# PROCEEDINGS AND PAPERS

of the

# THIRTY–FIRST ANNUAL MEETING

of the

# UTAH MOSQUITO ABATEMENT ASSOCIATION

held at

The Homestead
Midway, Utah

October 1 - 4, 1978

edited by
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and
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UTAH MOSQUITO ABATEMENT ASSOCIATION
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## *RESOLUTIONS*

*WHEREAS the Utah Mosquito Abatement Association has held its 31st annual meeting at The Homestead in Midway, Utah, October 1 – 4, 1978, and,*

*WHEREAS, the South Salt Lake County Mosquito Abatement District has served as host for the organization, and,*

*WHEREAS, the Local Arrangements and Program Committees have done an outstanding job,*

*THEREFORE, be it resolved that the UMAA extend sincere appreciation to the South Salt Lake County Mosquito Abatement District and its Board of Directors, and to all others concerned with the success of this convention.*

*WHEREAS, the papers presented by the speakers have been of high quality and highly informative to those who attended, and,*

*WHEREAS, many of the participants in this convention came considerable distances to take part in the convention,*

*THEREFORE, be it resolved that the UMAA extend its thanks and appreciation to all speakers and especially those who came from out of state.*

*WHEREAS, we were privileged to have in attendance Paul Hunt, President of the American Mosquito Control Association from Daytona Beach, Florida, and Robert K. Washino, Vice President of the American Mosquito Control Association from Davis, California,*

*WHEREAS, we again associated with Tommy Mulhern, Executive Director of the American Mosquito Control Association, and Don Murray, Treasurer of the Amercian Mosquito Control Association,*

*THEREFORE, let it be resolved that the UMAA extend its thanks and appreciation for the presence of the officers of the AMCA and for their contributions to the success of this convention.*

*WHEREAS, John Knighton, Utah State Entomologist, passed away this past year, and,*

*WHEREAS, he made contributions to the health and comfort of the people of the State of Utah by his actions in his office, and,*

*WHEREAS, he cooperated with the UMAA in their efforts to protect the health of the residents of Utah,*

*THEREFORE, let it be resolved that the UMAA extend its sympathy to his family and associates and to the State of Utah for this loss.*

*WHEREAS, Evan Lusty has served with distinction and devotion to UMAA as its president for 1977 - 1978,*

*THEREFORE, let it be resolved that UMAA extend appreciation for his meritorious service to the association.*

*WHEREAS, The Homestead at Midway, Utah has provided excellent facilities, food, and services, and,*

*WHEREAS, the banquet was of excellent quality,*

*THEREFORE, let it be resolved the the UMAA express appreciation to The Homestead for contributing to the success of the 1978 meeting.*

*WHEREAS, the contributing members have provided financial support and information about their products as well as displays of their products,*

*THEREFORE, let it be resolved that the UMAA extend its appreciation to those organizations for their support and services they have provided to further mosquito control throughout the State.*

*RESOLUTIONS COMMITTEE*

*Carl D. Clark, Chairman*

*Lewis Fronk*

*Gerald Purdy*

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## DR. JESSOP B. LOW
## 1978
## AWARD OF MERIT

*Dr. Jessop B. Low's contributions to Utah State University, Logan, represented 30 years as leader of the Utah Cooperative Wildlife Research Unit. He officially retired from his professorship in 1974 but has continued at USU as an educator, advisor, and friend to his associates and graduate students. He has received numerous awards for his outstanding work in natural resources. He is the author of some 150 technical reports and publications.*

*Years ago, Jess had the insight and the foresight to recognize the complex interrelationships between the two disciplines of waterfowl management and mosquito control. He helped establish the Mosquito Abatement – Fish and Wildlife Coordinating Committee and was a member of it for many years. Because of the high regard in which members of the Committee have been held by their colleagues, there has been excellent cooperation among the concerned organizations. Grateful acknowledgement is given to Dr. Low for the role he has played as a skilled mediator between the wildlife agencies and the mosquito abatement districts.*

## MERRILL L. MINER
## 1978
## AWARD OF MERIT

*M. L. Miner was Secretary-Treasurer of the Magna Mosquito Abatement District from 1951 to 1977. While Mr. Miner was never a member of the Board of Directors of the District, he influenced the members of that Board to advance the mosquito program to a high plane. His financial and sound business advice brought about the acquiring of property, buildings, and machines so the District could effectively challenge the hordes of mosquitoes present near the Great Salt Lake.*

