PROCEEDINGS
of the
FORTIETH ANNUAL MEETING

of the
UTAH MOSQUITO ABATEMENT ASSOCIATION

held at the
Yarrow Hotel and Conference Center
Park City, Utah

September 27 - 29, 1987

Edited by
SAMMIE DICKSON
and
ROBERT E. ELBEL

UTAH MOSQUITO ABATEMENT ASSOCIATION

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UTAH MOSQUITO ABATEMENT ASSOCIATION COMMITTEES - 1987

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RESOLUTIONS

WHEREAS, the Utah Mosquito Abatement Association has held its 40th Annual Meeting at Yarrow Hotel & Conference Center, Park City, Utah, September 28, 29, 1987 and

WHEREAS, Emery County Mosquito Abatement District, James Nielsen, Manager, has served as the host organization and

WHEREAS, the Arrangement and Program Committees have done an outstanding job,

THEREFORE, be it resolved that members of the UMAA extend sincere appreciation to the Emery County Mosquito Abatement District and all others concerned with the preparation and arrangements for this excellent convention.

WHEREAS, the papers presented by the speakers have been of high quality with much valuable information for those in attendance and

WHEREAS, many of the speakers came considerable distances to participate in these meetings,

THEREFORE, be it resolved that the Association extend its appreciation to all speakers and give special thanks to those who came from out of state including Dr. George Craig, President, American Mosquito Control Association and

WHEREAS, the West Central Mosquito and Vector Control Association has met jointly with the Utah Mosquito Abatement Association in this Convention and

WHEREAS, the officers and members of the West Central Mosquito and Vector Control Association have made significant contributions to the success of the Convention,

THEREFORE, be it resolved that members of the Utah Mosquito Abatement Association express appreciation to the members of the West Central Mosquito and Vector Control Association for their participation in this Convention.

WHEREAS, Yarrow Hotel & Conference Center has provided excellent facilities and services and

WHEREAS, the banquet was of excellent quality,

THEREFORE, be it resolved that the Utah Association express appreciation to the personnel of Yarrow Hotel who contributed greatly to the success of these meetings.

WHEREAS, the Contributing Members have provided contributions and interesting displays of their products,

THEREFORE, be it resolved that the Utah Association extend its appreciation to these organizations for the support and services they have provided to further mosquito control throughout the State.

WHEREAS, Glen C. Collett has been selected to be the recipient of the first annual Don M. Rees Award and

WHEREAS, the Board of Directors of the Utah Mosquito Abatement Association recognize the outstanding contribution Glen C. Collett has made to mosquito control both within the State of Utah and nationally,

THEREFORE, be it resolved that the Board of Directors of the Utah Mosquito Abatement Association extend its congratulations to Mr. Collett on being named to received this prestigious award.

RESOLUTIONS COMMITTEE

Rex Passey (Chairman)
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TABLE OF CONTENTS

Dr. Don Merrill Rees Memorial Award

This award was created in 1987 by the Utah Mosquito Abatement Association to acknowledge exceptional contributions to mosquito control in Utah. The award honors ***Dr. Don Merrill Rees, 1901 - 1976,*** who was often referred to as the 'Father of Mosquito Abatement in Utah'. Dr. Rees was directly responsible for the establishment of the Utah Mosquito Abatement Association in 1948, and served as its president from 1948-51, and again during 1974-75. His influence, knowledge and leadership were instrumental in maintaining the splendid cooperation between abatement districts and other state agencies directly or indirectly concerned with the affects of mosquito control. He was elected an Honorary Member in the UMAA in 1970.

Dr. Rees served as field supervisor for the Salt Lake City Mosquito Abatement District 1930 - 1935. In 1938 he was appointed to the Board of Trustees of that same district and served until his dealth. Nationally, he was one of the organizers of the American Mosquito Control Association and served as its president in 1952.

In 1926, Dr. Rees earned his B.S. degree and in 1929 an M.S. degree both from the University of Utah. He left Utah briefly to earn a Ph.D. in 1937 from Stanford University. As a professor at the University of Utah Dr. Rees authored over 200 scientific publications and produced almost 100 graduate students with M.S. or Ph.D. degrees in entomology. Four of these students went on to become president of the American Mosquito Control Association.

The recipient of the first Dr. Don Merrill Rees Memorial Award is ***Glen C. Collett***. Glen began his mosquito career in 1948 as a seasonal employee at the Salt Lake City Mosquito Abatement District while attending college. He received his B.S. degree in Biology in 1949, and an M.S. degree in entomology in 1951 both from the University of Utah. Dr. Rees served as the chairman of his thesis committee.

In 1951 Glen moved to California and worked as the entomologist for the Tulare Mosquito Abatement District. The following two years he served in the U.S. Army assigned in Korea with a preventative medicine unit. There he made mosquito surveys and identifications.

By 1954 Glen was back in Utah working as the field supervisor for the Salt Lake City Mosquito Abatement District. Glen worked as manager/entomologist of that district from 1955 until his retirement on Dec. 15, 1987. He served as the Utah Mosquito Abatement Associations president in 1962, and the president of the American Mosquito Control Association in 1972.

Having been a student of Dr. Don Merrill Rees, and having spent 40 years working in and promoting mosquito control in Utah it is only fitting that Glen C. Collett receive this award.

AN ADMINISTRATIVE AND OPERATIONAL REVIEW OF MOSQUITO CONTROL ACTIVITIES IN CALIFORNIA

CHARLES P. HANSEN

San Mateo County
Mosquito Abatement District
Burlingame, CA 94010

I am pleased to participate in this joint meeting between the Utah Mosquito Abatement Association and the West Central Mosquito and Vector Control Association. As President of the California Mosquito and Vector Control Association (CMVCA), I was asked to present an overview of what is currently happening in California. The information presented today will be a representative sample of how the CMVCA is molding its future for the 21st century and indicate the pace at which we are moving to achieve that goal. I have elected to divide my remarks into basic areas, administrative and operational. Within these areas I shall present only the highlights and the priorities upon which our Association currently finds itself expending most of its efforts.

CENTRAL OFFICE

The central office functions with a full-time secretary and a part-time Executive Director who oversees the affairs of that office and hires part-time help as needed. However, the great strength of our Association lies in an extensive committee structure upon which we have relied for many years. Examples of this dedicated service will be presented later in the presentation.

ADMINISTRATIVE

The CMVCA has been steadily professionalizing some of its activities over the past few years. The time has passed when we can realistically expect to maintain the status of a professional organization without soliciting professional services. No longer can all of the complex business affairs of the CMVCA be exclusively conducted by the volunteer assistance of managers, district staffs, etc. The complex world in which we labor and the decisions confronting us daily can no longer be resolved without seeking professional expertise and guidance.

Let me briefly describe a few of those areas.

Insurance - Everyone understands the problems faced in this area. The CMVCA formed a Vector Control Joint Powers Agency (VCJPA) approximately 8 years ago. Presently, there are 38 member districts. Changes have been made along the way to improve both the scope and breadth of the professional information vital for the continued success of the program. We recently put in place a Pooled Worker's Compensation Program and are now dealing with the more difficult area of General Liability Insurance.

Auditing - The CMVCA has set up more sophisticated internal accouting controls designed to help safeguard the assets of our organization and to promote the recording and reporting of transactions in a manner consistant with Board of Director's policies. The timing and implementation coincide with that of the AMCA - the reason for which most of you already know.

Legislative Advocate - The CMVCA's legislative needs are mounting. No longer is it possible or, in my opinion, advisable to first identify and then attempt to follow all legislative bills which may effect vector control with our Legislative Committee membership. We utilized the California Special District Association lobbyist for a few years but realized we required more direct representation on vector control-related issues. Therefore, we entered into a contract with a legislative advocacy firm, January 1, 1987, for the following services:

- representation in the State Capitol with respect to CMVCA's 1987 California legislative program.
- identify, review and monitor legislation affecting the CMVCA.
- legislative reporting services as may be required by the CMVCA.
- participation and attendance at board meetings and the conference.
- preparation, execution and filing of all reports required by the Political Reform Act of 1974.

For these services, CMVCA pays a $5,000 annual fee. Is it worth it? We are extremely pleased with the move to our advocate and the results achieved. Once again problems requiring professional expertise, handled by a professional in that field, have freed the committee structure to concentrate in areas where their expertise is requisite. The next obvious step was Legal Counsel.

Legal Counsel - The Association sought legal counsel in 2 areas: on matters pertaining to the administrative function of the Association and in the provision of information of general legal interest to the corporate membership. Examples of the administrative function would be the preparation and/or approval of contracts, the review of minutes, tax forms and the annual audit, bylaw review, minor research projects, legal opinions and such correspondence as necessary pertaining to the routine business of the Association. The provision of general information would include the effects of recent legislation and court cases upon district operations, review of general personnel policies, etc. Most member districts retain legal counsel locally but there was a real need for model resolutions and standardized procedures and policies available to the membership. Based on these criteria the CMVCA submitted a letter and request for proposals. And, effective January 1, 1988, we will have legal services available to the Association.

Conclusion - That covers the administrative procedures the Association has implemented to further the CMVCA's ability to confidently move into the next century. Now I would like to spend the balance of my time talking about some operational and technical activities you may find of interest.

OPERATIONAL

The CMVCA is very pleased to be the organization entrusted by Dr. William C. Reeves to print and publish his second monograph on the arboviral encephalitidies. We will also reprint his first volume titled "Epidemiology of the Arthropod Borne Viral and Encephalitides in Kern County, California 1943 - 1953". This two set volume will be available for purchase by agencies when printed. As you are aware, Bill is now an emeritus professor. A symposium held in Berkeley in his honor was an enormous success and the CMVCA has a three video-tape set for sale for those wishing to purchase it. Also in Bill's honor, we will be awarding a $1,000 prize for the best paper delivered at our conference by a graduate researcher other than a principal researcher.

We are in the process of having both our training manual "Field Guide to Common Mosquitoes of California" and "Fishes in California Mosquito Control" revised. In addition we are now publishing "Vector News", a newsletter which contains current information relative to mosquito and vector control events, trustee activities and other pertinent subjects. It has been favorably received by our membership.

COMMITTEE ACTIVITIES

Entomology and Biological Control - These committees are concentrating on revising the manuals mentioned earlier. In addition the Entomology Committee organized an Arbovirus Seminar/Workshop that was well attended and deemed a success both scientifically and financially. The seminar focused on the detection, prevention and control of SLE and included lecture, laboratory and field work.

Research - University Research has a very high priority. The Association must develop and promote the necessary background information and rationale to convince our State Legislature that we have an urgent need to have the research funds increased before a technological crisis in vector control is reached.

Continuing Education - At the board meeting in January, the Board of Directors of CMVCA approved a statewide continuing education program with the goal of maintaining a high standard of competence in mosquito and vector control workers in California. In essence the program requires that holders of Mosquito Control Certificates issued by the California Department of Health Services complete a minimum of 26 hours of approved continuing education in pesticide use, safety, application and related subjects. Current mosquito biology and control, as well as information on other aquatic invertebrates, is also required. Eight of the 26 hours may be in-service training provided at the district or agency-level in subjects such as superivision, general safety, first aid, or other similar subjects. The 26 hours must be completed every 2 years. Holders of Terrestrial Invertebrate Vector Control Certificates must complete an additional 6 hours of training and holders of Vertebrate Vector Control Certificates an additional 8 hours as outlined in the Continuing Education Program Curriculum.

Environmental & Liaison - This committee has been untiringly working on EPA's implementation of pesticide labeling to protect endangered species. The CMVCA is very concerned by the plan developed by EPA and has communicated those concerns by means of a white paper setting forth the Association's position. EPA has invited our Association to assist in developing criteria appropriate for a public health exemption to insure the protection of the public through effective vector control. AMCA has also been requested to address this same issue. In my opinion, every state association whose membership provides vector control services to protect the public health should be concerned about the Act and actively work towards resolving the conflicts it will create with vector control programs. Mosquito control agencies in California as well as Utah support the protection of endangered species and, in fact, have modified operations to preserve endangered species in their jurisdictions. In some cases, the activities and resources of mosquito control agencies have been effectively utilized to improve the habitats of endangered species. California is moving forward on this issue and would appreciate the support and help of all vector control associations to help resolve this conflict.

Who Expert - Gilbert L. Challet, Manager of the Orange County Vector Control District, has been asked by the Director-General of the World Health Organization to serve as a member of the WHO Expert Advisory Panel on Vector Biology and Control. The stated purpose of his appointment is to, ". . . give the organization the benefit of his knowledge and to inform it of important developments in their own subjects, particularly in the countries in which they are working". Mr. Challet will attend his first committee meeting in Geneva, Switzerland, September 15 - 21, 1987.

CONCLUSION:

That is a very quick overview of CMVCA's activities, although I have not mentioned mosquito control activities per se. As the President of the CMVCA, I extend a cordial invitation to all of you to join us in San Mateo, California on January 28 - 31, 1988, for our annual conference where those activities will be reported, including a review of any disease activity for the year.

THE UNIVERSITY OF CALIFORNIA RESEARCH PROGRAM

BRUCE F. ELDRIDGE

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The University-wide Mosquito Research Program of the University of California emerged in its present form in 1972 with the appropriation of $300,000 by the State Legislature for mosquito control research. The goals of the program were then, as they are now, to conduct research in support of mosquito abatement operations in California, especially research leading to the replacement of conventional pesticides by other methods of control. Over the years the program has been very successful and University of California researchers have been prominent in the development of mosquito abatement strategies using bacterial insecticides, mosquito pathogens and predators, insect-specific agents such as methoprene and larvicidal oils and habitat modification. Considerable research has also been conducted on diseases transmitted by mosquitoes, including St. Louis and Western equine encephalitis, and malaria.

Mosquito-borne virus diseases and malaria continue to be significant public health problems in California. Human cases of encephalitis occurred in various areas of the state. There were 3 human cases of St. Louis encephalitis and 2 human cases of western equine encephalomyelitis. There were no cases of encephalitis caused by California serogroup viruses. There were 31 cases of malaria, presumably locally transmitted, in California in 1986. Most of these cases were associated with a single outbreak in San Diego county but there were 2 small outbreaks in the Sacramento Valley as well. In 1987 there have been no human virus cases diagnosed to date but isolation of WEE viruses from *C. tarsalis* mosquitoes in the Sacramento Valley are at a higher rate than they have been for many years. The continued presence of these mosquito-borne pathogens in the state serves as a continual warning that mosquito abatement activities in the state cannot be slackened.

At the same time, other factors make mosquito abatement in the state ever more challenging. In 1986 legislation was passed by referendum which has the potential of restricting the use of mosquito larvicides. This act is called the Safe Drinking Water and Enforcement Act of 1986 or popularly, Proposition 65. In summary it says that any one of a number of toxic substances so designated by the Governor may not be placed in any water which comprises part of the drinking water supply. The act has not as yet been implemented into law and a number of state agencies are struggling with the implications of the act. It is impossible to tell at this point just what effect if any, it will have on mosquito abatement in the state. Since California's mosquito abatement program is heavily dependent upon larviciding, we are watching activities associated with the bill with great interest.

These challenges to mosquito abatement programs on the one hand, with a demonstration of continued need for strong abatement on the other, suggest clear goals for research on new methods of mosquito control, especially methods which do not call for the use of conventional pesticides.

RESEARCH PROGRAMS

Ecology of mosquito-borne virus diseases.

Traditionally, mosquito-borne encephalitides in California have been rural diseases. Consequently, research conducted over the last 3 decades has been in predominantly rural areas and much of what we know about the ecology of St. Louis encephalitis and western equine encephalomyelitis is based on rural/agricultural ecosystems. In 1984 there were 26 cases of SLE, all in suburban areas of southern California. With these cases, came the realization that much of what we know about the ecology of SLE and WEE from rural areas did not apply. This year a team of scientists under the direction of Dr. James Hardy is conducting detailed studies of mosquito-borne virus diseases in Orange and Los Angeles counties. This research involves intensive studies of 9-block areas surrounding sites of human SLE cases. This work is being done by Dr. William Reisen and Dr. Richard Meyer of UC working in close cooperation with mosquito abatement districts in that area. Considerable information has been gathered to date on breeding sites of *Culex quinquefasciatus, Culex pipiens, Culex peus,* and *Culex erythrothorax* in urban habitats as well as SLE and WEE infection rates in feral and domestic birds, biting habits of mosquitoes, flight range of mosquitoes nad other epidemiologically relevant factors. Studies are also ongoing in a broad area from the California-Arizona border in the vicinity of Yuma, Arizona and up into the Coachella Valley to study the movement of viruses during the winter.

In an entirely different setting we are beginning to study viruses belonging to the California and Bunyamwera serogroups. In mountainous areas, these viruses are probably transmitted by snow pool *Aedes* mosquitoes and we are particularly concerned about the possibility for human involvement in areas of high human density. In the last decade, California has had spectacular growth in mountainous areas where preliminary screening has shown high prevalence in deer of 2 viruses, Jamestown Canyon in the California serogroup and Northway in the Bunyamwera serogroup. We hope to expand this study to determine the prevalence of antibodies to these viruses in human hosts in the areas and to also study potential vectors.

Disease Surveillance.

Intensive disease surveilance has been a cornerstone of the overall mosquito abatement effort in California for many years. In conjunction with CDC in Fort Collins, Dr. Hardy and his colleagues at the School of Public Health in

Berkeley are continuing their research to develope improved methods of detecting virus in mosquitoes and antibodies in sentinel animals. This research is essential for improved turnaround time of testing as well as expansion of the surveillance program to include more areas. It is imperative that cost effectiveness and reliability be maintained at very high levels for surveillance to continue to be an effective tool in protection of people from these diseases.

Biological Control.

Research on parasites and predators of mosquitoes continues to be the number one priority for the Mosquito Research Program. I will mention briefly highlights of some of the programs that are ongoing in the state.

Bti. UC Researchers, Brian Federici, Sarjeet Gill, Dick Garcia, Mir Mulla and Bob Washino, are studying Bti on a broad front with research projects ranging from molecular studies of toxins, mode of action in whole insects and cell culture, ecological studies to determine the fate of the Bti toxin in nature and testing of new formulations alone and in combination with other mosquito control agents.

Bacillus sphaericus. Dr. Paul Baumann at Davis has been making excellent progress in understanding the specific protein toxins of *B. sphaericus.* He has cloned the larvicidal protein gene which should permit application of genetic engineering techniques to *B. sphaericus* production and improvement.

Lagenidium giganteum. Research on this fungal parasite of mosquitoes has been carried out for several years in the laboratory of Dr. Bob Washino of UC Davis. Recent research has emphasized methods of mass production of the asexual stage for operational field control of mosquito larvae. Fermentation media have been developed which contain sterols and unsaturated fatty acids which will reliably produce asexually competent fungal cells in large enough quantities to permit practical application. A number of safety tests have been completed using protocals developed by EPA for acute and chronic toxicity to vertebrates as well as enviromental safety. Aerial application trials are continuing this year to supplement tests carried out last year which showed excellent promise for practical application of this fungal parasite. *L. giganteum* in California has been far more effective against anopheline and culicine mosquitoes than *Aedes* mosquitoes. An exciting event, therefore, was the isolation this year of a new strain of *L. giganteum* that is many-fold more infectious for *Aedes* mosquitoes than exisiting strains.

Lambornella clarki. Research is continuing by Dr. John Anderson and colleagues on this interesting parasite of treehole *Aedes* in California. Recent studies have emphasized greater understanding of the life cycle of this pathegon and improvements of methods of mass production, storage and field release. In general, control strategies that are effective against treehole-breeding mosquitoes are relatively unsatisfactory and interest is therefore high for this parasite. Current research is being conducted to determine if the parasite will infect other species of treehole *Aedes* including *A. albopictus.*

Mosquitofish. Mosquitofish continue to be one of the most widely used and effective biological control agents of mosquitoes in California. Dr. Joe Cech of Davis is studying the effects of photoperiod on reproduction *Gambusia affinis* to determine if mass production can be improved. This continues to be one of the bars to the more widespread use of mosquitofish in biological control. David Reznik (UC Riverside) is studying the relationship between body fat in fish and their survival over winter and the evaluation of other species of fish which can be used in polluted environments.

Other parasites and predators. Researchers are always looking for new parasites and predators of mosquitoes. Two organisms which have been little studied in the past include tadpole shrimp and *Agabus* beetles.

Mosquito Ecology.

Rice field mosquito ecology. Both white rice and wild rice continue to be important components of agriculture in the state of California. Unfortunately, both are often associated with large numbers of mosquitoes. Research efforts continue on studying the basic ecology of rice fields and the relationship of different kinds of management practices to mosquito production. As the number of acres increases in wild rice, research efforts are shifting to this completely different type of rice ecosystem.

Freshwater marsh ecology. The use of freshwater marshes in the state of California for a variety of purposes is expanding significantly. Many of these marshes exist in areas of high human population density. Many of them are associated with species of organisms which are on the endangered species list. As the appreciation for freshwater marshes as multi-use enterprises increases, so the potential problems associated with the mosquito breeding increase. Dr. Vincent Resh (UC Berkeley) has been studying the ecology of these marshes for some time in an attempt to describe the diversity of the biota as well as the diversity of management and uses of the marshes in terms of mosquito breeding. He and his students have completed a classic study on the interrelationships between crayfish and mosquito breeding in marshes in Alameda County. Similar studies are being conducted in Orange County at Irvine.

Wastewater marsh ecology. Sanitary engineers and other wastewater specialists continue to promote the use of aquatic vegetation as a means of treating secondary-treated sewage for small communities. Because such technology promises great savings in manpower, pilot plants have been constructed in several areas of California. Because of mosquito problems, however, only 3 plants continue in operation. Up to now, no strategy has been developed which is compatible with the use of these wastwater marshes for sewage treatment on the one hand and effective control of mosquitoes on the other. Part of the problem is insufficient knowledge of the basic ecology of the system. Dr. Mir Mulla at Riverside and others continue to study the interrelationship between mosquitoes and other organisms present in these wastewater marshes.

Chemical control.

Although research on conventional mosquito control chemicals represents a relatively small component of the overall Mosquito Research Program, the realization that use of conventional chemicals remain the most important form of direct mosquito intervention plus the relative shortage of new chemicals means that new research in this area must continue. Most of the research on new agents involves specialized chemicals such as the mosquito growth regulators plus improved formulations and methods of application of existing pesticides. Research on insecticide resistance management techniques remains an important goal of the program. Dr. George Georghiou of UC Riverside and Dr. Charles Taylor of UCLA are presently working on a decision support system involving principles of artificial intelligence for implementing principles of insecticide resistance management on the local level.

