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

held at

Mountain Fuel Supply Co. Auditorium

First West and Forest Streets

Brigham City, Utah

edited by

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TABLE OF CONTENTS

TWENTY-SECOND ANNUAL MEETING

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

The opening session of the Twenty-second Utah Mosquito Abatement Association meetings convened at the Mountain Fuel Supply Co. Auditorium, Brigham City, Utah and was called to order at 9:30 a.m. by President Karl Josephson, presiding. Welcoming address was given by Olof E. Zundel, Mayor of Brigham City. Response for the Utah Mosquito Abatement Association was given by Karl Josephson.

THE EFFECTS OF PESTICIDES ON HUMAN HEALTH[1]

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Utah Community Pesticide Study
Utah State Division of Health
Salt Lake City, Utah

INTRODUCTION:

I appreciate the opportunity to report to you again this year on the progress of the Utah Community Pesticide Study.

We are all very much aware of the controversy going on regarding pesticides and the desire of some people to ban the use of DDT. It is probably some of these same people that do not want gun control laws so they can shoot the wildlife that DDT is supposed to be endangering.

Pesticides have contributed greatly to the high standard of living and longevity we now enjoy, but the use of these chemicals has resulted in increasing exposure to man and the environment.

The benefit versus risk is the dilemma of pesticides. Most of us face the dilemma almost daily as we decide if we would rather use pesticides or have insects attack us or our gardens or houses, and we show our thanks to pesticides by demanding the most attractive fruits and vegetables at the market place. As an example of the dilemma: The author has been asked by the Governor of Utah to serve on a committee to solve the "brine fly problem" on Great Salt Lake. It seems the fly is a nuisance and very detrimental to tourism and industry on the lake. For these obvious reasons, "it must be controlled." Pesticides offer the best chance to control the fly, but the committee has already received objections from the brine shrimp industry on the lake that the use of pesticides would endanger this important industry. If the use of pesticides is considered, I am sure the present public concern about pesticides would give rise to numerous other objections.

The pesticide dilemma is not to be solved by hysteria nor complacency but by continuing research on the possible long-term effects of low levels of pesticides on man and his environment. This is the objective of the Community Studies on Pesticides.

The Community Studies on Pesticides:

I will briefly describe the Community Studies for those of you who are not familiar with them. Fifteen of these studies are underway in areas of heavy pesticide usage throughout the United States. In each area, the population is characterized and total pesticide usage is determined. A group of people occupationally exposed to pesticides is subjected to all types of tests to see if they differ in any way from unexposed people. Each study has developed laboratory facilities to conduct all types of clinical and biochemical tests and pesticide analyses. This broad spectrum of data will provide the information needed to better evaluate the benefit versus risk equation of pesticides as related to human health.

The Utah Community Pesticide Study:

The Utah Community Pesticide Study is beginning its third year. The study has been organized into seven "work units." I will briefly review these work units and discuss some of the preliminary findings of our research.

I. THE COMMUNITY PROFILE

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

The study area has been carefully surveyed and the kinds and amounts of pesticides used for various purposes have been determined. Areas of heavy use and changing patterns of pesticide usage are identified. The profile is updated annually and was expanded this year to obtain much needed information for the whole state of Utah instead of just Salt Lake County. The use of DDT decreased about twenty percent from 1967 to 1968 and appears to have decreased another 20 per cent this year.

II. EPIDEMIOLOGY OF OCCUPATIONALLY EXPOSED AND CONTROL GROUPS

There are 70 exposed and 30 control people in the long-term study. They have been given extensive physical and neurological examinations annually. Blood and urine samples are collected quarterly and analyzed for pesticide levels and subjected to a battery of clinical and biochemical tests. The resulting data are evaluated medically and statistically in an attempt to see if there are pesticide-caused differences in the health of the two groups.

The data from the study of the exposed and control groups show little difference in the two groups. Tests that best differentiate the exposed people from the controls are: Serum glutamic oxalacetic transaminase, creatinine phosphokinase, serum DDE, DDD and dieldrin levels, white blood count, serum creatinine, hemoglobin, hematocrit, blood urea nitrogen, and lactic dehydrogenase.

As we begin the third year of tests on these people the data that have accumulated are very valuable. Means and standard deviations have been established for all the tests and normal values and seasonal fluctuations determined for each individual. It is now possible to identify deviations from these normal values that might be attributed to pesticide exposure.

[1]This study is supported by Contract PH 21-2013, Pesticides Program, Food and Drug Administration, United States Public Health Service.

III. PUBLIC RELATIONS WORK AND EPIDEMIOLOGY OF ACUTE POISONINGS AND ACCIDENTS

Public relations work has included communication with the Utah Poison Control Center, hospitals and physicians regarding poisoning cases and telling them of the desire of the Pesticide Study to investigate these cases and assist with the diagnosis and treatment. The study of acute poisonings teaches us a great deal about pesticide pathology that we can then look for in chronic exposures.

One fatal poisoning, a spray-plane crash, five suspected human poisonings, the Dugway sheep poisoning incident, four fish-kills, and several suspected poisonings of wildlife and domestic animals have been investigated. A community study gives the state the capability to make these investigations.

The records of the Utah Poison Control Center for the past seven years were examined and a summary of the causes of poisoning was prepared. An average of about 30 pesticide poisoning cases per year are reported in Utah, 45% of which involve rat and mouse poisons. Arsenicals, chlorinated hydrocarbons, and organophosphates each account for about 10-15%. There have only been three fatal poisonings reported in the past seven years.

IV. PESTICIDE RESIDUES IN THE GENERAL POPULATION

This work unit was set up to answer the question, "What are the body levels of pesticides in the general population of our area?"

Blood and adipose tissue are collected from about 50 selected autopsies each year, also about 400 blood samples representing the general population are obtained.

The data resulting from the analysis of these samples for pesticides are put through a computer program that gives composite mean levels and mean levels by sex, age, race and year.

Representative levels of total DDT in the fat of people of Utah are: males — 9.24 ppm; females — 6.87 ppm; composite — 8.56 ppm. By year: 1967 — 9.01 ppm; 1968 — 7.15 ppm. It is probably coincidence, but this 20% decrease in 1968 levels below 1967 parallels the 20% decrease in the use of DDT for the same period. Pesticide levels in the fat are about 350 times higher than in the blood.

The results are compared with other areas of the country and will be combined with them to give the picture for the whole country.

V. DOSAGE FROM THE ENVIRONMENT

The University of Utah Center for Environmental Biology has been given a subcontract to investigate environmental pesticide levels. They have set up a program to periodically collect samples of soil, water, housedust, and food from the homes of some of the participants in the exposed and control study groups.

Results so far show little difference in the samples from the exposed and control homes. There is some seasonal variation in the pesticide levels, especially in housedust.

Representative levels of total DDT in some of the environmental samples are: housedust — 14.0 ppm; cooked meat — 13.0 ppb; bread — 15.0 ppb; lettuce — 3.4 ppb; fresh fruit — 1.6 ppb; and irrigation water — 4 ppt.

Skin patches and respirator pads are also being checked in an effort to more accurately measure the dosage received by people occupationally exposed to pesticides.

VI. BIOCHEMICAL INVESTIGATIONS

Obvious effects of pesticides on health have not yet been identified, so this work unit is designed to investigate the more subtle effects of pesticides on the biochemical, metabolic and enzymatic functions of the human body. Research is set up to investigate in detail any findings in the study of the occupationally exposed group that can be correlated statistically to pesticide exposure or tissue pesticide levels.

The Utah State University Department of Animal Science has been given a subcontract to investigate the effects of diet, drugs, and other pesticides on the toxicity, storage, and metabolism of pesticides in mammals. Any effects or abnormalities that show up in these animal studies will be carefully investigated in the human studies.

Attention so far is being focused in the following areas: the liver enzyme system, recovery time from anesthesia as related to pesticide exposure, chromosome abnormalities, sputum cytology abnormalities, and pesticide storage and metabolism. Data from these studies will be available in the near future.

VII. DATA MANAGEMENT

The type of research being done by the Community Studies requires statistical competence and efficient data management. The investigations must be designed so that differences in study groups can be attributed to pesticides and not to age, sex, race or some other variable. Computer programs must be utilized to sift out significant information from the great quantities of numbers that are produced.

The Vital Statistics Section of the Utah State Division of Health is providing statistical services for the Utah Pesticide Study. A statistician is helping with the research design, coding and programming. Data are being run on a computer program at the Utah Data Processing Center. Also, the Washington State Community Pesticide Study has run three sets of Utah data through their computer program with good results. These two programs provide comparisons and valuable supplementary material.

In addition, 2,594 data forms have been completed and forwarded to Atlanta for inclusion with the data from all the Community Studies.

Preliminary Findings of the Other Projects:

ARIZONA:

Pesticide survey showed an 80% decrease in DDT use in Arizona (2,520,000 lbs. in 1967 down to 528,000 in 1968) as a result of legislative action and regulation. It will be interesting to see the effects of this reduced use of DDT on such things as acute poisonings, tissue residues and insect control.

CALIFORNIA:

A Sputum Cytology Study is nearing completion in which 1,873 sputum samples were received from all 15 projects. Preliminary analysis has shown that people occupationally exposed to pesticides have some abnormal cytology similar to that found in smokers, miners, traffic police, asbestos workers, and other people exposed to bronchial irritants.

COLORADO:

1. Correlations have been shown between house-dust and serum levels of DDT, showing air pollution is a source of body burden.
2. There is a higher incidence of abnormal electroencephalographs in the exposed group. The Utah Study has also found this to be true.

FLORIDA:

1. In 1968, 39 confirmed cases of acute pesticide intoxication were investigated: 44% were occupational, 53% suicides or homicides, 48% involved parathion, not DDT.
2. Metabolism of pesticides in hospital patients is induced with phenobarbital and dilantin. It may be possible to get rid of your DDT by taking phenobarbital.

HAWAII:

Chronic exposure to household insecticides has been linked with respiratory impairment.

IDAHO:

Analysis of 1,000 random blood samples reveals Idaho population pesticide levels are comparable with other areas of the country. The data show that blood levels of pesticides increase with age, and levels for males and females are about the same.

IOWA:

The College of Veterinary Medicine at Iowa State University has been given a subcontract to investigate animal poisonings. Within the second quarter of 1969, there were 100 episodes of animal poisoning investigated.

LOUISIANA:

A study of the renal effects of pesticides on mammals has been initiated.

MICHIGAN:

A study was undertaken to examine persons with a high exposure to Captan for leucocyte chromosome damage. Twenty exposed people and twenty controls were sampled once a month during the high-use season. The blood was cultured and 25 cells per individual were examined for chromosome numbers and aberrations. A significant increase (0.02% to 0.04%) in aberrations in the exposed group in the months of June and July suggests some risk to the group. There was a clear correlation between chromosome damage and total use of pesticides. Further study is underway with improved procedures including: (1) More frequent sampling during exposure; and (2) Animal feeding studies. The South Carolina Project is also doing some chromosome work and the Utah Project will be doing a chromosome study in an attempt to confirm the Michigan findings.

MISSISSIPPI:

Parathion is being exposed to ultra-violet light and techniques are being developed to isolate and identify the degradation products. Toxicological data are being obtained on these products using rats.

NEW JERSEY:

New Jersey has an excellent opportunity to study pesticides formulators since there are a great number of plants in the area. Their study group includes 1450 formulators and manufacturers. A definite incidence of skin and respiratory irritation has been found in the workers manufacturing malathion and Abate; but it cannot be shown from the medical records that formulating pesticides is contributing to chronic illness in these employees.

SOUTH CAROLINA:

South Carolina has developed a pesticide exposure index to help in the difficult problem of evaluating exposure. The index is calculated by multiplying the days of exposure-per-month by a factor that considers the toxicity and method of application of the pesticide. Statistical analysis has shown a high correlation between the calculated PEI value and blood levels of pesticides.

TEXAS:

This study places its emphasis on investigating agricultural chemicals. Agricultural practices and a long growing season require massive amounts of pesticides to be applied resulting in high exposure. There were 118 occupational and accidental poisonings investigated in 1968, including a case where 20 field workers became ill upon entering a field too soon after it had been sprayed with parathion.

WASHINGTON:

Computer analysis of the data has identified tests that differentiate the exposed group from the control group. Some of these tests are: blood DDE and DDT levels, blood urea nitrogen, urine creatinine, urine phosphorus, plasma and red blood cell cholinesterase levels.

CONCLUSIONS

In a recent paper, Keith R. Long, Project Director for the Iowa Community Pesticide Study expressed the position of the Community Studies when he stated that at the present time it would be scientifically improper to state that pesticides are responsible for differences between exposed and control groups. The work that has been done is the first step in the long-term study required to establish accurately any effect or lack of effect of pesticides on human health.

A very important first step it is, because organizations and laboratory facilities have been established and base line values determined so that progress in the future should be rapid and accurate. We all recognize that the true relationship of pesticides to health can be substantiated or denied only by continuing research. This is the objective of the Community Pesticide Studies.

ACTIVITIES OF THE ECOLOGICAL INVESTIGATIONS PROGRAM[1]

A. D. HESS[2]

The Ecological Investigations Program (EIP) of NCDC began operation in July 1966. The primary mission of the program is to conduct field and laboratory studies on the ecology, epidemiology, and control of communicable diseases. Major emphasis is placed upon studying specific disease problems in the actual areas where the problems occur, and upon the development of new and improved methods for disease prevention and control based upon a better understanding of man's interrelationships with his biotic and abiotic environment.

EIP was officially established in January 1967 with the responsibility to (1) plan, direct, and coordinate field station activities which include investigations of (a) viral meningitis and encephalitis; (b) hepatitis and gastroenteritis; (c) respiratory infections caused by viruses, bacteria, and fungi; (d) plague and other zoonoses; (e) schistosomiasis and other tropical diseases; and (f) epidemiology of oncogenic viruses; (2) develop measures for prevention and control of the communicable diseases under investigation. EIP provides technical consultation and assistance on communicable disease problems to state and local health departments and other interested agencies.

The program headquarters are located in a modern 3-story building in Kansas City, Kansas, on the grounds of the University of Kansas Medical Center. It provides administrative, statistical and other consultative services to all sections to support operational and investigative activities. The Mycoses Section, the Virus Disease Section, and the Leukemia and Oncogenic Virus Activities are also located in this building. The other sections are located in different areas of the United States, which include Fort Collins, Colorado; Phoenix, Arizona; San Francisco, California; and San Juan, Puerto Rico. In addition, personnel are assigned to conduct special projects in Anchorage and Bethel, Alaska; Hale County, Texas; Window Rock, Arizona; Bakersfield, California; and Honolulu, Hawaii. These projects are conducted in collaboration with various agencies including health departments, universities, and other components of the Public Health Service.

On the job training is available in both the field and laboratory to Epidemic Intelligence Service Officers and other scientific personnel who are interested in gaining experience in epidemiology and ecology.

Mycoses Section

The Mycoses Section conducts clinical, epidemiological, and laboratory investigations of histoplasmosis, blastomycosis, cryptococcosis, and other systemic fungal diseases. The clinical studies are conducted in collaboration with tuberculosis and chest disease hospitals participating in the NCDC Cooperative Mycoses Study. These hospitals have been active in the evaluation of anti-fungal agents and long-term follow-up cases to define the clinical course of fungal disease.

Epidemiological studies include the investigations of single cases and outbreaks to pinpoint sources of infection. Skin test surveys are employed to determine the prevalence of infection around sources of infection and to define endemic areas. Outbreaks of

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histoplasmosis traced to urban blackbird roosts led to the development of a procedure for chemical decontamination of sources of infection as a control measure. Control of *Cryptococcus neoformans* in pigeon coops by use of chemicals is also under investigation.

The laboratory studies of the systemic fungi range from the development of diagnostic techniques to the investigation of the survival and propagation of the fungi in nature. Projects are underway to develop or improve skin test antigens for blastomycosis and cryptococcosis and to investigate the cellular and humoral immunity to these and other system fungal diseases.

Virus Disease Section

The primary objectives of the Virus Disease Section are to conduct epidemiological and laboratory studies of viruses and mycoplasma related to acute respiratory and central nervous system diseases. Studies are planned and conducted by medical epidemiologists and epidemiology trainees. Several studies are conducted in collaboration with other investigators.

Epidemiological investigations include longitudinal studies of acute respiratory disease (ARD) in communities (Bethel, Alaska), children's homes, public schools, nursery schools, and other appropriate populations. In addition to the study of the etiology of respiratory disease in these populations, respiratory virus vaccines are being studied for antigenicity and efficacy in the nursery school, and are planned for the Bethel, Alaska, community. Surveillance of infectious disease in Kansas City and the surrounding area is provided through these longitudinal studies, and through requests to see patients in consultation.

Central nervous system disease studies include surveillance and epidemic investigation of encephalitis, aseptic meningitis, polio, and polio-like diseases. Long-term studies, as well as investigation of localized outbreaks, are conducted with an objective to provide information for effective prevention and control. Serological surveys for antibodies to selected infectious agents are conducted among various populations to provide additional information on the epidemiologic characteristics of these organisms.

Ecological Investigations Laboratories

A new research center on the foothills campus of Colorado State University in Fort Collins was completed in June 1967, and dedicated September 29, 1967. This center houses the Streptococcal and Arboviral Disease Sections of the Ecological Investigations Program and serves as headquarters for the Assistant Chief of the Program. The Vector Control Services Unit, *Aedes aegypti* Eradication Program, is also located in this facility.

Arboviral Disease Section

The Arboviral Disease Section conducts field and laboratory research on the ecology, epidemiology and control of western and St. Louis encephalitis and other arboviral disease problems. The principal field study areas are located in Weld and Larimer Counties, Colorado; Hale County, Texas; Kern County, California; and in the state of Hawaii.

Data are obtained from field study areas on population levels and behavior patterns of arthropod vectors and vertebrate reservoirs, and on enzootic and endemic levels of virus activity. The influence of temperature, humidity, precipitation, and other ecologic factors upon the seasonal dynamics of arboviruses is investigated under both endemic and epidemic conditions. Knowledge obtained from these field studies provides new leads for developing and testing measures for the prevention and control of arboviral disease.

The arbovirus laboratory supports the Section's field investigation by providing diagnostic services such as virus isolation and identification and serologic tests, and by conducting laboratory experimentation needed to compliment field studies.

Streptococcal Disease Section

The Streptococcal Disease Section conducts ecological, epidemiological, and laboratory research on factors relating to the incidence of streptococcal diseases and their nonsuppurative sequelae, acute rheumatic fever and acute glomerulonephritis.

Clinical materials, both throat cultures and blood specimens, are collected from selected individuals in the community under both endemic and epidemic conditions. Efforts have been concentrated on analyzing streptococcal dissemination patterns in family units since previous observations have demonstrated wide differences in susceptibility to streptococcal disease among families.