## WILLIAM H. WRIGHT
## 1978
## AWARD OF MERIT

*"Mosquito Bill" retired in May 1978 after 12 years as manager of the Utah County Mosquito Abatement Department. He was a key figure in the reorganization and development of mosquito control in Utah County. Mr. Wright served on the Board of Directors of the UMAA for many years, was president of the Association in 1970, and worked on various committees. He was given honorary membership in the UMAA. His experience with business and personnel management contributed much to both the UMAA and the Utah County MAD.*

# PROCEEDINGS OF THE THIRTY-FIRST ANNUAL MEETING OF THE UTAH MOSQUITO ABATEMENT ASSOCIATION

The thirty-first annual meeting of the Utah Mosquito Abatement Association convened at The Homestead, Midway, Utah with Evan Lusty presiding at the opening session. The welcoming address was given by Leland Cunliffe, Trustee of the South Salt Lake County MAD.

# REMINISCENCES OF FORTY YEARS IN VECTOR CONTROL

Richard F. Peters, Chief
Vector Biology and Control Section
California Department of Health Services
Sacramento, CA 95814

This is not going to be a paper but a top of the head recital of 40 years of beating my head against public inertia in an effort to improve the way of life in vector control. At this point, I still consider myself a young man in prospect of retirement in 2½ months. That decision to retire I made partly because I want to enjoy life for awhile and secondly, I don't like the way things are going in Government. It's not that I want to avoid a good fight or a good challenge in the future, because I have gotten into a few good fights and have taken on a few challenges over the years, but the situation is one now where I feel confidence in the capabilities of my staff to carry the torch even better. It has been an interesting period of time and if you can bear with me for a playback of the past 40 years, I'll tell you some of the highlights.

When I went to the University of California at Berkeley, I didn't really intend to be there; instead my intention was that of becoming a veterinarian and my goal was to go to Pullman, Washington, and take veterinary training and then proceed to deal with vertebrate animals. Early in my college career, however, a farseeing person convinced me that the real need in this world isn't to make animals well, it's to protect the public against all the nasty little animals in the world that are causing human disease and death. I took a close inventory at that time and concluded this wasn't bad advice. Medical entomology is an extremely important field when one considers that malaria still, despite the many years of an effort for eradication, is a major cause of death in this world and many other vector-borne diseases also contribute importantly. I was fortunate in my college training at the University of California at Berkeley in gaining a close contact with Professors William B. Herms and Harold Farnsworth Gray. In California, Herms and Gray are to us what Professor Don M. Rees is to you people here in Utah and what Dr. Headlee is to you people who are here from New Jersey.

I suppose some of you may have never heard of Herms and Gray, but Professor Herms was a kindly person, a very modest person, one who was concerned about his students and people in general. I well remember him coming to the various mosquito control meetings; of course he and Harold Gray founded the California Mosquito Control Association in 1930. Herms was the biologist and Gray was the engineer and between them they established a complementary way of looking at problems. Even though we have been led to believe, in recent years, that the word "ecology" originated with a lot of wild-eyed people who descended from the Rachel Carson influence, Professor Herms used the word ecology in the 1930's as his most important word in defining the only sensible, logical, practical way to deal with any insect problem. I have great admiration for that man and I think he inspired many people who are currently in mosquito and vector control today. Now Harold Farnsworth Gray was a crusty individual who didn't care whom he addressed with whatever words he used, but at the same time he was one of the most profound sanitary engineers I have ever met. Harold Gray was leader and championed mosquito source reduction before source reduction was even a term. His whole approach was the prevention of mosquitoes and looking back he contributed importantly to setting the pace for California mosquito control technology.

My interest as I was emerging from the University was that of getting into vector control but it didn't come easy. Jobs were few and far between. There was a depression and anyone who didn't go through the depression of the late 20's and 30's doesn't understand yet what can happen again one day. It was really a depression and it was almost impossible to find work of any kind. Today you think of 25 cents as being the price of a candy bar, but that is all one received per hour for working as I had to when I was at that age. I started out in environmental health and took additional training in this field, providing me with an outlook which has held strong and sound all the years throughout my career. Although many new potential technologies have appeared over the years, none has proved so profound as that of manipulating the environment, managing water and land and habitat to prevent vectors. I predict that none of the technologies yet to be created is going to replace that approach. They may supplement it but I don't think they will ever replace it.