FUTURE GOALS FOR RESEARCH

Biological control of mosquitoes, the public health importance of mosquitoes and the ecology of mosquitoes in relation to the enviroment remain the 3 most important components of the Mosquito Research Program. We feel that it is essential to have a broad array of biological control strategies under evaluation running the gamut from pioneering studies of new agents previously unevaluated for mosquito control to agents like *Lagenidium giganteum* which are nearly ready for EPA registration. In the area of public health, disease surveillance and detailed studies in the epidemiology of mosquito-borne agents in a number of environments in California will continue. Finally, although chemical control procedures represent a small component on the mosquito research effort, we must continue research on the more effective use of existing chemicals, especially in a way which minimizes insecticide resistance.

MOSQUITO CONTROL IN CAPE MAY COUNTY, NEW JERSEY 1915 - 1987

JUDY HANSEN

Cape May County Mosquito Commission
Cape May Court House, NJ 08210

It is a pleasure to be in Utah again discussing mosquito control in Cape May County. Our terrain is quite a bit different than yours since our highest elevation is the 15 foot man-made overpasses on the Garden State Parkway. We are the tip end of the famous Jersey Shore or perhaps out West it is not so famous. We have 60 miles of beaches, boardwalks, recreational parks and campgrounds. A recent addition of casino gambling in Atlantic City, about 10 miles north of our border, has created an influx of new residents in the county with spin-off casino-related or casino-service businesses.

I am getting ahead of myself. This is 1987. Let me begin by giving you a history of mosquito control in New Jersey and how Cape May County relates.

Serious thought was given to the mosquito problem in New Jersey previous to the turn of the century. In 1900 Dr. John B. Smith secured from the Director of the New Jersey Agricultural Experiment Station a small sum of money for a preliminary investigation. Dr. Smith contacted the State Board of Health and was assured of their support in his efforts to effect mosquito control measures.

In 1903 the legislature provided funds for this work. With the necessary funds in hand, Dr. Smith planned and carried out a very careful study of the structural characters, life history, habitat and methods of controlling the principal species. He proved for the first time that salt marsh bred species migrated for long distances over the upland, reaching points more than 30 miles away, in large numbers and infesting seriously more than ½ of the State's land surface and annoying very seriously nearly ¾ of the population.

As a result of this study the State Legislature was induced to pass an act in 1905 providing for State aid to communities that cared to spend their own funds in salt marsh drainage for mosquito control.

On July 17, 1903, a meeting was held at the Newark Board of Health in Newark, New Jersey. A temporary organization with a view of making it permanent was formed and a Legislative Committee appointed. The Committee drew up a bill which was presented as the Duffield Act, Chapter #119, Laws of 1904, which was passed by the Legislature and is now a law and part of the General Health Act. This was an important milestone in the progress of mosquito work.

Since 1906 the New Jersey Agricultural Experiment Station was steadily engaged in installing as large an amount of salt marsh drainage as funds, which the legislature saw fit to appropriate annually, would permit. The various local campaigns were steadily continued and extended. All this work in the year 1912 crystallized in the form of a bill which passed the Legislature and became a law under the Title of Chapter 104, Laws of 1912. This act was known as the County Mosquito Extermination Commission Law and provided for the appointment of a non-paid mosquito Commission in every county in the State. The duty of this Commission was to formulate plans, secure funds, build and operate an organization for the suppression of the mosquito pest.

Under the provisions of this law the New Jersey Agricultural Experiment Station was designated as the centralizing and general directing agency. The County Commission is the main operating body but the plans and estimate reviews, surveys, guidance and research is part of the State Experiment Station and plays an important part of Mosquito Control in the State.

The New Jersey Mosquito Extermination Association, now New Jersey Mosquito Control Association, Inc., a state wide society, organized for the special purpose of furthering anti-mosquito work in the State in all phases, was formed in the year 1913 by representatives of the County Mosquito Commission, the State Agricultural Experiment Station and certain interested private citizens.

In 1956 the State Mosquito Control Commission was formed and consisted of 10 members: 4 from the New Jersey Agricultural Experiment Station, the Department of Health, Department of Agriculture, the Department of Environmental Protection and 6 citizens appointed by the governor. Recently, an office was created in the Department of Environmental Protection entitled the Office of Mosquito Control Coordination. This office is responsible for coordinating activities between all agencies of the county, state and municipal governments and the State Mosquito Control Commission. There is also an Association of Superintendents, Ass't Superintendents and professional entomologists and biologists entitled Associated Executives of Mosquito Control Work in New Jersey which has become a strong and powerful factor in forwarding mosquito control efforts.

Since you are properly confused with all these organizations, let's talk about the County Commissions. There are 21 counties in New Jersey of which 20 have mosquito control commissions or agencies. The Cape May County Mosquito Commission became involved in mosquito work in 1913. Reviewing old minutes and records of the Commission reveals that the concern of the time was malaria. There had been outbreaks of yellow fever in Philadelphia immediately across the Delaware River from us, malaria in the county and people increasingly wished to be relieved of the mosquito nuisance and threat of disease. The seashore desperately needed to improve its economy. At that time, vector-borne disease was a new idea. You could perhaps compare the fears of the people in the early 1900's when diseases such as malaria and yellow fever took so many lives with the fears of the unknown causes of the disease AIDS. I do not mean to imply that mosquitoes transmit AIDS because all indicators seem to say they do not but only to compare the fears of disease at the turn of the century with the fears of AIDS today. It was in this atmosphere that the Cape May County Board of Chosen Freeholders (the County governing body) agreed to fund a newly created autonomous Commission created and mandated by State Law in 1906 and 1912 giving power to mosquito extermination commissions in New Jersey. The most important part of the law read: "The Commission shall constitute a body politic, with power: A. To sue and be sued B. To use a common seal C. To make by-laws and D. To perform all acts which in its opinion may be necessary for the elimination of mosquito breeding areas or which will tend to exterminate mosquitoes within the county." Additionally, the Commission has all the powers of a local Board of Health, creates mosquito extermination on a state level and generally is one of the most powerful mosquito laws in the nation. There have been many attempts to supersede this law, by litigation which failed, and more recently by additional laws and regulations.

Our lives have been complicated by permitting processes but it has not been possible to stop mosquito control in the state, merely to slow it down.

On Friday October 15, 1915, at 3 PM in the Bellevue Hotel in Cape May Court House the first meeting of the Cape May County Mosquito Extermination Commission was held with 4 members present and 2 absent. The members were appointed to the Board by the Justice of the Supreme Court of New Jersey until 1948 when the law was changed giving the County Board of Freeholders the power to make appointments and in 1971 requiring a member of the Freeholder Board to be a Commissioner. The first order of business at that first 1915 meeting was that the Secretary advise Dr. J. T. Headlee, State Entomologist that the Commission was now organized and awaited his advisement to proceed to work. Throughout the winter, meetings continued until the meeting on April 29, 1916 the Treasurer reported a balance on hand $19.94. Finally on May 13, 1916 the Commission received its first appropriation in the amount of $10,000.00 and "moved immediately to hire a foreman and such laborers as necessary to carry out the work of trenching on the salt marsh. The foreman was deemed to be paid not more than $3.50 per day and the laborers not more than $2.25 per day." Many resolutions were received by the Board of Freeholders and the Commission at this time from organizations such as the Cape May County Chamber of Commerce and the Cape May County Board of Trade. A quotation from one, "therefore be it resolved that the Cape May County Board of Trade hereby call the attention of the County Mosquito Extermination to the law and urge that it shall proceed with all possible dispatch to have prepared plans estimates as before recited and have the same presented in the proper manner to the Board of Freeholders of this County, and to demand and insist on receiving from them the appropriation as provided for in the Law of 1912 and to pledge to said Commission that this Board of Trade will assist in every possible way in the prosecution of this work, believing as it does that the presence of the mosquito in its present numbers is the greatest menace now existing to the success of the seaside resorts of the county and in the success of which the prosperity of the county so largely depends." The county's year round population at the turn of the century was 14,000. It is now approaching 100,000.

Mosquito control in new Jersey in 1916 consisted of ditching (parallel grid ditches), installing tide gates on sluices, blocking the area to tides and oiling the mosquito breeding areas of the marsh and upland sites. Most work concentrated on the salt marsh as monies were not available for upland control. The 1930 budget saw an increase to $25,000.00 with 16 employees: a chief inspector, a foreman, a machinist and 13 laborers. In the 1940's the budget decreased to $12,500.00 during World War II. In August 1945 the Commission approved the purchase of a DDT fog expelling machine equipped with the latest devices. DDT was first used in the County in 1946. Budgets continued to be small but slowly began to increase in the 1950's. In August 1959, New Jersey and Cape May County, in particular, experienced an outbreak of Eastern Equine Encephalitis with many horse deaths and 6 human deaths in the County itself. New Jersey had a total of 33 human cases that year. The seaside resorts emptied as people panicked after the news media published news of the outbreak and all of a sudden budgets increased. The 1961 budget was $123,000.00 with additional State Aid available in the form of the State Airspray Program. In 1974 my first full year as superintendent of the commission, our budget was $360,000.00. The 1987 budget for mosquito control in Cape May County was $1,004,000.00 with an additional $250,000.00 appropriated under the capital budget for building a new office-laboratory complex. We expect an increase again in 1988.

Mosquito Control in the County has progressed over the years. DDT was last used in 1960 in the county. A sophisticated surveillance program has been ongoing updated each year. Many years of back data are available and are in the process of being computerized. Viral sampling, bird bleeding with sentinal flocks, CDC traps, New Jersey light traps, landing rates and pigeon traps are all part of our program.

Larviciding is extensive. In 1983 the Commission purchased 2 Hiller Helicopters and our larviciding and surveillance efforts became timely and selective. We have the capability of adulticiding both by air and ground whenever necessary and additionally, have use of the State Airspray program when broods become more than we can handle which helps us financially as the State pays the bill. We have larviciding crews that follow pre-assigned routes throughout the County treating breeding areas once a week with inspections preceeding and following treatments. Complaints are solicited and a personal contact is made each time a person calls. We have educational programs in place with all the schools in the county. With our new laboratory and office facilities expected to be available in May 1988, we will have classes and educational sessions in our offices in conjunction with schools and civic groups. Incidentally, our new building complex of 8,400 square feet is being completely constructed by our own employees, with the $250,000.00 for materials and furnishings. Our employees are willing and versatile. When it is completed, they will have much of which to be proud.

Our Commissioners faithfully attend meetings and many in-house and experiment station sponsored training sessions throughout the year.

The Commission Entomologist conducts experiments with pesticide usage, viral sampling and works in conjunction with the Mosquito Research and Control Unit on the Vector Surveillance Program. All spray equipment in the county is inspected by our mechanics and calibrated by our entomologist before the Department of Enviornmental Protection will grant a permit to spray. We also must give advice on the proper use of pesticides.

Water Management and especially OMWM is an ongoing program. We have two rotary ditchers, one smalley excavator and rotary ditcher, a John Deere backhoe and an amphibious dragline. We have 53,000 acres of salt marsh in Cape May County and 10,000 acres of fresh water marsh. We are surrounded by water, the Atlantic Ocean and its marshes on the East and the Delaware Bay and its expansive marshes on the West. The permitting process has been difficult at times but we have built a rapport with the Corps of Engineers in the Philadelphia District and the Department of Environmental Protection in Trenton. The Office of the Mosquito Control Coordinator helps greatly with these permits when problems occur and keeps us abreast of proposed regulations in order that we may have input before they become reality.

Cape May County's economy is 90% tourism and 10% fishing. We must take great care with the environment because the environment is the reason people come to the county. The resorts have extended seasons and in the case of Cape May City, year-round tourism. If you have ever been in New Jersey in the corridors between New York and Philadelphia, especially along the New Jersey Turnpike, you probably see toxic waste dumps, oil refineries and chemical factories. South Jersey and especially Cape May County is not like that. It is a nice place to live as many new people are discovering. We now have to direct mosquito control efforts to uplands, as well as salt marsh, as people have moved into mosquito habitat. Our County has 48 campgrounds on the mainland and 10 large seaside resorts on the east coast. Our County is relatively clean. We police ourselves harshly. Past practices of illegal dumping are dealt with harshly. Litter laws and fines are high. Mosquito Control has kept pace with the growth in the County because we have made ourselves visible and available. We are a service oriented organization and in order to do our job we must serve the people. We let people know what we do, why we do it, and at times why we can't do it. For instance, we monitor all tidal streams for oxygen content and when oxygen is low, we do not use chemical near a stream. In the past, we had been blamed for fishkills that had been caused by low oxygen. Originally in the early 1960's there was a fishkill that could have been caused by our spraying. We have overcome this bad image by being diligent and letting people know we do not spray when oxygen is low in the streams.

OVERVIEW OF THE LARVICIDE PROGRAM OF THE ST. TAMMANY PARISH MOSQUITO ABATEMENT DISTRICT NO. 2

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St. Tammany Parish is located in the southeast part of Louisiana on the north shore of Lake Ponchartrain. The District headquarters is located about 30 miles north of New Orleans.

The District land area comprises approximately 250 square miles and within it there are four basic types of breeding areas. On the eastern side, one major breeding type is in association with the Pearl River basin which is considered to have the third largest swamp area in the United States.

The second breeding type is an upland/wooded area which is primarily pine forest mixed with hardwood. Scattered throughout the area are many housing developments and over the past 10 years, this mosquito breeding type has increased in significance because of increased housing developments within wooded areas. Scattered throughout these wooded areas are sloughs, creek beds and natural swales; as a result, we get quite a variety of woodland breeders.

The third mosquito breeding type is approximately 175 miles of roadside ditches which are characteristic of unincorporated areas of the parish where there is no subsurface drainage of waste water. In these areas, residents untilize filter beds and septic tanks for individual waste water treatment. The effluent is discharged to the roadside ditch. This condition of course creates septic and polluted water in the ditches and breeds mainly *Culex quinquefasciatus*.

The fourth breeding type, and by far the most significant one for us, is approximately 50,000 acres of brackish marshland that lies along the southern border of the parish. This area is highly productive for *Cx. salinarius,* our primary pest species, *Aedes sollicitans* and *Anopheles* spp.

Each year for the last 5 years, we have been increasing the scope of our larvicide program which now comprises about 35 - 40% of our total control program. An ongoing part of the program, which has been done for many years, is the treatment of roadside ditches for the control of the southern house mosquito, *Cx. quinquefasciatus*. Extremely large numbers of this mosquito are produced in these areas. Control is accomplished by the use of a right-hand drive-post-office jeep equiped with a CO_2 pressurized system. The procedure is a one man operation. Generally 2 jeeps are operated 4 days per week. The larvicide material used is Vectobac 12AS at an application rate of 3 pints/acre. Since we do not get any residual activity from the *B.t.i.*, retreatment is required approximately every 10 -12 days. The larvicide system is very simple; it is contained in the back of the jeep and is comprised of a 40 gallon water-well tank that is pressurized by CO_2. One 20-lb. tank of CO_2 will last approximately 10 working days.

Treatment of upland and wooded areas is accomplished by the use of ground equipment. These areas produce a variety of floodwater mosquitoes such as *Ae. vexans, Psorophora ferox, Ps. varipes* and *Ae. atlanticus.* We have found that the ground equipment that is most suited for negotiating these areas are 4-wheel drive, all-terrain cycles. Woodland breeding sites can be so extensive that decisions must be made as to what areas are practical to treat. When these areas are breeding, sites are scattered, non-continuous and non-uniform so if a broadcast application is attempted by air, a lot of chemical would be wasted. If one adds up all the scattered swales, pot-holes and creek beds, it amounts to a considerable mosquito problem. The only practical means we have found to larvicide these areas are with the 4-wheelers. All terrain cycles are very good to use in these areas because they are not very labor intensive, they are not a high maintenance item and they are versatile as they can be used for inspection as well as treatment using several types of spray systems. In one case, we have a simple fertilizer spreader mounted on the back of a 4-wheeler that dispenses *B.t.i.* granules. The granules of choice have been Vectobac G, 5/8 mesh at an application rate of 6 lbs./acre. This hopper can hold 25 lbs. of granules and dispense a swath of 40 ft. Backpack sprayers can also be mounted on the back of the 4-wheeler for spot treatments. This method gives one more control with the direction of the granules as opposed to the fertilizer spreader. The disadvantage is that the backpack sprayer can only hold about 10 lbs. of granules so an inspector can treat only 1½ acres before having to refill. This unit can also dispense the granules 25-40 ft. Open fields and vacant lots near populated areas are also a source of floodwater breeding. Many of these areas can be controlled with high volume sprayers mounted in the back of pick-up trucks. This method works well for breeding sites within 200 ft. from a road. These sites are also treated with Vectobac *B.t.i.*.

Larvicide of marsh areas up until about 3 years ago was not even attempted because of the unavailability of suitable equipment and because we felt it would not be practical due to the type of breeding conditions we have. We did not feel that ultra low volume (ULV) or low volume (LV) application would be effective because our marsh produces stands of dense *Spartina*, 3-4 ft. tall. In fact, we attempted ULV and LV application by air on a small scale test against our better judgement just to confirm our feelings. *B.t.i.* was aerially applied at a rate of 8 ounces and one quart/acre. Results indicated no larval reduction. We concluded from this test that if we were to be successful, the most suitable approach appeared to be a granular material in order to penetrate the vegetation. As mentioned earlier, our main pest species is *Cx. salinarius* which breeds in large numbers in the marsh. We wanted to find a method to larvicide this species since their populations are not syncronized; adults emerge each day necessitating repeated aerial adulticide ULV applications. Upon closer inspection, it was observed that *Cx. salinarius* was produced in very high numbers (as many as 10, 20 and 30/dip) only at certain elevations in the marsh. Those areas at a time, followed by removal of some but not all of the water before the cycle is repeated produced large numbers of *Cx. salinarius*. Breeding is directly related to elevation and vegetation. At this point, we had to identify where these high density levels were scattered throughout our 50,000 acres of marsh. We did this a few years ago and found that there were breeding sites of various sizes such as 5, 15, 50 and 100 acres scattered throughout. For the first 2 years, we worked with ground equipment applying *B.t.i.* granules. We wanted to see first how effective ground application and the material would be and if that looked good, we wanted to larvicide those marsh areas that were practical with ground equipment. One type of ground equipment is called a marsh master and is very suitable for negotiating marshland terrain. It has the same type fertilizer spreader as used on the 4-wheeler except that this hopper can hold 60 pounds of granules. The marsh master also produces a swath width of 40 feet and with this method, one is able to treat about 10-12 acres/hour. This system is used primarily in an impounded area of approximately 2,000 acres. This impoundment is an area that was previously marshland but altered when a levee and canal system were constructed to provide drainage in hopes for development of the area. The change occurred in the 1930's and to this day, no development has taken place. There are also some areas where it is practical to use a 4-wheeler with the granular application. Another means we have used to larvicide sections, is by airboat using a home-made liquid larvicide.

It wasn't until 3 years ago that our larvicide program got our last equipment improvement with the capability of aerially applying *B.t.i.* granules. The system is a helicopter sling unit that was developed by Dr. Jim Nelson and his staff at Fort Detrick, Maryland. We bought the application system and we rent the helicopter. We decided to go with a helicopter system because helicopter application seemed to be more suited for our areas since our breeding sites are so scattered, irregular and non-continuous. We would have more control in delivering the material this way than by fixed wing. The hopper can hold 500 lbs. of granules. The operational parameters of the treatment are an airspeed of 40 mph at an altitude of 100 ft. which produces a swath width of 75 ft. We have worked with several types of granular materials and found that the material that works best is 5/8 mesh Vectobac granules. The material is applied at 7 lbs./acre in the marsh. This system has worked well; it is very consistent in distribution of granules and we can safely rely on 95-100% control. This method of application has now become one of our main control strategies since it has reduced the amount of adulticide used; we are now attempting to determine how much it has saved us. We hope that when *Bacillus sphaericus* becomes available, we shall have another tool for *Cx. salinarius* control. *Cx. salinarius* produces at least 10 generations/year, and in some months, especially during the spring and early summer, 2 generations/month.

This gives an idea of some of the things that we do at St. Tammany Parish and I suspect that in the future we shall depend more on our larvicide program.

THE CHALLENGE OF CHANGE

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The people in this room and your contemporaries from all over the United States deal with mosquito control and vector control. Without a doubt, you have the greatest capability of dealing with change of any group of people I know. I'll outline some of the changes you so skillfully cope with. You know one of the challenges of change comes in the form of the change that's in your pocket. This is the money that your public service entities provide you to do the job of vector control and mosquito control. You extract every bit of value from the little bit of change you receive. You are to be commended for that stewardship performance. The real charge you have is to protect the health and the well being of the citizens in the communities you serve. That charge and that challenge is one you have met historically and will continue to meet every day. Let's now look at the challenges we are all trying to deal with together. How many of you expected to confront a newly imported species of mosquito? Such an occurrence likely did not even cross your mind a few years ago. You had plenty of other operational challenges on a day-to-day basis that occupied your every waking moment. Recent references have been made to the fact that there's quite a bit of media discussion relative to AIDS and the mosquitoes' possible involvement in transmission of this disease. Up to this time, we can say, "Thank heavens it isn't true." Let me turn the situation around and give you a real challenge. What if it had been true? What kind of challenging predicament would we have found? What sort of activities would we have to be involved in to cope with that kind of challenge? Who can say we won't be confronted in the future with something similar? The ways you prepare yourself, your control operations and the people working with you to cope with such a challenge are very important.

When you are confronted with the challenges of the Endangered Species Act, new regulations imposed by the Federal Government or by the State Government, etc., how do you choose to respond? There are several ways. One of them is to say, "It's new and I don't like it, as I like doing things the way I am doing them now." Sure, all of us are comfortable with our set patterns and in using things that have worked flawlessly for us for years. Known quantities make our lives very comfortable. That's one reaction. Other people when confronted with these changes respond, "Oh, good, here's something new I can learn." "Here's a new way I can do my job." "Here's a new way I can provide services to my community." How do you confront the changes imposed on you? Do you examine them with an open mind? Do you see what benefits you can get from these changes; or do you choose to hide behind the curtain of resistance? How many times have you thought, "Maybe it will go away if I don't acknowledge this change." I can say almost without exception that you, as a group of mosquito control and vector control specialists, when confronted with these challenges, meet them head on. You examine each of them to see how to best deal with each change. There was a time when most of our effort and energy was concentrated on developing the mosquito control techniques suitable for pest and disease causing species. We did a good job with those entomological and enviromental challenges. However, we find more and more of our efforts, our energy and our attention diverted away from these concerns. Now, we are thrust into areas of legal action, into areas of legal requirements and into an emphasis upon very strict enviromental rules. I will be the first to tell you we cannot afford to avoid giving the required attention to these new challenges. It's more than a little frustrating at times when people from outside our disciplines come into our lives and say, "We're fixing to tell you how to run your business." Many of you here have been involved in mosquito control for more than 30 years and indeed resent such intrusions! I really don't blame you either. The irony of today is that we serve a changed population of people, many of whom have not seen the terrible results of mosquito-borne disease outbreaks you have confronted. They don't know about the possible disease outbreaks you have prevented by virtue of your activities. You were able to confront these disease outbreaks by having an open mind to the challenges they presented and by being willing to change when it was warranted.