Field studies on development and spread of streptococcal illness include evaluation of type-specific antibody response in individuals and the relationship and magnitude of this response to immunity levels, virulence or invading organisms, therapy, repeated infections, and other factors. Such studies often require the development of new or improved laboratory techniques.

The ultimate objective of the laboratory and field studies is to provide a better understanding of the ecology and epidemiology of streptococcal diseases which will contribute to the development of more effective measures for the prevention and control of these diseases.

Phoenix Field Station Section

The Phoenix Field Station Section plans and conducts clinical and epidemiological investigations of selected communicable diseases with specific reference to enteric infections, including viral hepatitis, viral gastroenteritis and other diarrheal diseases. Investigations are made of sporadic cases to determine etiologic relationships with viral or bacterial agents, and longitudinal studies of population are conducted to obtain information on the relationships between specific infections and disease. It also develops and evaluates methods for diagnosis, prevention and control of these diseases.

In support of NASA programs, this Section develops and evaluates procedures for minimizing probabilities of interplanetary translocation of micro-organisms. These studies consist of laboratory development of techniques and methods for detecting low levels of microbial contamination on surfaces and within solids; evaluation of procedures used in industry for the manufacture and assembly of component parts to be incorporated into spacecraft; and the final monitoring of the microbial load of space vehicles after final assembly and prior to launch.

Tropical Disease Section

The Tropical Disease Section (TDS) conducts ecologic and epidemiologic investigations of tropical diseases and evaluates methods for their prevention and control. Its activities include studies of vectors, reservoirs, and etiological agents.

The current work program is devoted entirely to investigations in the ecology and control of *Schistosoma mansoni*. Special services and consultation are provided to the Bilharzia Control Program of the Puerto Rico Department of Health, which attempts to demonstrate disease abatement in six endemic areas by means of snail vector killing.

Testing of candidate chemical molluscicides is done in the laboratory and field. Biological control of snails through predation is studied, and methods are developed for field use adaptation and for mass production of the agents, such as snails, fish, and turtles. Economic combination of chemical and biotic control of the snail vector is the ultimate goal. Herbicides capable of both aquatic weed and snail destruction are studied. Ecological control of snails by improved water management procedures are under investigation.

Studies are also conducted on the ecology and control of the two parasitic life cycle stages, miracidia and cercariae.

Zoonoses Section

The Zoonoses Section plans and conducts field and laboratory investigations on selected zoonoses, including plague, *Pasteurella pseudotuberculosis* and *P. multocida*, tularemia, leptospirosis, and toxoplasmosis. The information obtained from these investigations is utilized to develop and test new or improved methods for the prevention and control of these zoonoses.

The Section investigates disease problems associated with national parks, monuments, and other outdoor recreational areas. It closely integrates its field and laboratory investigations with the California, New Mexico, Oregon, Nevada, Arizona, and other state and local health departments. It carries out cooperative and collaborative investigations and control projects with both governmental and non-governmental agencies, such as the Division of Indian Health and the Kaiser Research Foundation.

This Section is the principal facility of the Public Health Service devoted to plague investigations. It provides information on plague through the NCDC to the World Health Organization.

A PLAN TO AVERT AN ENCEPHALITIS EPIDEMIC

THOMAS D. MULHERN[1] AND RICHARD F. PETERS[2]

Mosquito transmitted viral encephalitis is endemic in California. The last major epidemic occurred in 1952, with cases dispersed throughout the Great Central Valley of the state. Of 813 reported cases, 420 were laboratory confirmed (375 western equine; 45 St. Louis). There were some 50 deaths, and a considerable number of victims suffered residual central nervous system impairment. Many of the more seriously impaired victims have become wards of the state and are being cared for in state hospitals. Other recent years in which the potential for encephalitis outbreaks was great, based upon extraordinary production of vector mosquitoes, were 1955, 1958, and 1967. In 1969, a major flood situation, occurring most acutely in the southern San Joaquin and Owens valleys, demanded emergency action.

The primary mosquito vector of encephalitis in California is *Culex tarsalis*, a species widely distributed throughout the state. It occurs in both natural and man-made sources and utilizes clean or foul water, in large or small areas, during spring, summer, and into the fall. It occurs in permanent bodies of water, but also utilizes flood or irrigation waters; hence it rarely lacks situations favorable for its development. In wet years the potential sources for its production are multiplied many-fold. Accordingly, in flood years an urgent need exists for extraordinary expansion of the mosquito control programs.

While the problem of preventing encephalitis epidemics in California is very great, there are substantial resources which can be mobilized in the time of need in order to carry out a dynamic action program

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[2]Chief, Bureau of Vector Control and Solid Waste Management, Department of Public Health, Berkeley, California.

to protect the public health. The primary program is provided by the local mosquito abatement agencies — comprising 62 autonomous agencies. There are nearly 1,000 trained personnel who know their own local areas in great detail, and utilize excellent equipment — including about 40 aircraft as well as ground units. In a normal year, the local agencies apply pesticides over an aggregate mosquito sources area of about 1-½ million acres, using local budgets collectively approximating $9 million. The local health departments collaborate with the mosquito abatement agencies in compiling morbidity and mortality data, and in eliciting the cooperation of the people.

The State Department of Public Health provides information, assists in coordinating the efforts statewide, serves as the coordination point through which federal and state technical and practical aid flows to the areas of need, and assists the local agencies in securing financial aid. The department also performs surveillance, technical development, and evaluation services. In emergencies the department may, by local request, conduct limited control operations where local resources are not available or are insufficient. The University of California provides basic research information upon which technical development activities are based. The California Water Resources Agency supplies information about water storage, runoff and any predictable flooding. The Department of Agriculture provides cooperation on problems relating to agriculture and the use of pesticides. The State Disaster Office and the Federal Office of Emergency Preparedness provide assistance in the securing of disaster or emergency funding for qualified work projects. The California National Guard provides aircraft for inspection purposes. Other state and federal agencies also cooperate within their respective areas.

EARLY SEASON WARNING SYSTEM

In order to prevent a recurrence of epidemics such as the one which occurred in 1952, a plan was activated in 1953 providing for more intensive surveillance of the conditions which are associated with the occurrence of encephalitis epidemics as a basis for the establishment of an "early season warning service." This continuing plan with evolutionary improvements, coordinated by the State Department of Public Health, is participated in by the local mosquito control agencies and by the University of California. Surveillance includes principally assessment of the environmental factors which affect the production of vector mosquitoes; evaluation of the occurrence of mosquito larvae in the potential mosquito sources and the density of adult mosquitoes penetrating residential areas; the presence of encephalitis virus in birds, mosquitoes, and mammals; and, intensive investigation of all reported suspected cases of encephalitis in horses or man. In years of increased potential for an encephalitis outbreak, surveillance is greatly intensified. In 1969, a new series of 50 mosquito light traps were added to obtain data about adult mosquito populations in the areas remote from centers of human population or in uncontrolled areas in order to supplement the data normally taken within centers of human population. Also, a team of specialists from the United States Public Health Service made a series of extensive sweeps throughout the areas of concern collecting mosquitoes for virus recovery.

When the data indicate that an epidemic may be imminent, an alert is circulated to all mosquito control and public health agencies within the state, as a basis for taking appropriate emergency action. The decision is not unilateral, but is made only after consideration of all of the pertinent data by the Vector Control Advisory Committee of the State Department of Public Health. This body, chaired by Dr. William C. Reeves, Dean of the School of Public Health, University of California, Berkeley, has representation from the Conferences of Local Health Officers and Directors of Sanitation and the California Mosquito Control Association.

"Yellow alerts" were sounded in 1955, 1958, and 1967, and mosquito control agencies in the affected areas immediately took emergency action, utilizing local emergency funds which had been accumulated as reserves to meet such contingencies.

1969 EMERGENCY

Key individuals met in March and April 1969 to evaluate the implications of the severe winter floods. On May 12, 1969, after sober consideration of the flood disaster situation in 37 counties, which found rain and snowfall up to 430% above normal in some areas, the Vector Control Advisory Committee concluded that the state faced a serious encephalitis threat and advised that all possible emergency preventive steps be taken immediately and that federal and state funds be sought to supplement local resources. Thereupon, local, state and federal agencies undertook an extensive epidemic control operation, unique because it was conducted on a preventive basis, *before* human cases of disease began to occur.

On June 5, the Governor of the State of California authorized the Department of Public Health to expend state funds as necessary up to $500,000. Twenty-six local agencies and the State Department of Public Health were allocated $1,600,000 of federal disaster funds, through the Federal Office of Emergency Preparedness and the California Disaster Office, to supplement normal larval mosquito suppression activities. By the exercise of a policy of intensive pre-treatment inspection, it was possible to avoid spraying extensive areas where predators were keeping the mosquito production at tolerable levels. Considerable economies were therefore possible, and approximately one-half of the authorized emergency funds were turned back unspent. The significance of this development should not be overlooked, for use of helicopters allowed personnel to thoroughly inspect large, difficult-of-access places, in some instances determining that only a narrow band along the edge of aquatic areas needed to be treated.

A supplement to the applications for federal funds to support anti-larval operations was approved, providing funds in the amount of $2,900,000 for extensive adult mosquito control measures, to be employed only in the event anti-larval operations failed to achieve the expected results. It was not necessary to activate this phase of the program, and the entire amount was saved.

PRACTICAL PROGRAM CONSIDERATIONS

Many insecticides were used, all in accordance with the specifications set down in the official list of "Acceptable Pesticides and Their Use by California Mosquito Abatement Districts and Other Official Mosquito Control Agencies." However, for extending the operations, and for all work performed by the state, the materials used were Dursban(R) at a dosage rate of 0.05 lb/acre for larviciding and 0.025 for adulticiding; and fenthion (Baytex) at a dosage rate of 0.1 lb/acre for larviciding and adulticiding. The application rates employed were 6 fl oz/acre for larviciding and 3 fl oz/acre for adulticiding, in each case using a diluent of low volatility (polypropylene glycol 400) instead of water, to minimize evaporation and consequent shrinkage of the spray droplets comprising the spray spectrum. Excellent results were obtained except in a few areas where there was high resistance to these pesticides. The specifications written into the state contracts for low volume spraying by helicopter were as follows:

Helicopters must be equipped to carry two additional employees, essential to the operations to be performed, in addition to the pilot.

Helicopters must be equipped with a low-volume spraying device (acceptable to the representative of the state), capable of dispensing mosquito control pesticides (fenthion, Dursban) at low volume application rates adjustable within the range of 20 psi to 60 psi, at a spray flight speed of 60 mph, over swaths from 100 feet wide to 1320 feet wide. Spray pump must have a capability of discharging up to 10 gpm. Operation will be mainly in the valley and foothill areas of California.

The helicopters must be able to maintain continuous flight for a period of 2.5 hours, at the following speeds: ferrying or observation small helicopters —80 mph, large helicopters — 85 mph, spraying up to 60 mph.

It is anticipated that most of the operations will be performed at less than 1500 feet altitude, but helicopters must have the capability of operation for limited periods at altitudes up to 6,000 feet, with reduced loading as indicated hereafter.

It is expected that the helicopters will average more than 100 hours per 30-day period, of which up to 30% may be spent in spraying.

For adulticiding, the objective is to produce and maintain a constant spray output (plus or minus 10% of the required volume output per minute) of any application rate per acre as specified by the state from 2.0 to 4.0 fluid ounces per acre. The droplets comprising the spectrum of spray discharged from the helicopter should have a mass median diameter of 50 to 75 microns. No more than 20% of the volume of sprayed liquid should be in droplets having a diameter greater than 125 microns, as determined by readings made of microscopic slides coated with Dri-film, or by other standard droplet measurement methods.

The spray operations should produce a distribution yielding a consistent average of at least ten (10) droplets per square inch, as determined by count of spray particles impinged upon recovery cards placed in the target area. The pesticide will be dispensed from an altitude of from 10 to 400 feet above ground, as specified in the field by the state. The representative of the state may specify the number and the size of flat fan spray nozzles to be used.

For larviciding, the objective is to produce and maintain a constant spray output (plus or minus 10% of the required volume output per minute) of any application rate per acre as specified by the state from 3 to 8 fluid ounces per acre. The spectrum of spray droplets discharged from the helicopters shall have a mass median diameter of 100 to 200 microns. No more than 20% of the volume of sprayed liquid shall be in droplets having a diameter less than 50 microns, and no more than 10% of the volume of sprayed liquid shall be in droplets having a diameter greater than 300 microns, as determined by readings made of glass plates coated with magnesium oxide or by other standard spray droplet measurement methods.

The spray operation should produce a distribution yielding a consistent average of at least five (5) droplets per square inch, as determined by count of spray particles impinging upon recovery test cards placed in the target area. The pesticide will be dispensed from an altitude of from 10 to 400 feet above ground, as specified in the field by the state. The representative of the state may specify the number and the size of flat fan spray nozzles to be used.

Spraying operations will normally be conducted during the daylight hours under FAA VFR conditions, with the one exception that they will be allowed down to one mile visibility. Should night adulticiding operations be required, the state reserves the right to require night operations under FAA VFR conditions. Where helicopters are operated under nighttime flying conditions, helicopters will fly with landing lights on. All helicopters employed for nighttime use over urban areas must be equipped with adequate lighting for night air spray operation.

The strategy employed in meeting the emergency placed greatest emphasis upon prevention, by destroying the developing vector mosquito populations while they were still in the aquatic larval stage. By using this approach, the acreage treated was kept to only a fraction of the area which would have been treated had adulticiding been the primary method employed. Furthermore, by emphasizing the anti-larval approach, all of the larviciding operations performed within the normal programs of the local agencies contributed directly to the total effort. We may also postulate that preventing the emergence of the vector mosquitoes tends to reduce the opportunities for multiplication of the virus of encephalitis in the mosquito and wild bird populations in the areas which would not ordinarily be treated in a program limited to adulticiding.

The emergency program as finally adopted consisted of three phases. Phase I provided for:

a. Intensification of the on-going early season intelligence collecting procedures by local and state agencies, and by extending the adult vector mosquito collecting to uncontrolled or remote areas.

b. Immediate intensification of mosquito control operations by local agencies (begun in early March) through the use of local reserves, standby equipment, temporary personnel, contract spray, aircraft, etc.

c. Processing by the California Disaster Office and the U.S. Office of Emergency Preparedness of application from the local mosquito control agencies of requests for reimbursement to offset the unbudgeted costs of extraordinary operations performed in the flood disaster area. In an average year, local mosquito control agencies spray about 1-½ million acres; in 1969, the total approached 2-½ million acres.

Phase II was concerned mainly with the development of operational programs in areas of urgent need where no local agency normally provides mosquito or vector control services, with some supplemental assistance being provided by the State Department of Public Health upon request where resources of local agencies were insufficient to meet the extraordinary need. These operations were mainly in the nature of a "search and destroy" program. Helicopters were utilized to greatly increase the inspection capability of the personnel of the Bureau of Vector Control and Solid Waste Management and the same aircraft performed spraying by the low volume technique. Each helicopter was capable of carrying two inspectors so the "leap-frog" system of inspection was utilized in places requiring intensive detailed coverage. However, normally only one inspector was carried. The inspectors were required to leave the helicopter while spraying was being performed and in areas without good landmarks they also served as flagmen for the spray operations. The helicopter spray equipment was adjusted to give an application rate of 6 fluid ounces per acre, over a 100-foot wide swath, at a forward speed of 60 mph. Five No. 8002 "Spraying Systems" flat fan nozzles were used on most of the spray booms. The equipment had pump capacity sufficient to supply more nozzles, allowing swaths up to 1320 feet wide when using the HI-LO method of application on large areas. Approximately 100,000 acres of mosquito sources were treated under Phase II. Note should be taken of the fact that vast flooded areas inspected were found to be well supplied with mosquito fish, and in these situations, it was rare to find sufficient mosquito larvae to justify spraying.

Phase III would have been an emergency large-scale, aerial adulticiding-larviciding program, employing low volume spray over urban and rural communities, to a maximum of 3,000,000 acres, in the event extraordinary infestation by mosquito species of public health importance occurred. Fortunately, Phases I and II proved to be so efficacious that Phase III did not have to be implemented.

CONCLUSION

The encephalitis season is now over and operations have terminated in an orderly fashion. Only five cases of St. Louis encephalitis were confirmed; all in the Sacramento Valley.

Table 1 gives a summary of cases occurring since 1951.

TABLE 1

REPORTED CASES OF ARTHROPOD-BORNE ENCEPHALITIS CONFIRMED BY LABORATORY EVALUATION CALIFORNIA, 1951-1969

	Arthropod-Borne Encephalitis		
Year	Total	Western Equine	St. Louis
1951	55	22	33
1952	420	375	45
1953	36	14	22
1954	121	22	99
1955	9	6	3
1956	21	14	7
1957	26	3	23
1958	53	37	16
1959	42	2	40
1960	13	1	12
1961	10	2	8
1962	21	5	16
1963	12	3	9
1964	12	10	2
1965	10	9	1
1966	17	9	8
1967	15	7	8
1968	15	10	5
1969	5	....	5
Totals	913	551	362

Source: State of California, Department of Public Health, Morbidity Records

FIG. 1 A comparison of the number of pools with only *Culex tarsalis* larvae in South Salt Lake County Mosquito Abatement District in 1958 and the following five years.

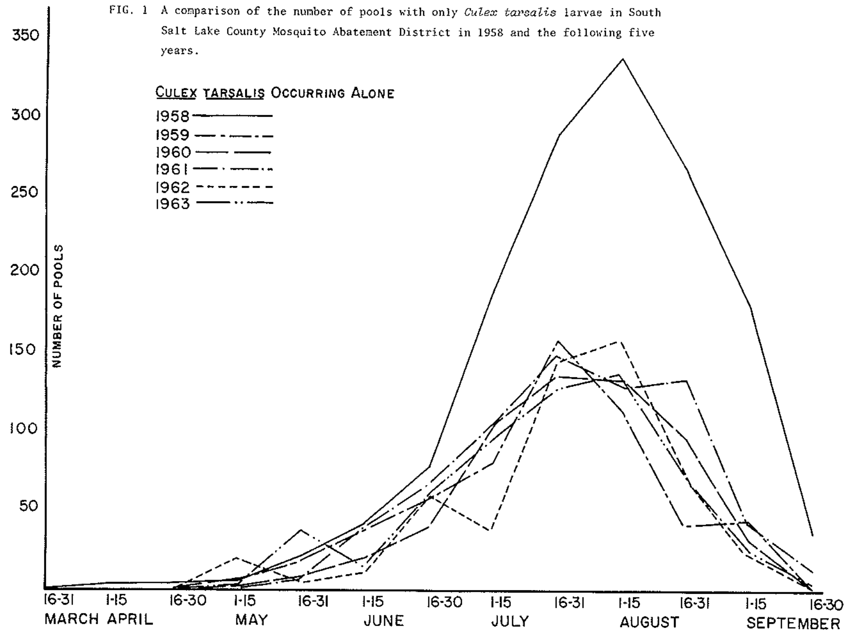


FIG. 2 A comparison of the number of pools with only *Culex tarsalis* larvae in South Salt Lake County Mosquito Abatement District in 1958 and the five year period from 1964 through 1968 inclusive.