After 2 years in general environmental health, I was appointed the State Mosquito Control Officer of California and given full responsibility to take the message of mosquito control to the then some 25 local mosquito control programs, which collectively covered no more than 5000 of the state's 159,000 square miles. All of these agencies had collective funds amounting to about $400,000 and there was only one professional man in that entire group of agencies, namely Harold Farnsworth Gray, who then was running the Alameda County District. My job was to disseminate information to local agencies and circulate about and handle the needs of areas of California interested in developing mosquito control.

Alas, came December 7th, 1941, Pearl Harbor; and Uncle Sam subsequently beckoned, so I spent almost 3½ years in the Army of the United States where I encountered Sergeant Russell E. Fontaine, now Dr. Fontaine, who is present today. Russ and I became very close technical associates and friends. Russ has set his own marks throughout the world and is still doing so. Finally the war was over and I was allowed to return, after General MacArthur decided it was permissible for us to come back. It took a long time.

Upon returning to California, I found a real crisis. Every last overseas serviceman was coming back through California bringing the potential of malaria, Japanese B encephalitis, filariasis, haemorrhagic fever, dengue fever, all these mosquito-borne diseases and perhaps other diseases. The California legislature was really aroused and concerned and they appropriated $600,000, which was a lot of money in those days. $400,000 went to subvent local control agencies in California and the balance of $200,000 went to the State Public Health Department to set up our program, first as a mosquito control section and then as the Bureau of Vector Control, which was formed in 1947. The Bureau of Vector Control amalgamated the program on plague supression with malaria, encephalitis, mosquito and other obnoxious animal control. In 1951 I was fortunate to be named Chief of that Bureau, which station I have been privileged to maintain since that time. Other changes also occurred in California in 1951, creating the State Water Resources Control Board program. All of the solid waste activities in the State Public Health Department's sanitary engineering program were transferred to vector control because of the significance of flies and rats primarily. We acquired one additional man when we took on this great responsibility. Anyway, to bring you up-to-date, there is now a State Solid Waste Management Board, established in 1972 and they have some 100 people at this point, dealing with general aspects of solid waste management. We still retain all the health-related aspects and have only three staff members.

In 1955, probably before I was ready for it, I was privileged to become the President of the American Mosquito Control Association. I think I might have done a better job if I had been around a little longer and been more seasoned. It wasn't until 1973 that I became President of the California Mosquito Control Association and that was by a mere technicality. I happened to have been a trustee in the Contra Costa Mosquito Abatement District for a period of time and thereby gained eligibility.

I also had an opportunity in 1960 to be part of the founding organization sponsored by the Communicable Disease Center called the Public Health Vector Control Conference. John Mulrennan was the first acting chairman and I followed as first official Chairman of the Public Health Vector Control Conference.

Throughout my career I have been favored by being selected for a number of foreign assignments. I went to a conference on resistance of mosquitoes to insecticides in Panama in 1958. In 1962 I was invited by the World Health Organization to Geneva to discuss further the implications of resistance, following which I was designated to make a mosquito survey of Southern France where the mosquito problem was so severe that it was interfering with the tourist trade. In this particular assignment I was armed with an interpreter, which was fortunate as I don't know a word of French. We arrived in Montpellier and the Senator from that area met us at the train and proceeded to walk us up the streets to our hotel in full view, more or less proclaiming that "Here is the so-called expert from California (which has mosquito problems similar to those of the Mediterranean) I have arranged for who is going to help us solve this problem." It was a most interesting experience to be accorded this welcome, to be accepted and then to have the advice given implemented.

I also had the opportunity to visit Russia in 1965 for a 1 month (travelling) seminar with Dr. Norman Gratz who many of you well know. In 1967 I went to Korea to help found the Japanese B encephalitis research unit there and to follow it on during 1969. I also spent some time in Thailand getting acquainted with that country as a member of a malaria eradication assessment team. Taiwan and Malaysia were also visited. I even made a short trip down to Mexico to conduct a mosquito survey of the little town of San Blas in the State of Nayarit with representatives of the Partners Alliance. All in all these have been some very interesting experiences that have allowed me to get a better grasp of what is happening in the world in general. This kind of perspective is extremely important when one gets back and look at one's own program in the light of what was seen in other areas.