Remember this quote, "When these winds of change blow on us, we can't always direct the wind but if we are very careful in what we do and how we observe situations, we can adjust the sails on our craft and get us where we want to go." The real challenge is for us to be able to cope with the changes successfully. Changes occurring in mosquito control can take many forms. Changes are not always better; often, they are just different ways of doing things. Sometimes, we have to undertake different practices or different methodologies to achieve the level of mosquito control we are called upon to provide.

You know for whom we provide mosquito control. We provide it for the individual citizens so they can enjoy their homes and we provide it for the community on an area-wide basis. These places change and our methods of mosquito control practices have to change also. Every now and then, we must go back to one of the traditional means of mosquito control. This one was brought back to us very vividly by virtue of the recent problems of *Aedes albopictus* in tires. One of our time-honored methodologies of mosquito control is known as "Environmental Sanitation." Simply clean the neighborhood! It's not very exciting but the results can be very dramatic. It's also very difficult to do because some of our elected officials would rather you choose an easier way saying, "Let's spray a little bit and cure the problem." You and I know that response is only a temporary cure and not a true solution to the problem.

I want to point out a few more of the challenges you have coped with quite satisfactorily. You are struggling right now to solve the challenge of liability insurance. How are we to pay for it? If we have it, do we invite nuisance lawsuits? Until recently nobody even thought very much about such things. Such thoughts now occupy a major part of your work time. We've mentioned *Aedes albopictus* and

AIDS already and some attention has been directed to the Endangered Species Act. We are confronted with changes in local and state tax structure which provide your operating budgets. Many of the districts represented in this room probably use a computer in some way to support their mosquito control efforts. You have added this tool to your repertoire of control equipment. No thought of it came to you ten years ago; at least not as a useful tool. Today, by contrast, there are many districts which cannot operate without one.

Looking out over this audience, I see a number of very charming ladies here. We are delighted as well as fortunate to have you. Your contribution to mosquito control and to vector control throughout the United States is much greater than that for which you have been given credit. Ladies now serve in all types of jobs. They are directors of mosquito abatement districts. We have ladies serving as commissioners and trustees. We have ladies employed at every level in mosquito control programs. Accepting them was a challenge. It was a change that has occurred and I happen to think it was a very good one for these ladies bring a different perspective to our business of mosquito control.

There are some very personal questions now that I refuse to answer for you but I want you to answer in your own mind's eye. How do you deal with change? How do you personally deal with change in the ways you conduct your business in mosquito control activities? Do you prepare for change or do you just let it happen? When you know change is inevitable, what steps do you take to manage it properly? Again, do you just let it happen or do you prepare your mosquito control workforce for the changes that are going to be imposed upon you? Do you work at reducing resistance to changes and to challenges that you encounter? I'd like for you to look at your own mosquito control program activities. Evaluate the changes you have imposed on yourself and on your control system during the last 5 years. Ask yourself, "Hey, what impact do those changes have on what I do?" You will be absolutely astonished to discover what some of those impacts may have been.

To look at mosquito control over time and some of the changes that have occurred therein, I went back and picked topics from selected editions of *Mosquito News*. I looked through 6 issues covering from 1943 until 1987. In these volumes, I found samples of the challenges you have encountered and the ways you have solved them. These volumes contained advertisements for control materials and application equipment. One early article called for a national organization of mosquito control workers to provide for the exchange of ideas. It was a good idea then and it's a good idea now. We're still striving to keep organizations in place to share ideas. The people who participate in these groups change but the sound scientific principles and the ideas of public service represented by these groups don't change. Listings of reference works were included to guide mosquito control workers to the latest information on mosquitoes and their control. Wide-ranging articles addressing everything from mosquito behavior to insecticide resistance to ecologically sound environmental modifications are a mirror of the challenging changes with which you have been confronted. I will say again, "You have confronted them successfully." Remember, "When you are challenged by change, the techniques we use for mosquito control and prevention may change, but the basic scientific principles we use don't change." With that thought and the title of a recent country and western song, I'll close. Every mosquito control program director sings this song during the season when everything goes wrong. When a mosquito control program director has broken spray equipment, has encountered insecticide shortages and has received two calls from the governor on the same day, he sings his own version of "Why does hard living come so easy to me?"

EPA'S IMPLEMENTATION OF THE ENDANGERED SPECIES ACT UNDER FIFRA

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The endangered Species Act (ESA) was originally passed by Congress in 1973 to provide protection for species determined to be endangered or threatened. The Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) administer the ESA with the latter having primary responsibility for marine species and the former having responsibility for other species. Section 7 of the ESA requires that all Federal agencies ensure that the actions that they take or authorize will not jeopardize listed species. Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Environmental Protection Agency (EPA) sets the conditions for registration of pesticides and provides for their controlled use. In order to comply with the ESA, the EPA conducts an assessment of the potential impact of pesticides on listed species. If EPA determines that a particular pesticide use may affect endangered or threatened species, the Agency initiates a formal consultation under section 7 of the ESA. Because pesticide uses are unlikely to affect marine species, consultations have been, and typically will be, with the FWS. Upon completion of the consultation, the FWS issues a Biological Opinion regarding jeopardy to listed species. If jeopardy is declared, the FWS provides "reasonable and prudent alternatives" to minimize the impact. Typically, such alternatives call for the prohibition of the pesticide within the currently occupied range of the species.

Initially, EPA's consultations were conducted only on individual registration actions that were submitted to the Agency. When the criteria of toxicity and expected exposure indicate a "may affect" situation where listed species occur, EPA initiates a case-by-case consultation. To date 60 case-by-case consultations have been conducted resulting in 37 jeopardy opinions. It was soon realized that this approach was both inconsistent and inefficient because it resulted in restrictions only for new or amended pesticide uses, while some highly toxic older pesticides escaped restrictions.

As a result, the EPA developed the approach of evaluating together all registered pesticides with similar uses. This cluster approach is much more efficient and results in consistent jeopardy opinions for a particular use. As many as 180 active ingredients may be addressed for a particular cluster. At this point, consultations have been completed for 8 crop clusters (corn, cotton, soybeans, grain sorghum, wheat, oats, barley, and rye), rangeland/pastureland cluster, forestry use cluster, and mosquito larvicide cluster. It is the Agency's intent to implement portions of these clusters beginning during the 1988 growing season.

At present consultation is in progress for an aquatic herbicide cluster and a non-crop cluster to include such uses as vertebrate control agents, mosquito adulticides, and rights-of-way. Clusters for rice and alfalfa are under development; additional clusters will be developed over a period of time as resources permit.

EPA plans to implement the Biological Opinions issued by the FWS by prohibiting the use of pesticides, for which jeopardy has been declared, within the currently occupied range of the jeopardized species. Pesticide Registration Notices 87-4 and 87-5, issued on May 1, 1987, direct the registrants to label affected pesticides, beginning in February 1988, and indicate the counties in which there are endangered species restrictions. The labeling then would require the pesticide user to obtain a Pesticide Use Bulletin for Protection of Endangered Species (county bulletin) for cropland and rangeland uses, and for 1988, to contact the FWS to determine restrictions for forestry and larvicide uses. After 1988 the latter 2 uses will be incorporated into county bulletins along with new clusters that are ready for implementation. County bulletins will be readily available from farm supply stores and other pesticide dealers, county extension offices and other appropriate outlets.

County bulletins generally will contain a map of the county with shading to show where endangered species restrections apply. In a number of cases, a descriptor will further define where, within the shaded areas, specific pesticides may not be used. The bulletins also will contain a table of the affected pesticides, indicating which species may be jeopardized from the particular uses. The Agency has attempted to have the restricted areas correspond as closely to actual occupied ranges as possible. If it is determined that the range information is inaccurate, EPA will defer implementation for the species until we can obtain better information. At present freshwater molluscs have been deferred for 1988 and other species are under consideration for deferral. The Agency is working with the FWS, States and others to obtain accurate data so that these situations can be implemented in 1989.

During 1988 users of forestry pesticides or mosquito larvicides in affected counties will be required to contact the FWS at a telephone number listed on the labeling. The user will identify the location of the intended treatment area within the county. Actual range information on the species will not be provided by the FWS in order to protect them from collection or vandalism. Because there are relatively few major users of these pesticides (e.g. USDA, timber companies, mosquito abatement districts), it is expected that this is a feasible approach for the FWS, until these uses are included in county bulletins, beginning in 1988.

The use of mosquito larvicides will not be greatly impacted by the program in Utah and Wyoming with restrictions for such uses applying only to 2 species in 2 counties for each state (Table 1). Because of the low application rate for most mosquito larvicides, no jeopardy in Utah or Wyoming was found by the FWS for fish, such as the Colorado Squawfish, Humpback Chub or Bonytail Chub, inhabiting deep or fast moving aquatic habitats. In addition, it should be noted that of the nine mosquito larvicides for which labeling is required, only 3 cause jeopardy to mammals and 6 cause jeopardy to birds. Therefore, in addition to those larvicides for which no jeopardy was found, some of the labeled larvicides may be used where only birds or mammals may be jeopardized.

The Agency assumes that when users are aware of the risks to endangered species, they will comply with the restrictions. Given the large number of pesticide users, voluntary compliance will be necessary to achieve widespread protection. However, like other FIFRA programs, actual enforcement will be a delegated function to most of the states wherein EPA sets policy and requires "Enforcement Plans" from each of the delegated states. Therefore, FIFRA violations will be handled by state enforcement but ESA violations will be referred to the FWS. In some cases, joint action may be appropriate.

The Agency plans on updating the program to include new chemicals, newly listed species and additional pesticide use patterns (clusters) for which we have consulted with the FWS. Additions and revision of bulletins will be made on an annual basis as necessary. Where jeopardy opinions are removed, restrictions will be deleted as soon as feasible. For example, the older dicofol products contained up to 10% of DDT and related contaminants and were considered to jeopardize a number of avian species. With the development of a new process to reduce these contaminants, the jeopardy opinion was removed in summer, 1987 and the avian restrictions for dicofol were deleted from the program.

Of particular note for public health concerns, the Agency is working with the Center for Disease Control and the user associations to develop criteria for determining when a public health emergency exists and to establish procedures for dealing with such emergencies without unduly affecting endangered species. We expect to have these criteria and procedures in place prior to the implementation of the mosquito adulticide portion of the non-crop cluster that is now undergoing consultation.

The EPA's Endangered Species Implementation Project has provoked controversy in part due to misinformation in the press that the Agency has not had sufficient time to rectify. The Agency intends to be flexible during implementation in 1988 to the point of deferring for species for which more data are needed. Pesticide users are familiar with the requirements of FIFRA to balance the risks and benefits of pesticide use, but they are not used to the ESA, which does not weigh benefits against the possible extinction of a species. However, most pesticide users support the protection of endangered species. Through education of users and necessary adjustments of the program, I believe that the Agency's program will be beneficial to listed species with a minimum of disruption of vector control programs or agricultural production.

Table 1. Endangered Species in Utah and Wyoming that May Be Affected by Mosquito Larvicide Uses

Species	State	Affected Counties[1]
Woundfin	Utah	Washington
June Sucker	Utah	Utah
Kendall Warm Springs Dace	Wyoming	Sublette
Whooping Crane	Wyoming	Sublette, Lincoln

[1]Restrictions apply only within currently occupied habitats within these counties.

Table 2. Mosquito Larvicides for which the Fish and Wildlife Service Has Declared Jeopardy

Types of Species Jeopardized	Affected Larvicides
Fish, aquatic invertebrates	Methoxychlor Methoprene Pyrethrins
Fish, aquatic invertebrates, birds	Methyl parathion Temephos Chlorpyrifos DDVP
Fish, aquatic invertebrates, birds, mammals	Fenthion Ethyl parathion

PLAGUE IN NEW MEXICO, 1986 - 1987: WHAT HAPPENED?

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From 1949 through 1985, New Mexico recorded a total of 171 human plague cases. An increase in these cases occurred during the 1970's and early 1980's, culminating in a maximum of 26 cases reported in 1983, the greatest number in any state since 1925. During the next 2 years, this number decreased to 16 cases in 1984 and 14 in 1985. There were only 5 human cases in 1986 and 5 cases to date (2 November 1987) this year. This reflects a general decrease in the number of cases reported nationally from 40 cases in 1983 to 10 in 1986, with 11 known from 1987 (Centers for Disease Control 1985).

Four of New Mexico's 5 cases recorded in 1986 were in children under 10 years of age. Two Mescalero Apaches, ages 2 and 8 years, were infected with the disease in May and June. The exact source of these infections was not determined but was thought to be from flea bites resulting from an extensive rodent epizootic in the part of the Mescalero Reservation where they lived. The 8-year-old boy almost died of complications of the disease. His 2-year-old cousin was retrospectively diagnosed by testing blood serum when physicians remembered her symptoms closely resembled his. Two cases from the foothills of the Sandia Mountains in eastern Bernalillo County were also 2 and 8 years old and both were girls. The younger had been with her family on a picnic at the home of friends and had apparently been attacked by infected fleas from rock squirrel burrows in boulders piled up along the driveway to the home. The other girl had recently moved into the area with her family. Their home was built near colonies of prairie dogs and rock squirrels which were experiencing a massive plague epizootic. Neither family of these patients had been in the area long enough to avail themselves of the plague information provided by the Albuquerque Environmental Health Department's Insect and Rodent Control Program.

The fifth case in 1986 was an Albuquerque man who had hunted cottontail rabbits near Ladron Peak in northern Socorro County in early December. He wore welder's mitts when he skinned the 10 rabbits but removed the mitts when he eviscerated them. Two of the rabbits were cooked and eaten that day; the others were frozen. These 8 rabbits were submitted to the N.M. Scientific Laboratory in Albuquerque and tested negative for plague. It is highly likely that one or both of the rabbits that had been eaten were the source of his bubonic infection resulting from removal of the mitts while handling the rabbits. Although his family ate the rabbits he'd cooked, the fact that he was the only person to get plague suggests that his barehanded handling of the meat was the source.

None of the 10 nationally reported human plague cases in 1986 were fatal. This was the first year since 1973 in which no human fatalities were recorded from plague in the United States (personal communication). Of the 11 human plague cases recorded in the United State in 1987, five occurred in New Mexico, 2 in Colorado, and 1 each in Arizona, Idaho, Montana, and Oregon. The Arizona and Oregon cases were fatal. New Mexico's first 2 cases of the year involved the handling of infected animals. In March a 27-year-old man in Rio Arriba County was infected from contact with fluids draining from axillary lymph nodes of his sick cat. The cat was diagnosed as plague-positive and died. The second case resulted from a Navajo man picking up a dead prairie dog and stuffing it inside his shirt. The other New Mexico cases seem to have resulted from the bites of infected fleas; in at least 2 of these cases, dogs and cats may have been involved in transporting fleas into homes.

Eighteen domestic cats proved plague-positive so far in 1987. Thirteen (72%) of these were from Bernalillo County's Sandia and Manzano mountain areas. These cat cases are indicators of more widespread rodent plague. Two cats in the Grants area of Cibola County became infected through involvement with an epizootic occurring in nearby prairie dog (*Cynomys qunnisoni*) colonies in June and September.

The number of rodents and rabbits submitted by the public and by other government agencies decreased greatly during 1987. This is a further indication that rodent populations were on the decline last year and this year. Three "hot spots" for plague activity were seen in 1987: the Sandia-Manzano area of Bernalillo County, the Grants area of Cibola County and the Guadalupe Mountains of Eddy County, New Mexico and nearby Texas. A dead Plains wood rat (*Neotoma micropus*) was found at the entrance of a limestone sinkhole near Carlsbad, NM in April. Later this summer, rangers at Guadalupe Mountains National Park found a dead and plague-positive antelope ground squirrel (*Ammospermophilus interpres*) near one of the visitor's centers. These discoveries led to more thorough investigations by staff from El Paso office of the Texas Department of Public Health and the Vector Control Staff of the New Mexico Health and Environment Department. The Texas researchers found a plague-positive feral house cat and a ringtail (*Bassariscus astutus*) in the Dog Canyon area of the Park in September. An October survey of rodent populations in the Guadalupe Mountains of New Mexico revealed that a substantial number of rodents seems to have been eliminated, very likely by plague. More field work in this area is planned for later in 1987 and in 1988.

Most public health biologists working in the area of plague surveillance and control expect to see and increase in the numbers of human, cat and rodent plague incidence in 1988 in New Mexico and in other parts of the country. Preparations are now being made for this increase. We hope to report on the results at the 1989 meeting of the West Central Mosquito and Vector Control Association.

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STATUS OF PLAGUE IN IDAHO

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The likelihood of plague in the Intermountain West is very high. In Idaho sylvatic plague is endemic. The first plague isolation was from a ground squirrel in 1932. Evidence for plague has been shown in 23 counties.

From 1932-1986, serological testing was done routinely using Nobuto strips (blood sampling filter paper) (Toyo Roshi Kaisha, Ltd). and direct blood sampling. Only 3 human plague cases have been reported. According to Wayne Heiskari, Vector Control Analyst, Division of the environment, Idaho State Department of Health and Welfare (personal communication), the area south of the Salmon River is the reservoir for plague in Idaho.

HUMAN PLAGUE CASE INVOLVING AN ELEVEN (11) YEAR OLD BOY

My involvement with the third human case in Idaho began June 17, 1987. A Meridian, Idaho boy played with and was bitten by a ground squirrel. As part of my duties with the Central District Health Department, one of the 7 District Health Departments in Idaho, I was notified by the State Epidemiologist that the Idaho State Bureau of Preventive Medicine had received notification from Centers for Disease Control (CDC), Plague Branch, Ft. Collins, CO that a blood sample was positive for *Yersinia pestis*.

Since the biting incident occurred in another health department's jurisdiction (Lemhi County) but the victim lived in my district, I coordinated the investigation and wrote a short report.

Onset for this case was May 28, 1987, four days after the boy had been bitten by a ground squirrel at Birch Creek near Lone Pine, Idaho. From the camping area where this boy was bitten, Wayne Heiskari collected ground squirrels which were identified as *Spermophilus elegans aureus* by Dr. Eric Yensen, Department of Biology, College of Idaho, Caldwell, ID. No fleas were recovered, all specimens were free of ectoparasites. Due to the remote location from human population, the only action taken was to recommend that warnings be posted.

A series of confusing events attended this case because no one from the medical community reported to the Health Department that there was a suspected plague case. Other public health workers have had similar problems. For example, there is the Colorado plague case where the patient mentioned it to the health department representative at the local Planning and Zoning meeting several weeks after treatment and recovery.

Other actions complicated the investigation. First, the emergency room physician could not be interviewed and did not return calls for several days. The hospital also did not return calls until someone admitted several days later, that the original report had disappeared in circulation because of the medical interest it created among the staff; other copies also disappeared.

On June 18, 1987, a receptionist from the hospital reported that the victim's file was not available but that she was acquainted with his mother. In a telephone interview, the following information was released: an 11-year old male had been bitten by a ground squirrel, contracted plague but was now recovering following the regimen suggested by the Idaho State Health Department physician.

The boy had been fisning with his uncle in a remote fishing area near Lone Pine, Idaho called Birch Creek. He played with a sick and dying ground squirrel, then picked it up and took it back to camp where it bit him on the left thumb. His mother went with him while he released it at the area where it was found. Four days later, May 28, 1987, the boy was brought into the emergency room with a 104 degree F. fever, a small lesion on the left thumb and a painful left armpit that was red and swollen. The following day a heparin lock was placed and intravenous ceftriaxone (Rocephin) administered. On May 30, the patient had failed to respond to this treatment so the attending emergency room physician contacted the Bureau Chief of the Idaho Department of Preventive Medicine and asked if he thought it could be rabies from a ground squirrel bite. He was told, "No, but had tularemia or plague been considered? If so, treatment would be tetracycline and amoxicilin."

After this antibiotic change, the boy's condition made marked improvement. The next day the heparin lock was removed. On June 23, 1987, the boy was doing well; he still had a lump in his left armpit but otherwise was healthy.

DISCUSSION

CDC plague personnel expressed active concern with the public implication of this case and the following cases. The death of a Roseburg, Oregon man, August 29, 1987, shows what can happen if plague diagnosis and antibiotic treatment are delayed (Jack Warren, Oregon State Health Department, 1400 SW 57 AV, Portland, OR, personal communication). A 1968 death of an Idaho trapper was very similar in that this individual did not receive treatment until it was too late. Both victims had advanced cases of infection from *Yersinia pestis*; when treatment began, as in similar cases (Stark 1969), the antibiotics killed large numbers of bacteria releasing their toxins which killed the victims.

CONCLUSION

In the Intermountain West, individuals are likely to contract plague by direct contact with sick or dead rodents and/or their fleas (Ebeling 1975). To protect the public's health, a rapid system of reporting plague and informing the public of dangerous areas must be implemented. One course of action is to placard plague warnings at campgrounds in enzootic areas. These placards warn users of the dangers of contact with sick or dying rodents, rabbits or their fleas. It is very important to implement public education programs that warn outdoorsmen, hunters and campers of the danger of plague transmission. Figure 1 is a copy of a suggested placard for that warning.

A real danger exists to all health care providers who are handling plague victims that become pneumonic. These personnel are at risk of disease from droplet infection from the plague victim (Anderson *et al.* 1962). Unless we alert all medical personnel to promptly report plague cases to health agencies, a real epidemic may occur.

ACKNOWLEDGMENTS

For advise and criticism during this investigation and preparation of the article, appreciation is expressed to Drs. Allen M. Barnes and Tom Quan, Centers for Disease Control, Plague Branch, P.O. Box 2087, Ft. Collins, CO and Dr. Robert E. Elbel, Department of Biology, University of Utah, Salt Lake City, UT.

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Fig. 1. Warning Placard (Adapted from: Joseph M. Benson, Entomologist, U.S. Army Environment Hygiene Agency, Denver, CO.)

PLAGUE WARNING

CHIPMUNKS, GROUND SQUIRRELS, AND OTHER WILD RODENTS IN THIS AREA MAY BE INFECTED WITH PLAGUE. PLAGUE MAY BE TRANSMITTED BY AN ANIMAL BITE OR BY THEIR FLEAS.