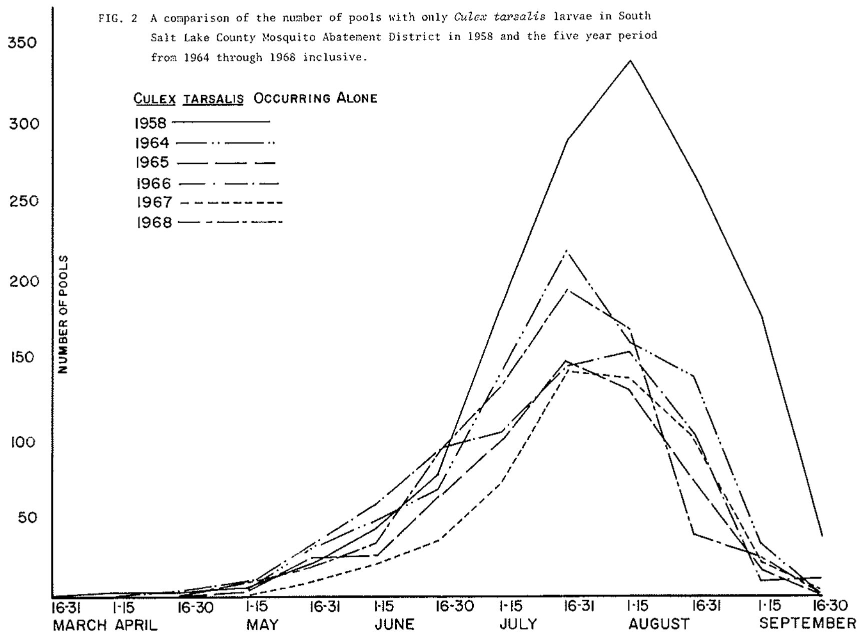
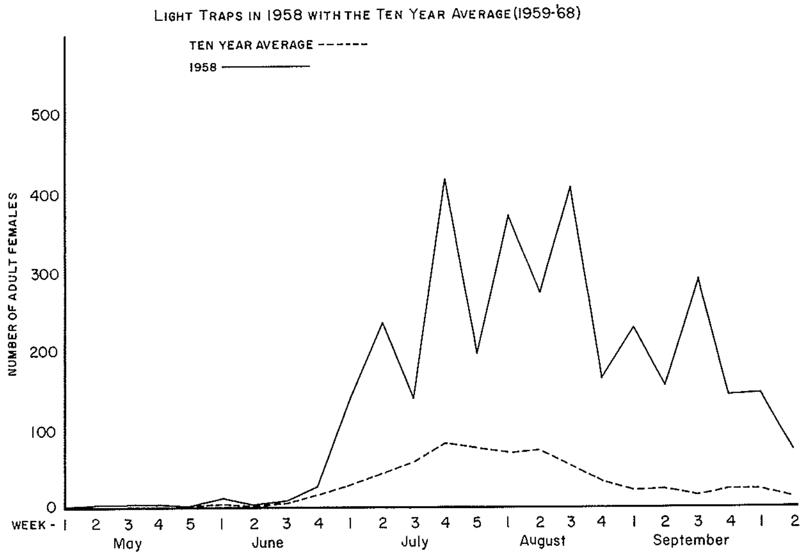


FIG. 3

COMPARISON OF ADULT CULEX TARSALIS FEMALES COLLECTED IN EIGHT LIGHT TRAPS IN 1958 WITH THE TEN YEAR AVERAGE (1959-'68)



PRESENT PROCEDURES FOR WESTERN EQUINE ENCEPHALITIS SURVEILLANCE IN UTAH

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Midvale, Utah

and

Salt Lake City Mosquito Abatement District
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After the Western Encephalitis outbreak in Utah in 1958 a limited surveillance program was initiated. We made a five year report on this program in 1964 and a ten year report in 1969. Detailed information on the program for surveillance for Western Equine Encephalitis in Utah can be obtained from these papers.

The program is primarily based on populations of *Culex tarsalis* and weather factors affecting these populations. Information on virus activity is not at this time adequate for sound decisions but is considered. We feel such information is essential and we are trying to build it into our program.

Figs. 1, 2, and 3 show population trends of *C. tarsalis* larvae in the South Salt Lake County Mosquito Abatement District and adults in the Salt Lake City Mosquito District for 1958 and for 10 subsequent years.

Weather factors utilized in the surveillance program are abundant precipitation for the first part of the water year either as snow pack in the mountains or rainfall in early spring followed by a hot dry period.

In 1969 early weather conditions were favorable for *C. tarsalis* production. Runoff in Salt Lake County was predicted at 132% of normal and the weather for May and the first half of June was warm and dry. Larval populations of *C. tarsalis* were at record high levels in the South Salt Lake County Mosquito Abatement District and there was considerable concern that a serious problem might develop. About the first of June this problem was discussed with Archie Hess and Dick Hayes and an agreement reached whereby the C.D.C., Ecological Investigations Laboratory in Fort Collins would test pools of *C. tarsalis* from Utah for virus activity.

During the last half of June Utah weather was cold and wet, conditions we feel would be detrimental to *C. tarsalis* larval production in our area. At this time the Salt Lake City M.A.D. collected record numbers of *C. tarsalis* in light traps reflecting early larval production. During June and July larval production dropped back to normal levels and continuing above normal rainfall in July apparently reduced the threat of extremely large numbers of *C. tarsalis*. These changes in population further substantiate the relationships mentioned earlier of weather factors and *C. tarsalis* populations.

The testing for virus activity by C.D.C. showed no activity of Western Equine Encephalitis virus in the pools sent to Fort Collins. The pools of mosquitoes submitted to the Fort Collins laboratory were collected and identified by Bettina Rosay and Hal Arnell, both trained entomologists. Each pool consisted of 50 female *C. tarsalis* without visible blood from feeding. Each week these were frozen in dry ice and airmailed to Fort Collins. The value of obtaining data on virus activity is obvious but is beyond the capacities of local mosquito abatement districts. Hopefully the Ecological Investigations Laboratory will find such information useful for their own studies and continue this kind of cooperation in the future.

Plans have been made to act on the basis of the factors mentioned for the surveillance program. When early weather conditions indicate the possibility of an outbreak, health authorities will be notified and mosquito abatement districts alerted. If this is followed by above normal larval population increases in *C. tarsalis*, control operations will be intensified and concentrated on this species. If this is followed by light trap catches and biting counts that further indicate a large increase in population of the vector, control efforts will be further intensified and possibly other mosquito species will be ignored if necessary to bring as much effort as possible against this species.

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EMERGENCY PLANS FOR CONTROLLING SUSPECTED ENCEPHALITIS THREAT IN SALT LAKE COUNTY

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During late spring of 1969, the Salt Lake County Mosquito Abatement District felt an outbreak of Western Encephalitis was probable due to an above average snow pack, warm weather, and an early and rapid build up of *Culex tarsalis* larvae and adults.

The following program was outlined to combat the threat:

(1) A list of all known sources producing *C. tar-*

salis larvae at least five times during each of the previous two seasons was made from data obtained from our detailed larval survey (Graham 1959). These sources were to be checked carefully and were to be pre-treated, where possible, with Dursban because of its effectiveness and its residual quality. Sources producing this species were to receive priority treatment. Other positive sources were to be ignored if necessary so as to apply maximum pressure on *C. tarsalis* larval spots.

(2) Source reduction measures were to be aimed at the above listed pools.

(3) Biting counts were to be made throughout the district so as to note increases in the adult population of *C. tarsalis.* Light trap catches were utilized in evaluating these populations. ULV Malathion was to be applied by aircraft over those areas with high concentrations of *C. tarsalis* adults.

(4) Adult female *C. tarsalis* mosquitoes were captured and sent to the USPHS Ecological Investigations Laboratory in Fort Collins, Colorado for evidence of viral activity. This was done on a weekly basis.

(5) Additional people were to be employed so that all of these objectives could be met.

Until the middle of June the threat of a major outbreak of Western Encephalitis was considered a real possibility. We felt at this time that we would be able to meet the challenge if the threat became a reality. However, an abrupt change in the weather occurred, resulting in above normal precipitation and below normal temperatures for the period. One of the important factors of an outbreak — a long hot dry spell — had been interrupted (Graham and Collett 1969) and it was felt that the possibility of an outbreak had greatly diminished.

The only aspect of the emergency program carried out was that of sending adult female *C. tarsalis* mosquitoes to the USPHS laboratory in Fort Collins, Colorado to be examined for the causative virus. All examinations proved negative.

We at the Salt Lake County Mosquito Abatement District are certain we could have reduced the incidence of the disease appreciably had the outbreak occurred.

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PRELIMINARY INVESTIGATION OF THE BRINE FLIES IN THE GREAT SALT LAKE, UTAH

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Antelope Island State Park was opened for visitors in May 1969. Many of those visiting the park complained about the great number of adult brine flies present and the abundance of pupal skins that accumulated along the shore of the Great Salt Lake.

Harold J. Tippetts of the state Division of Parks and Recreation requested information about the brine flies present at Antelope Island State Park and recommendations for their control.

In order to better understand the problems created by these flies and in order to recommend effective and acceptable control measures this study was instigated the latter part of July 1969.[3]

Jorgenson (1956) reported for Utah sixty-nine species of the family Ephydridae, representing twenty-four genera. Aldrich (1912) recognized two species of the genus *Ephydra* as occurring in the Great Salt Lake, *Ephydra gracilis* Packard the most abundant and smaller species, and *Ephydra hians* Say the larger species, less abundant, but widely distributed.

The following information was obtained and conclusions derived as a result of this preliminary study conducted in 1969.

Numerous brine flies exist at other resorts and industrial plants on the shores of the Great Salt Lake where conditions are similar to those at Antelope Island. Adults of both species were found in great numbers on the surface of the water and along the shores of the lake. They appear to be widely distributed in the lake but more concentrated in certain areas. Weather conditions seem to have some effect on their distribution. They first appear in April and continue until late September. The population peak is during July and August with a decrease in numbers as the daily temperatures decrease. These observations agree with those of Vorhies (1917).

Egg laying is continuous as long as adult flies are present. The eggs are laid on the surface of the water or on floating debris consisting mainly of dead brine shrimp, *Artemia salina* Leach, brine shrimp eggs and brine fly pupal cases. Each female deposits approximately 75 eggs. It was observed that the eggs generally sink in water containing 18 per cent salt

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[3]This study was financed in part by the Utah State Department of Natural Resources, Division of Parks and Recreation, Harold J. Tippetts, Director.

or less, but in water with salt concentrations above this level they float for a period of time and then gradually sink to the bottom where they hatch.

Larvae and pupae of *Ephydra* have been found widely distributed in water depths ranging from 1 inch to 20 feet wherever algal bioherms or reefs are present on the bottom. The larvae, under certain conditions not yet determined, remain free swimming for a period of time during which they are dispersed by the currents of the lake. It appears that when they find a suitable habitat, such as algal bioherms, they remain on the bottom in the crevices of these structures.

The larvae exhibit an ability to adjust to varying salt concentrations. It was observed that when larvae were taken from water with a 16 per cent salt content and placed in water having a 25 per cent salt content, they did not submerge below the surface of the water until approximately 8 hours later when they began to descend with some effort. After about 12 hours, they were able to descend and remain on the bottom of the containers.

In the lake the last larval instar attaches to the algal bioherm or some other stationary object where it pupates and the adults later emerge.

During this study, larvae and pupae were collected from the lake adjacent to Antelope, Fremont, Carrington, and Stansbury Islands, and on the algal bioherms on the bottom of the lake between these islands. It has been reported that 10 per cent of the lake bottom, approximately 100 square miles, is covered with algal bioherms (Cohenour 1966).

Adults brought into the laboratory from Antelope Island completed egg laying in three days and most adults were dead by the end of the fourth day. Adults which emerged from pupae brought into the laboratory from Bridger Bay, mated and completed egg laying within six days after emergence. Eggs were laid three to five days after emergence of these adults. In the laboratory it required from seven to ten days for the eggs to hatch. Larval development was slow, possibly due to the rearing methods used or a longer life cycle than had been previously suspected.

Salt tolerance of the larvae was studied by placing 50 larvae in each of seven one quart bottles having various salt concentrations. The dead larvae were counted and removed periodically. Counts were totaled after four weeks and again after eight weeks. See table 1.

TABLE 1

PER CENT MORTALITY OF ***EPHYDRA*** LARVAE IN VARIOUS SALT CONCENTRATIONS

Per Cent NaCl	Per Cent 4 Weeks	Mortality 8 Weeks	End of 8 Weeks No. Pupae	No. Adults
29.4	48	100	0	0
*25.6	72	100	0	0
*22.2	44	94	1	0
*12.6	32	68	2	1
8.4	8	30	9	5
3.4	0	26	7	6
0.2 (Distilled H_2O)	76	100	0	0

*These concentrations are within the range found in the waters of the Great Salt Lake.

It appears that the larvae of *E. gracilis* and *E. hians* have a high salt tolerance but the mortality is higher when the concentration is 12 per cent and higher or less than one per cent. It seems that these species of brine fly prefer a lower concentration of salt than is found in much of the water of the Great Salt Lake but are very successful in higher concentrations probably due to a lack of competitors and predators in the lake. This has been reported as being the case with brine shrimp, *A. salina* (Woodbury 1936).

It appears from the early reports of Fremont (1845), Captain Stansbury (1852), and other later accounts that these flies have always been abundant in the Great Salt Lake. The present suggested increase in their numbers may be the result of a cyclic increase in the fly population as the result of a recent increase in the number of people exposed to these pests. This may be determined by further investigation.

The abatement of these flies to a level where their numbers are acceptable to the public visiting the Great Salt Lake appears to be possible if suitable methods can be devised. These methods can only be determined by additional studies and the application of applied experimental control measures.

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UTAH'S ECONOMIC FUTURE— A FLY IN THE OINTMENT

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Perhaps never in the history of the state of Utah has the environment for economic growth and development been so favorable as it is today. The state is blessed with an adaptable and high quality labor force; the formation of new technologically based commercial enterprises is increasingly evident; development of the state's mineral and recreational resources is moving ahead; and, perhaps most important, the general attitude of the citizenry of the state toward economic growth and development is as positive as it has ever been.

Certainly one of Utah's major resources in terms of both recreational and industrial development is the Great Salt Lake, America's Dead Sea. The Great Salt Lake has always been a major, if relatively undeveloped, tourist attraction, and now with the development of a state park on the northern tip of Antelope Island, the potential recreational utilization of the lake is greater than ever. Furthermore the industrial potential of the lake is absolutely staggering. The mineral salts contained in the lake's brines have immense commercial value. Although brines of the Great Salt Lake are used only for the production of sodium chloride at present, we are all aware of the tremendous new surge of development activity which has now begun in relation to the recovery of other elements from the lake. Among the many products which can be produced from those brines are chlorine, hydrochloric acid, magnesium, sodium sulphate and potassium salts. Perhaps the major area of immediate interest is the production of magnesium metal which has experienced growing use in structural products and aluminum alloys. Expanding applications for magnesium are now being made in automobiles, aircraft, missiles, and spacecraft.

The mineral reserves of Great Salt Lake are so substantial that, at current rates of domestic production and use the lake could conceivably supply the entire United States demand for those minerals for dozens, and in some instances, hundreds of years. It is estimated, for example, that Great Salt Lake contains 377 million tons of sodium sulphate, 211 million tons of magnesium chloride, 168 million tons of magnesium sulphate, and another 168 million tons of potassium chloride. As the processing technology develops which will make the recovery of this mineral wealth commercially feasible, Utah will have gained an economic asset of substantial importance and value.

But even though the Great Salt Lake has tremendous potential for both recreational and industrial use, there is a "fly in the ointment." Actually there are billions of flies in the ointment. Our professional staff at the Utah Industrial Services Agency became concerned with the insect problem approximately 2½ years ago when we first contacted the resort owners and busines concerns located at or near the lake. We became so concerned with the problem that we actively began to solicit the interest and support of other agencies and professional personnel who might be able to contribute directly to a solution to the problem.

You may be interested in some of the comments of people who work at or near the lake and who must deal with the insect infestation every year. For example, Mr. John Silver, proprietor of Silver Sands Beach, addressed a letter to our agency one year ago in which he said:

> My sons and I have boated and roamed the Great Salt Lake and all the islands many times. On some occasions we did encounter the brine fly but never in mass on the south shores of Great Salt Lake. Now we have noticed the hatch steadily increasing from year to year. This hatch must be appreciably reduced before shoreline resorts, such as Silver Sands Beach, can justify development and continued facility improvement. The man hours and amounts of fuel oil required by fogging and hand spraying to drive away, kill, and partially rid the infestation of our beaches and the surrounding Lake water, is a tremendous drain on our available monetary resources. Almost without exception during the heart of the tourist season, which is June, July and August, the brine fly is multitudinous and there are times when the entire beach and picnic areas are vacated by our patrons because of this obnoxious insect. To fight the brine fly we have used an average of 25 to 50 gallons of fuel oil daily but killing the flies also creates a problem. The millions of flies we kill daily create a thick and heavy layered mass of rotting brine flies which runs like a wide black band along the water's edge of our beach extending for miles east and west of our facility. The stench is terrible. Each day, almost all day long, it requires the full time services of two beach boys just to rake and shovel up the piles of decaying flies and haul them off the beach and bury them. Not only do the bodies of the fallen insects we kill blacken our entire beach by the water's edge, but likewise the very much alive brine flies cover the Great Salt Lake waters for a good block or so out from the shore and oftentimes sweep over

the higher beach areas and spread out like a huge brown blanket for miles around the south end of the Lake. On numerous occasions the air has been so thick with these insidious creatures that many of our patrons in their cars have refused to open their windows or doors and often leave our beach resort saying that they will never return.

Also approximately one year ago we received a letter from the management of Great Salt Lake Minerals and Chemicals Corporation. They too pointed out the problem that they encounter with insects:

> We presently have two problems with the insects at our solar pond complex. One is caused by the super abundance of flies that plug up the radiators of vehicle cooling systems, and the cooling systems at the pump stations and motor control stations. On occasion these flies are so dense that the truck radiator can become plugged in less than a day. These flies have caused damage to this equipment which has resulted in down time. While these particular flies do not bite, they occur in such abundance that they are occasionally inhaled, caught in the eyes, or crawl into the ear channel. Another insect despised at our site because of its bite is a small blood sucking gnat which does not seem to be repelled at all by insecticides and which will quickly drive away anyone who is not protected by nets or other protective devices. These insects seem to be prevalent at Little Mountain and Promontory Point. An Ogden salvage firm of our acquaintance found it difficult to hold employees much over a few days while they worked at Promontory Point. Visitors to that area during May, June and July are usually quickly driven away and we often hear them refer to the insect as 'teeth with wings.' We certainly need and support every initiative that could lead to control measures.