I think it is extremely important to comment that most of the world doesn't have any protection against mosquitoes. Having visited the interior areas of Thailand and Korea (and I'm sure it's true in most of the less developed countries), I know that these people don't even have a window let alone a screened window. They experience mosquitoes on a 24-hour basis. Really, when the American public complains about a mosquito, we must recognize how fortunate and advanced we are and how much mosquito abatement has done for this nation.

Now, as to some of the concerns I've had during recent years which might be summed up in terms of what I said at the start: "I don't like the way things are going in government." I hope Jim Smith will allow me to criticize the Center for Disease Control, because Jim is going to have an opportunity to counter in a few minutes. I'll put it this way, it is indeed sad that Jim hasn't been the Director instead of Assistant to the Director of that Center over past years and I dare say it wouldn't be the same kind of abstract program it is today. CDC has almost lost touch with environmental program in support of vector control. In this same context, we are now saddled with an Environmental Protection Agency which knows all, hears all, sees all and yields nothing. I don't like that kind of government. Before EPA was created it conceivably was possible, if indeed CDC had sought to go environmental as well as medical, that the Communicable Disease Center might very well have acquired those responsibilities given to EPA, in which case I dare say environmental programs would be in proper coordination and relationship to each other. As I've said before, agriculture is agriculture, health is health and conservation is a proper prerogative of the Department of Interior. When you superimpose an Environmental Protection Agency upon the primary activities of these departments, you automatically cause them all to be less effective, leading to administrative chaos. EPA has sought by legal jargon to define everything, to make everything black and white, to seek to encompass everything so the public can't accept a calculated risk from anything. It has simply taken away from program-oriented experts who have been trained by our Universities to think and to act upon the basis of the evidence, the right to make responsible technical decisions in the public interest. You cannot possibly cause everybody to live by written rules and regulations: this is a sad trend, it is stifling the American way of life and it should never have been permitted. Some people will one day say the Nixon Administration will always be known for its Watergate. I contend the greatest sin occurred when he allowed the Environmental Protection Agency to become established. It's the philosophy of EPA that I'm objecting to, it isn't the people.

This trend in government is a disturbing one for me. It puts the word shall prominently on everyone. It gives no freedom of thought on actions. After all is said and done why are we training people to become competent if we are going to destroy the opportunity for them to exercise this right. I have always been a strong believer that the greatest force for right that exists in this world is peer pressure. People in competition insist upon doing things right and they are the most forceful in dealing with the "crumb" who is doing things wrong because he is destroying their role in life, their area of application. What we are doing at this point is destroying this perfectly viable and otherwise effective way of causing people to live together without discipline other than the discipline of peer pressure. I'm hoping the day will come when we'll return to our senses and recognize that you don't shackle people as a way of getting them to advance more intelligently and completely; you do it by opening doors and facilitating their interests.

Speaking of facilitating, this is the other discouraging thing that is happening in government. We have more facilitating people, who have no program role whatsoever, springing up in every possible area of government to the point that program people can no longer make any important decisions; they are made for us. I can recall when every last decision in vector control was mine, but now half a dozen people enter the scene before the decision is made and I may never hear what the decision is.

One of the most pleasant experiences in my 40 years of being in this field has been to travel to meetings of this kind and to be able to talk to people like you here in Utah, New Jersey, Florida, New England, Texas and the other regions of the United States to obtain the values by personal communication and by listening to presentations made of technological progress. This certainly amounts to association with the Associations. The American Mosquito Control Association has a very important role for participation by all of us. I have previously expressed myself that the AMCA has many opportunities to expand because for all practical purposes it is now a Western Hemisphere Association and has the potential of being more than just a mosquito control association. I have worked toward creating this perspective in the past and I do hope that in the future the AMCA will take an even larger role in vector control. I would certainly like to see it become the (voluntary) complement of the World Health Organization representing individuals in this field who are doing their part throughout the world in the field of vector control as free agents. I do think there is much to be gained in this regard and hope that more developments will occur in this direction.