1. AVOID ALL CONTACT WITH CHIPMUNKS, SQUIRRELS, OR OTHER WILD RODENTS.
2. DO NOT FEED OR PLAY WITH WILD ANIMALS.
3. DO NOT CAMP, SLEEP, OR REST NEAR ANIMAL BURROWS.
4. AVOID ANIMAL FLEAS: PROTECT PETS WITH FLEA COLLARS.
5. SEE A PHYSICIAN IF YOU BECOME ILL WITHIN ONE WEEK OF VISIT TO A CAMPSITE. **PLAGUE IS A TREATABLE ILLNESS.**
6. DO NOT TOUCH SICK OR DEAD ANIMALS.

PLAGUE IN PUEBLO COUNTY, COLORADO, PRAIRIE DOGS
(Cynomys ludovicianus)

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In late June 1987, several citizens reported unusual die offs of prairie dog (*Cynomys ludovicianus*) colonies in Pueblo West, a large housing development just west of the city of Pueblo and just north of the Pueblo Reservoir and State Park.

Health officers from the Pueblo City-County Health Department (PCCHD) investigating these reports confirmed very large, widespread die offs of colonies in several areas and also at the Pueblo Motorsports Park, a complex of drag racing, motocross, quarter midget and road race tracks. This racing complex is located just west of the city limits.

The health department had been keeping fairly close track of the colonies in Pueblo West and the Motorsports Complex since early summer and had assisted the track personnel in treating over 1,000 prairie dog burrows with Gastoxin-R (Phostoxin) pellets about one month prior to the extensive natural die offs. This action was undertaken because of the sizeable crowds that were coming to organized racing events and the numerous prairie dogs burrowing throughout the facility. This selective eradication program produced significant reduction in the number of animal reservoirs that probably helped tremendously in keeping the disease from infecting any humans during July.

Just prior to the 4th of July weekend, Health Protection Officers (HPOS) collected flea pools and animals (prairie dogs, rabbits, squirrels, cats, mice, etc.) from the areas of die off and from the areas adjacent to the die offs. These were shipped to the Division of Vector-Borne Disease, CDC, Ft. Collins, CO for bacteriological examination for *Yersinia Pestis* and related agents.

The local television (Pueblo, Colorado Springs, and even Denver) and newspapers were already interested in these developments and were constantly calling the Division asking for any "news" (e.g. could we confirm bubonic plague in the county?). Any contact with the press was carefully screened through management and a cautionary approach was stressed. One development that particularly interested the press as well as the health department was a report that some 7-9 children had been playing with dead prairie dogs in one of their garages and that many of the children received flea bites. A parent of 2 of these children was an employee of the State Health Department who contacted other parents and informed them of early signs and symptoms of plague (fever, swollen lymph glands, etc.). The children were watched closely for sickness. Flea pools and animals from the area of this incident were sent to CDC for examination.

Since the CDC facility was shut down for the long holiday, results of these tests did not reach the PCCHD until the middle of the week. Dr. Richard Hoffman from the State Health Department Epidemiology Division called me with the news that many of the animals tested positive for *Y. pestis* by flourescent antibody. Dr. Redwine and I contacted the local media and held a press conference that morning to announce these laboratory findings concerning confirmed plague in animals in the county and to warn the public to avoid contact with dead prairie dogs. The mode of transmission via flea bite was explained and it was urged that domestic pets be temporarily confined and dusted for fleas. The major control efforts to be taken by the Health Protection Division were also listed so that the public would not be unduly alarmed by the presence of animal plague.

Ted Davis, State Entomologist/Vector Control Specialist, arrived to assist the division in planning and implementing control efforts. He arranged for a shipment of 500 pounds of Sevin-r dust to be used to kill fleas in burrows in areas of die off and also in active colonies. This dust arrived in 2 or 3 days which was just about when the Health Department's supply of Sevin and Diazinon dust was expended. A local Pest Control Operating firm, Huchininson Pest Control of Pueblo, also assisted by offering men, application equipment, and 75 pounds of insecticide dust. The dust and 2 dust applicators were given to the Health Department but the Division decided to use HPOS for all the dusting activities.

A massive program of burrow dusting was mounted, using 8 HPOS, aides and management personnel forming numerous 2-man teams. A large scale, detailed map of Pueblo West and the city of Pueblo was obtained and mounted with plastic overlay so various sectors and zones and activities could be marked with colored wax marker pens. Active colonies, dead colonies, samples submitted, positive samples, dusted areas, etc. were all marked on the map as well as team assignments. This map was updated in the Director's office with teams reporting by radio transceiver. The Assistant Director had on-site, field supervision of the control efforts while the Director coordinated the overall activity, maintained liaison with the State Health Department and CDC and handled public relations with the public and the press.

The primary goals of these initial dusting efforts were: 1) To kill infected (blocked) fleas in burrows in dead colonies; 2) To kill fleas in burrows of live colonies immediately adjacent to diseased colonies to limit the spread of animal infection; 3) To attempt to confine the animal epidemic outside the city limits (keep it west of Pueblo Blvd.) and areas of dense human populations. Ted Davis and Dutch Gruse collected pools of fleas from both active and dead colonies to evaluate the dusting efforts. Two species of fleas, *Pulex simulans* and *Opisocrostis hirsutus* were collected and sent to CDC.

During the second week of activities, Ted Davis collected 12 pack rats from Liberty Point Area of Pueblo West, the site of a human plague case in 1985. The animals were bled and the blood sent to CDC for examination.

any sickness and the flea pools and animals from their area came back negative for plague. An interesting incident was noted by team members dusting in an area just north of the Motorsports Park, near a sewage pond. A prairie dog emerged from a burrow, shook, and died right in front of them. It was collected, sent to CDC and later turned out to be positive for plague. It was the opinion of Ted Davis and the Health Protection Division that the area of the sewage ponds was the edge of the line between living and dead colonies (the front of the advancing animal plague!). Dusting was increased in this area and colonies monitored very closely. The city and dense residential housing was just east of this location as was the high concentration of prairie dog colonies. A particularly dangerous situation existed at a school ground in the path of this advance with hundreds of active burrows all around and right up to the school. In fact, burrows were present in the baseball diamonds, playground and even the "jungle gym" and slide area.

The teams worked long, hard hours in heat over 100 degrees but their efforts were sucessful in that no human cases were reported. It was estimated that 750,000 animals died from *Y. pestis.* After the third week, it was noted that animals were moving into areas of die off from healthy colonies. All samples submitted were negative for plague, and team members returned to their normal assignments.

FELINE PLAGUE IN BERNALILLO COUNTY, NEW MEXICO 1980 - 1987

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ABSTRACT

Thirty cases of feline plague have occurred in Bernalillo County, New Mexico since 1980. Increasing incidence is evident in that 10 cases were acquired in 1987. This increase is attributed to increased public and veterinary awareness combined with a growing human population in endemic areas. The most common clinical feature was the involvement of submandibular lymph nodes resulting from the ingestion of infected rodent tissues. Ages ranged from one week to 9 years with 13 cats less than 2 years old. Of 18 survivors, 11 were treated with tetracycline. Field investigations conducted in 28 of the cases reavealed 14 instances where plague was confirmed or suspected in the rodent population. In only 3 of these instances, plague infected rodents or fleas were found in the immediate vicinity of the residence. Cats which are allowed to roam in endemic areas increase risk to their owners by bringing plague back to the household. As a result of these 30 cases 29 individuals were treated with tetracycline because of their close contact with the cats.

INTRODUCTION

Thirty cases of naturally occurring plague in domestic cats have been reported in Bernalillo County, New Mexico since 1980 (Table 1). Prior to 1980, only 8 cases of plague in domestic cats had been reported to the Centers for Disease Control (Rollag, et. al. 1981).

Plague in cats is usually associated with marked lymphadenophathy and fever. The primary buboes are typically on the head and neck and this localization suggests that the disease is usually acquired by eating *Yersinia pestis* - infected rodents (Kaufmann, et. al. 1981).

In this report, a general summary of the clinical features of the 30 cases is offered and findings of epidemiological field investigations resulting from the cases are discussed.

MATERIALS AND METHODS

Clinical information for each case was obtained by the author from the attending veterinarian or in some instances from the records of the Office of Epidemiology, New Mexico Health and Environment Department. Complete information was not available for all of the cases. Field investigations were conducted by the Plague Surveillance Section of the Albuquerque Environmental Health Department.

Field activities included the capture of rodents using Sherman and Tomahawk live traps. Rodent burrows were examined for the presence of fleas using the burrow flagging technique described by Barnes (1972). Captured rodents were anesthetized with Metofane (methoxyflurane), their fleas collected and placed in vials of 2% saline. Rodent and burrow fleas were sent to the Centers for Disease Control, Plague Branch, Ft. Collins, CO to identify and test for the presence of plague, *Y. pestis*. Blood samples were obtained from rodents by direct heart puncture. Serum was extracted and submitted to the Plague Branch to determine if antibody to *Y. pestis* was present. Liver and spleen samples from rodents that were found dead by investigators were sent to the New Mexico Scientific Laboratory Division to test for the presence of *Y. pestis*.

RESULTS

As shown in Table 1, an increasing number of plague-infected cats in Bernalillo County is evident as 10 cases have occurred so far this year. In 1985 and 1986, 6 cases were seen each year while from 1980 through 1984 there were 8 cases.

The temperatures of the cats listed in Table 1 are generally those recorded by the veterinarian. The fevers ranged from a low of 99.2 °F to a high of 107.5 °F. The most common temperatures were from 104-105 °F, occurring 12 times. Normal temperature for domestic cats is about 101 °F.

The most common clinical feature of these cats, other than an elevated temperature, was the presence of enlarged submandibular lymph nodes. This was observed in 12 cases with 7 having node involement on one side and 5 having bilateral node involvement. Other swollen lymph nodes included cervical, prescapular, axillary, and illiac. Seven of the cats with lymphadenopathy also had abscesses (Table 1).

Laboratory confirmation in those cats with lymphadenopathy was based on lymph node aspirate upon which a flourescent antibody test was performed. Five cats were confirmed serologically, 3 confirmed through culture of *Y. pestis* from the blood, and 6 (all fatal cases) were confirmed through flourescent antibody and culture tests on tissue samples, primarily liver and spleen, removed from the cat at necropsy.

The ages of the 30 cases ranged from one week to 9 years. Thirteen of the cats were less than 2 years old (Table 1).

Of the 12 cases resulting in death, 5 were euthanized, 2 were discovered by their owners near death and shot and 5 succumbed to the disease. Of 18 survivors, 11 were treated with tetracycline and two with doxycycline. Five of the remaining 7 cats were treated with ampicillin, penicillin, amoxicillin, or lincomycin and 2 cats survived having received no treatment.

Field investigations conducted in 28 of the cases found laboratory confirmed *Y. pestis* infections in the rodent, rabbit, or associated flea populations in 11 of the cases. In 3 other instances, rodent die-offs were suspected of being due to *Y. pestis* infection because of an absence of specific rodent populations coupled with inactive rodent burrows in an area although these die-offs were not confirmed by positive laboratory findings. Investigators found evidence of plague in the immediate vicinity of the home in only 3 of the 14 instances where plague was confirmed or suspected in the rodent population.

DISCUSSION

The increasing incidence in the number of cases of plague in domestic cats can be attributed to 3 factors: (1) an increased awareness of people living in the plague endemic area of eastern Bernalillo County; since 1979, the Albuquerque Environmental Health Department has emphasized public awareness programs aimed at people living in this area. (2) an increased awareness in the veterinary community; one veterinarian in particular opened a practice in the endemic area in January 1987 and routinely submits samples from any cat that has a high fever and lymphadenopathy which has resulted in 4 cats being diagnosed this year. (3) a growing human population and subsequently cat population in the plague endemic area. There are simply more cats to become infected.

The cats with lymph node involvement on the head and neck probably acquired their infection from eating infected rodents as these symptoms are consistent with those seen in cats fed experimentally infected rodents in the laboratory (Kaufmann et. al. 1981). Those cats with node involvement other than about the head and neck (axillary, prescapular, illiac) are thought to have acquired their infection from infective flea bites as their symptons were consistent with parenterally infected cats in the laboratory (Rust et. al. 1981). Three cats developed septicemic plague without buboes (Table 1, cases 22, 23, 30). Complete necropsy reports were not available in all of the fatal cases but none of the cats exhibited symptoms consistent with or were confirmed as having secondary pneumonic plague.

Tetracycline therapy is recommended for cats as well as streptomycin or chloramphenicol (Poland et. al. 1979). *Y. pestis* infection normally does not respond to the penicillin family although the cats treated with this class of antibiotics did improve. Improvement in these animals may have occured without penicillin treatment as cats infected experimentally with *Y. pestis* have survived with no treatment (Rust et. al. 1971).

Field investigations conducted after the cases indicate that cats are contracting their infections away from the residence and bringing plague back to the home, thereby increasing the risk to family members. During the last 2 years in areas where documented epizootics occurred, cats have been infected at a high rate. For example, 4 cats acquired plague infections in a 1 x 3 mile area where an epizootic occurred in 1986. In 1987, along a 1.4 mile stretch of road, 7 cats were infected. In all but one instance, there was no risk to humans from infected rodent populations around the residence. Investigations revealed that there was very little evidence of rodent activity in the yards as most were well kept and relatively devoid of suitable rodent habitat. Although no human cases have resulted from the 30 infected cats, 29 individuals were placed on tetracycline therapy because of their close contact with infected tissues or fluid. Those individuals included veterinarians, veterinary technicians and owners of the cats.

Routine flea control programs have lone been recommended for cats and dogs in plague endemic areas to prevent the transporting of *Y. pestis* infected fleas into the home (Kaufmann et. al. 1981) however, cats are still susceptible to infection through ingestion of infected rodents. Therefore, it is recommended that owners of cats living in known plague endemic areas confine these cats and not allow them to roam.

Table 1. Feline Plague 1980-1987

Case	Date	Temp	Lab	Age	Positive Field Results	Outcome
1	6/80	105.8	SM-Ab	2	---	F
2	9/80	105	SM	8mo	*C. gunnisoni* die-off	R
3	10/80	104	BSM	8	13 flea pools	F
4	9/81	103.6	SM	1	*S. variegatus* 1:256	F
5	6/82	104	C	-	*A. interpres* die-off	R
6	5/84	106.2	PS-Ab	2	---	R
7	9/84	105	BSM	6mo	5 flea pools; *S. auduboni**	R
8	10/84	-	BSM-Ab	-	5 flea pools; *S. auduboni**	F
9	4/85	105.5	SM	1	---	R
10	5/85	99.2	1:8192	8	*S. variegatus* die-off	R
11	7/85	-	SM	4	---	F
12	7/85	-	1:1024	9	---	F
13	7/85	103	1:2048	2	---	R
14	7/85	104	1:2048-Ab	3	---	R
15	1/86	-	Tissue	2	---	F
16	8/86	104.5	BSM-Ab	1	flea pool	R
17	8/86	-	BSM	1	flea pool	R
18	8/86	105.6	Ax-Ab	3	flea pool	R
19	8/86	106	Il	1	flea pool; *S. variegatus**	R
20	8/86	104	SM-Ab	1	---	R
21	1/87	104.6	SM-Ab	1	7 flea pools	R
22	6/87	107.5	Blood	6	2 flea pools; *S. variegatus*	R
23	6/87	107	Blood	4	2 flea pools; *S. variegatus**	R
24	6/87	105	1:4096	4	---	R
25	7/87	-	Tissue	3	---	F
26	7/87	-	Tissue	1wk	---	F
27	7/87	-	Tissue	1wk	---	F
28	7/87	-	Tissue	1wk	---	F
29	7/87	-	Tissue	1	---	F
30	7/87	106.6	Blood	6	---	R

Ab = abscess
SM = submandibular
BSM = bilateral submandibular
C = cervical
PS = prescapular
Ax = axillary
Il = illiac

C. gunnisoni = *Cynomys gunnisoni*
S. variegatus = *Spermophilus variegatus*
A. interpres = *Ammospermophilus interpres*
S. auduboni = *Sylvilagus auduboni*

* = positive tissue

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STATUS OF THE VECTOR CONTROL JOINT POWERS AGENCY (INSURANCE POOL)

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Since the formation of the VCJPA and under the tutelage of Warren Cook, many changes have occurred and new plans added.

While skyrocketing general liability costs were the prime impetus behind the VCJPA, we started (1979) with a self-insured workers compensation plan which became a full fledged pooling program as of July 1 of this year under our new administrator, Mr. Ed Bickmore. As the Workers Compensation Pool was becoming a reality, the administrator at the request of the Board and member agencies attempted to put together a program of Pooling for General Liability. The hope was to put the new pooling program in-place this past September. It did not happen. The major obstacle to implementation was the absence of an insurance company willing to accept a group the size of ours at the level of self insured risk we desired, $500,000. Their requirement was a pool 3 times our self insured risk or 1.5 million and the underwriters questioned our ability to meet these levels at this time. So, as of September 1, 1987, we have renewed our coverages and with the same carriers, in most cases. As with the insurance market in general there have been changes in coverages. Our General and Auto liability deductible has gone from $1,000 to $5,000 but at least we were saved the double insult of a premium increase. The costs, all things considered, were quite good.

Our new brokers, Johnson and Higgins of San Francisco, marketed our needs right up to the eleventh hour and, using their considerable contacts and experience, did an excellent job. Our premiums for 38 agencies statewide were:

I. GENERAL LIABILITY: $277,242. down approximately 5%.

General Aggregate: $2,000,000. (other than Products - Completed Operations)

Products - Completed Operations: $2,000,000.

Personal & Advertising Injury: $1,000,000.

Each Occurance Limit: $1,000,000.

Fire Damage Limit: $50,000. (any one fire)

Medical Expense Limit: $5,000. (any one person)

Deductible: $5,000. (per occurrence)

II. AUTO LIABILITY: $296,084. down over 9.0%

	Each Person	Each Accident
Comb PI/PD		$1,000,000
Auto Med. Payments	$5,000	
Uninsured Motorist (PI/PD) Vector Vehicles		100,000

Exposure Base: 841 Power Units for Liability

III. AUTO PHYSICAL DAMAGE: $74,506.

	Deductibles	
Comprehensive	$ 250.	(owned autos
Collision	1,000.	only)

Exposure base: 622 Power Units for Physical Damage Deductibles

IV. UMBRELLA LIABILITY COVERAGE:

(American International - through C.V. Starr)

Limit: 3 million per occurance/aggregate excess of FFIC $1,000,000; primary; $2,000,000. general agr. & $2,000,000. Prod. agr.

Deductible: $25,000. Defense included in limit of Liability.

Exclusions: Absolute pollution, absolute asbestos, discrimination, ERISA, Care, Custody and Control, Cross suits, all Aircraft & Aerial Crop dusting & related contractual.

Minimum Employers Liability Coverage: $500,000.

Premium: $155,000. Based on $1.26/$100. payroll

EXCESS UMBRELLA LIABILITY:
(Industrial Insurance - A ± XIV Best Rating)

Limit: 1 Million each occurrence/aggregate where applicable excess of $3,000,000. each occurrence, aggregate where applicable, excess of primary.

Terms follow umbrella, plus exclusions of care custody and control and occupational disease.

Premium: $28,868.

V. ALL RISK EXCLUDING EARTHQUAKE & FLOOD:

Covers all real & personal property/extra expense/rents

Limit: $5,000,000. per occurrence

Premium: 33,773.

Deductible: 2,500.

VI. COMPREHENSIVE COVERAGE EXCLUDING PRODUCTION MACHINES:

Covers Boilers & Machinery at locations owned & controlled by VCJPA property program

Limits: $250,000. per accident

Premium: 7,500.

Deductible: 1,000.

VII. PUBLIC OFFICIALS ERRORS AND OMISSIONS:

Claims made: placed with American Empire Insurance Co.

Limit: $1,000,000. per claim
$1,000,000. per aggregate

Deductible: $5,000.

Premium: $38,861.45 based on 0.3025 per $100.
plus taxes. (23%)

A bonus this year was an endorsement for pollution as "Pesticide or Herbicide Applicator Coverage." When all the language is deciphered our coverage is for:

A. Sudden and accidental discharge, dispersal, release or escape of toxic chemicals.

AND

B . If, the discharge, dispersal, release or escape is away from the premises owned by the named insured and if such operations meet all standards of any statute, ordinance, regulation or license requirement of any federal, state or government having application to such operations.

As you can see we have coverage as complete as possible in today's market place. Being aware of the swings of the commercial market place we are carrying out the necessary studies and taking the preliminary steps for implementation of pooling for any and all of the coverages I have just mentioned. Ultimately, being in total control of our monies is the most desireable position to be in. Our experience to date shows us that while we have paid out hundreds of thousands of dollars in premiums, our costs have been in the tens of thousands. The dollar difference sitting in our own pooled program account would be working for the member agencies.

The other programs offered by VCJPA are a Health Plan, Life Insurance, AD&D and Long Term Disability. These are not mandatory and have less than half of the member agencies involved.

As a manager of a member district, I am very happy with the JPA. Besides the positive monetary aspects we have benefitted greatly from the attention to and emphasis on risk management by our administrator. The JPA is currently working on a risk management manual that will standardize our approach to risk management in every aspect of our programs. This standardization will provide consistency statewide and allows for the implementation of a standardized educational program rather than one that has to be adjusted by region or even by district. We are already improving on our already enviable safety and performance record in California, and this improvement will be reflected in lower insurance payouts resulting in monetary gains for member agencies.

If you are interested in more information, I suggest you contact Mr. Ed Bickmore at VCJPA in Sacramento, California. (P.O. Box 420426, Zip 95842) He is an excellent administrator and an insurance professional who can provide more detail than I.

CALIBRATION OF BACKPACK SPRAYERS AND OF CHEST STYLE BROADCAST SPREADERS

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SEYMOUR SPREADER CALIBRATION DIRECTIONS

To calibrate for the proper application of granules adhere to the following:

1) Determine the product to be used (e.g., Vectobac Granules).

2) Consult the label for proper rate of application (e.g., 5 lbs/acre).

3) Select a labeled application site (e.g., roadside ditch).

4) Measure and mark out an area of convenient size (e.g., 100 ft. x 100 ft. = 10,000 sq. ft.).

5) Determine proper application rate for that given area selected in step #4:

$$\frac{x}{10{,}000 \text{ sq.ft.}} = \frac{5 \text{ lbs/acre}}{43{,}560 \text{ sq. ft./acre}}$$

(cross multiply and divide to determine - x)

x - 1.15 lbs

6) Set swath width of spreader (e.g., 10 ft.).
   a) Pre-set width lever - best guess.
      * closed is about 4 ft.
      * wide open is about 12 ft.
   b) Spread some granules.
   c) Measure actual swath width.
   d) Readjust swath width lever if necessary.