Now let me refer to a letter which was addressed to the editor of the *Deseret News* and published on Friday, August 8th of this year. The letter from a housewife in Bronxville, New York read in part as follows:

> My husband, six children and I have enjoyed visiting your beautiful City during our tour of the National Parks. We were impressed by your wide boulevards, green landscape and friendly people. We were appalled, however, by what we found at Great Salt Lake. The facilities were crude, the water was littered with dead flies and the sand was covered with refuse. As we left we encountered a man spraying clouds of what I assume was bug repellent aimed carelessly at anything in his path. I was shocked to find this world famous spot in such sorry condition. I am sure visitors come from all parts of the globe to see the Great Salt Lake. Utah tourist literature encourages people to do so. If it is a place Utah is proud of, it should be cleaned up soon.

Among the public agencies which we contacted was the State Department of Natural Resources, Division of Great Salt Lake Authority. Mr. Harold J. Tippetts, director, and his colleagues, have of course been seriously concerned over this problem for a long period of time. In October of 1968 Mr. Tippetts wrote me describing the development which has now taken place of the recreation complex on the north end of Antelope Island. It is a multi-million dollar development which is expected to result in visitation levels to the park of approximately one million people per year. The development will provide an outdoor recreation opportunity of broad scope including scenic drives, view points, picnic and overnight camping opportunities, boating activity and broad expanses of beach with the attendant land and water activities related thereto. In his letter to me Mr. Tippetts observed:

> I am confident you are aware of the major insect problem of the Lake and its environs. The problem is not limited to the vector hazard and nuisance of the insects themselves but includes a management problem with regard to the disposition of the residue from the insects such as the decaying fly larvae. We feel the problem is one of major proportions and can possibly terminate recreation activity on the Lake at certain periods of the year. We feel that to solve the problem a cooperative aggressive effort must be undertaken.

In this connection last July 29th our agency hosted a luncheon meeting attended by those whose interests and public responsibilities are most directly connected with the problem. We are extremely pleased that Lee Jorgensen, Director of the Utah Travel Council, has assumed management responsibility for efforts designed to control the insect problem. He and his associates have already made exceptional progress and I am hopeful that he will tell us more concerning the present and future activities of "Operation Brine Fly."

One of the principal problems to overcome, of course, is the fact that, at present, effective control procedures to reduce or eliminate the brine fly nuisance are unknown, and the only way they can be developed is to increase our knowledge of the species which are involved. A project proposal entitled "Biology and Control of the Brine Flies and Other Noxious Insects in and Around the Great Salt Lake" has recently been developed by Donald W. Davis of Utah State University, Don M. Rees of the University of Utah, and Jay E. Graham of the South Salt Lake County Mosquito Abatement District. Their proposal points out that brine flies have appeared in extremely large numbers around the Great Salt Lake for the past several years, particularly in the areas where recreational sites are being developed. The proposal mentions that, in the past, several chemicals have been applied to the beaches, all of which have been effective in destroying adult flies but none of which has succeeded in eliminating or even materially reducing the nuisance. New movements of flies to the treated areas have quickly recreated the problem of living flies, and the bodies of the dead flies have created still another nuisance by producing an extremely offensive odor and serving as a larval habitat for houseflies. The Davis, Rees, Graham project proposal has as its objectives the determination of the importance and abundance of the various species of brine flies and other noxious insects which infest the shore of the lake. The proposal suggests that studies be made of the distribution, ecology, biology, and life cycle of the brine fly and other species, and that this research then serve as the basis for the development of effective, practical, and safe methods of control. Total cost for the two year study is projected at $45,500. This is certainly a nominal cost in relation to the large investment in recreational and industrial development which has already been made, and also in relation to the multi-million dollar return which can be expected from that investment in the immediate future from the lake and its environs. The economic impact of recreational and industrial development at Great Salt Lake is certain to make a substantial contribution to the Utah economy, provided, of course, that the insect problem can be controlled. It is time now to "remove the fly from the ointment" and begin a cooperative battle against the insects of Great Salt Lake.

We commend the state and University personnel who are now moving ahead on this project. They deserve our support and they need it now.

BRINE FLY PROBLEMS ON GREAT SALT LAKE AND PROPOSED ACTION

LEE JORGENSEN

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Salt Lake City, Utah

Before delving into the exact subject matter of my topic, it is important that I give you a little background and purpose concerning the Utah Travel Council, and offer a little in the way of promotion.

Formed by the 1953 legislature, the Utah Tourist and Publicity Council (as it was formerly known) is charged with the responsibility of promoting and advertising the state as a tourist attraction with the hope of developing another economic base. Let me state here that the initial hopes of those legislators have today exceeded their wildest dreams.

Today, the Utah Travel Development Division, as it is now known, is responsible for continuing and improving what has been called by professional economists as the state's second largest industry. More on that in a moment. First, let's point up the competition our state is involved in to attract the travel dollar which economists also claim turns over 3½ times in Utah.

America is on the move. Each year millions of people who have more money, more time, and better travel, take to the road in a mass exodus called "tourism." Winter, spring, summer and fall Americans from the four corners of the country set out to see new things and to learn about new places.

The basis for tourism is very often the natural and historical resources in a region. This is true in Utah.

Tourists come from all the states of the Union and from many foreign countries to see Utah's Great Salt Lake, Temple Square, Canyon Country, Zion, Bryce, and many other things. They come to ski the "Greatest Snow on Earth." They come to just relax and enjoy Utah, the land of contrast.

The tourist — why do we often refer to them as set apart from the home-bound individual, the local resident? Who are they? Where do they come from? What do they want? On and on go the questions about the visitor — the stranger from that other place.

Let's take a closer look at the tourist and see what he presently means to Utah and can mean in the future.

The funny thing about the tourist is that most of them are like you and me. At least they are when they are at home. However, when they hit the road to see the U.S.A., they take on a few different characteristics. It's almost a disease which lasts for the length of a weekend or vacation, then subsides only to pop up again next year.

There are all kinds of symptoms and several cures. Usually, the guy next door who is on vacation shows signs of absentmindedness. He's preoccupied. Often he has fear in his eyes. Sometimes he can only be recognized by the road map that is stuck firmly in his face. Other times, he can be recognized by heaps of paraphernalia he masses which generally obstructs his view. He usually has his pockets full of money. He asks questions that are unbelieveable. In fact, he hardly seems real at all.

The visitor or tourist exhibits three other strong and important characteristics:

1. Desire for comfort.
2. Desire to see and learn new things.
3. Altered spending habits.

The urbanized citizen of today is conditioned to comfort. He expects and deserves prompt, courteous quality service. While on vacation, many want fine motels with a variety of services. Others want well-developed camping or trailer parking facilities. They want good food and most of all, kind, friendly service.

The tourist is on vacation to see new things, to learn about places he has only heard of from his neighbors or friends or the car pool on the way to work. While on vacation he is far more interested in seeing, hearing and learning about new places than he is in doing those things which he does at home.

Finally, the tourist has an altered sense of money value in contrast to that which governs his actions at home. Spending money is an essential delight of the vacation experience.

This, in a nutshell, is the tourist; the individual who comes to see Utah's natural resources on review. What does he mean to our state? What does the future hold for Utah's travel industry?

One of the prime concerns of Utah and especially of communities, is that of economic growth and increased employment. Over the years the leaders of this state have reviewed Utah's economic outlook and have considered various plans for attracting and developing industries to fill the gap left by declining agricultural activities.

This is not any easy task. Anyone who is involved in community, county and regional planning knows that a lot of effort goes into the attracting of a new manufacturing industry.

But so often we overlook the one industry that by 1975 will be Utah's number one industry — its travel industry. According to the U.S. Department of Commerce, if a community will attract 6,000 tourists a year — or an average of two dozen a day throughout the year, it would add to the economy as much as if that community acquired a new manufacturing industry with an annual payroll of $100,000.

Here's what the U.S. Chamber of Commerce has to say: "Tourist promotion is the key operation in any regional, state or community development program. Basically, there are three ways in which to bring new money and business into any given area. These are agricultural development, industrial development, and tourist development. Tourist development is probably the quickest and the least difficult of the three."

The development of Utah's full potential tourist industry is the major concern of the Utah Travel Council. In 1966, the University of Utah reported that 639,000 tourists visited Utah. They each spent about 2.2 days here and left behind $219,000,000 in revenue.

That's big business all right, but what about the future? We have set our goals on a high, but entirely realistic achievement: By 1975 we aim to have a one billion dollar tourist industry in Utah.

That's right — one billion dollars in revenue — far and away Utah's number one industry, offering jobs, income, taxes, and many other benefits to Utah's economy: benefits for every county, every community.

How do we propose to develop this billion dollar travel industry?

The formula is simple: We must increase the number of visitors to Utah — from 6 million to 10 million a year. We must also double the length of their stay — from 2.2 days to nearly 5 days. And we must increase by one third the amount of money they spend.

How difficult will it be to accomplish this?

It isn't difficult at all, when we consider Utah's unique location at the veritable heart of the West — where in 1975 there will be a population of 50 million people living in ten western states where we draw the majority of our visitors.

It is not difficult when we realize that states such as Colorado and California are already keeping their visitors an average of 8 or more days — 10 or 12 days on the average for California.

It is not difficult, too, when you consider the kind of product — scenery and tourist attractions — Utah has to offer: Utah really is a different world:

Different because we *are* a water state — a mountain state — a desert state — a red rock state — a state with history — not any one thing, but many — a wide variety — truly a different world.

This, then, is our product — this different world of Utah. A different world with three national parks, nine national monuments, including our latest development at Golden Spike Historic Site, two national recreation areas, seven national forests, three historic landmarks and 24 state parks in use and others designated. We have more acres of national forests and parks than any other state.

To develop this billion dollar industry, we are *all* faced with two important jobs. I emphasize that word *all*, because while the Utah Travel Council is spearheading and coordinating the state's tourist development, the scope of such an undertaking is far beyond the ability of any state agency. The full development of Utah's potential tourist industry depends on unified, coordinated state, regional, county, community, and individual effort.

Our first job — that of attracting tourists to Utah — is fully underway with advertising and publicity programs by the Utah Travel Council and by a number of forward-looking groups. The second big job we have is not so easily accomplished by one or two such groups. This is the job of local action in preparing our businesses and our citizens to assist the visitor in enjoying our state to the fullest. We must help our own people know what we have to offer and the kind of treatment the tourist expects and should have. Such a program of local action can best be accomplished by close cooperative effort between the Utah Travel Council and regional, county, and local organizations.

This brings us closer to the subject matter of developing our recreation areas as attractions for the travel economy involving the cooperation and support of all agencies.

Early in July of this year, the Utah Travel Council spearheaded a drive to clean up the shores of the Great Salt Lake after numerous complaints from visitors to the area concerning the nuisance of insects particularly involving what is called the brine fly.

This insect moves in great swarms across the lake surface and seems to collect in even greater numbers along the shallow areas of the shore line. This particular migration is the primary effect noticed by visitors. The fly has been experienced in numbers so great at times that people have complained of the insect making it even difficult to breath and that it has crawled into the ear channel.

The position of the Utah Travel Council is that this and other insects must be eradicated or the lake, one of the state's greatest tourist attractions, must be closed up. We cannot afford the continued ill-will and damaging publicity resulting from this situation.

On August 13, 1969, the Utah Travel Council called a meeting of all available sources in the state to investigate any and all possibilities that could be initiated to eradicate the insect nuisance. The discussion was well-received by some 35 attendees representing governmental and professional institutions. Following the meeting, a 14-man action committee was assigned to prepare a document which would encompass all available information on the brine fly. That document has been prepared and it is now in the hands of the state Planning Coordinator and myself to include information concerning a request for federal funds to accomplish our goal. This entire proposal is due for completion and submittal by October 30, 1969.

Here are brief activities involved in the meetings and discussions on this matter.

Mr. Gunn McKay, administrative assistant to Governor Rampton, expressed the Governor's interest in solving the problem through a combined effort. He stated that the Great Salt Lake is one of the largest single tourist attractions in the state, but that complaints are received daily by mail, telephone or in person from visitors to the area, concerning the brine fly and the odor it causes.

Harold Tippetts, State Parks and Recreation, made note of the fact that there were 75,000 visitors during 1969 to Antelope State Park, 25,000 in the month of July. He stated people were interested enough to go to the lake even after the ranger had told them of the brine fly problem. The Park and Recreation Department has been in contact with the South Salt Lake County Mosquito Abatement and has recognized the problem involved. The department is presently working with Dr. Don Davis of the Utah State University Entomology Department and Dr. Don M. Rees, University of Utah Biology Department. Mr. Tippetts stated that some parathion and dieldrin sprays had been applied to the lake by aircraft but with little success.

The State Planning Coordinator reported that federal assistance for such an eradication program was highly possible. He is working with the action committee in an advisory capacity to prepare material to obtain such assistance.

Dr. Rees stated that the brine fly presents a very unique problem which seems to be solely with our area. He proposed a survey be made of all insects, including horse fly, biting gnat, brine fly, deer fly, etc., in order to control all such pests; to find out where they came from and what could be done to exterminate them before attempting to set up funds for the project. He stated that the brine fly hatches at the bottom of the lake, down about 7 or 8 feet, and that it would be improbable to kill these with an insecticide as the brine shrimp would be contaminated. Dr. Davis agreed with this and said that even if this were done, the flies would be back again within a few days, and suggested finding the weak points of the life cycle of the fly.

John Silver of Silver Sands Beach reported on measures he had taken at the beach this year. He stated that the flies seemed to come in cycles due to the rise and fall of the lake. For the past five years the flies have steadily increased; five years ago one or two sprayings a year would have been sufficient to control the fly; last year he estimated it cost $50 a day for spraying; this year around $75 to $100 per day plus hiring four men for spraying and fogging the area. He stated that if the situation got worse, the beaches would have to be closed. In Mr. Silver's opinion the wind blows the fly from the lake onto the beaches, or they develop on the lake and drift in seeking fresh water. Mr. Silver said that the flies have caused machinery to be stopped by plugging the fans; and it was his opinion that the fly was definitely the cause of the beach odor.

According to Jay Graham, South Salt Lake County Mosquito Abatement:

> The problem of brine flies along the shores of Great Salt Lake is only one facet of a complex problem involving many species of insects. Other insects affecting the health and comfort of man in the area are horse flies, stable flies, deer flies, mosquitoes, chironomids, *Leptoconops* and many species of *Culicoides*. At the moment, brine flies are the most pressing problem partly because mosquito abatement programs, although they do not routinely reach all the shore line, have greatly reduced mosquito populations.
>
> The increasing rate of recreational and probably industrial development will focus attention on other pestiferous insects not now controlled.

When mosquito abatement districts were created, mosquitoes were the major concern but the current problem of brine flies illustrates how changing conditions bring other pest species to our attention. The development of separate control organizations for each insect species would be ridiculous particularly in view of the acute shortage of professional people adequately trained and aware of the ecological implications of control.

One thing is certain: Control programs that are not based on precise knowledge of the life history and the biology of the pest species are apt to fail or at least be unnecessarily expensive.

Present studies indicate the following:

1. Very little has been done on the biology of the brine fly.
2. Adults are found in great numbers on the water surface and shore line.
3. Egg laying is continuous on the water surface with approximately 75 eggs per female.
4. Eggs sink to the bottom in widely distributed depths from one inch to 20 feet (in spite of the flotation ability of the lake), attach to a reef where pupation occurs and the adult emerges.
5. Complete life cycle from egg to adult is 3 to 4 weeks.
6. Since great abundance of this fly was reported as early as 1848, there is little evidence that any sewage pollution of the lake has perpetuated its presence.
7. Abatement of the fly to an acceptable level is possible.
8. Laboratory rearing and experimentation are continuing at the University of Utah.

Studies to date have been directed primarily towards distribution, biology and life history with some preliminary observations on control attempts by various interests.

It appears that adult brine flies are generally dispersed over the Great Salt Lake. The larvae are found developing in protected shore line pools and on the algal bioherms on the lake bottom at depths up to 20 feet.

Adult populations are present from early May to September, depending on climatic conditions. Adults seem to display a tendency to congregate in "wind rows" on the surface of the water and along the shore. It is suspected that these flies are mating and ovipositing. The time from emergence to oviposition must be determined in order to plan an effective control program. Adults have been observed feeding on the rocks and bioherms along the shore and in shallow water.

Present studies are directed primarily towards determining length of time for each step in the life cycle, salt tolerance of the immature stages, and life stages most vulnerable to the various control measures.

In a few preliminary tests with adulticides the adult brine flies seemed to be readily destroyed. These tests were made in small selected areas. The flies reinvaded these areas shortly after treatment.

According to the recent research proposal submitted by Dr. Don Rees, Dr. Don Davis, and Jay Graham, a cost of $45,500 is estimated to cover professional research, equipment, and materials to initiate a 2-year program of eradication. This cost is now being included in the present effort to prepare a proposal for funds as already mentioned.

This program must be accomplished. To say we need the funds for the project is only one certainty . . . we also need the full cooperation of expertise in the field of this matter. It's for the good of the entire state and has been cited as a definite impact on our total economy.

We have asked a lot of questions about the tourists in Utah. Who they are? How much they spend? Where they come from? When they come? When they plan their vacations? Why they travel? Average size of families?

All in all, we know these things about the traveler. There are 200 million men and women in the USA who will spend some 20 *billion dollars this year,* $17½ billion on domestic travel.

When it comes to Utah tourists we find that the 10 western states provide us with more than 66% of all our tourist business. There are other markets.

Travel in the USA has increased at 10% per year. We want a larger increase. Is it possible? It appears so. We have studied the states around us, and find that states that spend more money on tourist promotion tend to have more rapid increases in both tourist revenue and in number of tourists.

Why do people pick a state? Why do they come back? We have found the results in a study by the Spokane Review. *The future depends on in-state public relations* — our being a better host. We have decided we must use *advertising, publicity, development and strong public relations* if we are going to accomplish our objectives.

We want to attract more tourists to Utah. We want to keep them here longer, and we want to encourage them to spend more money.

I can't give you a cure for all of Utah's economic ills, but I can predict an industry potential that will mean many more jobs, higher per capita incomes, statewide benefits and an increased tax dollar if we all cooperate in the total development and improvement of our major attractions, one of which is certainly the Great Salt Lake. This particular attraction is advertised and promoted more than any other single attraction.

We of the State of Utah can only be thankful that we have our great scenic attractions that make it a different world . . . we cannot especially be proud of our wonders because we didn't make them . . . they were already here. After God had practiced on the rest of the world, He made Utah. Let's protect and develop these wonderful resources and extend our efforts in travel development to the fullest degree in order that others may share these wonders and benefit the economic structure of the state. It's for the good of all of us historically, and economically. When thinking of travel development . . . think of our slogan . . . "Keep Utah Green, Bring Money."