I'm sure by now all of you know that California often leads the way in progressive things, but allow me to reverse this remark by telling you that we have just gone through one of the most negative developments in the history of California, namely Proposition 13. It is without doubt the most shattering thing that has happened to government. It has kept everyone in a daze and its full impact is still not understood. We know this much however, that our State constitution is now changed and the one thing I have tried my very best to protect over the years, namely to local autonomy in vector control, has now been thoroughly mesmerized. The situation now exists that mosquito abatement districts are knocked back in the vicinity of 50% of their former budgets. How many of you people in Utah could get by if your budgets were suddenly cut in half? At this point we don't know how it is going to end up, but there are some moves underway to seek a special subvention or other means of restoring fiscal capability to mosquito and other vector control agencies. This is something that really staggers me. Our statewide vector control program which today embraces some 80 local vector agencies in California (as opposed to 25 as mentioned earlier) covering close to 50,000 sq. miles, (as opposed to the former 5000 square miles) with collective budgets close to 17 or 18 million dollars (as opposed to the $400,000 I mentioned before) is in serious trouble and it needs help.

I hope I haven't bored you with these remarks which have come to mind reflecting upon 40 years of trying. If anyone would like further discussion on specific points, I'll be happy to talk to them during and after the meeting.

Thank you.

# AMCA DIRECTIONS IN 1978

Paul J. Hunt, President of AMCA
Director, East Volusia Mosquito Control District
Daytona Beach, FL 32014

I'm very glad to be meeting again with the Utah Mosquito Abatement Association. You always have a knack for leading us to your beauty spots. I am glad also to bring you greetings from the American Mosquito Control Association.

In the five short months since April, I have found myself entertaining some very sobering thoughts. Some of the more sobering ones revolve around the question of why I have had to follow someone as efficient and as effective a communicator and doer as Lew Nielsen. What a challenge it is to try to walk in his steps.

Many other of my sobering thoughts are centered upon the challenge tossed out by Richard F. Peters more than two years ago at the Boston meeting, when he gave the keynote address entitled, "Which Way AMCA?".

If his address is to be taken seriously (and I recommend that you pull out the December, 1976 issue of MOSQUITO NEWS and carefully read it again), there can rarely be peace of mind for the officers and Executive Director, the regional directors, committee chairmen and committee members, who have accepted a responsibility to share their knowledge and energies in behalf of the AMCA and mosquito control workers worldwide.

Having served with distinction as President, and as an AMCA member who has contributed much, Dick has knowledgeably related to our levels of service as he saw them at that time, and our ability to develop clout as an association, pretty much in plain spoken language.

Aside from this challenge, though, we have to recognize that normal protocol is necessary and important in the ongoing activities of AMCA, and these many housekeeping chores require a lot of energy from those doers with the responsibility.

Since AMCA created the position of Executive Director more than two years ago, we have been fortunate to have Tommy Mulhern occupying that position. Tommy has done an exceptional job in trying to encourage open expression of the membership on all matters where AMCA can be of service and has championed the nourishment and close cooperation with state and regional associations.

The central office performs a tremendous amount of routine work necessary for the ongoing, smooth operation of the association. The close liason between our most able Treasurer Don Murray and Executive Director Tommy Mulhern assures us by experience that we have a team unsurpassed in fiscal responsibility, and we owe them a debt of gratitude that AMCA is presently in relatively sound financial condition.

In the steady growth in scope during the past several years, and which has continued since the "Which Way AMCA?" challenge, several maturing signs are evident.

1. The AMCA News Letter, instituted under Harold Chapman's presidency, continues to provide prompt communications with the membership on the programs, affairs and activities of the Association. It is expected to continue its maturing with age and be increasingly useful to the membership.

2. A Financial Support Committee was created under the Nielsen administration and was very active last year. Its general purpose was to locate possible sources of funding which may be in the form of donations or sponsorships toward the cost of special projects and to examine other means of financial support for the association.

a. "Skeeter Mosquito", a cartoon booklet by Kathy Moore, was sponsored by the Zoecon Corporation. This booklet is geared for educational use in the middle elementary grades, can be extremely useful to operational programs in their educational efforts, and is expected to be a money-maker for AMCA.

b. Dr. Harry Pratt's color brochure on mosquito control in the United States has been sponsored by Chevron Chemical Company. If we will buy this brochure after its publication, and use it in our community relations efforts, it too can be a money-maker for AMCA and an effective tool for our members.

Although the board of directors has placed a temporary moratorium on beginning any new financial need projects this year, we all recognize that to serve its members, AMCA must continue to move forward in the future with service projects which will require initial funding. The Financial Support Committee will therefore be needed as a hard working committee deep into the foreseeable future.

