REFERENCES

Bonnell, D. E., and D. C. Mote, 1941. The Klamath Midge. J. Econ. Entomol. 34:325.

Branch, Hazel E., 1923. The life history of *Chironomous cristatus* Fabr. with description of the species. J. N.Y. Entomol. Soc. 31:15-30.

Hilsenhoff, Wm. L., 1966. The biology of *Chironomus plumosus* (Diptera: Chironomidae) in Lake Winnebago, Wisconsin. Entomol. Soc. Amer. Ann. 59:465.

———, and Richard P. Narf, 1967. Colonization of *Chironomus plumosus* (Diptera: Chironomidae) Mosquito News. 27:363.

IMPACT OF SOCIOECOLOGIC FACTORS UPON ZOONOSES PROBLEMS IN NORTH AMERICA

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I. Types of zoonoses:
   A. Direct, Cyclo-, Meta-, and Sapro-zoonoses

II. Some of the more important zoonoses in North America
   A. About ⅓ of the human diseases are zoonoses

B. International Northwestern Conference on Diseases in Nature Communicable to Man papers, 1957-1967

Arboviral	38	Psittacosis	6
Rabies	16	Mycotic	6
Diarrheal	13	Leptospirosis	6
Enteroviral	7	Tularemia	5
Plague	7	Tick paralysis	5

III. Some socioecologic developments which influence the importance of zoonoses in North America:

A. Population explosion

1. Threatens to nullify all efforts for higher living standards
2. Increasing at about 2% per year (70 million annually).
   a. If this rate had prevailed since the time of Christ we would now have 60 million billion people, or 100 per square foot of surface area.
3. World and U. S. populations in billions:

	1840	1920	1960	2000	2200
World (billions)	1	2	3	7.5	150
U.S. (millions)	4.2	13.7	179	350	

B. Expanded Utilization of Outdoor Recreational Areas

1. 1952-62 population increase 20%, outdoor recreation increase 100-200%
2. Number participating in summer outdoor recreation (billions):

	1960	1976	2000
Total	4.4	6.9	12.5
Hunting, Fishing and Camping	0.8	1.2	2.0

3. Some zoonoses which influence outdoor recreation in the Rocky Mountain area: Plague, tularemia, Rocky Mountain spotted fever, Colorado tick fever, encephalitis and leptospirosis
4. Importance in comprehensive health planning

C. Suburbanization

1. Plague in suburbs of San Francisco, Denver, and other western cities
2. Encephalitis in suburban areas

D. Man-made changes in ecosystems

1. Autochthonous vs. anthropurgic biotopes
2. Synanthropic (peridomestic) vs. exoanthropic vectors and reservoirs
3. Irrigated farming and arboencephalitis
   a. Irrigated acres in the United States in millions:

1940	1960	1975
18	35	46

   b. 95% of the irrigated area is in 17 western states
   c. The typical farmsite in **irrigated areas** of the West is a perfect maintenance **for endemic transmission of WE and** SLE viruses
4. Urban plague habitats created by man
   a. Domestic rats and oriental rat fleas
   b. Eastern fox squirrels and plague in Denver
5. Others — particularly with regard to pets and domestic animals
   a. Brucellosis, Q-fever, psittacosis and rickettsial pox

E. Ecological adaptation of pathogens to new ecosystems and enzootic cycles

1. Genetic plasticity of viruses
2. Clinically apparent range of Kyasanur Forest Disease apparently being extended due to ecological adaptation
3. Potential for establishment of new arbovirus-vector systems in West
4. Could also happen with diseases such as schistosomiasis

F. Effects of wars and disasters

1. Over 27,000 cases of human plague reported in Viet Nam last year and may have been as high as 100,000
2. Distribution and introduction of vectors, reservoir hosts, and infected human hosts
   a. Man and malaria in U.S. — Colorado malaria cases and deaths in returning war veterans
   b. Rodent reservoirs of plague being introduced by surface and air transport from war areas
   c. Arthropod vectors of malaria, yellow fever, and other zoonoses may be introduced from war areas
   d. Etiologic agents of exotic zoonoses may also be introduced

G. Increased speed and extent of domestic and international travel increases chances for international spread of zoonoses

IV. Looking into the future — same trends will continue at accelerated rate.

A. "Emerging zoonoses"

1. As result of mutation or ecological adaptation

B. Increasing importance of the ecological approach to improved prevention and control of zoonotic diseases

1. Need for a better balance between naturalistic and artificial control measures
2. Danger of premature and inadequate attempts to eradicate zoonoses
   a. Vast programs based on half-vast plans