RELATIONSHIP OF VECTORS TO POLLUTION CONTROL

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Whenever man degrades any of his three basic resources — water, land, and air — he is polluting his environment. The degradation cause and effect relationship is, however, not always easily defined. Questions of what, where, when, how and why, applied to pollution control, have provoked many people to participate actively in various enterprises to curb pollution.

People with knowledge, training and experience and, unfortunately, people with no training, no experience and armed with a little knowledge, are making statements to an attentive public. This dilemma is further confused by the remedy-seeking public who, through their increasing awareness of pollution problems are "out-distancing" the capability of the responsible control authorities to resolve them.

The authorities are, therefore, not hampered by a total lack of public interest but rather by the time lag between public demands for remedies and interpretation of these demands into action by federal, state, and local elected officials to provide not only sufficient funds but organization and laws to do the job.

We have come to recognize that the ultimate control of pollution is not the answer to man's desire for his environment. Providing him with the quality of his environment that will satisfy his ideals is a very large order. Nevertheless, this is the goal viewed by more and more people. Pollution control people and environmental quality people may be one in the same person but as a distinct group they are probably in the minority at the moment. Gradual merger of pollution control and environmental quality is inevitable but many growing pains are in store for all.

What has this to do with vector control? There are at least five good reasons why persons engaged in vector control need to concern themselves with pollution control:

(1) The public demands are great and will be greater to meet these pressures. Water, land and air pollution control agencies will be hard-pressed to fulfill these demands.

(2) Answers to all the problems are not available, yet action will be taken to do the best possible to relieve the pollution problems.

(3) Industries and governing units, ill-advised by many band-wagon pollution controllers armed with little knowledge, will probably act wrongly on their advice.

(4) Lack of sufficient funds, organization and laws will limit the effectiveness of pollution control authorities until this situation is corrected.

(5) The extremists in environmental quality will be outraged at the slow progress toward meeting the environmental quality ideals. In good faith he will disrupt, entangle and cloud the issues with a multitude of unanswerable questions that will not aid some of the practical pollution control efforts. In the same manner he will also provide a service in stimulating research, guiding pollution control activities, and field investigations.

All five of these factors can result in one or more situations conducive to vector problems:

a. Over- or under-designed pollution control facilities

b. Poorly maintained facilities

c. Facilities operated by inadequately trained people

d. Loading of facilities beyond designed capacity, either over or underloading

e. Diversion of a pollutant as a temporary expedient

f. Conversion of a waste or byproduct to a condition suitable for vectors

g. Creation of greater volumes of wastes that are susceptible to vector production

h. Facilities located in vector problem areas

i. Facility construction itself creating a vector problem

j. Stopping of processes by injunction or other legal means

k. Others.

It is apparent that vector control people need to be aware of what is happening in pollution control, need to be prepared to answer many questions, need to conduct a continuous education and information service, need to expand their knowledge of ecology, need to take a firm stand on issues, need to work ever more closely with other agencies, and need to "stay loose."

THE ROLE OF SOME PATHOGENS AND PARASITES IN THE REDUCTION OF MOSQUITO POPULATIONS

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SUMMARY

The abundance, distribution, host-parasite relationship, and efficacy of *Coelomomyces* (a fungus), nematodes, viruses, and protozoans were discussed. The most promising biological control agents seemed to be nematodes (Family Mermithidae) and *Coelomomyces* since they infect and eliminate substantial segments of some mosquito populations and continue to exist and infect mosquitoes in the same habitat over a number of years.

RESISTANCE OF CALIFORNIA MOSQUITOES TO INSECTICIDES — 1969

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Resistance to insecticides has been confirmed for five species of California mosquito larvae. However, the situation was not critical until 1968, when the pasture mosquito, *Aedes nigromaculis* demonstrated resistance to all the currently available organophosphorus compounds. In 1969, California's most important vector species, *Culex tarsalis,* joined *A. nigromaculis* in this operationally crippling organophosphorus resistance. Fortunately, at the present time, the occurrence of resistant populations of other species is limited and there are alternative chemicals available for control. Table 1 summarizes known resistance in California mosquito larvae.

TABLE 1.

	Malathion	Parathion	Methyl parathion	Fenthion	EPN	Abate®	Dursban®
Aedes nigromaculis	X	X	X	X	X	X	X
A. melanimon	X	X					
Culex tarsalis	X	X	X	X	X	X	X
C. pipiens subsp.	X	X		X			
C. peus	X	X	X	X			

High levels of tolerance have been demonstrated by *Anopheles freeborni* larvae, but there is insufficient data to determine wheher this is a natural tolerance or wheher it has been induced by chemical pressure.

Insecticide resistance in *A. nigromaculis* has been an ever present spectre since widespread resistance to the chlorinated hydrocarbon insecticides largely negated control efforts in the early 1950's (Gjullin and Peters 1952). Parathion was substituted and used effectively until 1958, when the first organophosphorus resistance was confirmed for this species (Lewallen and Brawley 1958). The initial organophosphorus resistance was limited to the Kings, Tulare and Delta Mosquito Abatement Districts in the southern San Joaquin Valley, but by 1963, ten mosquito control agencies in three widely separated areas of the Central Valley were involved (Brown et al. 1963). Substitutions including methyl parathion, fenthion, EPN, and Dursban® were necessary as the resistance progressed. Each succeeding material had a shorter effective life. In some instances, the general organophosphorus tolerance conferred by cross-resistance had progressed to the point a material was obsolete before being used operationally (Gillies et al. 1968).

During the 1968 season, the control problem became acute when both larval and adult *A. nigromaculis* from the Tulare Mosquito Abatement District were found to be resistant to all currently available organophosphorus compounds, including Abate® and Dursban®, which had never been used operationally. Control was re-established in the highly resistant areas using Baygon at 0.05 lb/acre as an adulticide (Ramke et al. 1968). By the end of the 1969 season, six mosquito control agencies in two widely separated areas of the state were experiencing these comprehensive insecticide failures.

Insecticide resistance in *C. tarsalis* is not a new phenomenon. DDT resistance was a factor in complicating control efforts directed at this species during the 1952 encephalitis epidemic. Resistance to malathion was first confirmed in 1956 (Gjullin and Isaak 1957) and has since been determined for larval populations throughout most of the controlled areas of the state. Some scattered tolerance to other materials had been demonstrated prior to 1969, but was not believed to be of general operational significance (Womeldorf et al. 1968).

The first comprehensive organophosphorus resistance problem in this species became apparent in July, 1969. Dursban® had been applied to a flooded acreage in the Kings Mosquito Abatement District. Post-treatment inspection revealed large numbers of live larvae. Laboratory tests verified resistance as the cause of the failure. Further testing, both in the laboratory and in the field, revealed resistance, not only to Dursban®, but also to malathion, parathion, methyl parathion, fenthion, EPN and Abate®.

Table 2 lists test materials, applied by aircraft, in an attempt to control *C. tarsalis* larvae in the Kings Mosquito Abatement District during 1969. The dosage rate given for each insecticide is the highest rate tested. None of the applications gave satisfactory mortality.

TABLE 2

	Malathion	Parathion	Methyl parathion	Fenthion	EPN	Abate®	Dursban®
dosage (lb/acre)	0.5	0.2	0.1	0.1	0.1	0.2	0.1

Richfield larvicide oil was field tested at three gal/acre and did provide satisfactory larval control. Unfortunately, problems in handling and dispersing the large volumes of oil necessary for widespread aerial control largely preclude operational use.

Laboratory testing of larval populations from surrounding areas was initiated in an attempt to delimit the problem. It is believed that at least 12 mosquito control agencies are presently involved in this control dilemma. Possibilities for adult control of this species have not been fully investigated. However, preliminary laboratory results indicate that the adults are also resistant.

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CHIRONOMID CONTROL IN THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

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Man has encountered those little flies commonly referred to as midges, (flies belonging to the family Chironomidae), for eons of time. However, it has been just during the fairly recent industrial revolution that chironomid midges have become a problem to man. As industrialization developed, great cities have arisen near natural waterways, thus placing man in the midge environment. As agrarian man became urbanized, his tolerance to these pesky little flies lowered until today he has little tolerance to chironomid midges invading his ecosystem. It has only been in the last twenty years that control measures against midges have been demanded by the public.

Midges become important to man when they build up in large numbers and invade homes and businesses in the urban and industrial areas adjacent to water impoundments and natural or man-made drainage areas. They do not bite, but can be destructive by sticking to fresh paint, becoming embedded in plastic articles rendering these useless, annoying office workers, entering the home and annoying the occupants and just being a general nuisance wherever people encounter them.

History of Chironomid Midge Problems in Southern California

In recent years, the development of flood control and water conservation projects such as dams, spreading basins, and channels have provided excellent conditions for the production of chironomid midges in urban areas.

Since 1952 urbanization of the areas adjacent to water spreading basins, flood control dams, and flood control channels have resulted in an increase of chironomid midge control activities in the Southeast Mosquito Abatement District.

When the Southeast Mosquito Abatement District was first formed, the only major midge producing areas were the Los Angeles, San Gabriel, Rio Hondo Rivers, and the Rio Hondo Spreading Basins. As industry and housing encroached in these areas, it became apparent that midge control in addition to mosquito control was necessary. Gardner McFarland, Manager of the Southeast Mosquito Abatement District, recognized that economical control measures should be instituted to control pest midge species. However, there was a void in the available information regarding chironomid midge control. Mr. McFarland along with the California State Bureau of Vector Control and Los Angeles County Flood Control District approached the University of California at Riverside for the purpose of initiating a research project on the control of chironomid midges. In 1959, an agreement between the Los Angeles County Flood Control District and the University of California at Riverside was reached and the research project was started. The data obtained from this project have provided the basis for the chironomid midge control programs throughout the state.

Since the inception of the Southeast Mosquito Abatement District, many new midge-producing areas have been added with the expansion of the District. In the future, the midge control activities will increase as new projects, such as the Feather River water project, increase the amount of available water during the peak midge breeding season.

Today we find that concrete flood control channels, rivers, and earthen, water spreading basins provide an ideal habitat for midge production. There are many reasons for this; but the primary reason is the elimination of predatory animals or the prevention of the establishment of a balanced biota, due to intermittent waters.

Primary Pest Chironomid Midge Species Found in Southern California

The following is a list of the common pest chironomid species encountered in the Southeast Mosquito Abatement District with some brief notes on life history (Bay, Anderson, and Ingram 1961).

Chironomus attenuatus: egg to adult 18 days; most prevalent in spring and early summer; larvae large, bright red in color; build tubes on bottom sediment.

Chironomus californicus: egg to adult 3-4 weeks; most prevalent in spring and fall, seem to decline in mid-summer; larvae moderate size, dark red in color; build tubes on bottom sediment.

Chironomus stigmaterus: egg to adult 13 days; most prevalent in late summer and fall; larvae large, dark red in color; build tubes on bottom sediment.

Goeldichironomus fulvipilus: egg to adult 13 days; most prevalent in mid-summer; larvae moderate size, bright red in color; build tubes on bottom sediment.

Cricotopus sp.: egg to adult 11-14 days; most prevalent in spring, fall, and winter; larvae small and greenish white in color; build tubes on aquatic vegetation, debris in the water and on bottom sediment.

Tanypus grodhausi: egg to adult?; most prevalent in late spring, summer, and early fall, population declines in late fall; larvae moderate size. orange red in color; live in bottom sediment but do not construct tubes.

Tanytarsus sp.: egg to adult 11-14 days; most prevalent in spring and late summer; larvae very small in size, light red in color; build tubes on the bottom sediment.

Procladius culiciformis: egg to adult 16 days; most prevalent in spring through fall; larvae yellowish white in color and moderate in size; found in bottom sediment, do not construct tubes. This species maintains a rather constant population level usually not becoming extremely abundant.

Control

Chironomid midge control is slightly more complex than mosquito control; however, the methods available for midge control are the same as those used for mosquito control; biological, chemical, and physical. We find in midge control that it is difficult to generalize due to the diversity of situations and species involved.

Our approach to midge control is slightly different than that of mosquito control in that the adult population level is considered before control measures are effected, whereas mosquitoes are controlled regardless of the adult occurrence. In the Southeast Mosquito Abatement District, midge control is directed towards the larval stages as it is in mosquito control; however, the type of control method utilized depends on the individual situation encountered.

The control procedures utilized by the Southeast Mosquito Abatement District will be summarized under the following control categories:

Biological:

Biological control measures are utilized wherever possible in the Southeast Mosquito Abatement District. The primary biological control agent currently employed is the German carp, *Cyprinus carpio*. The work of Bay, Anderson, and Ingram showed that this fish is the most effective biological control agent for chironomid midge larval control to date. Other fish, such as several species of catfish, bluegill, *Gambusia*, goldfish, trout, and bass feed on midges, but their feeding activity is limited; and they do not effect adequate control in most cases.

The situations where carp are used for control are primarily in permanent impounds, such as, golf course lakes, reservoirs, spreading basin forebays, and other areas where the general public does not have access. We attempt to restrict the distribution of carp to those water impounds that do not have game fish and are not open to the public. We cooperate with the California State Department of Fish and Game in the distribution of carp within our District. There are many limitations in the use of carp, but at the present time the favorable attributes outweigh the unfavorable factors.

Physical Methods:

It is fairly obvious, that the most effective means of midge control would be the elimination of the source; however, in most cases the midges are coming from a permanent impoundment of water and this cannot be eliminated. Another limiting factor would be the cost of eliminating a large impoundment of water even if the water was not desired, consequently other alternatives must be used.

In the Southeast Mosquito Abatement District, we have several locations where water conservation spreading basins occur. During the midge season, these basins are filled with water from storm runoff, and, after 10 to 15 days, midge adults begin emerging in large numbers. The most effective and economical means of controlling the midges in this situation are to switch the water to a dry basin and allow the infested basin to dry completely before refilling it. Consequently, water rotation in these basins every 10 days eliminates midge production.

Chemical Methods:

Chemical control of chironomid midges is the "last resort" method, but it is the method most frequently used. Many insecticides are toxic to midge larvae — among these are DDT, BHC, DDD, dieldrin, and Lindane, but these have been replaced by the organophosphates. Chlorinated hydrocarbons are no longer used due to their effects on the total environment so the organophosphates are the insecticides of choice.

An important factor in the chemical control of midges is to get the toxicant down to the substrate harboring the midge larvae. This is accomplished using granular formulations, particularly formulations of hard-core, slow-release granules, which allow maximum concentration and distribution of the toxicant in the vicinity of the larval habitat. Emulsions are suitable only in shallow standing water where diffusion of the toxicant through the water occurs rapidly. If the water is moving, the emulsion should be injected from a given point, over a sufficient period of time to allow the midge larvae to receive a lethal dose of toxicant. The time required for this usually runs one to two hours. However, from our experience, granular formulations are preferred over emulsions even in running water as the granules tend to stick in the bottom sediment and provide a longer period of exposure.

Organophosphate insecticides presently used by the Southeast Mosquito Abatement District are parathion, fenthion, Abate, and Dursban. The type of situation and the species of midges determine which insecticide one should use. Some species of midges are able to tolerate certain of the toxicants listed above. For example *Tanypus grodhausi* is tolerant to fenthion and Abate at the recommended dosage rate so Dursban is the material of choice against this species (Mulla and Khasawinah 1969). In this District where the population is urban, parathion is used only in areas where the public is permanently excluded — for example, Los Angeles County Flood Control property. Abate gives good results on most species and is used primarily in areas where fish and wildlife are present as this material has a low toxicity to fish, birds, and mammals.

Midges in concrete flood control channels are normally controlled in our routine mosquito abatement activities as we spray these on a weekly basis.

The insecticide dosages used in midge control are normally higher than used in mosquito control. For this reason, many factors must be weighed in choosing a toxicant such as: access of public to area treated, fish and wildlife present, residual life of toxicant, access of toxicant to underground water supply, and cost of application, to name only a few.

Interagency Cooperation:

The Southeast Mosquito Abatement District has entered into contracts with the Los Angeles County Flood Control District, Los Angeles City Department of Water and Power, and the U. S. Army Corps of Engineers to abate chironomid midges and other insect pests affecting the health and well-being of residents adjacent to properties owned and controlled by the above named agencies.

Since the District specializes in this type of insect control, the cooperating agencies reimburse the District for time, equipment, and materials used in controlling pests at their request.

All of the mentioned agencies have control of water at certain times of the year and during these periods contribute to the pest problems in areas under their control. Rather than abate the pests themselves, they find it is less expensive to contract with our District for abatement of the pests.

Summary

Over the past few years, the public's tolerance to chironomid midges has dwindled to an almost no tolerance level. Usually it is people who live near flood control channels, water spreading basins, and permanent lakes that are most affected by midges. As the Southeast Mosquito Abatement District has an abundance of midge sources and people living near these sources, midge control has become a part of our program.

There are a wide variety of midge species common to the Southeast Mosquito Abatement District and all the various methods of insect control are utilized for their control. In permanent impounds of water, German carp are used as biological control agents where possible. Also water rotation is used in water conservation activities of the Los Angeles County Flood Control District in their spreading basins (1200 acres).

In addition to biological and physical control, chemical control is utilized. The insecticides used in chemical control belong to the organophosphate family and include fenthion, parathion, Abate, and Dursban. All of the insecticides mentioned are effective against most midge species; however, there are a few species which show a tolerance to some of them.

Midge control is still in its infancy as is the knowledge of the habits and biology of many midge species. Research is continuing in the various aspects of midge control; and it is hoped that as new problems arise, we will be able to meet the challenge.

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THE *LEPTOCONOPS* PROBLEM IN UTAH

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The biting gnat, *Leptoconops kertezi* var. *americanus* Carter is present in great numbers in many areas of Utah. From approximately April to the end of June, this biting gnat can be extremely annoying in most of the areas where it is present.

In the spring of 1948, at the request of the Salt Lake Refining Company, a study was instigated by Rees and Smith (1950; 1952) to determine possible methods for the control of this gnat. At this time the number of adult gnats was so high at the construction site of a new oil refinery north of Salt Lake City, that it was estimated that a loss of 20 per cent efficiency of the workers resulted from their extreme annoyance.

Control measures were successfully carried out through 1952 at this location for this company. Residual insecticide treatment of the soil was found to be effective as a larval control for a two year period after treatment. The third year following treatment, adult gnats were again observed in the area, and by the fourth year, they had increased in numbers to an annoyance level (Rees 1958).

Each spring following this initial investigation, some general observations have been made on the distribution, ecology, population levels, and duration of adults of this gnat at this and other locations in Utah. Experimental control measures on a limited scale have been attempted with some success in this and other areas.

In May of 1964, the Marquardt Corporation requested assistance in the control of *Leptoconops* at their test site at Little Mountain on the eastern shore of the Great Salt Lake. At their request a survey was conducted to determine the source of gnat production and recommendations were made for control of the gnats on the Marquardt property. A follow-up survey was conducted in 1965 which indicated that these treated areas were free of larvae, but gnat producing areas adjoining the Marquardt property were the source of gnats invading this property in numbers sufficient to create considerable annoyance to employees.