7) Determine and maintain a consistent application walking speed. Be able to verify it. Determine speed in m.p.h.

$$\frac{15 \text{ seconds}}{50 \text{ ft.}} = \frac{3{,}600 \text{ seconds/hr.}}{x}$$

(cross multiply and divide to determine x)

x = 12,000 ft. per hour or 2.27 m.p.h.

Actual speed is irrelevant as long as you are consistent.

8) Always maintain a consistent cranking speed and spreader height.

9) Position the 10 point shutter to provide the proper application flow rate.

   a) Pre-set shutter opening - best guess.
      * 0 is closed.
      * 10 is wide open.
      * Start at about 5.

   b) Pour a pre-measured amount of granules into the hopper (e.g., 5 lbs).

   c) Spread the granules as follows:
      * Proper area (#4).
      * Proper width (#6).
      * Proper speed (#7).

   d) Stop and measure remaining granules. Subtract from the beginning amount (5 lbs). If setting 5 was correct then about 3.85 lbs should remain.

   e) Re-adjust shutter setting if necessary.

10) In summary, we need to provide the following to properly apply granules with the Seymour Spreader:

   - proper swath width.
   - consistent speed of travel and cranking speed.
   - proper shutter setting.
   - product and label.

Miscellaneous Notes

*Always use common sense and look at the big picture (i.e., if you have 1 acre to treat at the end of the job, have you used 5 lbs total?).

*You obviously must recalibrate for each operator.

SMALL HAND HELD OR BACKPACK SPRAYER CALIBRATION

To calibrate for the proper application of a liquid spray through a small sprayer, adhere to the following:

1) Determine the product to be used (e.g., Vectobac AS).

2) Consult the label for proper rate of application (e.g., 1 qt/acre).

3) Select an application site (e.g., graveled or asphalt parking lot), but DO NOT start calibrating with the product in the tank.

4) Measure and mark out an area of a convenient size (e.g., 4 ft x 70 ft = 280 sq ft).

5) Select a sprayer (e.g., Solo Backpack Sprayer).

6) Determine tank size and fill with water (e.g., 3 gallons).

7) Do your best to maintain a constant pressure (e.g., pressure limiting valve with a 15 p.s.i. spring).

8) Do your best to hold a constant nozzle height to maintain a consistent swath width (e.g., at my comfortable height, my flat fan nozzle gives me a 4 ft swath). Check nozzle pattern.

9) Do your best to maintain a consistent application walking speed. Be able to repeat and/or verify it.

10) Spray the area as follows:

* Proper area (#4).
* Proper pressure (#7).
* Proper height (#8).
* Proper speed (#9).

Time yourself while spraying the area (e.g., 20 seconds).

11) Catch the spray from the nozzle while spraying the same amount of time (20 seconds) it took to cover the pre-measured area. Measure the amount of liquid (e.g., 12 oz).

12) Determine the amount of water applied per acre:

$$\frac{12\text{ oz}}{280\text{ sq ft}} = \frac{x}{43{,}560\text{ sq ft/acre}}$$

(cross multiply and divide to determine x)

x = 1,867 oz = approximately 14.5 gallons/acre.

13) Determine the amount of product to be addeed to the sprayer tank. Use the following information:

* Step 1 - Vectobac AS
* Step 2 - Rate (1 qt/acre or 32 oz/acre).
* Step 6 - Amount of water in tank (3 gal.).
* Step12 - Rate of spray per acre (14.5 gal/acre).

$$\frac{32\text{ oz}}{14.5\text{ gal/acre}} = \frac{x}{3\text{ gal.}}$$

(cross multiply and divide to determine x)

x = 6.6 oz of Vectobac AS needed in tank.

14) Fill the tank with 3 gallons of water. Pour in 6.6 oz of Vectobac AS and go out and make your application. This should be enough to do about 9,000 sq ft.

15) In summary, we need to provide the following to properly apply a pesticide with a small hand held backpack sprayer:

* Consistent pressure
* Consistent nozzle height
* Consistent speed of travel
* Known spray application rate
* Product and label

Miscellaneous Notes

* You obviously must recalibrate for each operator.

PRACTICAL ASPECTS OF COLDFOGGING

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My Webster's *New Collegiate Dictionary* (seventh edition) defines "practical" in three ways:

1. Capable of being put to use
2. Disposed to action as opposed to speculation
3. Qualified by practice

The definitions are quite applicable to the everyday use of coldfoggers. To put a fogger to use, one must appreciate the necessity to understand the flow of aerosols in the environment. Swath width is a function of insecticide dose, droplet size and weather condition (Mount *et al.* 1970). Most aerosol generators try to produce 85% of the droplets in the "less than 20 micron" range. Several researchers have shown that the optimal ground aerosol droplet is between 5 and 15 microns (Mount 1970). As a rule of thumb, one ounce of insecticide will produce 26 billion 10 micron droplets. The fog will react according to the atmospheric conditions at the time of application.

Christensen *et al.* (1969) report that when stable conditions exist, there are no thermally induced vertical fluctuations; therefore, a cloud of spray droplets drifting during such an atmospheric condition will experience very little vertical dispersion allowing for relatively high chemical dissemination downwind. Two atmospheric conditions, inversion and air movement, are necessary to carry the fog through the killing zone for mosquitoes. An inversion exists when warm air is above and cool air is near the ground. Considering that the target or killing zone is from ground level to 30 feet above, temperature measurements should be taken near these. Taking the lower temperature at 6 feet eliminates the possibility of measuring ground radiation. The higher temperature should be measured at about 30 feet. Wind velocity should be at least 1 mph. and less than 10. Several types of anemometers or wind gauges are available. The Stability ratio (SR) is a function of wind speed and inversion:

$$SR = \frac{T_2 - T_1}{(\bar{u})_2} \times 10^5$$

T_2 = temperature at 30 ft. (C°)

T_1 = temperature at 6 ft. (C°)

$\bar{u}$ = average wind velocity (cm/sec.)

A positive SR indicates stability and a higher number indicates more stable conditions. Generally, positive numbers will range between 1 and 100. An acquisition system for micrometeorological data has been described by Christensen *et al.* (1972). Data on efficacy of insecticide application has more value when weather measurements are included.

The second part of the "practical"definition tells us that speculation is of little value. Evaluation of coldfogger application must be made and made according to the ability of the investigative unit. The evaluation of application equipment and efficacy of insecticide can be done in several ways. Equipment: Both home built and commercial foggers have been evaluated and seem to produce a droplet size spectrum that is acceptable. Droplet size has been measured by slide-wave, slide-in-the-hanger, laser-computer and hot wire techniques. Not one operational machine of which I am aware has been altered due to ineffective droplet size. More important for field use is the output or number of fluid ounces per minute applied. Knowledge of output is necessary to maintain label requirements and to keep track of costs of applications. Both operational and test line evaluation can be simplified by the use of calibrated test tubes to determine flow rate. Application: On site, evaluation of the application can be made by pre- and post-treatment counts of the target insect. Pant-leg biting counts or light trap data are limited in their usefulness. On successful applications, when most or all of the target insects have been eliminated, there is no problem. However, when the target insects continue to be abundant, application under poor atmospheric conditions or failure of the insecticide may be the problem. Evaluation with caged mosquitoes is an effective method for operational or test line coldfogger applications. Disposable paper and nylon tulle cages as described by Townzen and Natvig (1973) are sensitive and cost effective. Susceptible mosquitoes are used as air samplers and indicate operational effectiveness of the application. Susceptible and autogenous *Culex pipiens* are laboratory reared and available for most of my work. Target species can be field collected by aspiration, sweep net or EVS trapping for use as indicators of the operational effectiveness of the chemical used. Approximately 20 mosquitoes are placed in each cage up to 3 hours before the applications are made. Controls for all species used are placed several miles up wind from the application route. Cages are affixed to the top of a 3 ft. surveyor's lath by using rounded coat hangers clamped to the lath with binder clips. One or more cages make a cage station. Placement of cage stations depends upon the need to understand the application and the ingenuity of the evaluator. Urban applications have been described by Womeldorf *et al.*, (1973) and Townzen and Whitesell (1975). Field and test line applications are described by Townzen *et al.* (1987). Examples of, the type of useful data that can be generated are shown on Tables 1 and 2. Table 1 shows wild *Culex tarsalis* population that cannot be controlled with malathion, even at excessive dosages. Table 2 indicates chlorpyrifos resistant population of *Aedes nigromaculis*. In both of these cases, the material is no longer effective for the indicated mosquito populations. Data can be gathered to evaluate both the application and the efficacy of the material used with this technique. Equipment is not overly expensive and laboratory space needed is minimal. Safety is a further consideration that must be noted in coldfogger operations, safety for the operator, the public and the environment. It is not in the scope of this paper to go into detail on safety, however, I do recommend continued education for operators, limit in town applications to below 3 fl. oz./min. and apply only those chemicals necessary to do a job.

CONCLUSIONS

Coldfoggers are practical tools in mosquito control when used under proper atmospheric conditions. Applications of aerosols can and must be evaluated for efficacy of insecticide and the application itself. With training and involvement, operator confidence will increase as he or she learns to use these tools. And finally, confidence in the materials used will promote operational success of the mosquito control program.

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Table 1 - Percent mortalities of caged *Cx. pipiens* (Lab) and *Cx. tarsalis* (Wild) following nonthermal aerosol applications of malathion, Colusa MAD, August 12 and 27, 1986.

	12 hour mortalities (%)					
	95% Malathion		95% Malathion		56% Malathion	
Distance (ft)	Lab	Wild	Lab	Wild	Lab	Wild
0	100	100	100	87	100	31
200	100	90	100	69	100	77
400	100	73	100	80	97	32
600	100	59	100	68	95	46
1320	100	57	100	55	96	16
2640					100	44
3960					70	27
5280					71	48
Control	3	25	3	25	10	3
lb AL/100 ft		0.124	0.087		0.033	
Wind velocity (mph)		4	4		1	
Inversion (°F)		0.2	0.3		3.0	
Stability ratio		0.6	0.8		100	

Table 2 - Mortalities (%) of *Ae. nigromaculis* (Wild) and *Cx. pipiens* (Lab) following nonthermal aerosol application of chlorpyrifos, Zumwalt pasture, Colusa MAD, June, 1985.

	12 hour mortality (%)			
	Line A		Line B	
Distance	Lab	Wild	Lab	Wild
0	100	86	100	62
200	100	75	92	68
400	100	71	88	61
600	100	24	100	71
800	88	65	100	78
1000	94	61	100	94
Wind velocity (mph)	1			
Inversion (°F)	0.5			
Stability ratio	15			

1987 ABBOTT LABORATORIES PRODUCTS EVALUATION

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Since 1985 the Maryland Department of Agriculture has contracted with Abbott Laboratories to evaluate several mosquito control products. These evaluations enable MDA to assess potential mosquito control agents and provide Abbott Laboratories with data on products under field conditions. This report is a synopsis of the work done in 1987.

MATERIALS AND METHODS

The evaluations were carried out in the tidewater marshes adjacent to Fishing Bay, Dorchester County, Maryland. The test sites are typical larval habitat of salt marsh *Aedes*. The characteristics common to all of the sites are: (1) mosquito breeding confined to well defined depressions ranging in size from one to 20 sq. ft. in surface area and 0.5 to one foot in depth (2) no canopy over the breeding site (3) short (ca. one foot high) vegetation composed of *Spartina alterniflora, Spartina patens* and *Distichlis spicata* surrounding the breeding depressions and (4) high elevation marsh not affected by daily tides.

The Abbott Lab. products evaluated were ABG-6138F, ABG-6193, ABG-6197, ABG-6221, ABG-6214, ABG-6215 and ABG-6231 2EC and ABG-6243. ABG-6138F is a 5/8 mesh granular formulation with a *Bti* concentration of 200 ITU per mg, ABG-6197 is a 400 ITU/mg granular formulation with a 10/14 mesh, ABG-6193 and ABG-6221 are liquid *Bti* formulations with 1200 and 2400 ITU/mg concentrations respectively, ABG-6214 and ABG-6215 are ganular formulations containing 1% (by weight) fenoxycarb, a carbomate growth inhibitor, ABG-6215 is a 5/8 mesh granule which incorporates 200 ITU/mg of *Bti* and ABG-6214 is a 10/14 mesh granule with no *Bti*, ABG-6231 2EC and ABG-6243 are liquid and wettable powder formulations respectively of fenoxycarb. Methoprene was used as a standard to compare with the fenoxycarb products.

Twenty seven tests of the above products were conducted in 1987. Nine aerial and 18 ground applications were made between June 28 and September 28. Evaluations of *Bti* products were based on larval dip counts prior to and up to 96 hours after application. Fenoxycarb and methoprene treated plots were monitored for pupal survival in the field and a sample of pupae was taken to the lab. to determine the percentage of successful adult emergence. From each plot, a sample of ca. 100 larvae was collected prior to treatment and returned to the lab. for identification and instar determination. Water temperature, salinity and pH were measured at the time of application. A control plot was established for each test series.

Ground applications of the granular formulations were made by hand, applying a premeasured weight of granules to a breeding site of a known surface area to achieve the desired application rate. The granules were weighed with an RCBS 505 powder measure scale. The granules were distributed as evenly as possible on the water surface.

A solo model 425 backpack sprayer was used for the liquid spray formulation ground applications. The size of all ground liquid spray plots was 1/100 of an acre. The shape of the plots was square, each side of which was approximately 21 feet in length. The proper volume of liquid formulation, or weight of wettable powder, was mixed with one quart of water and this mixture was applied over the entire plot. This rate is equivalent to 25 gallons of finished spray per acre. The swath width was 5 feet.

Aerial applications were made by a Grumman Ag Cat 600. Granular applications were calibrated for a swath width of ca. 40 feet using a Swathmaster spreader equipped with a blocking plate. The flight speed for granular applications was ca. 100 mph. Aerial liquid formulations were applied with a conventional spray system which produced a volume of 0.5 gallon of finished spray per acre over a swath width of 90 feet at an airspeed of 110 mph. To achieve this dosage, the aircraft was equipped with 24 Teejet nozzles with D5 hollow cone tips and # 45 cores. The system was pressurized to 30 psi with a variable pitch wind driven pump.

RESULTS AND DISCUSSION

A summary of the work carried out during 1987 is presented in Table 1. Control plot data are not included in the following discussion because of negligible mortality (less than 5%) in all controls.

The results of the ground applications of ABG-6138F are presented in Table 2. The effectiveness of this formulation has diminished over the past two years. In 1985 this product produced greater than 95% control at 5 lbs./acre in Maryland field tests (Lesser, 1985). In 1986 the same dose rate resulted in 89% control (Lesser, 1986). In 1987 the rate of 5 lbs./acre was less than 42% effective, 8 lbs./acre provided 61% control and 10 lbs./acre was 82% effective. Complete control (100% mortality) was achieved at 15 lbs./acre.

One aerial application of ABG-6138F and four of ABG-6197 were conducted in 1987 (Table 3). The 6138F was applied at 15 lbs./acre which provided ca. 95% control. The results of the 6197 applications are variable. At 5 lbs./acre, no reduction in larval numbers was observed when applied against third instar larvae; however, an application of 4 lbs./acre resulted in 60% control of second instar larvae. Two applications of 6197 were made at 8 lbs./acre against a mixed population of second and third instar larvae and provided 91% and 93% control.

Four ground applications of ABG-6221 were made at rates ranging from 0.25 to one pint/acre (Table 4). At the rate of 0.25 pint/acre no reduction of a population of third instar larvae was observed. Applications of 0.5 and one pint/acre produced 63.5% and 95% control respectively of third instar larvae. When applied to a population of second instar larvae at 0.5 pint/acre, ABG-6221 provided 100% control.

The results of the aerial applications of ABG-6193 are presented in Table 5. At the low rate of application (0.5 pint/acre), no control was observed of third instar larvae. Two applications at one pint/acre produced ca. 95% and 96% control of third instar larvae.

The results of the 8 applications of fenoxycarb formulations are presented in Table 6. The 6214 formulation produced a 69.2% reduction of adult emergence when applied to a population of second instar larvae and 83.45% control when applied to a population of third instar larvae at 2.5 lbs. of granules per acre (0.025 lbs. a.i./acre). The 6215 formulation (which also contains 200 ITU/mg *Bti*) provided no reduction in the larval population but did inhibit adult emergence by ca. 73% when applied to a population of second instar larvae and ca. 84% when applied to a population of third instar larvae. The 6231 EC formulation was evaluated at 0.01 and 0.02 lb. a.i./acre against a mixed population of second and third instar larvae. At the 0.01 lb. a.i./acre rate, a reduction in adult emergence of ca. 72% was realized. The degree of control was ca. 14% greater when the rate was increased to 0.02 lb. a.i./acre. The 6243 formulation was applied at 0.02 lb a.i./acre. Against second instar larvae, this rate produced a 64% reduction in adult emergence. However, when applied to a population of third instar larvae a reduction of ca. 95% was achieved. The effectiveness of each fenoxycarb formulation was greater when applied to third instar larvae than second instar larvae. implying that at the dosage rate of 0.02 lb a.i./acre, or less, sufficient degradation occurs prior to pupation to cause a reduction in effectiveness in a direct relationship with larval age (i.e. the younger the larvae are when fenoxycarb is applied, the less adult emergence will be inhibited.).

In summary the results of 1987's work show that the efficacy of Abbott Laboratories *Bti* products against salt marsh *Aedes* is variable and dependent upon larval age and density. All *Bti* products appear to be more effective against light to moderate numbers of young larvae than high populations at older larvae. From review of the 1987 data and comparison with similar data colected in Maryland in 1985 and 1986, it appears that the efficacy of ABG-6138F and ABG-6193 has diminished. However, the data are so variable, no valid conclusions can be drawn. The ABG-6221 formulation was particularly disappointing. It was thought that due to its higher content of *Bti* this product would be proportionately more effective but this was not found to be true.

The fenoxycarb products showed lower levels of control than anticipated and were less effective than methoprene when applied at the same rate.

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Table 1. Summary of Abbott Laboratory products field tests in Maryland during 1987.

Formulation	Application Data Rate	Date	Type[1]	Plot Size(A)	$\overline{X}$ Number Larvae/Dip Pretreat	Posttreat	% Control
ABG-6138F	2.5#	9/10	G	1/100	36.3	39.5	-0-
ABG-6138F	5.0#	9/10	G	1/100	71.7	41.7	41.84
ABG-6138F	8.0#	9/10	G	1/100	38.2	14.9	60.99
ABG-6138F	10.0#	9/10	G	1/100	53.5	9.6	82.06
ABG-6138F	15.0#	9/10	G	1/100	44.4	-0-	100.00
ABG-6138F	15.0#	9/18	A	40	17.5	0.9	94.86
ABG-6193	0.5 pt	7/29	A	520	18.58	22.83	-0-
ABG-6193	0.5 pt	9/10	A	12.5	22.90	35.30	-0-
ABG-6193	1.0 pt	9/10	A	25	14.10	0.52	96.31
ABG-6193	1.0 pt	9/14	A	25	34.17	1.83	94.64
ABG-6197	4.0#	9/10	A	25	42.20	16.70	60.43
ABG-6197	5.0#	7/29	A	48	44.83	137.08	-0-
ABG-6197	8.0#	9/10	A	10	54.50	3.60	93.39
ABG-6197	8.0#	9/18	A	20	15.60	1.40	91.03
ABG-6214	2.5#	9/10	G	1/100	N/A[2]	N/A[2]	69.20
ABG-6214	2.5#	9/28	G	1/100	N/A[2]	N/A[2]	83.45
ABG-6215	2.5#	9/10	G	1/100	38.93	58.71	73.15[3]
ABG-6215	2.5#	9/28	G	1/100	24.12	27.40	84.32[3]
ABG-6221	0.5 pt	6/28	G	1/100	30.60	-0-	100.00
ABG-6221	0.25pt	9/11	G	1/100	38.33	63.66	-0-
ABG-6221	0.5 pt	9/11	G	1/100	108.66	39.66	63.50
ABG-6221	1.0 pt	9/11	G	1/100	54.66	2.66	95.13
ABG-6231EC	0.01#	9/11	G	1/100	N/A	N/A	72.16
ABG-6231EC	0.02#	9/11	G	1/100	N/A	N/A	86.00
ABG-6243	0.02#	9/10	G	1/100	N/A[2]	N/A[2]	63.87
ABG-6243	0.02#	9/28	G	1/100	N/A[2]	N/A[2]	94.72
Methoprene	0.02#	9/10	G	1/100	N/A[2]	N/A[2]	100.00

[1] G = Ground Application; A = Aerial Application
[2] Pre and Post larval counts were not used to evaluate these products.
[3] The percentage of control of ABG-6215 was based on inhibition of adult emergence, not by reduction in larval counts.

Table 2. Field evaluation of ground applications of ABG- 6138F against salt marsh mosquitoes in Maryland during 1987.

Rate of Application	Mosquito Species	Larval Instar	Water Quality Temp[1]	Salinity[2]	pH	% Control
2.5/A	*Ae. sollicitans*(73%) *Ae. taeniorhynchus*(27%)	2 & 3	19	11	6.5	-0-
5#/A	*Ae. sollicitans*(65%) *Ae. taeniorhynchus*(35%)	3	20	11	6.5	41.84
8#/A	*Ae. sollicitans*(100%)	3	25	11	6.5	60.99
10#/A	*Ae. sollicitans*(78%) *Ae. taeniorhynchus*(22%)	2 & 3	27	10	6.8	82.06
15#/A	*Ae. sollicitans*(100%)	3	27	14	7.0	100.00

[1] degree C.
[2] parts per thousand.

Table 3. Field evaluations of aerial applications of ABG-6138F and ABG-6197 against salt marsh mosquitoes in Maryland during 1987.

Formulation	Rate of Appl.	Mosquito Species	Larval Instar	Water Quality Temp	Salinity	pH	% Control
6138F	15#/A	*Ae. sollicitans*(100%)	3	15	8	6.2	94.86
6197	4#/A	*Ae. sollicitans*(100%)	2	23	12	6.7	60.43
6197	5#/A	*Ae. sollicitans*(84%) *Ae. taeniorhynchus*(16%)	3	22	15	6.7	-0-
6197	8#/A	*Ae. sollicitans*(67%) *Ae. taeniorhynchus*(33%)	2 & 3	19	11	6.5	93.39
6197	8#/A	*Ae. sollicitans*(91%) *Ae. taeniorhynchus*(9%)	3	20	12	6.6	91.03

Table 4. Field evaluation of ground applications of ABG- 6221 against salt marsh mosquitoes in Maryland during 1987.