3. Under Bruce Francy's presidency, an Information Coordination Committee was created in June, 1976 in response to the many expressions of frustration over encroachments upon the legal prerogatives of mosquito control agencies. This committee continued through Lew Nielsen's presidency to gather information and to document regulatory problems encountered by mosquito control agencies, and the report was assembled and filed early this year in the Library of Congress. The current committee will continue to document these problems, and we need to respond to their requests when called upon.

It is obvious to a good portion of the AMCA membership that positive efforts must be made to seek relief in the areas that adversely effect integrated operational programs. A prime example is the curtailment of some of the most effective mosquito control measures, including some source reduction procedures, due to often insurmountable environmental regulations and restrictions. The current committee has now been asked to gather and document any successes experienced by mosquito control agencies, or various state and regional associations, or state health departments or other state agencies, in obtaining relief from regulations, and how these successes were accomplished. I believe that documentation of this kind of action can be a source of encouragement to state and regional associations, or local agencies, to involve themselves in some positive effort of their own.

The board of directors in Chicago did take a positive step toward communicating with regulatory agencies, at the federal level in particular, and this action can be a bright spot in the future. It approved the position of an AMCA Extension Representative, and Dick Peters is scheduled to fill that role after his retirement from the California State Department of Health. He has generously offered to serve without pay except for his actual travel and miscellaneous expenses. It is our hope that through his inquiring effort, AMCA can clearly state to the regulatory agencies the plight of mosquito control programs when they are sometimes obstructed by over-regulation in their effort at protecting the public health and determine if there can be any relief. When this information is more nearly at hand, we will know a little more about what the future influential role of AMCA might have to be in this regard. The board of directors will soon be considering the guidelines which are being formulated for this position.

Another bright spot occurred last March, when AMCA was requested to provide input for a report, on the status and prospects of integrated pest management in the United States, being prepared by the Council on Environmental Quality, Office of the President. Tommy Mulhern has sent various pieces of information since then, and we will continue to supply additional information as it is prepared.

One of the more pleasing assignments the Information Coordination Committee has this year is to do the initial work in setting up an historical exhibit of early mosquito control equipment and memorabilia in an appropriate museum area at Rutgers University. Hopefully, this exhibit will depict the evolution of mosquito control from the early days, the formation of the Eastern Association of Mosquito Control Workers, and the American Mosquito Control Association which evolved from it. This is the area where AMCA had its beginning, and it is the appropriate repository for these historical things to be kept. Chairman Bob Ostergaard has already made a good deal of progress, and the various state and regional associations will be hearing more from him on this later.

The standing committees are all working on their important assignments or their routine duties. Certainly, no committee has a better reputation for hard work and success than the Membership Committee, chaired by Steve Romney. We hope you will encourage new memberships in your area. We also expect some good results from the Operational Articles Committee, chaired by Larry Nielsen, and you are encouraged to submit operational articles to him.

Jay Graham's Worldwide Committee has done some very significant work in the past year, and this year he has taken on the job of defining what we really mean by integrated mosquito control. This has been recognized by Jay as a worldwide need among mosquito control agencies and foreign governments for some time, and he finally wound up with the job.

One of the important tasks this year will be to bring our bylaws up to date and publish them in MOSQUITO NEWS. The Bylaws Committee will have its assignment completed after the board of directors interim meeting in New Orleans. There will be some bylaws changes proposed and you will be notified of these, and they will be circulated to you well before the Washington, D.C. meeting next April.

A very productive thing about AMCA officers and the Executive Director attending meetings of state and regional associations, is that it affords an excellent opportunity for mosquito control workers to express themselves and to discuss on a person-to-person basis any ideas they may have about AMCA, its services, and how we may develop our strengths. This is very important, because we're no different than any conscientious public servant trying to respond to the needs of the public. The association officers and directors want to respond to the needs of the members, and we want to express your ideas to the various committee chairmen, the regional directors, any of us officers, or to the Executive Director.

If we continue to grow in maturity, AMCA can be a still stronger authority on mosquito and vector control on an international basis, and we can develop a stronger influence when communicating the pressing problems affecting our operations. To arrive at a higher status though, we must somehow involve the support of enough individual members and other vector control workers, and the total leadership team must continue to take aim at the type of AMCA program which will represent and be deserving of a growing influence.