As a result of the seriousness of the *Leptoconops* problem in many parts of the state and the frequent requests for assistance in controlling this annoying pest, an application for funds to support a study of this gnat in Utah was submitted by Don M. Rees, as principal investigator, to the United States Army Research and Development Command. The application was approved and funds were awarded by this agency for a two year study beginning March 1, 1969. The stated objectives of the study are: to determine unknown phases of the life history and behavior of the *Leptoconops* gnats in this area; to improve methods of sampling larvae; and to develop non-chemical and chemical methods for adult and larval control.

During this study adult gnats have been found to

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be very widespread throughout the state of Utah and the annoyance caused by these gnats is more extensive and severe than previously suspected. The flight range appears to exceed ten miles in certain areas. In some study areas, adults have been present from May through September but the peak adult gnat population in most localities occurs in a six to eight week period in late spring and early summer.

From the above findings it becomes evident that it is very important to find out more about the biology, life history, ecology, and distribution of these gnats. To accomplish this, systematic collections are being made of larvae and adults to determine breeding places, extent of distribution, numbers of generations per year and abundance of these gnats in the selected study areas. Soil samples from breeding areas are being taken and the moisture content, structural and chemical composition is being determined. Effects of moisture and temperature changes are being evaluated through these samples.

Studies are also in progress to determine the overwintering stage and the type of habitat preferred by the larvae during more severe climatic conditions.

When these studies are completed, it should be easier to apply and evaluate the effectiveness of control measures. At the present time, limited experimental applications of Abate, baytex, Dursban, and DDT have been applied to the soil as larvicides. As adulticides, the following insecticides were applied by ground equipment: baytex; Dursban; parathion; malathion; and Diazinon. Low volume Dursban is being applied by airplane. Results for some of these chemicals are promising. Another control method which is effective in certain areas is the reduction of the moisture content in the soil to a level which prevents larval development and emergence of adults.

Control of these gnats is a very complex problem and can be successful only after study and controlled experimentation. Methods of more readily locating breeding areas must be developed and specific control methods must be developed for each type of habitat. At present it appears that acceptable and pracical control measures can be developed that will be effective for the control of these gnats in certain areas where the studies are in progress.

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CONFIRMATION OF OVARIAN CYCLES AND LONGEVITIES IN SOME UTAH MOUNTAIN *AEDES* WITH A NOTE ON THE PRESENCE OF MITES

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INTRODUCTION

After extensive observations on the behavior of snow mosquitoes in the Rocky Mountain region, Nielsen (1959) concluded that the adults were relatively short-lived and that death probably occurred soon after the first oviposition. At that time techniques were not available for assessing physiological age to determine the longevities of the mosquitoes. Carpenter and Nielsen (1965) continued studies on the longevity and reproduction of mountain *Aedes*. By using the technique of ovarian dissection as reported by Detinova (1962), they were able to judge the age of female mosquitoes in terms of reproductive potential, numbers of ovipositions completed, and the effective biting period. Remarkably similar results were obtained during the two consecutive years of their study, 1963 and 1964, which led them to believe that genetic factors controlled the life spans of the species involved.

From 10 July to 13 September 1969 we did a comparable study in the mountains of Utah which closely duplicated some of their results.

MATERIALS AND METHODS

The 1969 study was conducted on five univoltine mosquito species: *Aedes cinereus* Meigen, *Aedes communis* (De Geer), *Aedes hexodontus* Dyar, *Aedes increpitus* Dyar, and *Aedes pullatus* (Coquillett).

The collecting areas were as follows:

Lambs Canyon, Salt Lake County; 20 miles east of Salt Lake City in the Wasatch Mountains; elevation about 8000 feet.

Brighton, Salt Lake County; 25 miles southeast of Salt Lake City in the Wasatch Mountains; 8730 feet elevation.

Oakley, Summit County; high mountain valley, 6517 feet elevation; 40 miles east of Salt Lake City.

Midway, Wasatch County; high mountain valley, 5569 feet elevation; 44 miles southeast of Salt Lake City.

Provo River, Wasatch County; 41 miles southeast of Salt Lake City, 4 miles east of Hailstone Junction; elevation about 5600 feet.

Lemon Grove, Wasatch County; campground on the Provo River; 60 miles southeast of Salt Lake City; about 6000 feet elevation.

Mirror Lake, Duchesne County; 80 miles east of Salt Lake City in the high Uintah Mountains; 10,050 feet elevation.

Collecting methods used in 1969 were the same as those used by Carpenter and Nielsen (1965). The procedure was to capture female mosquitoes with an aspirator as they attempted to bite human bait. During most of July the mosquitoes were plentiful and samples were easily taken. During late July and August the females became significantly less abundant and were most often taken in "pockets" where groups of females were resting in the vegetation. Locating the pockets often required considerable searching. It was noted that as the season progressed the surviving females were much less active and did not attack with the voraciousness of those earlier in the year.

Mosquitoes, in pint containers, were kept alive until the time of dissection by transporting them in an ice chest, then storing them in a refrigerator. Standard dissection methods were employed. When a female mosquito feeds on blood and matures a batch of eggs, a dilatation remains at the site of development of each individual egg after the eggs are deposited. When female mosquitoes are dissected, the numbers of dilatations found on the ovariole pedicels are counted and these designate the number of ovarian cycles completed.

DISCUSSION OF RESULTS

The original data from Carpenter's (1965) thesis were used for comparisons of 1963-1964 and 1969 observations because individual records were not included in the published paper. Results of the 1969 dissections are given in Tables 1 and 2. In 1969, 116 mosquitoes were examined in contrast to 722 of the same species in the earlier study.

1. Longevities of Individual Species

A. communis (Fig. 1)

Carpenter and Nielsen (1965) thought *A. communis* to be especially short-lived. Of 197 females examined, none were older than the third ovarian cycle. The data gathered for the present study agreed very closely with their results. Twenty out of 22 specimens were in the first, second, or third ovarian cycle. However, two females, one in the fourth and one in the fifth, were collected on 24 August at Mirror Lake which demonstrated that *A. communis* is able to achieve greater longevity than was previously suspected.

A. hexodontus (Fig. 2)

The former information obtained for longevity of this species, to the third and fourth cycles, was virtually duplicated at the Mirror Lake location. Three females were found in the third ovarian cycle at Brighton two to three weeks sooner in 1969 than in 1963 and 1964. None were collected in 1969 on 19 August at Brighon although in both 1963 and 1964 females of this species were collected there after the middle of August.

A. increpitus (Fig. 3)

Because of the frequency of the 1963 and 1964 collections of this species in the Oakley area, the data are shown to illustrate age progression with time. Only one trip was made to Oakley in 1969. The ages of the females, in the first and second ovarian cycles, were exactly in accordance with the previous results.

Although Carpenter and Nielsen (1965) collected extensively at Brighton, they did not find any *A. increpitus*. In 1969 a single female in the second ovarian cycle was taken there on 30 July.

Large numbers of *A. increpitus* were found in the Midway area on 27 July 1969. These included one female in the fifth cycle.

A. pullatus

At Mirror Lake, Carpenter and Nielsen (1965) were able to find this species at the end of July in the first ovarian cycle and in early August in the second cycle. At Brighton they found it toward the end of August in the second cycle. In spite of intensive collecting in the Oakley area, only two specimens were taken and these were in the second cycle. During the 1969 study, no *A. pullatus* females were collected at either Oakley or Mirror Lake. However they were collected at Brighton through 19 August at which time two specimens were in the third cycle. Carpenter and Nielsen (1965) found one female at this location in the second cycle on 20 August 1963. The tendency of this species to emerge late in the season probably restricts the length of the adult life span.

A. cinereus

According to Carpenter's (1965) records, *A. cinereus* is not widespread and is short-lived. This had been noted by Nielsen and Rees (1961) who described it as being uncommon, localized, and rarely persisting after July. Carpenter and Nielsen (1965) examined 21 females of this species from a number of localities in the western United States. All were in the first or second ovarian cycle and none were collected later than 11 August. Only two females were collected in 1969, on 10 July, and both were in the first cycle. One was taken at Oakley and the other by the Provo River near Hailstone Junction.

2. Longevities, Altitude, and Seasonal Occurrence

Nielsen (1959) related the seasonal appearance of mountain *Aedes* to altitude and temperature. The

TABLE 1

SPECIES COLLECTED DURING 1969 BY DATE AND LOCATION TO SHOW NUMBERS OF FEMALES IN EACH OVARIAN CYCLE

	OVARIAN CYCLE				
	1	2	3	4	5
A. cinereus					
10 July—Oakley (1), Summit County	1	....	....	....	....
Provo River, Wasatch County	1	....	....	....	....
A. communis					
30 July—Brighton, Salt Lake County	1	8	....	....	....
3 August—Brighton, Salt Lake County	....	6	3	....	....
24 August—Mirror Lake, Duchesne County	....	....	2	1	1
A. hexodontus					
30 July—Brighton, Salt Lake County	....	10	3	....	....
3 August—Brighton, Salt Lake County	....	6	....	....	....
24 August—Mirror Lake, Duchesne County	....	....	2	1	....
A. increpitus					
10 July—Oakley (1), Summit County	16	3	....	....	....
Oakley (2), Summit County	5	8	....	....	....
Lemon Grove, Wasatch County	2	....	....	....	....
Provo River, Wasatch County	1	....	1	....	....
Midway, Wasatch County	....	2	....	....	....
27 July—Midway, Wasatch County	1	14	....	....	1
30 July—Brighton, Salt Lake County	....	1	....	....	....
A. pullatus					
10 July—Lambs Canyon, Salt Lake County	1	....	....	....	....
30 July—Brighton, Salt Lake County	....	2	....	....	....
3 August—Brighton, Salt Lake County	....	2	....	....	....
19 August—Brighton, Salt Lake County	....	8	2	....	....

Collection efforts on the following dates and locations resulted in no mosquitoes:

14 July—Lambs Canyon, Salt Lake County
31 August—Brighton, Salt Lake County
7 September—Mirror Lake, Duchesne County
13 September—Brighton, Salt Lake County

TABLE 2

TABULATION OF 1969 RESULTS OF TOTAL NUMBERS OF FEMALE MOSQUITOES DISSECTED ACCORDING TO PHYSIOLOGICAL AGE

SPECIES	NUMBER OF FEMALES EXAMINED	OVARIAN CYCLE				
		1	2	3	4	5
A. cinereus	2	2	....	....	....	....
A. communis	22	1	14	5	1	1
A. hexodontus	22	....	16	5	1	....
A. increpitus	55	25	28	1	....	1
A. pullatus	15	1	12	2	....	....
Total Number	116	29	70	13	2	2

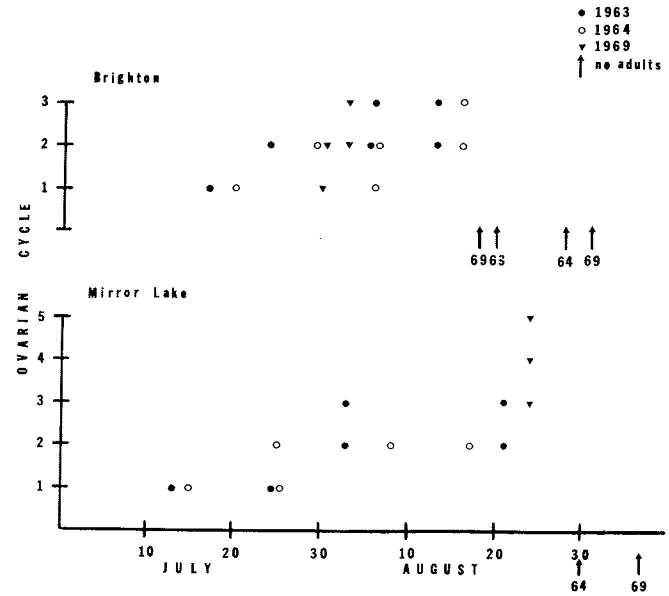

FIG. 1 Longevity of *A. communis* during three seasons at two locations.

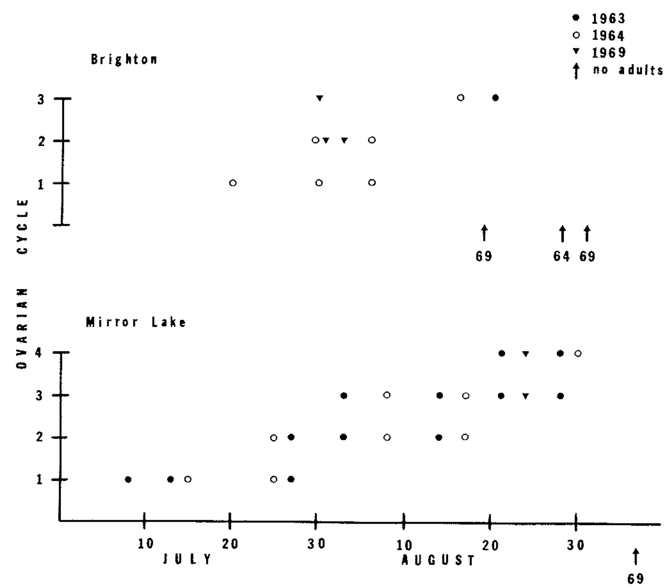

FIG. 2 Longevity of *A. hexodontus* during three seasons at two locations.

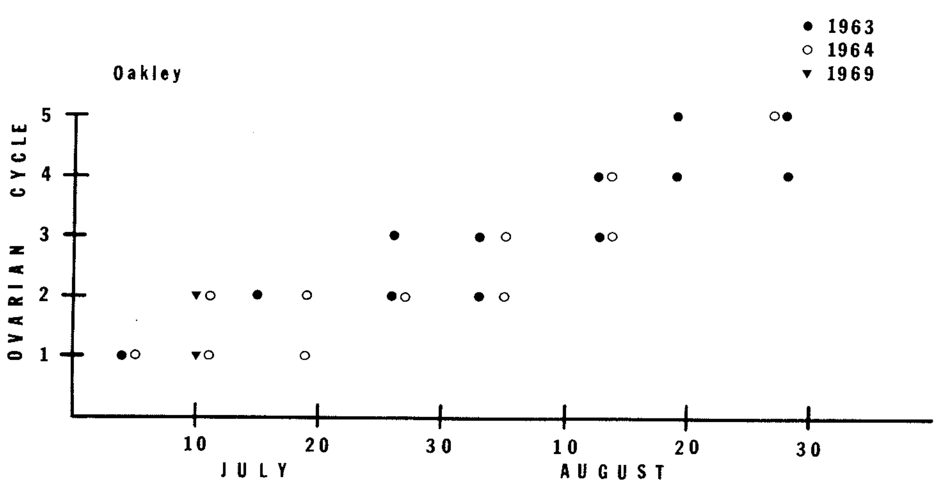

FIG. 3 Illustration of advancement of physiological age of *A. increpitus* with seasonal progression.

correlation is also evident in the longevities of adults. In his thesis, Carpenter (1965) gave some average durations of ovarian cycles based on age groupings and dates of collections. If an estimated 10 days are allowed for each ovarian cycle, approximately 50 days would be required to complete five ovarian cycles. According to the 1963 Oakley data for *A. increpitus*, females in their first cycle were taken on 4 July and in the fifth cycle on 19 August — this is 47 days. By applying this formula to the 1969 data, calendar ages were determined from the date of the first occurrence of the oldest specimens collected at each locality and the approximate time of emergence became clear.

In Utah, *A. increpitus* generally occurs in mountain valleys at elevations below 7000 feet, and for this reason it appears earlier in the season than other mountain *Aedes* (Nielsen and Rees 1961). The females taken at Midway and Provo River were calculated to have emerged somewhat sooner than those taken at Oakley which is about 1000 feet higher. At Brighton, a single *A. increpitus* female indicated that emergence was about 20 days later than at Oakley with a difference in altitude of about 2000 feet.

According to Dyar (1916), the hatching of snow mosquito eggs was related to altitudinal location, that for each 1000 feet of increased elevation there was one month's delay in hatching. Nielsen's (1959) disagreement was based on the fact that the entire larval developmental period in the high mountains was much too short to permit such a time differential. His impressions were reinforced by suggestive evidence from the calculated emergence times of the females collected in 1969. There appeared to be a delay in emergence time of about 10 days for each 1000 feet of increased elevation but it is expected that much variation would be seen among localities due to differences in environmental exposure and climatic diversities from season to season as well as within a given season.

Such effects have been observed over many years by the junior author. A considerable number of pools produce larvae, and many of these differ in flooding time depending on snow depth and melting rate. Snow covering the more sheltered forest pools melts slowly, and sometimes hatching occurs in these pools when larvae of the same species in more exposed pools are in the third or fourth instar. Deeper pools with the consequently lowered water temperature slows developmental rates. On occasions a sudden late-season period of cold weather can prolong larval development for a week or more even though some adults have already emerged from different pools or even from the same pool.

Figures 1, 2, and 3 demonstrate the results of environmental and seasonal variations. At Brighton, Mirror Lake, and Oakley differences in emergence times within each locality for each species varied as much as two to three weeks. At Brighton and Mirror Lake his was primarily due to environmental exposure. At Oakley, *A. increpitus* breeding sites were produced by both stream overflow and irrigation. Differences in flooding times for pools in this area varied by as much as three weeks, and emergence of adults probably continued for a period of over a month. In Figures 1, 2, and 3 the showing of females in the same ovarian cycle from the same locality over periods of two to four weeks was due to differences in emergence times rather than physiological or inherent characteristics of the females. Further investigations are necessary to define the relationships of altitude, snow melting time, longevities of adults, and species dissimilarities. Continued work on physiological ages of females will more clearly establish the seasonal incidence of snow mosquitoes.

3. Association with Mites

At one time the presence of water mites attached to the bodies of female mosquitoes was an indication of nulliparity because it was thought that the attachment of the mite took place at the water surface as the mosquito escaped from the pupal skin. The mites then dropped off when the mosquito returned to the water or damp site for oviposition. Hitchcock (1969) has reviewed the literature on this subject in conjunction with his studies, and the current opinion is that mites can be found as well on parous females and therefore they are not a reliable external indicator of age.

Hydracarinid mites were observed on two specimens of *A. hexodontus* during the 1969 study. One female, from Brighton on 30 July, was in the second ovarian cycle. The other was from Mirror Lake, 24 August, in the fourth cycle. This again demonstrates that the presence of mites on mosquitoes is more accidental than relative to physiological age.

SUMMARY

During the summer of 1969, dissections of five species of snow mosquitoes in Utah confirmed work done in 1963 and 1964. The reproductive potentials as evidenced by numbers of completed ovipositions were amazingly similar between the two studies. *A. cinereus* was represented by only two females, both in the first ovarian cycle. *A. pullatus* reached the third cycle. *A. hexodontus* and *A. increpitus* accomplished four and five ovipositions, respectively. The 1969 investigation extended the longevity of *A. communis* from three to five ovarian cycles. Depending on time of emergence, it seems that all mountain *Aedes* are probably capable of at least five ovipositions.