Rate of Application	Mosquito Species	Larval Instar	Water Quality Temp[1]	Salinity[2]	pH	% Control
0.25 pt./A	*Ae. sollicitans*(41%) *Ae. taeniorhynchus*(59%)	3	18	13	6.7	-0-
0.5 pt./A	*Ae. sollicitans*(59%) *Ae. taeniorhynchus*(41%)	3	21	9	6.5	63.50
0.5 pt./A	*Ae. sollicitans*(98%) *Ae. taeniorhynchus*(2%)	2	20	12	6.6	100.00
1.0 pt./A	*Ae sollicitans*(78%) *Ae. taeniorhynchus*(22%)	3	23	17	6.6	95.13

[1]degree C.
[2]parts per thousand.

Table 5. Field evaluation of aerial applications of ABG- 6193 against salt marsh mosquitoes in Maryland during 1987.

Rate of Application	Mosquito Species	Larval Instar	Water Quality Temp[1]	Salinity[2]	pH	% Control
0.5 pt./A	*Ae. sollicitans*(100%)	3	20	13	6.3	-0-
0.5 pt./A	*Ae. sollicitans*(63%) *Ae. taeniorhynchus*(37%)	3	18	10	6.8	-0-
1.0 pt./A	*Ae. sollicitans*(81%) *Ae. taeniorhynchus*(19%)	3	18	11	6.4	94.64
1.0 pt./A	*Ae. sollicitans*(100%)	3	22	13	6.5	96.31

[1]degree C.
[2]parts per thousand.

Table 6. Field evaluations of fenoxycarb and methoprene against salt marsh mosquitoes in Maryland during 1987.

Formulation	Rate of Appl.	Mosquito Species	Larval Instar	Water Quality Temp	Salinity	pH	% Control
6214	2.5#/A	*Ae. sollicitans*(8%) *Ae. taeniorhynchus*(92%)	2	18	16	6.0	69.20
6214	2.5#/A	*Ae. sollicitans*(70%) *Ae. taeniorhynchus*(30%)	3	21	12	6.4	83.45
6215	2.5#/A	*Ae. sollicitans*(100%)	2	19	12	6.4	73.15
6215	2.5#/A	*Ae. sollicitans*(100%)	3	20	12	6.5	84.32
6231EC	0.01#/A	*Ae. sollicitans*(100%)	2 & 3	22	18	6.9	72.16
6231EC	0.02#/A	*Ae. sollicitans*(69%) *Ae. taeniorhynchus*(31%)	2 & 3	19	15	6.7	86.00
6243EC	0.02#/A	*Ae. sollicitans*(54%) Ae. taeniorhynchus(46%)	2	18	15	6.7	63.87
6243	0.02#/A	*Ae. sollicitans*(100%)	3	21	17	6.7	94.72
Methoprene	0.02#/A	*Ae. sollicitans*(100%)	3	19	15	6.7	100.00

WESTERN EQUINE ENCEPHALITIS OUTBREAK IN COLORADO, 1987

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Colorado experienced a widespread outbreak of Western Equine Encephalitis in 1987. An equine case was reported as having a date of onset the first week of June. A human case was confirmed with onset in early July. This case occurred in Pueblo County. Two other human cases were confirmed from Pueblo County in mid-July. The Pueblo City-County Health Department had contacted all area veterinarians and discovered several suspect equine cases were known but had not been reported. Reporting is not required. The Pueblo City-County Health Department then increased the adulticiding aspect of their ongoing mosquito control program. At the same time they contacted all hospitals to determine the incidence of central nervous system infections. Epidemiologists at the Colorado Department of Health began a statewide search of hospitals to determine the scope of the outbreak. It was evident that a serious threat existed in the front range area. There was no indication that this threat existed in other parts of the state. Cases were confirmed in Boulder, Larimer and Weld Counties in late July and early August. All jurisdictions with any adulticiding capabilities were urged to begin control if not already involved.

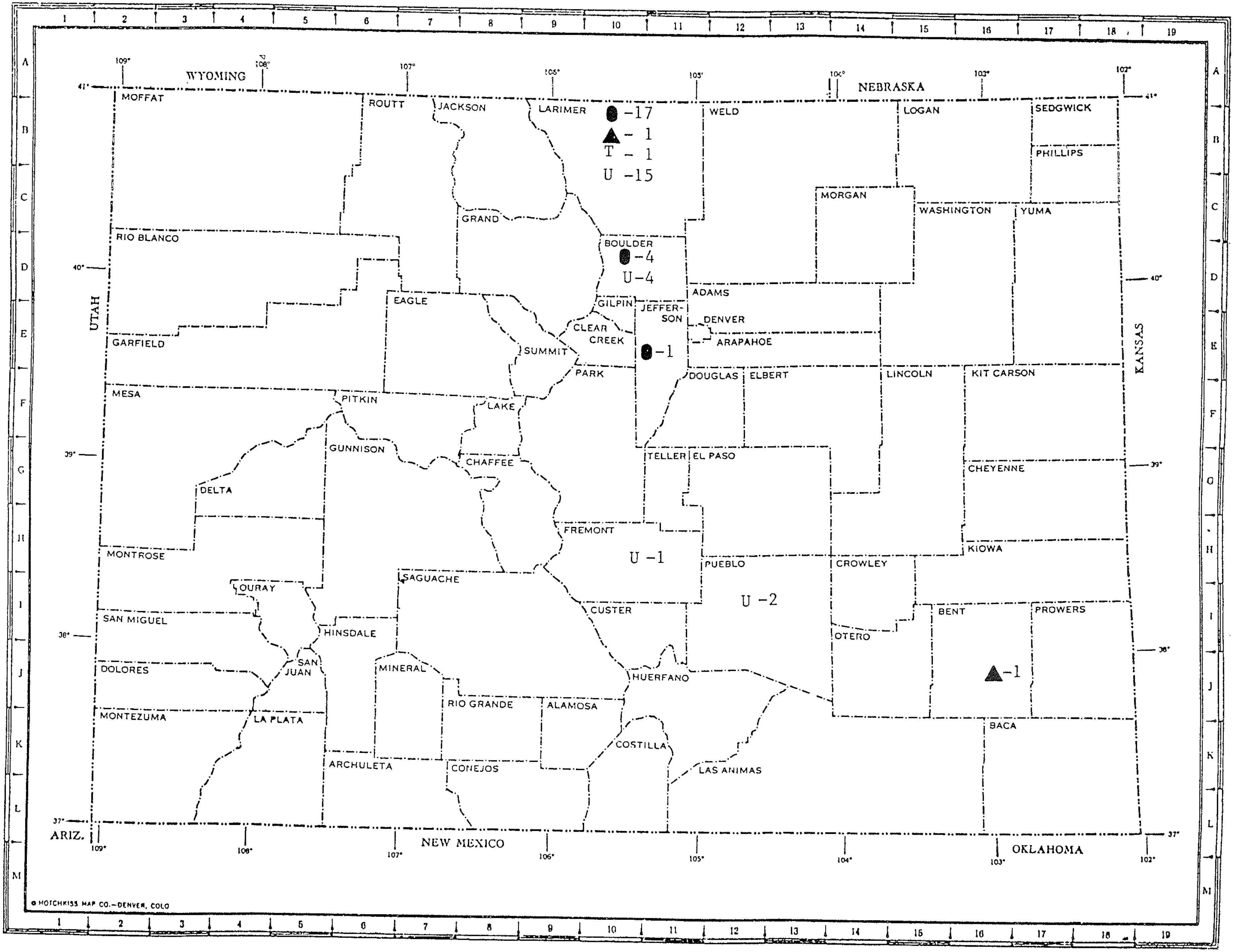
Mosquito trapping was carried out in several areas of the state in an effort to determine levels of infection. As of September 23, 1987 there were a total of 25,248 mosquitoes segregated into 1226 pools for virus isolation. There were 47 positive pools with the following results (Fig. 1): Western Equine Encelphalitis (WEE) 22; St. Louis Encephalitis (SLE) 2; Turlock (TUR) 1; Unknown (UNK) 22. Those listed as unknown are in test to be identified. There are many pools of mosquitoes yet to be tested, therefore these totals are not final. Virus isolations have come only from *Culex pipiens* and *Cx. tarsalis.*

There have been 31 human cases confirmed, 27 (see Fig. 2) WEE and 2 (see Fig. 2) SLE. These totals must be considered as preliminary as others are waiting confirmation. All human cases are located in the eastern part of the state. Of the 40 equine cases only 5 have been reported from Western Colorado. These numbers will also probably change as testing continues.

Mosquito control in Colorado, is conducted by various jurisdictions. There are 10 control districts; four local health departments have ongoing programs and numerous municipal and county supported programs exist. Most of the districts and the local health departments conduct integrated control programs while the emphasis in the municipal programs is adulticiding. None of the districts operate in the area of the outbreak. However, local health department programs operating in that area are well organized and effective within the limits of their funding. The outbreak would in all probability have been much more serious without their extra efforts. The insecticides used in the adulticiding programs were chlorpyrifos, malathion and resmethrin. It should be noted that a private firm is contracting to conduct integrated mosquito control in parts of the eastern front range. Their efforts seem to be acceptable to the residents and administrators of the areas they serve. This effort coincides with insurance problems of communities that engage in mosquito control and the anti-adulticiding cries from factions within those communities.

Fig. 1 ISOLATES FROM LIGHT TRAP COLLECTIONS

WEE= ⬮ SLE= ▲ TURLOCK=T UNKNOWN=U



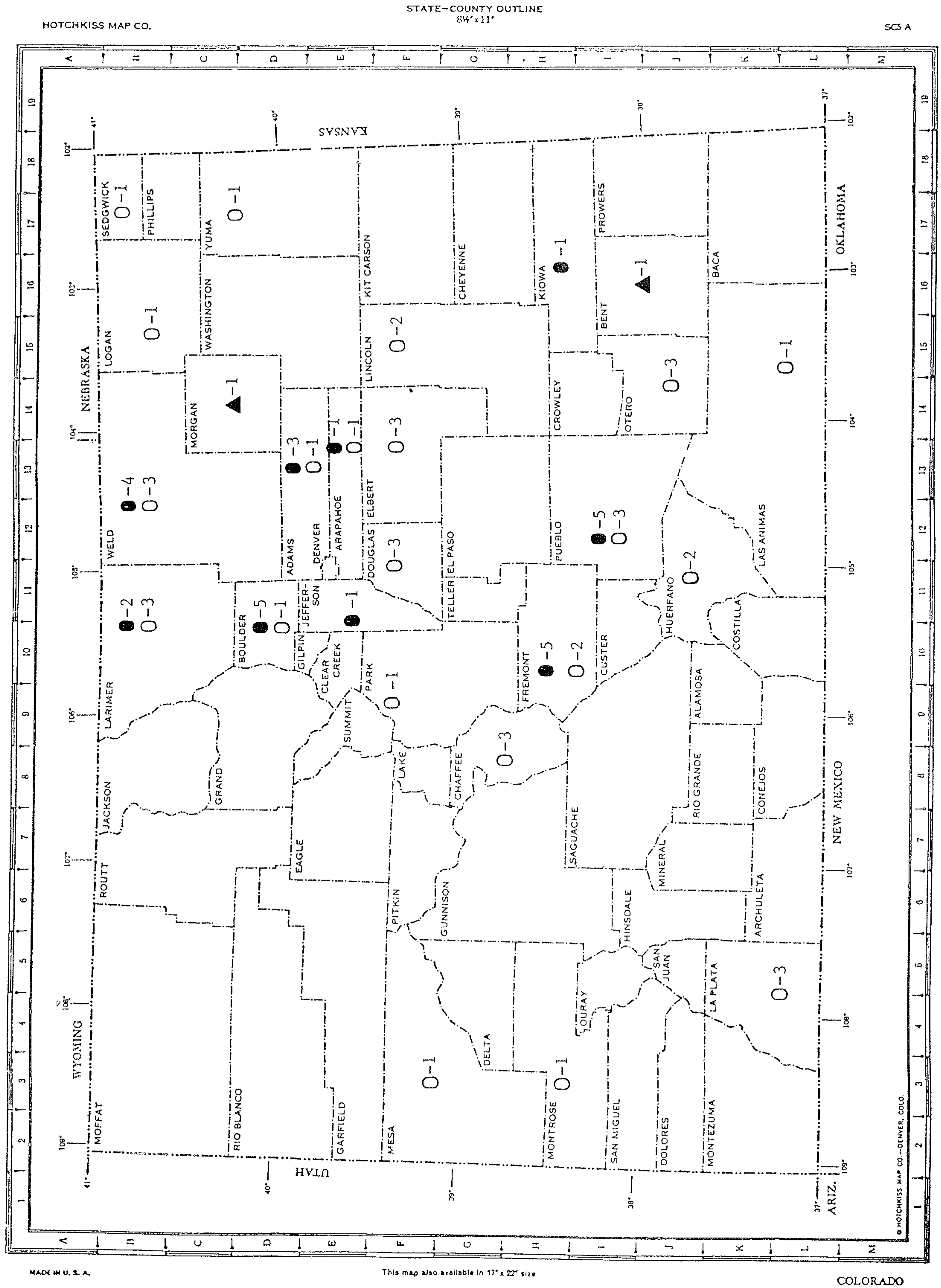
MADE IN U. S. A.

This map also available in 17" x 22" size

COLORADO

Fig. 2 HUMAN AND EQUINE CASES BY COUNTY

WEE= ● SLE= ▲ EQUINE= O



ENCEPHALITIS SURVEILLANCE - 1987

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ABSTRACT

During 1987, five chickens from the Jensen Uintah County flock were found to have virus antibodies to Western Equine Encephalitis following the August 3. bleeding. This flock was added in 1987 and is located in the midst of good *Culex tarsalis* habitat. Uintah County District personel adulticided the area around the flock site immediately after receiving the report. No further conversions occurred in the Jensen flock or any of the other 21 flocks throughout the State.

RESISTANCE OF UTAH LARVAL MOSQUITOES TO CHLORPYRIFOS, FENTHION AND MALATHION

THOMAS J. FINK[1] AND MALCOLM A. THOMPSON[2]

Organophosphorus larvicides were introduced into Utah in 1956 (Graham and Rees 1956, 1958) and from the 1960's until the present have been the chief agents used to control larval mosquitoes. No resistance was found to parathion in 1965-1967 (Womeldorf 1967) and no resistance was found in 1970 to malathion in untreated (Shiozawa and Havertz 1971) and treated areas (Shinney and Havertz 1971). Hart and Womeldorf (1977) classified very few of their 1976 samples as resistant to parathion, fenthion and malathion although LC50 values for parathion ranged higher in 1976 than in 1965-1967 for all species tested. Tests run in 1977 (Merrell and Wagstaff 1978), 1978 (Wagstaff and Merrell 1979) and 1979 (Merrell and Rosay 1980) indicated slightly increased levels of resistance to parathion, fenthion and malathion (Merrell and Rosay 1980).

Since the early 1980's chlorpyrifos and fenthion have been used extensively in Utah to control larval mosquitoes. Our study investigated the status of larval resistence to these insecticides and to malathion (the primary adulticide in Utah, Sammie Dickson, personal communication).

METHODS

Larvae collected by personnel of participating mosquito abatement districts were placed in ziplock bags and transported by car or bus in insulated containers. These containers usually contained ice or other coolants which did not directly contact the larval bags.

The number of samples and the number of tap water tests (in brackets, repeats of tests not counted) brought in by participating mosquito abatement districts (MADs, for complete names see Table 1) were: Salt Lake City 32 (64), South Salt Lake 14 (24), Uintah 12 (21), Davis 7 (10), Magna 6(9), Tooele 4 (5), Box Elder 4 (9), Weber 3 (7), Emery 2 (4), Utah 2 (2) and North Summit 1 (1).

Methods for preparing test chemicals from technical grade insecticides, handling larvae in the laboratory and running tests were similar to that described by Gillies and Womeldorf (1968). Larvae received from the field were transferred to white enamel pans where the water was cleaned of excess debris. Larvae were fed rabbit pellets or ground up rat food and allowed to rest in a darkened area for at least one hour prior to sorting into test cups. Late third to early fourth instar larvae were used in all tests. Usually 20 larvae were transferred with window screening into each disposable waxed paper cup containing 100 ml of aged tap water (aged 12 hours or more). Various concentrations of test chemicals were dispensed using one ml pipettes controled by a syringe. Control samples received an amount of acetone (up to 0.7 ml) equal to the greatest amount of test chemical/acetone solution used in that run. For each chemical tested on a population, 2 replicates per dose and 2 controls were usually run when sufficient numbers of larvae were available. After insecticide treatment, larval cups were covered with an opaque tray and left undisturbed for 24 hours, after which live and moribund or dead larvae were counted. Counts in all tests were made by one person. A small number of tests were also run using the original source water filtered of large debris. Room temperature ranged between 15 and 21 °C over the course of the study (mean = 18.2 °C, standard deviation = 1.12). Tests were run from May 19 to August 6, 1987.

Data presented here was analyzed by a probit computer program developed by Raymond (1985) and also by graphing mortality results on probit graph paper. Counts from the replicates of each dose were combined for the final data analysis. When lumping data or computing heterogeneity correction factors, we followed recommendations of Raymond (1985) and Finney (1971).

RESULTS AND DISCUSSION

All results, except for repeats and source water tests, are presented in Table 1[1]. We have not discarded data due to high pupation rates, high control mortality, mixed species assemblages (less than 90% dominance by one species) or data heterogeneity as suggested by other studies (e.g. Thompson 1985, 1987) since all our data generally resulted in similar conclusions. Statistically significant heterogeneity of the data points is not considered here as grounds for invalidating a test since it is often characteristic of a population. Potentially compromising features of our database are indicated in Table 1.

From extensive laboratory and field experience in California, a threshold dose (TD) has been determined for different larvicides to allow correlation of laboratory results (lethal concentration values) with operational resistance in the field. LC50 values which are one or more times greater than the TD suggest resistant populations (control failures possible under adverse conditions) and values 2 or more times greater than the TD indicate highly resistant populations (control failures expected under most conditions using recommended application rates) (Womeldorf et al. 1966, Gillies et al. 1968). LC50 threshold doses of 2.5 ppb for chlorpyrifos, 5 ppb for fenthion, and 100 ppb for malathion have been used in this study and are taken after Thompson (1987). The above resistance criteria is often supplemented with the LC90/LC50 ratio (Thompson 1985) but it results in a system of criteria which is more complex and often ambiguous. We have used this system of criteria in this paper only when we refer to specific mosquito abatement districts but in problematical cases we have given more weight to the LC50 value as discussed above.

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In Fig. 1, the LC50 value divided by the TD is plotted for each sample for each species for chlorpyrifos, fenthion and malathion. Values have been sorted to ease comparison. Identically created plots were made from all published and unpublished (Salt Lake City) data for 1976 - 1979 studies for fenthion and malathion in Fig. 2. In at least 4 of the 6 species evaluated resistance has risen dramatically since the 1970's for fenthion and chlorpyrifos.

In the 1970's, all *Aedes dorsalis* (Meigen) LC50 values for fenthion were less than twice the TD while in 1987 44% of the fenthion and 53% of the chlorpyrifos values equaled or exceeded 2 times the TD. Most of the LC50 values for fenthion and chlorpyrifos exceeded the TD for *Ae. dorsalis* in 1987 while only 31% of the fenthion values exceeded the TD in the 1970's[2]. Resistance to organophosphorus larvicides (parathion, fenthion and malathion) was developing by 1979 since of 102 tests in Utah 7% were classified as resistant and 57% as borderline (Merrell and Rosay 1980).

Only *Ae. dorsalis*, resistant to chlorpyrifos (22 tests) and fenthion (12 tests), was collected from the contiguous MADs of Salt Lake City, South Salt Lake, Davis and Magna while only one resistant test was registered for both chlorpyrifos (10 tests) and fenthion (6 tests) from all the other MADs. *Ae. dorsalis* was generally susceptible to malathion throughout the state in 1987 despite frequent use of malathion as an adulticide during this time (Sammie Dickson, personal communication). Larvicides used in Utah would have little effect on larval susceptibility to malathion since it is known that there is relatively little cross resistance between malathion and fenthion or chlorpyrifos (Brown 1983, 1986).

While very few *Aedes nigromaculis* (Ludlow) samples were analyzed in 1987, most of the values indicated high resistance and one population was extremely resistant with LC50 values exceeding the TD by 52 and 36 times respectively for chlorpyrifos and fenthion. LC50 values in the 1970's did not approach such high levels and more than half of these values were less than the TD[2].

Too few samples of *Culiseta inornata* (Williston) (and with limited number of individuals per test) were tested in 1987 to allow comparisons to be made with tests in the 1970's. All 4 tests in 1987 resulted in LC50 values exceeding the TD.

Culex pipiens Linnaeus and *Culex tarsalis* Coquillet showed very increased levels of resistance in 1987 when compared to values of the 1970's. The entire scale of the plots for the 1970's data would form only the very bottom of the scales for the 1987 data for both species. Based on LC50 values alone, all *Cx. tarsalis* and most *Cx. pipiens* samples tested in the 1970's would be classified as susceptible to fenthion and malathion while in 1987 most *Cx. pipiens* would be classified as resistant to fenthion, chlorpyrifos and malathion. In 1979 no sample for either species was classified as resistant to parathion, fenthion or malathion, although 37% of *Cx. pipiens* (total of 49 tests) and 45% of *Cx. tarsalis* (total of 11 tests) were judged as borderline.

Culex quinquefasciatus Say, *Cx. pipiens* and *Cx. tarsalis* commonly become resistant to organophosphorus insecticides by esterase detoxification of the insecticides. In California the most common esterase correleated with general organophosphorus resistance in *Cx. quinquefasciatus* and *Cx. pipiens* is Bl (Raymond et al. 1987), and this enzyme has been detected in a *Cx. pipiens* population from Salt Lake City by starch gel electrophoresis (P. Wirth, unpublished data). Using the S-lab susceptible strain as a comparison El-Khatib and Georghiou 1985) LC50 and LC95 resistance ratios were respectively: chlorpyrifos 12.2, 22.8; fenthion 13.4, 31.1; malathion 6.9, 9.6; and temephos 9.6, 24.4 (P. Wirth, unpublished data). In California *Cx. tarsalis* and *Cx. quinquefasciatus* resistant populations are often resistant to many organophosphorus compounds (Georghiou et al. 1975, Apperson and Georghiou 1975).

Unlike *Ae. dorsalis*, *Ae. vexans* (Meigen) was largely susceptible to chlorpyrifos in 1987. Resistance to fenthion was also much less in *Ae. vexans*. In 1987 no *Ae. vexans* fenthion LC50 value reached 2 times the TD while 44% of the *Ae. dorsalis* values exceeded 2 times the TD. *Ae. vexans*, like *Ae. dorsalis*, remains susceptible to malathion and LC50 values were similar to the 1970's. *Ae. vexans* generally colonizes very temporary irrigated and flooded habitats while *Ae. dorsalis* occurs in older-less temporary habitats. *Ae. dorsalis* with more continual presence in the field than *Ae. vexans* is probably more heavily pressured by larvicides and thus has become more resistant than *Ae. vexans*. Alternatively, *Ae. vexans* may have lesser genetic potential to develop resistance to these insecticides or other factors may be important.