A correlation between altitude and time of emergence as determined by physiological age was suggested by the 1969 data.

Hydracarinid mites were found on two parous specimens of *A. hexodontus.*

ACKNOWLEDGEMENT

Grateful acknowledgement is given to the special friends who served as "guinea pigs" to help attract mosquitoes on collecting trips: Ronald and Mary Benge, Roger and Ahna Clarke, Elizabeth Cole, and Glen Collett.

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INDICATIONS OF THE DISPERSAL OF *Aedes melanimon* DYAR IN THE WEST SIDE OF THE SAN JOAQUIN VALLEY

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Aedes melanimon, commonly known as the field mosquito, is a native California species found in the semi-arid and alkaline portions of the Central Valley. Its relative, *Aedes dorsalis,* was once considered to inhabit the Central Valley, but it was later discovered that *A. dorsalis* was found mainly in the coastal marshes and in the higher elevations and Sierra regions whereas *A. melanimon* was, in fact, the major species in the Central Valley (Bohart 1956). Prior to 1955, most publications which relate to *A. dorsalis* in the Central Valley may be considered as referring to *A. melanimon* (Barr 1955).

The west side of the San Joaquin Valley is a part of a major waterfowl flyway used each year by millions of ducks, geese and pelicans as an over-wintering site. These over-wintering sites have been reduced at an alarming rate, and as a consequence, naturalists, conservationists, State and Federal Fish & Game and duck hunters have been doing all they can to preserve natural waterfowl habitats. One of the largest of these is the grass-land area in western Merced County. This area is owned and operated by some 300 small, private duck clubs. Around mid-September water becomes available to these unleveled lands and flooding results in the heavy production of *A. melanimon* (Mortenson 1963).

The southern limit of the grass-lands area is fairly well-defined. Beyond this boundary to the south there is intensive agriculture in which cotton, rice, cantaloupes, tomatoes and seed alfalfa are the major crops. September and October are harvest months in this area, therefore *A. melanimon* sources are scarce.

Much has been written relative to the dispersal of *Aedes* mosquitoes. In Florida it was found that *Aedes taeniorhynchus* disperses about 8 hours after emergence (Provost 1957). Exodus from larval sites seemed to be in waves (Haeger 1960) with migrations of 25 miles or more being noted. In Utah, dispersing *A. dorsalis* appeared to follow waterways. Diminishing light was found to be an influential factor in *A. dorsalis* activity (Marlor and Rees 1958).

Workers in California have studied the dispersal of *Aedes nigromaculis.* Studies in the Turlock area indicated very limited dispersal (Thurman *et al* 1951). Passive flights of greater distances caused by mosquitoes rising with thermal currents in the valley areas and being deposited miles away in the foothills have been suspected. A study in Kern County indicated that *A. nigromaculis* and *A. dorsalis* (= *A. melanimon*) appeared to follow this pattern. About one-half of the tagged mosquitoes recovered were *A. melanimon* (Smith 1952, Smith *et al* 1956).

Recent work with *A. melanimon* in the westside of the San Joaquin Valley indicates dispersal to be generally in a down-wind direction (Kliewer & Miura, in press). Flight activity of *A. melanimon* is considered to be mainly nocturnal in this area during the fall (Miura & Reed 1969).

Dispersal of *A. melanimon* over distances in excess of 15 miles from the duck club area has been suspected. A light trap located 3 miles downwind from major duck club production areas has monitored these flights since 1960. A block area of about 5,000 acres of duck clubs adjacent to the southern limit was treated from 1960 to 1966 with sprays and granules in an attempt to reduce the adult mosquito population in the agricultural areas downwind. Only partial success was attained with these treatments.

In 1965 body counts over an area of 150 square miles downwind from the duck clubs were made about three days following a large rise of *A. melanimon*

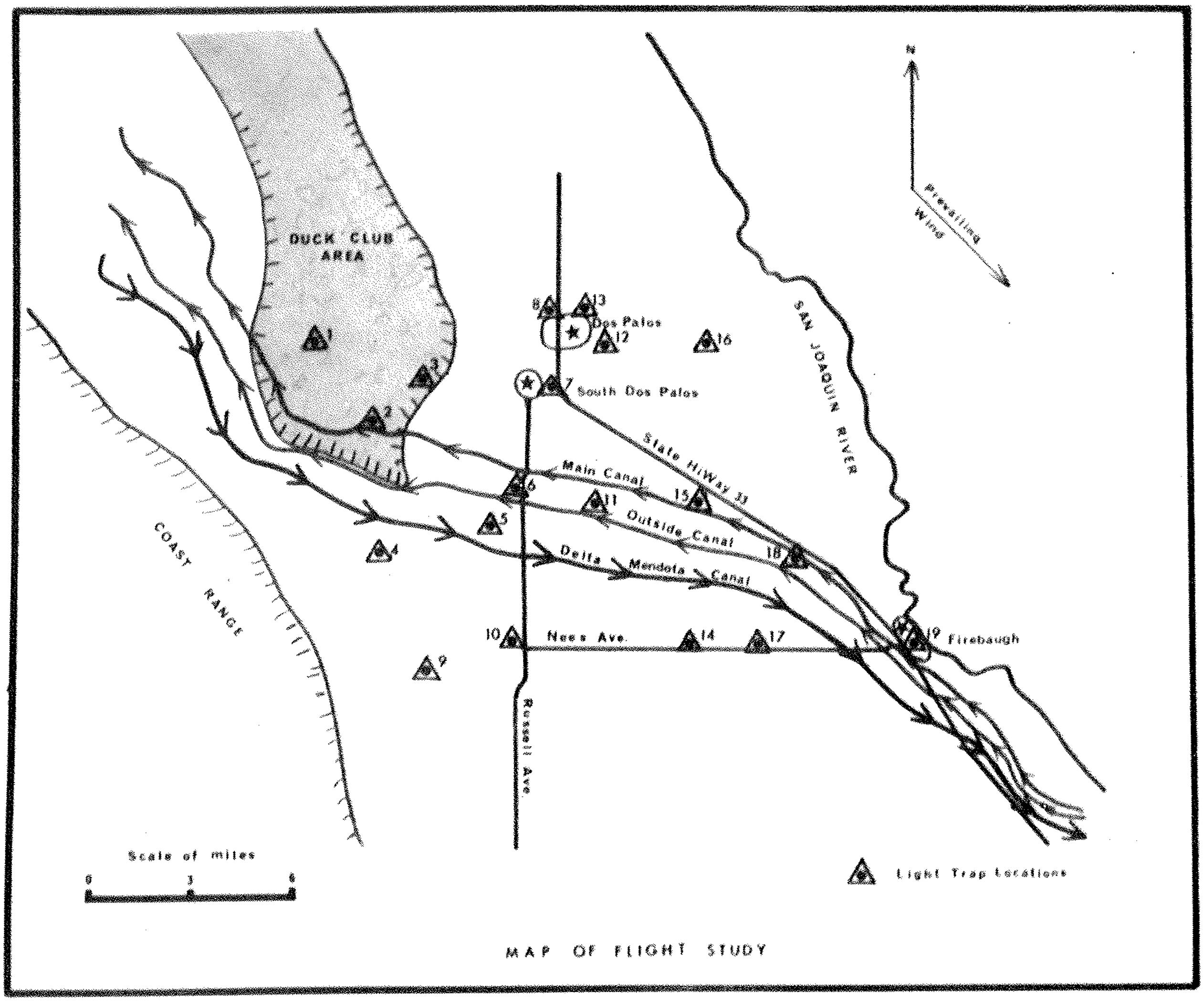

Figure 1. *Map of flight dispersal area showing some of the features of the environment that influenced the direction of movement.*

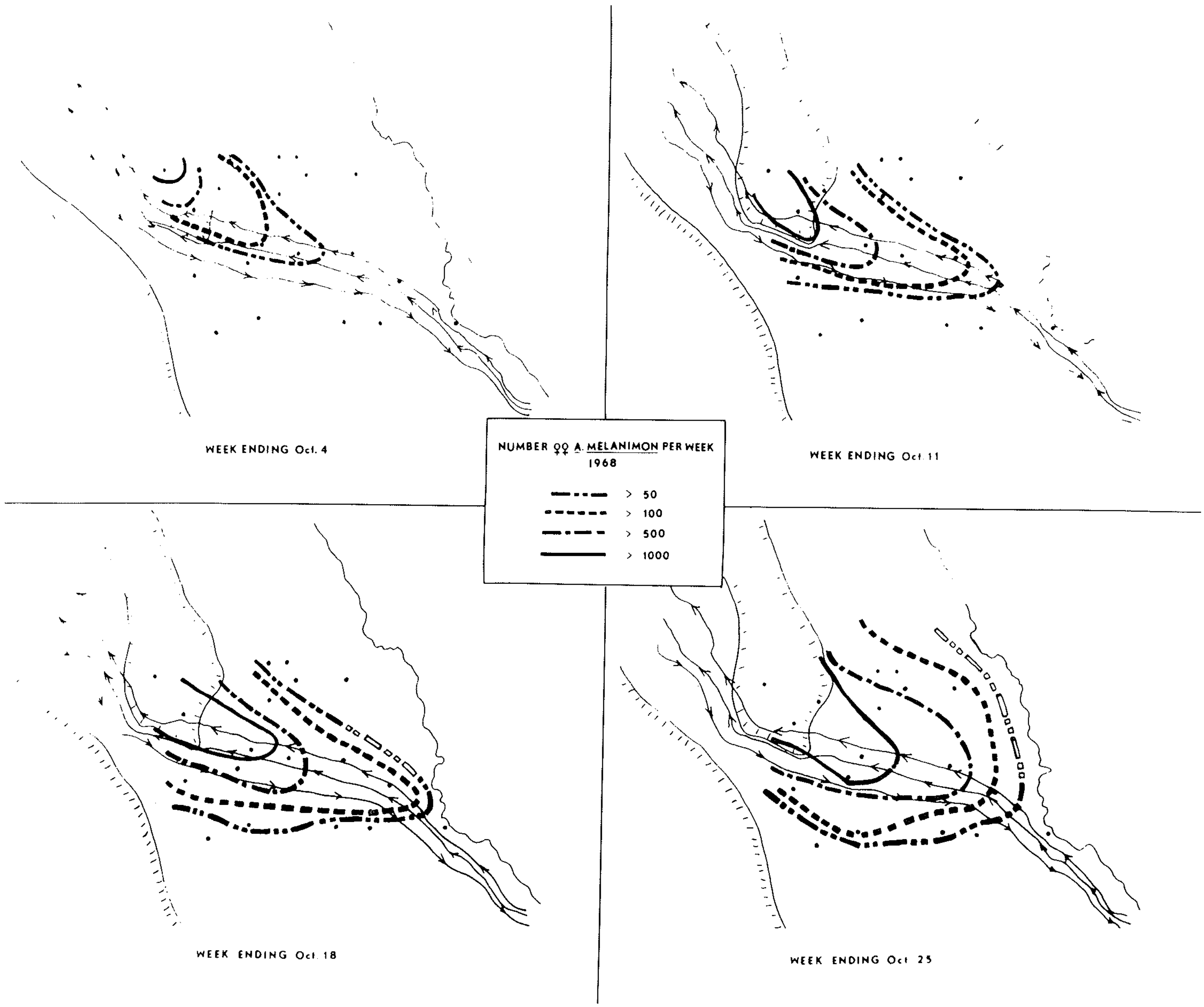

Figure 2. *Aedes melanimon flight dispersal based upon light trap collections for four consecutive weeks.*

in the monitor trap. Medium to high counts of *A. melanimon* were recorded at distances up to 12 miles and revealed indications of a dispersal of major proportions during a very short period of time.

Most of the area of mosquito production in the duck clubs was not treated with insecticides during the period of this study. The only exception will be mentioned later in the discussion.

METHODS AND PROCEDURES:

The "American" model light trap (Mulhern 1953) has been the basic tool used to measure *A. melanimon* dispersal. In 1968 three traps were located about 3 miles apart in the duck clubs and 16 light traps were scattered over an area of 150 square miles downwind from these three. Distance of the furthest trap from the duck club area was about 17 miles (Figure 1). Light trap catches were collected daily through the month of October.

Body counts (landing rates) were used as supportive data in 1967 but were found to be unreliable in this study. Sweep net counts were taken, but information was sketchy. Sweep collections were used mainly for age determinations.

An area approximately 5,000 acres in size in the duck club area was inspected and sampled twice weekly for mosquito larvae development and relative density. An estimation of *A. melanimon* adult populations also was made in duck clubs by using pant leg count. Pant leg measurements were made by facing downwind and counting *A. melanimon* landing on the downwind leg. The agricultural area downwind from the duck clubs was thoroughly inspected for *A. melanimon* sources and treated to eliminate a potential local influence on the results of the study.

Wind direction and velocity were measured by a standard wind recording system. The instrument was located at the District headquarters, near Firebaugh, 17 miles downwind from the duck clubs. Temperature and relative humidity were recorded by two hygrothermographs, one located near Firebaugh, and one located near light trap No. 11, about 5 miles from the duck clubs. Accuracy of these instruments was checked at least weekly with a standard Weather Bureau sling psycrometer. Rainfall was measured by a standard U.S. Weather Bureau rain and snow gauge.

RESULTS:

Light traps located in the duck club area collected the largest numbers of *A. melanimon.* Collection of males in these traps was, understandably, very high. Collections of each of the traps in the duck clubs were affected by flooding practices in their immediate surroundings. Light traps No. 1 and No. 2 were in areas of primarily fall flooding, whereas the No. 3 location was influenced by abundant summer irrigations. Treatment with chemicals in and around light trap No. 3 and the presence of high populations of the fish *Gambusia affinis* in many ponds undoubtedly influenced production of *A. melanimon* in this area.

Temperatures during October recorded a mean of 64.29° F. Normal for the month is 64.55° F.

Light traps No. 5, 6, 11, 14 and 18, located southwest of the duck clubs (receiving area) collected the largest numbers of *A. melanimon* females; thus indicating a movement, generally, in a downwind direction. Wind directions on the weather station indicated prevailing wind to be from the northwest and generally less than 10 miles per hour. The movement, however, appeared to follow the three major canals to a large extent rather than strictly with the prevailing winds. These canals roughly follow an easterly and southeasterly course. The five light traps indicated above are all located alongside or between the three canals.

Light traps located within or near cities (No. 7, 13, and 19) and those in rural areas of intensive chemical control during this period (No. 8 and No. 16) collected relatively few *A. melanimon.* In and around cities, competitive lights and adult mosquito control practices may have influenced the results.

Although only 19 light traps were used in this study, it is interesting to note indications of *A. melanimon* dispersal can be made by using "contour lines." Contour lines were drawn on a map of the area to define the areas of relatively similar *A. melanimon* (female) populations (Figure 2). This method of analysis shows an ever-extending and broadening "front" of mosquito numbers as the month progresses.

Although Figure No. 2 gives no indication that a break occurred in this ever-expanding front, a complete breakdown of the front occurred on October 14 and 15 due to the first winter storm of the season which occurred in this area about noon on October 13. This storm dissipated rapidly and by October 16, the front pattern as originally recorded was almost completely reestablished. Why a complete breakdown in the front occurred during this storm, which deposited .6 to 1.3 inches of rainfall in the area, is uncertain. It is believed that the breakdown was due primarily to inactivity on the part of the mosquito during these two days rather than a population reduction due to the storm.

SUMMARY AND CONCLUSIONS:

Fall dispersal of *A. melanimon* from duck clubs apparently begins within 48 hours of adult emergence. Movement from the duck clubs is in the general direction of the prevailing winds, but following of waterways in a downwind or crosswind direction appears to be the usual pattern of flight. Peak activity appears to coincide with peaks of adult emergence in the duck clubs. Flights in excess of twelve miles were recorded.

This study illustrates one of the continuing activities of the Fresno Westside Mosquito Abatement Disrtict and, although more light traps would provide better data, it is felt that data accumulated over a period of years will greatly aid our program and increase our knowledge of *A. malanimon* biology.

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MOSQUITOES AND ARBOVIRUSES FROM CALLAO, UTAH FOR THE YEARS 1966 AND 1967

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ABSTRACT

Mosquitoes were collected by CDC Miniature Light Traps each year from three sites in Callao and two in Redden Springs, a marsh 7 miles north of Callao. These areas are east of the Deep Creek Mountains in western Utah. Mosquitoes were pooled by species, and the pools were assayed and identified by routine procedures in suckling mice. In 1966 each month from May to September, the total precipitation was considerably below normal, and the average temperature was slightly above normal. In 1967 total precipitation was considerably above normal for May, June, and September; average temperature was slightly below normal for May, June, and July.

Collections from the Callao sites totaled four times more mosquitoes in 1967 than in 1966 although 232 fewer trap nights were used in 1967. The 1967 mosquitoes yielded 25 of the 26 California encephalitis virus isolations, 18 from *Aedes dorsalis,* 7 from *Culiseta inornata,* and 1 from *Anopheles freeborni.* Because of the larger number of high infection ratios, *C. inornata* was considered to be the best vector. The mosquito species were at their population peaks for 17 of the isolations.

Collections from the Redden Springs sites totaled three times more mosquitoes in 1966 than in 1967, but 287 fewer trap nights were used in 1967. However, *C. inornata* and *A. dorsalis* were more abundant at each site in 1967, and 19 of the 21 arbovirus isolations were from 1967 mosquitoes. California encephalitis virus was isolated from 16 pools of *C. inornata,* 2 pools of *A. dorsalis,* and 1 pool of *C. tarsalis.* Because of the larger number of isolations and high infection rates, *C. inornata* was considered to be the best vector. The mosquito species were at their population peaks for 9 of the isolations. Cache Valley virus was isolated once from *C. inornata* collected in 1967 when the mosquito was at a population peak and once from *A. freeborni* collected in 1966.

An additional 7 isolates were obtained from 1966 mosquitoes. Cache Valley virus was isolated from a pool of *C. inornata* collected by light traps at a Callao site not used in 1967. *A. freeborni* collected in livestock-baited stable traps at South Redden Springs yielded the other 6 isolations; 4 were California encephalitis virus and 2 were Cache Valley virus. Stable traps were not used in 1967.

ISOLATIONS OF HART PARK-LIKE AND CALIFORNIA ENCEPHALITIS GROUP VIRUSES FROM MOSQUITOES OF CEDAR AND UTAH VALLEYS, UTAH IN 1967[1]

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ABSTRACT

In an arbovirus survey of the Great Basin, 18,878 mosquitoes from five sites in Cedar and Utah Valleys, Utah were collected and pooled by species. Pools were

[1]Presented at the 1968 meetings of the Utah Mosquito Abatement Association.

assayed and identified by routine procedures in suckling mice. Hart Park-like virus was isolated from 8 pools of *Culex tarsalis,* and the 15 California encephalitis group virus isolates included 7 from *Culiseta inornata,* 6 from *Aedes dorsalis,* and 1 each from *Culex tarsalis* and *Culex erythrothorax.* Of the 23 isolates, 18 were from mosquito species collected at their population peaks.