Larvae appeared slightly more susceptible to the test chemical (chlorpyrifos or fenthion) in source water than tap water in most of the tests (Fig. 3). Further testing is necessary to determine if the differences are statistically significant.

Merrell and Wagstaff (1978, for 1977 data) and Wagstaff and Merrell (1979, for 1978 data) presented only data that they considered to be borderline or resistant. Susceptible data was eliminated from their papers. We were able to obtain the complete data set only for Salt Lake City MAD. Thus the 1976 - 1979 data shown in Fig. 2 underestimates the proportion of susceptible populations actually found. Merrell and Rosay (1980) did not present any individual LC50 or LC90 values for their 1979 data, and we have used in Fig. 2 only raw data from their study from the Salt Lake City MAD.

CONCLUSIONS

In Utah levels of resistance to the organophosphorus larvicides, chlorpyrifos and fenthion, have increased since the 1970's for *Ae. dorsalis, Ae. nigromaculis, Cx. pipiens,* and *Cx. tarsalis*. In contrast, *Ae. vexans* has largely remained susceptible to organophosphorus larvicides throughout the state. The very low number of samples submitted by most of the participating districts does not permit a detailed geographic analysis of resistance in Utah. Resistance testing should continue in any areas where organophosphorus chemicals are still used, although many districts are phasing out the use of such chemicals (Dickson 1988). *Cx. pipiens* and *Cx. tarsalis* can be easily and inexpensively monitored for organophosphorus resistance using the filter paper spot esterase test (Pasteur and Georghiou 1980, 1981) which has recently been improved in the laboratory of G. P. Georghiou at the University of California at Riverside (P. Wirth, personal communication). Unfortunately, this test determines only the frequency of resistant individuals in a population and not the level of resistance (i.e. lethal concentration values such as the LC50 and LC90) (Pasteur and Georghiou 1980).

ACKNOWLEDGEMENTS

We thank Glen C. Collett and Sammie Lee Dickson for initiating and encouraging this study and for comments on the manuscript, Peggy Wirth for permission to use unpublished data, for periodic advice and for comments on the manuscript, for space and facilities L.T. Nielsen and George F. Edmunds, Jr., Department of Biology, University of Utah and the Utah Mosquito Abatement Association for providing the funds for the study.

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Table 1. Results of 1987 Utah larval mosquito resistance study (156 non-replicate tap water tests).*

MAD	Date & Code	Sp.%	Ch	LC50 Value	LC50 XTD	LC90 Value	Ratio	% P	%CM	#Doses	df	X2 Prob
BE	16-VII-87-2	Ad100	C	2.0	.79	3.4	1.74	.0	5.0	5	3	.224
BE	28-VII-87-2	Ad100	C	1.3	.52	2.3	1.78	.5	.0	6	4	.745
BE	25-VI-87-2	Ad100	C	3.2	1.29	5.2	1.62	.0	.0	7	5	.139
BE	16-VII-87-2	Ad100	F	6.1	1.22	8.8	1.43	.0	.0	6	4	.504
BE	28-VII-87-2	Ad100	F	2.8	.56	5.0	1.79	.3	5.0	5	3	.125
BE	25-VI-87-2	Ad100	F	6.5	1.29	9.3	1.43	.0	.0	5	3	<.001
BE	16-VII-87-2	Ad100	M	46.6	.47	71.8	1.54	.0	5.0	6	4	.189
BE	28-VII-87-2	Ad100	M	35.5	.35	54.6	1.54	1.4	5.0	5	3	.98
BE	24-VII-87-2	Ct97	C	1.6	.63	12.0	7.61	.5	.0	6	4	.693
Da	10-VI-87-2	Ad100	C	5.8	2.33	10.2	1.76	.0	.0	5	1	.074
Da	16-VI-87-1	Ad100	C	4.5	1.82	12.0	2.64	.0	.0	5	3	.042
Da	29-VI-87-2	Ad98	C	4.3	1.72	9.4	2.19	.0	.0	4	2	.637
Da	16-VI-87-1	Ad100	F	9.5	1.90	14.3	1.51	.4	.0	4	2	.256
Da	2-VII-87-2	Av100	C	.9	.37	1.4	1.57	.8	.0	4	2	.381
Da	14-VII-87-1	Av59	C	1.6	.62	3.0	1.90	31.6	.0	5	3	.938
Da	2-VII-87-2	Av100	F	4.1	.82	6.1	1.48	1.6	7.5	6	3	.797
Da	2-VII-87-2	Av100	M	70.0	.70	111.5	1.59	3.3	.0	4	2	.261
Da	10-VI-87-1	Ct100	C	12.6	5.04	40.4	3.20	22.9	47.1	5	3	.626
Da	8-VII-87-3	Ct98	C	4.6	1.82	24.8	5.45	13.1	.0	7	5	.935
Em	27-VII-87-1III	Ad70	C	4.7	1.86	6.7	1.45	1.9	.0	5	3	.855
Em	28-VII-87-1	Av54	C	1.9	.74	3.4	1.85	4.0	.0	5	3	.308
Em	27-VII-87-1I	Ci80	C	4.5	1.80	11.8	2.62	13.0	.0	8	6	.44
Em	27-VII-87-1II	Ct100	C	4.5	1.78	11.4	2.56	10.0	14.3	4	1	.365
Ma	28-V-87-3	Ad100	C	5.4	2.15	12.0	2.23	.0	.0	5	3	.33
Ma	11-VI-87-1	Ad100	C	3.8	1.52	13.9	3.67	.0	15.0	7	5	.198
Ma	23-VII-87-2	Ad100	C	6.2	2.48	20.2	3.26	.0	.0	9	7	<.001
Ma	23-VII-87-2	Ad100	F	9.1	1.82	18.8	2.06	.4	.0	8	6	.025
Ma	23-VII-87-2	Ad100	M	79.4	.79	112.5	1.42	.0	2.5	6	2	.562
Ma	6-VIII-87-1	Cp100	C	23.7	9.46	218.6	9.24	.0	.0	15	13	<.001
Ma	6-VIII-87-1	Cp100	M	260.2	2.60	852.4	3.28	.0	.0	8	6	.293
Ma	18-VI-87-4	Ct100	C	2.4	.96	16.3	6.78	1.4	.0	5	3	.906
Ma	15-VII-87-2	Ct100	C	1.6	.62	9.2	5.90	.0	.0	5	3	.857
NS	9-VII-87-5	Ad100	C	2.0	.79	2.9	1.45	.0	.0	6	4	.035
SL	10-VII-87-3	Ad100	C	4.7	1.87	10.8	2.31	.0	.0	8	6	.173
SL	26-VI-87-1	Ad100	C	5.6	2.24	18.7	3.34	.0	.0	8	6	.092
SL	1-VII-87-2	Ad100	C	5.8	2.32	15.0	2.58	.8	.0	10	8	.466
SL	29-VI-87-1	Ad100	C	5.9	2.34	20.1	3.44	27.7	25.9	11	9	.704
SL	19-V-87-1	Ad81.3	C	6.1	2.42	17.7	2.91	6.7	.0	7	5	.233
SL	28-V-87-2	Ad100	C	6.6	2.64	15.4	2.33	.0	.0	5	3	.054
SL	27-V-87-3	Ad100	C	6.8	2.73	15.1	2.21	.0	.0	6	4	.738
SL	28-V-87-5	Ad100	C	7.6	3.04	24.8	3.27	5.3	.0	6	4	.118
SL	8-VI-87-1	Ad70.7	C	8.1	3.24	20.3	2.51	32.0	20.0	8	6	.167
SL	27-V-87-1	Ad100	C	8.8	3.52	25.1	2.85	.0	.0	6	4	.557
SL	28-V-87-1	Ad100	C	10.0	3.98	26.6	2.67	6.6	5.3	6	1	.076
SL	28-V-87-4	Ad100	C	10.8	4.32	22.6	2.09	.7	.0	5	3	.527
SL	27-V-87-2	Ad100	C	11.5	4.59	27.6	2.40	5.4	.0	5	3	.186
SL	29-VI-87-1	Ad100	F	8.7	1.73	35.2	4.06	29.6	8.3	7	5	.252
SL	27-V-87-3	Ad100	F	10.9	2.19	24.1	2.20	.0	.0	5	3	.318

SL	28-V-87-2	Ad100	F	11.2	2.24	18.2	1.62	.3	.0	4	2	.753
SL	28-V-87-1	Ad100	F	12.2	2.44	22.9	1.88	8.0	15.0	5	3	.967
SL	26-VI-87-1	Ad100	F	12.3	2.45	26.2	2.13	.0	.0	8	6	.443
SL	8-VI-87-1	Ad70.7	F	12.4	2.49	18.1	1.45	27.4	31.2	3	1	.993
SL	1-VII-87-2	Ad100	F	12.7	2.53	28.7	2.26	.7	.0	7	5	.443
SL	27-V-87-1	Ad100	F	15.2	3.04	31.7	2.09	.0	.0	5	3	.186
SL	27-V-87-2	Ad100	F	16.2	3.24	34.9	2.16	6.1	.0	4	2	.134
SL	26-VI-87-1	Ad100	M	57.7	.58	104.6	1.81	.0	.0	5	3	.093
SL	1-VII-87-2	Ad100	M	66.1	.66	115.9	1.75	.0	.0	7	5	.887
SL	27-V-87-3	Ad100	M	69.9	.70	103.5	1.48	.0	.0	4	2	.993
SL	27-V-87-1	Ad100	M	98.7	.99	166.4	1.69	.0	.0	4	2	.178
SL	27-V-87-2	Ad100	M	114.0	1.14	210.0	1.84	2.9	2.9	3	N/A	N/A
SL	31-VII-87-3	An96	C	7.7	3.07	19.2	2.50	.0	.0	8	1	.057
SL	4-VI-87	An94	F	10.6	2.13	18.1	1.70	.0	.0	7	5	.54
SL	12-VI-87-1	Av100	C	1.5	.60	2.2	1.43	.0	.0	3	1	.532
SL	9-VII-87-2	Av100	C	1.7	.68	2.3	1.36	.0	.0	5	3	.044
SL	1-VII-87-3	Av100	C	1.8	.71	2.3	1.30	.0	.0	4	2	.775
SL	6-VII-87-1	Av98	C	2.6	1.03	3.6	1.38	.0	.0	5	3	.81
SL	1-VI-87	Av100	C	2.8	1.12	3.9	1.39	.0	.0	5	3	.985
SL	12-VI-87-1	Av100	F	4.0	.80	5.9	1.48	.0	.0	5	3	.497
SL	9-VII-87-2	Av100	F	4.2	.84	5.4	1.29	.0	.0	3	N/A	N/A
SL	1-VII-87-3	Av100	F	5.3	1.05	6.8	1.28	.0	.0	4	2	.94
SL	1-VI-87	Av100	F	8.2	1.64	12.8	1.56	.3	.0	4	2	.814
SL	6-VII-87-1	Av98	F	9.5	1.89	14.4	1.52	.0	.0	6	4	.019
SL	9-VII-87-2	Av100	M	33.6	.34	50.6	1.50	.0	.0	4	2	.649
SL	12-VI-87-1	Av100	M	72.4	.72	126.7	1.75	.0	.0	6	4	<.001
SL	1-VII-87-3	Av100	M	76.5	.76	96.8	1.27	.0	.0	4	2	.946
SL	6-VII-87-1	Av98	M	92.0	.92	128.9	1.40	.0	.0	4	1	.186
SL	1-VI-87	Av100	M	105.9	1.06	145.4	1.37	.0	5.0	5	2	.161
SL	17-VII-87-1	Ci100	C	4.7	1.89	7.6	1.60	7.0	.0	3	1	.411
SL	3-VII-87-1	Cp100	C	29.5	11.80	67.0	2.27	1.5	.0	7	5	.317
SL	7-VII-87-2	Cp100	C	3.3	1.31	19.5	5.96	4.5	.0	8	6	.18
SL	8-VII-87-1	Cp100	C	2.9	1.17	18.6	6.38	10.7	.0	11	9	.002
SL	23-VI-87-1	Cp56	C	8.3	3.34	61.8	7.41	5.9	2.6	14	12	<.001
SL	18-VI-87-2	Cp92	C	7.2	2.86	30.6	4.29	24.5	.0	8	6	.103
SL	31-VII-87-2	Cp92	C	20.7	8.26	182.5	8.83	6.1	.0	17	15	.021
SL	22-VI-87-1	Cp94	C	10.2	4.07	92.8	9.12	3.7	.0	12	10	<.001
SL	7-VII-87-1	Cp96	C	5.8	2.32	39.0	6.73	3.9	.0	12	10	.241
SL	16-VII-87-1	Cp98	C	52.9	21.14	133.2	2.52	1.3	14.3	6	4	.712
SL	7-VII-87-2	Cp100	F	7.3	1.47	52.0	7.09	8.8	.0	9	7	.282
SL	23-VI-87-1	Cp56	F	19.4	3.88	247.9	12.78	6.0	2.9	14	12	.07
SL	22-VI-87-1	Cp94	F	51.6	10.32	466.3	9.04	4.2	.0	9	4	.48
SL	7-VII-87-1	Cp96	F	16.7	3.35	123.6	7.39	4.3	.0	12	8	.108
SL	16-VII-87-1	Cp98	F	143.4	28.69	274.3	1.91	1.0	10.0	4	2	.66
SL	7-VII-87-1	Cp96	M	148.7	1.49	458.3	3.08	3.5	.0	8	6	.51
SL	16-VII-87-1	Cp98	M	901.9	9.02	2,030.4	2.25	2.6	10.0	8	5	.114
SL	24-VII-87-1	Ct72	C	7.4	2.96	59.9	8.09	7.7	5.7	8	6	.011
SL	17-VI-87-2	Ct96	C	3.1	1.25	22.8	7.28	5.0	.0	7	5	.011
SL	17-VI-87-2	Ct96	F	8.8	1.76	91.8	10.45	9.5	5.9	4	2	.341
SS	29-V-87-1	Ad100	C	5.0	1.99	12.4	2.50	.0	.0	6	4	.483
SS	14-VII-87-2	Ad68	C	2.9	1.14	6.9	2.40	1.9	2.6	8	6	.098
SS	8-VII-87-4	Ad84	C	5.9	2.35	27.3	4.65	37.7	3.6	11	9	.104
SS	14-VII-87-2	Ad68	F	7.3	1.47	15.4	2.09	3.2	.0	9	7	.598
SS	29-VI-87-3lr	An100	C	129.9	51.96	476.1	3.67	10.8	14.7	10	8	.79

SS	29-VI-87-3&r	An100	F	179.5	35.89	1,125.3	6.27	12.1	15.4	5	3	.435
SS	21-V-87-1	Av100	C	1.5	.58	2.6	1.80	.0	.0	4	2	.197
SS	11-VI-87-2	Av100	C	2.8	1.12	3.9	1.39	10.6	2.8	6	3	.588
SS	19-VI-87-1	Av100	C	1.0	.38	1.4	1.48	.0	.0	4	2	.243
SS	9-VII-87-1	Av100	C	1.7	.67	2.7	1.61	.0	.0	6	4	.293
SS	21-V-87-1	Av100	F	4.5	.90	7.2	1.59	.3	.0	4	2	.476
SS	11-VI-87-2	Av100	F	5.5	1.10	7.1	1.29	18.9	2.8	4	1	.677
SS	19-VI-87-1	Av100	F	3.8	.75	4.8	1.28	.0	.0	4	2	.972
SS	21-V-87-1	Av100	M	48.0	.48	69.0	1.44	.6	.0	3	N/A	N/A
SS	11-VI-87-2	Av100	M	83.0	.83	113.8	1.37	19.7	.0	4	2	.603
SS	19-VI-87-1	Av100	M	67.1	.67	100.1	1.49	.3	.0	5	3	.848
SS	31-VII-87-1	Ci100	C	6.4	2.58	17.6	2.74	10.7	.0	5	3	.229
SS	18-VI-87-1	Cp100	C	5.8	2.30	33.8	5.87	2.2	2.5	9	7	.001
SS	2-VII-87-1	Cp100	C	25.5	10.19	52.3	2.05	2.3	.0	7	5	.649
SS	28-VII-87-3	Cp100	C	34.6	13.83	97.1	2.81	15.2	.0	9	7	.508
SS	29-VII-87-2	Cp100	C	4.9	1.97	23.8	4.83	5.0	.0	13	11	.391
SS	31-VII-87-1	Cp56	C	2.8	1.12	11.3	4.04	10.8	.0	6	4	.087
SS	9-VII-87-3	Cp92	C	4.9	1.94	23.9	4.92	7.2	.0	9	7	.145
SS	18-VI-87-1	Cp100	F	18.0	3.60	182.3	10.13	4.7	.0	7	5	.004
To	29-VII-87-1	Ad100	C	1.9	.77	6.4	3.31	.4	30.0	10	8	.545
To	29-VII-87-1	Ad100	F	7.9	1.58	17.9	2.26	1.2	32.5	6	4	.117
To	8-VII-87-2	Ci100	C	2.5	1.01	3.3	1.32	1.5	.0	4	2	.811
To	25-VI-87-3	Ct100	C	1.2	.47	6.1	5.25	3.6	.0	9	6	.242
To	18-VI-87-3	Ct96	C	2.4	.95	10.5	4.44	6.8	.0	10	8	.295
Ui	16-VI-87-2	Ad100	C	3.3	1.33	4.6	1.37	2.5	.0	5	3	.971
Ui	24-VII-87-3	Ad90	C	3.2	1.29	4.4	1.36	1.5	.0	5	3	.336
Ui	10-VII-87-2	Ad98	C	1.3	.51	2.4	1.92	.0	.0	6	4	.164
Ui	16-VI-87-2	Ad100	F	6.8	1.36	10.8	1.59	8.7	.0	5	3	.535
Ui	16-VI-87-2	Ad100	M	61.4	.61	94.0	1.53	16.7	.0	5	3	.602
Ui	5-VIII-87-2	Av48	C	2.1	.85	3.3	1.56	3.8	.0	6	4	.116
Ui	24-VII-87-4I	Av90	C	1.7	.68	2.6	1.54	.4	.0	5	3	.844
Ui	9-VII-87-4	Av98	C	1.1	.42	1.4	1.34	.0	2.5	4	2	.108
Ui	5-VIII-87-2	Av48	F	5.4	1.08	7.7	1.42	4.4	.0	4	2	.271
Ui	24-VII-87-4IV	Av90	F	3.0	.59	6.3	2.12	1.3	.0	3	1	<.001
Ui	5-VIII-87-2	Av48	M	36.1	.36	58.6	1.62	2.2	.0	5	3	.788
Ui	24-VII-87-4VI	Av90	M	36.4	.36	55.3	1.52	.4	.0	5	3	.327
Ui	24-VI-87-1	Ct100	C	.9	.35	4.6	5.26	1.5	.0	10	8	<.001
Ui	22-VII-87-1	Ct100	C	42.7	17.06	112.3	2.63	5.6	.0	6	4	.442
Ui	23-VII-87-1	Ct100	C	24.8	9.90	50.0	2.02	.8	2.6	3	1	.582
Ui	23-VII-87-3	Ct100	C	3.1	1.26	21.9	6.98	.2	.0	6	4	.817
Ui	1-VII-87-1	Ct98	C	1.8	.74	6.9	3.76	5.2	2.8	12	6	.523
Ui	23-VI-87-2	Ct100	F	4.5	.91	33.5	7.40	.0	.0	5	3	.105
Ui	24-VI-87-1	Ct100	F	3.3	.66	10.4	3.17	3.5	.0	9	7	<.001
Ui	23-VII-87-1	Ct100	F	41.6	8.32	110.5	2.66	1.0	10.0	9	6	.202
Ui	1-VII-87-1	Ct98	F	6.0	1.20	19.9	3.31	6.9	.0	7	4	.113
Ut	30-VII-87-1	Ct92	C	5.2	2.10	35.1	6.71	.0	.0	7	3	.211
Ut	5-VIII-87-1	Ct85	C	3.1	1.25	10.0	3.20	4.2	.0	6	4	.065
We	15-VII-87-1	Ad80	C	2.9	1.18	4.8	1.64	4.8	2.9	6	3	.405
We	15-VII-87-1	Ad80	F	6.9	1.37	9.7	1.41	4.0	2.5	5	2	.422
We	15-VII-87-1	Ad80	M	81.6	.82	127.2	1.56	5.0	.0	5	3	.031
We	24-VI-87-2	An100	C	1.9	.75	5.1	2.71	.0	5.0	6	4	.001
We	24-VI-87-2	An100	F	3.0	.59	6.7	2.25	.0	2.5	5	3	.2
We	24-VI-87-2	An100	M	262.1	2.62	1,340.9	5.12	.0	.0	8	6	.461
We	10-VII-87-1	Av100	C	1.1	.43	1.5	1.41	.0	.0	5	3	.088

*TABLE 1: ABBREVIATIONS AND EXPLANATIONS

MAD = mosquito abatement district: BE = Box Elder County Mosquito and Fly Abatement District, Da = Davis County MAD, Em = Emery County Weed and Mosquito Department, Ma = Magna MAD, NS = North Summit County MAD, SL = Salt Lake City MAD, SS = South Salt Lake County MAD, To = Tooele Valley MAD, Ui = Uintah County MAD, Ut = Utah County Mosquito Abatement Department, We = Weber County MAD. Sp.% = the dominant species and the percentage it composes of a sample, (see Fig. 1 legend for species abbreviations). Ch = larvicidal chemical: C = chlorpyrifos, F = fenthion, M = malathion). LC50 and LC90 values are in parts per billion. XTD = LC50/threshold dose. Ratio = LC90/LC50. %P = percentage pupation. %CM = percentage control mortality. df = **degrees of freedom (df** = # doses - 2, unless there has been lumping of data): X2 Prob = chi-squared probability or goodness of fit alpha values (a value less than or equal to 0.05 indicates that a plot of the data significantly departs from a straight line). N/A = does not apply because data was generated by graphic analysis only.

Copies of the raw data, probit plots, computer probit analysis printouts and spreadsheets on file at the Salt Lake City MAD.