THE ZONE OPERATOR

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Administrative Assistant-Entomologist
Sacramento Co. - Yolo Co. Mosquito Abatement Dist.
Sacramento, California

The Sacramento-Yolo Mosquito Abatement District works on the policy of the one man, one zone concept. All mosquito control activity in a given area is performed by a mosquito zone operator who, with few exceptions, is a long-time resident of the work area (zone). When it is considered this man has sole responsibility for a zone, it necessarily follows this is an important position, and in most cases the life work of the individual.

Average tenure of our senior zone operators is 14 years. A senior zone operator attains the classification after the completion of 5 years on the job, and after passing a qualifying examination which entitles him to an additional 2 steps in salary.

TABLE 1

Position	No. of	Average Length of Employment	Salary Scale
Sr. Operator	25	14 years	\$763-\$801
Operator	11	6 years	\$598-\$727
All Operators	36	11½ years	
P/t Sr. Operator	2	10 seasons	\$763-\$801
P/t Operator	11	4 seasons	\$598-\$727
All P/t Operators	13	5 seasons	

It follows then that this man must be given incentive, and necessarily provided benefits commensurate with this important job. These benefits include; 11 holidays (this includes election day) and 3 hours off for Good Friday. Employees receive 10 days vacation leave for the first 3 years, 15 days for 3 years through 15 years and 20 days for over 15 years of employment. All employees receive 15 days a year (with a limit of 90 days on the books) of sick leave. The permanent operators are entitled to 4 hours a month emergency leave. Our work week is 40 hours, with compensating time off for over 40 hours. Time and a half is given for overtime worked. We participate in the State Retirement plan. The District pays \$9.00 of the Employee's premium for Group Hospital Insurance. This insurance plan also includes life insurance, which is paid entirely by the employee. The employees also carry a long term disability insurance plan, which is also paid entirely by the employee.

Board policy has set a .06¢/\$100.00 assessed value tax rate, encompassed the entire land area of Sacramento and Yolo counties (2013 square miles), created 47 zones encompassing 9 incorporated communities, and allowed for 8 foreman divisions. They adopted a decentralized concept of man power deployment, with operators working out of outlying depots placed strategically over the District.

I would like to enumerate, in part, the duties and responsibilities of the zone operator. He is the "counterman," the primary, and in most cases, the only contact many constituents have with their District. He's inspector, spray man, map man, mechanic and improvisor. He knows local individuals, groups and agencies to turn to for assistance and cooperation; he initiates any corrective measures as in source reduction on property within his jurisdiction. He is a diplomat. He's husband-man over biological or naturalistic control in his zone. A good mosquito man has the ability to work by himself. He is an inquisitive type; he is in most cases an ardent hunter and fisherman. He's a family man.

The zone operator can be a source of much detailed information, coming up with ideas and innovations in various aspects of his work. The development of the *Gambusia* mosquito fish program in the Sacramento-Yolo Mosquito Abatement District is a good example of the value of this man.

Give this some thought. If your zone operator is not given opportunity to exercise initiative in his work, aren't you missing the opportunity to improve your effectiveness? The zone operator is the key man if given the opportunity.

THE EXPERIMENTAL USE OF LOWER AIRCRAFT SPRAY VOLUMES IN UTAH MOSQUITO CONTROL — A PRELIMINARY REPORT

W. E. BURGOYNE[1], G. C. COLLETT[1], R. GOLD[2], J. ELDRIDGE[2]

INTRODUCTION

A Call-Air A9, 290 hp spray plane was contracted to the Salt Lake City and Magna Mosquito Abatement Districts to investigate the use of lower total spray volumes than two gallons per acre. All flight operations were the responsibility of the operator; mixing and loading were done by the districts. At the season's start the plane was calibrated at a total delivery rate of one gallon per acre, half the usual Utah rate. Swath width was 75 feet and remained so for all applications. The chemical of choice for this area is methyl parathion at a dosage rate of 0.1 to 0.2 pounds per acre.

[1]Salt Lake City Mosquito Abatement District, Salt Lake City, Utah.
[2]Pesticide Laboratory, University of Utah, Salt Lake City, Utah.

Air speed was 87 miles per hour, the usual altitude 8-12 feet.

OPERATIONS

Experimental applications were made, in addition to the operational 1 gal/acre rate, at total rates of one quart and 5.6 fluid ounces (fl oz) per acre. Chemicals used besides methyl parathion (Mt Para) were Baytex (fenthion) at 0.1 lb/acre and Dursban at 0.05 lb/acre. Baygon (2 lbs/gal LV formulation) mixed with Baytex in a 1:4 ration was applied against both adults and larvae.

In cooperation with the University of Utah Pesticide Laboratory five gas chromatograph tests were performed to measure the amounts of chemical reaching mosquito larvae breeding water through various types of plant cover.

Forty plots were evaluated for larvae and adult kill using various rates and formulations.

RESULTS

In general the 1 gal/acre applications worked well. On 40 plots there were 35 kills of over 90%. In early July there were some operational failures that we believe were caused by improper mixing on the ground.

The applications made at 5.6 fl oz/acre were irregular in their effectiveness, kills being 100% or near zero. These plot results could usually be correlated with the weather; if the wind was less than three miles per hour in velocity, chances of a successful treatment were good. The Salt Lake districts, however, are located against the west slope of the Rocky Mountains and periods when less than one pint per acre total material can be used seldom extend over one hour a morning.

With light aircraft many of the economic advantages of low volume spraying at total rates of less than one pint per acre are lost because the pilot must return to base for fuel and a rest long before his hopper is empty. An analysis of the Salt Lake City flight operations prior to 1969 convinced us that a rate of one qt/acre, total mix in water, would empty the A9's hopper at about the same time the fuel was exhausted (2½ hours flying time plus 15 minutes reserve). It is claimed that lower volumes mixed with water cannot be used in the desert because evaporation on a hot day may reduce droplets to dust between boom and target; however, Salt Lake Districts spray marshes, not desert, and relative humidities in the duck clubs, which comprise much of the mosquito breeding areas, range from 75-80% at dawn to 30-40% at 11 a.m. during the summer.

These factors led us to calibrate at 1 qt/acre total mix for the latter part of our 1969 spray season. This rate was especially effective for adult control using a Baytex/Baygon mixture while obtaining substantial larval control in the same plots. Applications for larvae alone, using Mt Para and Dursban at this rate, are less conclusive at this writing, but promising, and we hope to continue to investigate the 1 gal/acre rate.

WARNING! Methyl parathion applied in such a concentrated form is not recommended except for experimental use and full protective clothing, including respirator, should be worn by the pilot.

PENETRATION STUDIES

The penetration tests were made by flying a single swath over clusters of 36, three inch aluminum microbalance weighing pans placed above and under various types of plant cover. The pans were washed and the deposit evaluated by electron-capture detector gas chromatograph.

A preliminary analysis of our data indicates the following:

(1) The altitutde of the aircraft (boom height) is of importance when the amounts of chemical recovered in the *open* is considered; however there is very little difference (6% vs. 8%; 5 tests, 9 replications) in the amount of pesticide that penetrates heavy plant cover. Boom height was 5 ft. vs. 12 ft.

(2) Penetration through the various types of cover (tree, alfalfa, laid-over salt-grass) common to the Great Basin, in all cases averages less than 10% of the material released. Under no conditions of application did any test produce, from the covered pans, a recovery greater than 20%.

The recovery from under alfalfa was exceptionally low: average 1.7%, range 0.8 to 2.6%. The vegetative cover under the 40-foot Russian Olive tree used for test purposes was less dense than either salt grass or alfalfa, but this was balanced by the fact that the plane was forced higher during the spray run: recovery 3%; one test, 9 replications.

(3) Of interest is the fact that the 5.6 fl oz/acre rate gave greater recoveries in the open at a plane altitude of 8 to 12 feet than did the one gal/acre rate (average 17% vs. 14%). This may be due to the fact that a non-evaporative oil extender, rather than water, was used for the low volume application.

Dye cards were used to check the droplet spectrums from these applications, but at this writing (October 1969) drop analysis is not complete. Study of the gas chromatograph data indicates that the recoveries may be revised downward about 10% due to higher aircraft boom pressures than expected, but it is unlikely that any of the data will be adjusted upward.

FINANCIAL CONSIDERATIONS

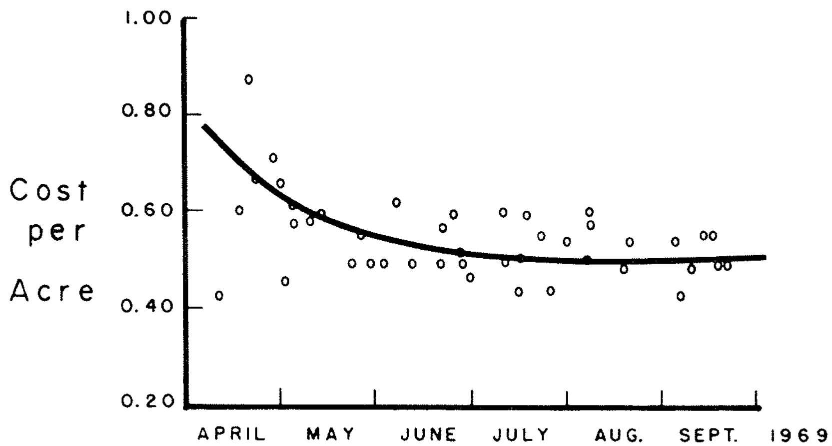
Agricultural operators (crop dusters) have the reputation of detesting low volume; this feeling is

SALT LAKE CITY M.A.D.

Flight Operations 1969: Cost per Acre

CALL A-9, 290 hp

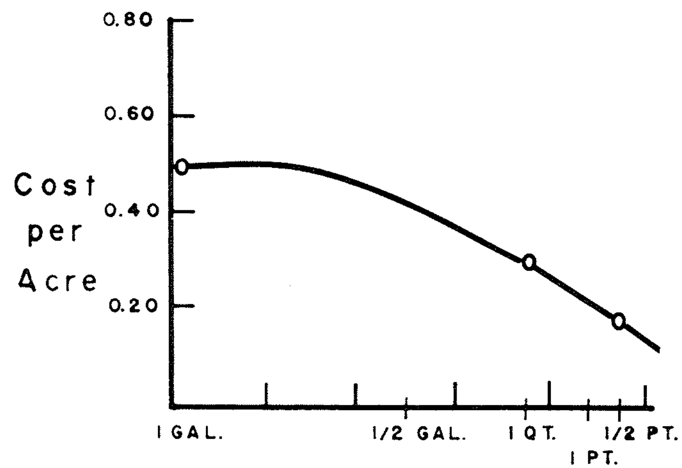
GRAPH I



TOTAL MIX: 1 gal./acre, normal application rate

90 missions, 1.8 acres/minute, 15,000 acres (3)

GRAPH II



Total Rate per Acre:

1 gallon/A (1)
1 quart/A (2)
5.6 fl. oz./A (2)

(1) NORMAL APPLICATION RATE

(2) EXPERIMENTAL RATES

(3) MECHANICAL ABORTS AND FLIGHTS FROM AIRPORTS OTHER THAN HOME BASE NOT INCLUDED IN DATA

often well justified. When a farmer has his crops LV'd at perhaps 1/10th the normal rate, he is likely to consider himself entitled to an equivalent reduction in price. However the applicator's fixed costs remain the same — in fact today they are going up fast. The only way he can reduce his prices along with his application rates is to increase substantially the amount of acreage he treats. This is seldom possible today with the American farmer increasing his yields while decreasing his acreage. Nevertheless, there are few abatement district managers who do not want to increase the acreage they spray by plane or raise the number of applications they make. Therefore, it is in the field of mosquito control that lower volumes can be most effectively used to the mutual benefit of the control district and the contracting applicator.

Our experience with the 290 hp Call A9, leased at $50.00 per flying hour, is as follows:

TABLE 1

Call A9 Rate	Operating Costs 1969 Acres/Minute Sprayed	Cost/Acre $
1 gallon/acre	1.8	$0.50
1 quart/acre	3.0	0.29
5.6 fl oz/acre	4.5	0.19

This compares with 1.5 acres per minute at a cost of $0.60 per acre for the 2 gal/acre rate used by the Salt Lake City District prior to 1969. It should be noted that our Call's 290 hp engine was mounted on an airframe with gas tanks designed for a 235 hp engine, making necessary more frequent landings for fuel.

Graph I illustrates the cost per acre of flight operations using a total application rate of one gal/acre. The higher costs in April and May reflect the more scattered nature of our early season applications, increasing ferry time, and the necessity of a new pilot to learn the area. Graph II illustrates the per acre costs of our experimental applications at one quart and 5.6 fluid ounces per acre.

CONCLUSIONS

The Salt Lake City Mosquito Abatement District reduced their routine air application rates from 2 gal/acre to one gal/acre total mix in 1969 with no appreciable change in mosquito control effectiveness. A reduction of total aircraft costs from $55.00 to $50.00 per hour was made possible.

Experimental applications at a rate of one qt/acre were successful against adults and larvae, promising additional reductions in total aircraft costs if accompanied by a corresponding increase in acreage.

Dursban and Baytex, extended with No. 2 diesel oil, were effective against mosquito larvae at total rates of 5.6 fl oz/acre. Applications at this rate are most effective when applied in winds of less than three miles per hour.

Studies on the ability of airsprays to penetrate vegetative cover in various formulations and at three different application rates indicate that 80% and higher of the pesticide applied does not reach the larval habitat under the centerline of the spray plane when applied over three types of plant cover common in the Great Basin.

Preliminary results of research performed in Utah during 1969 indicate that a reduction of total airspray volume to one gal/acre would be satisfactory for Utah mosquito control, and that an additional rate reduction to one qt/acre should be investigated.

ACKNOWLEDGEMENTS

The authors wish to offer their thanks to members of the Salt Lake City Mosquito Abatement District who cooperated in this study; to Chemagro Corporation, Kansas City, who supplied funds for the investigations; to the Dow Chemical Co. who provided generous amounts of chemicals; and to the Department of Biology, University of Utah, whose research facilities and generous advice were constantly utilized.

SOME NEEDS OF MOSQUITO CONTROL IN UTAH AND A PLAN TO MEET THEM

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Mosquito control, like all other activities, always falls short of perfection. The best programs recognize and strive continually to correct faults. A complete list of the failings and shortcomings of control in Utah is too extensive to include here but they are no greater or any more serious than in other areas. Improvement of mosquito control can be obtained by defining and attacking at least some of the existing deficiencies. These deficiencies for the most part are local problems and must be solved by each local district. However, there are some that can be attacked only by a cooperative effort of the districts operating through the Utah Mosquito Abatement Association. This paper is concerned with some of the latter problems.

Proper mosquito control procedures require more professional services than districts can usually afford. Entomology is a basic professional service but only 3 of 7 districts in Utah feel they can afford an entomologist and the 3 districts that do have one have combined that service with the position of director or manager. As a result none of the 3 trained entomologists in mosquito control in Utah function as entomologists. However, we have at least recognized the need for entomology.

We also need engineering services. For a time the Salt Lake City Mosquito Abatement District employed an engineer, again as manager, but at present no engineer is employed in mosquito control in Utah.

Also needed are a limnologist to study water quality and the effects of pollution on mosquito production; a well-trained ecologist or wildlife biologist to determine the effects of our operations on other organisms and to determine the effects of other activities over which we have no control but for which we are often asked to assume responsibility; a toxicologist to check for effects of our pesticides on man and other animals and to provide for safe disposal of pesticides and pesticide containers; an expert business manager to study all of our procedures in purchasing and other activities; professional services in public relations and many other specialized services. In addition to the special services mentioned above, we also need a research program tailored to our local needs. Results of research in other areas can be obtained and used but hardly ever are such results ideally suited to our specific problems.

The managers try to provide all of these services but do a much less satisfactory job than is desired. At this point examples could be given but perhaps they should remain unstated. Evidence could be presented to indicate we are doing well with the resources available but still, obviously, we are not doing all that should be done.

There are at least 3 major obstacles to obtaining the professional services and a research program for the mosquito control districts in Utah. The first is that the need is not clearly seen by each agency; the second is that the professional services required are of such a nature that people employed for this purpose would find, if they were as capable as desired, that each district provided too little in the way of work and challenge within the objectives of the program; and the third reason is a lack of funds.

If the first obstacle can be overcome and the will to overcome the other two developed, mosquito control in Utah can make progress in this direction through the Utah Mosquito Abatement Association. We have already taken a small step in this direction by purchasing granules through the association for the entire state rather than each individual district doing their own. The savings are considerable. For the South Salt Lake County district the annual saving using this procedure fluctuates between $650.00 and $1,000.00.

Now seems to be an appropriate time to expand the activities of the state association so as to provide more help for individual districts. A planned, orderly development of association functions could lead step by step to central planning to meet the needs of each district and the expenses could be apportioned according to the use each district made of available resources.

The next logical step would be to explore the possibilities of additional savings through central purchasing. Another step would be the temporary employment of a consultant in management to study procedures in all districts and make recommendations to the respective managers for improvement in the districts. Also such a person could make recommendations to facilitate cooperative efforts. Eventually such procedures could lead to a staff of professional people serving mosquito control in all of Utah.

We do have an obligation to provide the best mosquito control possible. We are also obligated to use control procedures which have minimal adverse effects on other aspects of the environment. Meeting our responsibilities in these areas requires that we employ more highly trained professional people than we have today. Our responsibilities and obligations can be ignored but to ignore them is to expose the people to undue expense and unwarranted damage to our environment.

LIABILITY AND INSURANCE PROBLEMS OF MOSQUITO ABATEMENT DISTRICTS

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SUMMARY

Attention was given to all of the various types of insurance protection; however, due to the lack of time only the highlights were covered.

Most of the time was spent covering the various types of liability protection necessary for the districts. Consideration of the auto portion of the policy was given. A discussion followed of driver ability, the relationship of the driver's record with regard to citations and accidents, and the underwriting necessary to properly insure the district with sufficient limits. Claims were discussed and two of the large claims presently outstanding were considered.

The business portion of the liability policy was outlined and the members of the districts were able to discuss both the coverages and claims. Due to a recent change in the law, all districts should now have their own liability policy with limits high enough to protect them in the event of a claim. Consideration of agent and company were discussed and the members were given an outline of what to look for when making appointment of both the agent and the company.

Mention was made regarding the property insurance, that is, insurance for fire protection on the buildings and contents.

It was noted that Utah has a good record regarding insurance claims and that the management of the Utah districts stand out as leaders in their field.