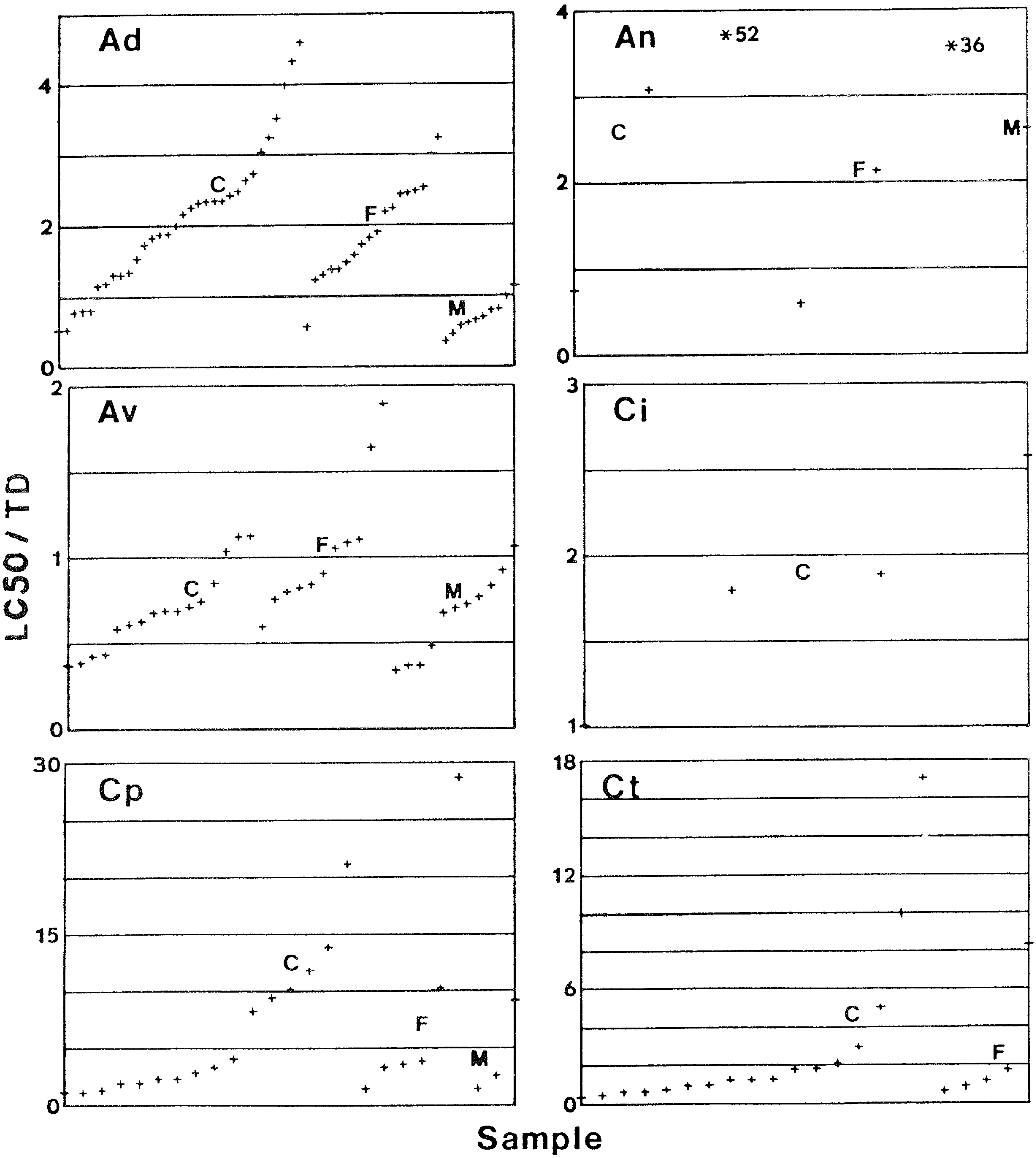


FIGURE LEGEND

Fig. 1. The LC50 value divided by the threshold dose (TD) is plotted for each sample for 1987 data for *Aedes dorsalis* (Ad), *Ae. nigromaculis* (An), *Ae. vexans* (Av), *Culiseta inorata* (Ci), *Culex pipiens* (Cp), and *Cx. tarsalis* (Ct). Data have been sorted for each chemical: C = chlorpyrifos, F = fenthion, and M = malathion. 1987 Data, Fink & Thompson.

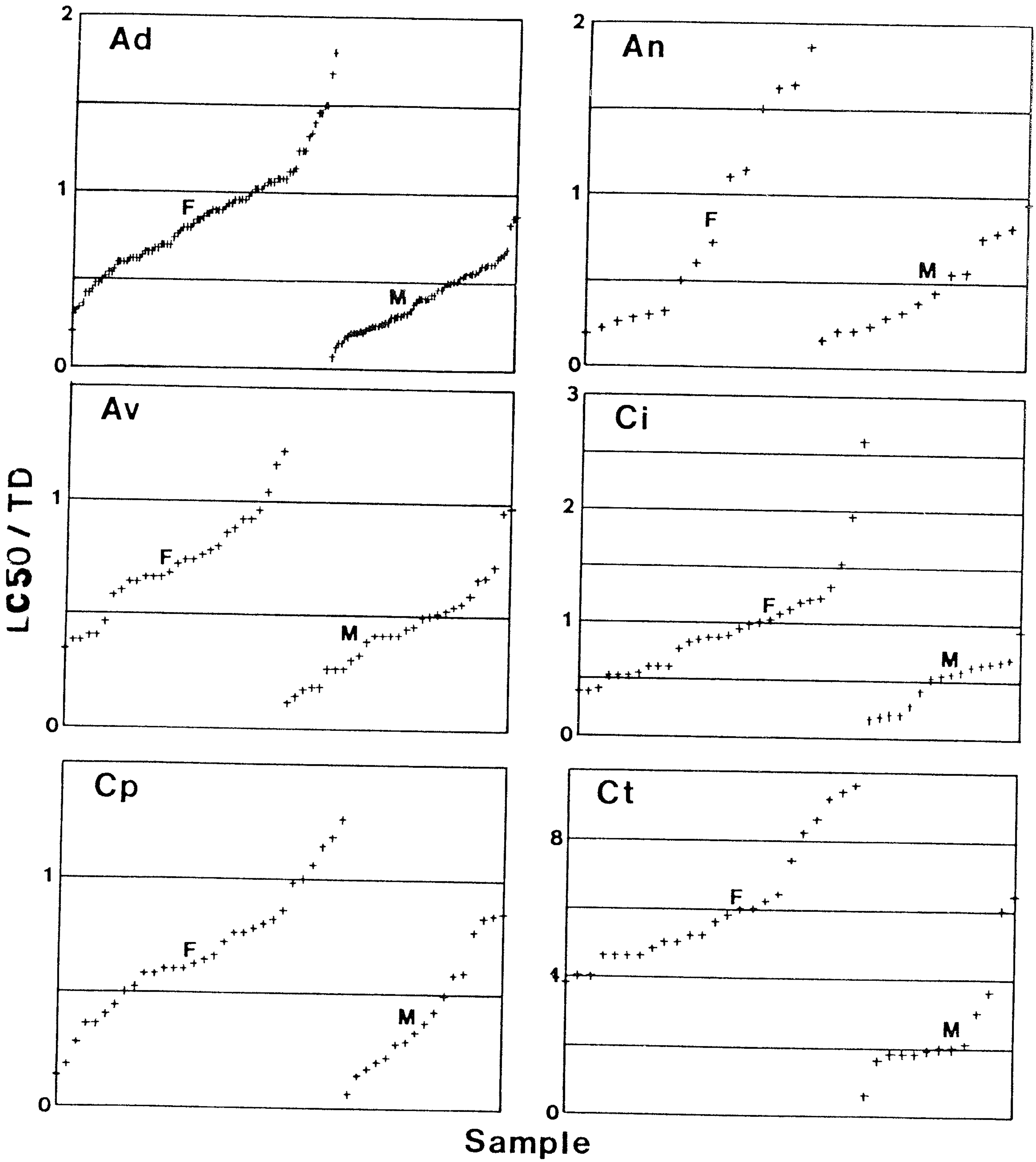
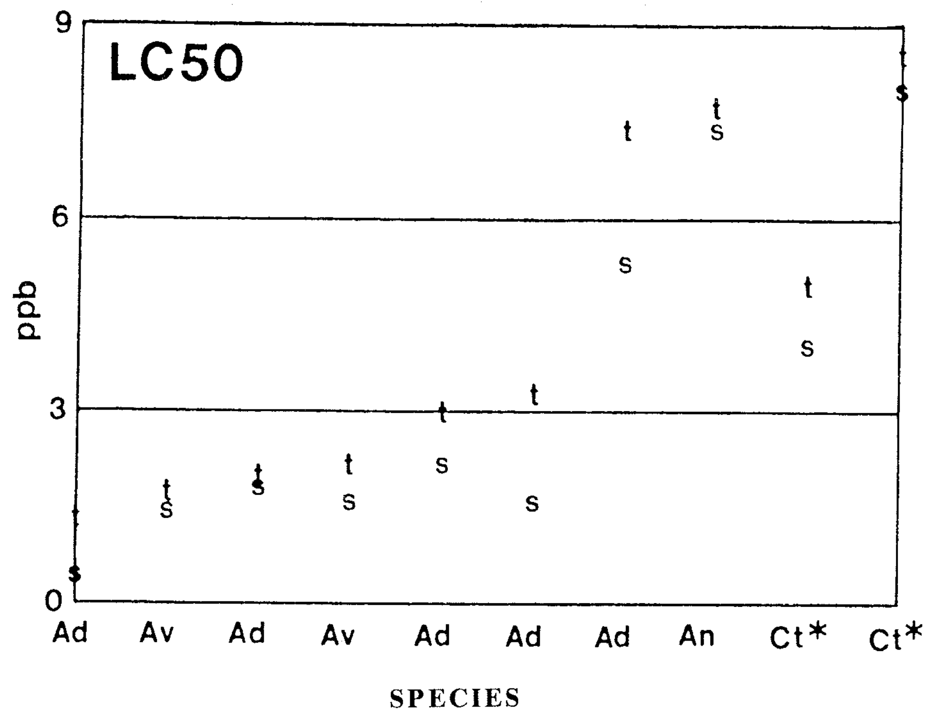


FIGURE LEGEND

Fig. 2. Similar to Fig. 1 for 1976, 1977, 1978, and 1979 data. Source of data: 1976 = Hart and Womeldorf (1977); 1977 = Merrell and Wagstaff (1978); 1978 = Wagstaff and Merrell (1979); 1979 = unpublished data from Salt Lake City MAD from Merrell and Rosay (1980). 1976 - 1979 Data, Fink & Thompson.



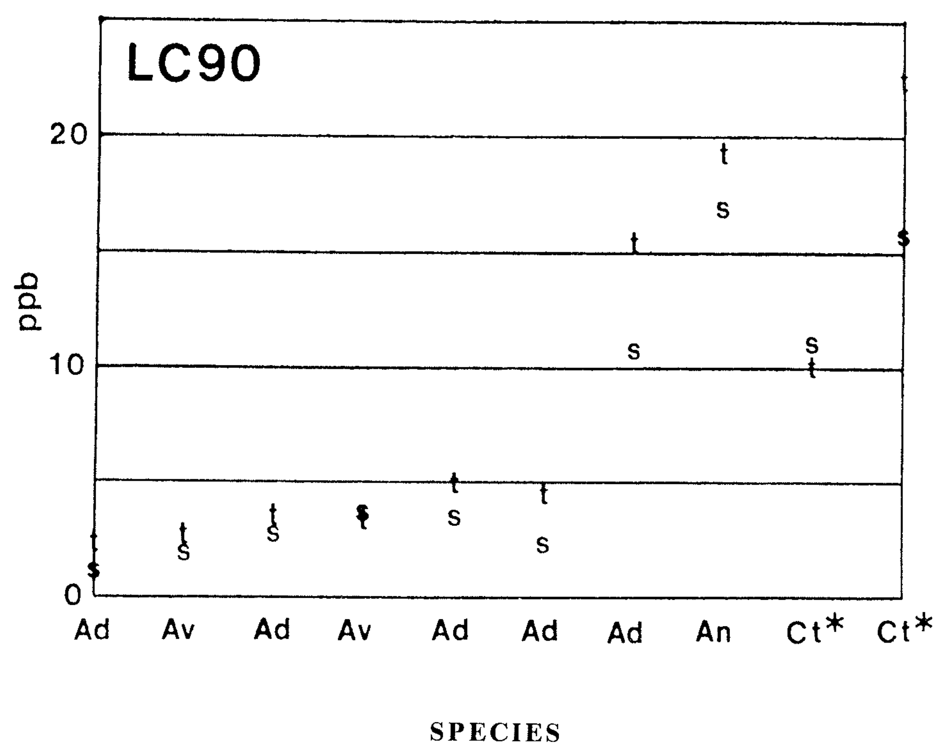


FIGURE LEGEND

Fig. 3. LC50 and LC90 values in parts per billion (ppb) from tap (t) and source (s) water tests using chlorpyrifos and fenthion (only 7th sample from the left). t and s values in the same column are tests from the same sample. Species abbreviations are as in Fig. 1. *LC50 and LC90 values are divided by five for *Culex tarsalis*. Fink & Thompson.

LABELING OF MOSQUITO LARVICIDES FOR ENDANGERED SPECIES PROTECTION

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The EPA, like all federal agencies, is required to comply with the Endangered Species Act of 1973 which protects endangered species and their habitats. This act is administered by the U.S. Fish and Wildlife Service. To accomplish this, the EPA is requiring amended labeling of many mosquito larvicides to restrict or prohibit their use in the range or habitats of endangered species (Table 1).

Table 1. Endangered Species and Counties Included on EPA's Labeling of Mosquito Larvicides.

State	Endangered Species	Counties
Washington	0	0
Oregon	2	1
Idaho	1	3
Montana	0	0
Wyoming	2	2
Nebraska	0	0
Colorado	0	0
New Mexico	2	3
Utah	2	2
Arizona	4	8
Nevada	6	4
California	16	29

Pesticide active ingredients that are used in the control of mosquito larvae will be impacted by these endangered species labeling requirements. These active ingredients include: chlorpyrifos, dichlorvos, ethyl parathion, fenthion, methoprene, methoxychlor, methyl parathion, pyrethins, and temephos. Listed in Table 2 are the Utah counties and their endangered species that will be affected by these labeling requirements which take effect as of February 1, 1988 for shipment of new pesticide products and as of February 1, 1989 for all pesticide products containing the listed active ingredients and application sites. In the interim, EPA will distribute advisories regarding the potential threat to endangered species from the use of these pesticides.

The standard labeling statement that will be required on new MOSQUITO LARVICIDE products after February 1, 1988 will read as follows:

> "ENDANGERED SPECIES RESTRICTIONS Before using this product to control or eradicate mosquito larvae in a county listed below, you must contact the Endangered Species Specialist in the Region/Field Office of the U.S. Fish and Wildlife Service (FWS) indicated below. You must provide FWS with your name and phone number, the product you intend to use, and the specific location in which you intend to use it. The U.S. Fish and Wildlife Service will inform you whether your proposed use is in the range of endangered species. *Use of this product in the range of endangered species, as defined for you by FWS, is prohibited.*"

The FWS Field Office telephone number for Utah is 801-524-4430 in Salt Lake City.

Table 2. Utah Counties and endangered species.

County	Endangered Species
Utah	June Sucker
Washington	Woundfin Desert Tortoise
Beaver, Garfield, Iron, Kane, Piute, Sevier and Wayne	Utah Prairie Dog

In addition to the above labeling restrictions on mosquito larvicides, restrictions will be placed on various rodenticides used on rangeland and pastureland to control rodents that sometimes are disease vectors or reservoirs. Rodenticide restrictions will be on products containing any of these active ingredients: aluminum phosphide, chlorophacinone, gas cartridges, magnesium phosphide, sodium cyancide, strychnine, or zinc phosphide.

The standard labeling statement that will be required on new Range or Pasture Land products after February 1, 1988 will read as follows:

> "ENDANGERED SPECIES RESTRICTIONS Before using this pesticide on range or pasture lands in the counties listed below, you must obtain the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES for the county in which the product is to be used. The bulletin is available from your County Extension agent, State Fish and Game Office, or your pesticide dealer. *Use of this product in a manner inconsistent with the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES is a violation of federal laws.*"

If your product will be used for control of prairie dogs, the following restrictions must appear in the product labeling immediately following the county listing above:

"Even if applicable county bulletins do not prohibit the use of this product at the intended site of application, you may not use this product for control of prairie dogs in the states of Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah or Wyoming unless the user conducts a pre-control survey. This survey must be in compliance with the Black-Footed Ferret Survey Guidelines, developed by the U.S. Fish and Wildlife Service, and a determination must be made in accordance with the Guidelines that black-footed ferrets are not present in the treatment area."

As of December 1987, the EPA had decided to delay implementation of this plan for up to one year in those states and counties where the "Pesticide Use Bulletin For Protection of Endangered Species" is in need of correction for accuracy of the currently occupied habitat or for better detail in the map portion of the bulletin. These situations apply to all of Utah's county bulletins and maps. Full implementation of these labeling changes should take place by February 1, 1989. Also as of that date additional pesticide use prohibitions pertaining to endangered species and the pesticide application sites alfalfa, aquatic, rights of way, and rice will be implemented.

BLACK FLY CONTROL IN NORTHERN CANADA USING *BACILLUS THURINGIENSIS* VAR *ISRAELENSIS*

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Black flies (Simuliidae) are a pest problem in many regions of northern Canada rather than a vector of serious disease to man or domestic stock. Although transmission of parasites does occur and the *Leucocytozoon* parasite can be lethal to domestic ducks and geese, these are not at present of sufficient economic importance to initiate control measures. Thus, the main impetus for control is to alleviate biting activity around man and/or domestic stock. The present work involved reduction of biting populations, effecting people in northern communities, using the bacterial agent *Bacillus thuringiensis* var *israelensis* *(Bti)* against the larval stage. *Bti* was first recovered from mosquito breeding sites but was soon found to be an effective black fly larvicide as well (Undeen and Nagel 1978; Undeen and Colbo 1980) and is widely used for control of both families (Lacey and Undeen 1986). A local pilot control program in 1980-81 against northern black fly pest species showed that *Bti* could be effectively used to reduce adult populations by applying a one-minute dose of material to streams serving as larval habitats on 4 occasions over the summer (Colbo and O'Brien 1984). For an operational program, the problem is to be able to treat a sufficient number of these stream larval habitats at the appropriate time to significantly reduce biting in and around the target communities at a cost that the communities can afford.

In brief, this entails the following: a) knowing potential and probable flight range of the pests, b) knowing their larval habitats and the relative production of these habitats, c) knowing the life cycle of the pest species to determine optimal treatment strategies, d) knowing water volumes in the target streams and thus dose quantity and points of application, e) determining the best method for application given accessibility of the dose points and the equipment available, f) determining the impact of control on female pest populations in target area, g) determining the cost of the program.

In Labrador we have initiated 2 control programs and are planning a third. In brief, we use the following basic approaches with local modifications to suit the various situations. In general, a 10 km radius from perimeter of target community is used to define the control area but this is extended up to 20 km if prevailing winds are coming down a river valley that is also a large fly source. The pest species, at least as we recognize them now (*Prosimulium fuscum/ mixtum* complex *Simulium venustum/ verecundum* complex and *S. corbis* which does not bite but comes to man in large numbers), breed in almost all running water habitats but adult yield varies greatly. To estimate sources we consider not only the larval density in the stream but also the area of stream bed, e.g. a stream 1m wide from a pond with an average larval density of 10,000/m² for 100m will potentially yield 1 million adults, half females, a stream 20m wide with 100 larvae/m² for 10km could yield 10 million females. Thus, a low density may produce a very high adult population. In general, lentic outflaws have high larval densities so all of these are treated within 5km of the town and all outlets greater than 4+m wide beyond that distance. Small streams, not originating from ponds, are treated in or near the town but not elsewhere. All streams greater than 10m wide in the control area are treated unless known to contain very low pest populations or not to contain pest species, because of silted waters, sand bottoms, current velocity and etc. In Labrador treatment is in early spring just after the initial spring floods to catch the over wintering *Prosimulium* and the early hatching *Simulium*. Two more treatments, approximately 3-4 weeks apart, follow to control the later hatches of *Simulium* spp.

To determine dose an estimate of the discharge of each target stream is needed. Due to the specificity of *Bti*, discharge can be crudely estimated. From a data base of about 200 stream measurements an empirical formula was derived giving discharge estimates based on stream width (W) at a rapids:

$$\text{Discharge} = 6W[K^{\ln(w+e)}] - (20 - 14/W)$$

Three levels were calculated from non-flood conditions of high flow, medium and low, not minimum which are obtained by using the constant K set at 1.8, 1.6 and 1.4. If we use a 600 ITU *Bti* product, the target concentration is not less than 10ppm or 10ml/m³. The distance controlled below dose point in uninterrupted stream is about 100m for each meter of width for small streams up to 10m wide and can be, under some conditions, more than 150m per meter of width in large deep fast flowing rivers. In a 50m wide stream, control from 5 to 7.5 km below a dose point can be expected while in a 2m wide stream probably only 200m control will result. Although the dose is calculated for one minute, it is applied as quickly as feasible, i.e. poured in, dropped on surface from the air or applied across stream by boat. When applied on the surface, a certain distance downstream will not be completely controlled due to incomplete mixing. In streams this can be remedied by moving dose point upstream, but at lake out flows one must either apply on bottom or far enough into lake to assure material reaches the bottom of stream at outflow as larval densities are greatest at that point. Method of application will depend on access. Three control products are operational in Labrador. One is treated by ground delivery plus the dropping of material from fixed-wing aircraft to remote sites greater than 15m wide. The other two are treated by dropping the appropriate doses from helicopters either as prepackaged doses or meter-pumped from a slung container with on/off control in cockpit. Streams to be dosed are marked on a map along with approximate dose points and quantity. For small streams, this is a color code and for large streams actual dose is provided. A catalogue of all the streams is also maintained as a planning tool and to keep records of treatments and quantities of material used. The master catalogue is copied for each treatment and filled in, becoming the final record.

Adults are monitored at points inside and outside the control area in comparable habitats. Normally, this is done as counts of landing flies/minute and/or sweep net catches. This can provide an estimate of reduction and also an idea of invasion patterns for future planning. Finally, the cost is estimated for the first time and then recorded for future programs. This will vary considerably, depending on accessibility of streams, volume of discharge and availability of delivery equipment. If very accessible by road and foot, then local labor can be used; under guidance of a local licensed applicator, a program could cost less than $10,000. With no ground access, numerous large streams and no locally available helicopter, cost could rise to $50,000 / community. The current Labrador programs cost $20-30,000, with an adult reduction of 70-80+% in the target areas.

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