# THE ROLE OF THE CENTER FOR DISEASE CONTROL IN VECTOR CONTROL

James V. Smith, Assistant Director
Bureau of Tropical Diseases
Center for Disease Control
Atlanta, GA 30333

To talk about vector control at the Center for Disease Control (CDC) requires that we look briefly at some history and the changing times.

The U.S. Public Health Service was involved in malaria control even prior to World War II, largely through drainage projects of the WPA. "Mosquito Control in Defense Areas" became an organized program in May 1941 as an offshoot of the WPA activity.

In February 1942, the predecessor to CDC, Malaria Control in War Areas (MCWA) was inaugurated with technical support from the H. R. Carter Laboratory in Savannah, Georgia. By 1945 this organization included Malaria Vector Control, *Aedes aegypti* Control, and impounded water surveys as major activities. Cooperative work in these areas was done with the National Institutes of Health and the Tennessee Valley Authority.

CDC was inaugurated on July 1, 1946. Vector control interests were centered in three branches - engineering, entomology, and technical development with activities emphasizing the disease interests of the intended malaria control activities. Encephalitis investigations were begun in cooperation with the Hooper Foundation.

In 1947 a program was implemented to eradicate malaria from the continental United States. Encephalitis studies were being conducted in Greeley, Colorado.

By 1950, the Plague Laboratory in San Francisco was attached to CDC: there were pesticide studies in Wenatchee, Washington: malaria investigations facilities at Helena, Arkansas, Newton, Georgia, and Manning, South Carolina: typhus investigations at Thomasville, Georgia: and a midwest CDC activity in Kansas City, Missouri, which concentrated on encephalitis studies and vector problems associated with water resource developments.

In 1951, malaria activities were diminishing in continental U.S., and the fifties and sixties saw increased vector control activity through the Ecological Investigations Programs in the western states, largely concerned with encephalitis vectors as related to water resources and a variety of activities under the Technology Branch at Savannah with increasing emphasis on community vector control-solid waste demonstration programs through the State Aids Section.

Significant events of the sixties included the establishment of the *Aedes aegypti* Eradication Program in 1964 and the assumption by CDC of the AID responsibilities in the Worldwide Malaria Eradication Program.

In 1967, the Technology Branch was abolished and vector control functions were transferred to other programs. During that year the Central America Malaria Research Station was inaugurated in El Salvador and a pesticide activity was established at Perrine, Florida. The Ecological Investigations Program began at Ft. Collins and training activities were assigned to the *Aedes aegypti* Eradication Branch. In 1968, the *Aedes aegypti* eradication program was abolished and pesticide activities were transferred to the Food and Drug Administration and later to the Environmental Protection Agency.

By 1973, the Malaria Eradication Program had become the Bureau of Tropical Diseases, and the Ecological Investigations Program was under the Bureau of Laboratories. The Disease Ecology Section became the Vector Borne Diseases Division (Ft. Collins) and vector control training was assumed by the Bureau of Tropical Diseases. This is essentially the organization under which we currently operate.

## II. Current Activities and Recent Involvement

Vector control activities of the Center are, by mandate, in the context of vector-borne disease control. Thus, you have seen in the recent past the appearance of a Vector Topics series with such titles as "Control of St. Louis Encephalitis" and "Control of Dengue." In preparation are similar publications, e.g., "Control of Western Equine Encephalitis" and "Control of Plague." Other topics in this series will be offered to meet the needs of the vector control community.

Subject areas of broad interest to the field of public health continue to be produced as they relate to the control of vector-borne diseases. For example, technical manuals on such topics as "Mosquitoes of Public Health Importance", "Insecticides and Their Application", and "Epidemiology and Control of Vector-borne Diseases" will continue to appear in updated form. The policy of updating, revising, and distributing the familiar vector control manuals used in the home study training program continues.

The complexities involved in the direction, epidemiological understanding, prevention, and control of vector-borne diseases require a varied but coordinated program within the Center's framework. Thus, we have laboratories at Ft. Collins dedicated to disease ecology, with emphasis on viruses as causative agents, working largely with encephalitis, but also with Colorado tick fever and plague as a function of geography and professional expertise; a laboratory at San Juan, Puerto Rico, uniquely suited to the study and control of dengue fever and schistosomiasis; a field station in El Salvador devoted to the resolution of such vector-borne disease problems as malaria, Chagas' disease, and onchocerciasis; and professional staff in Atlanta distributed in various bureaus, including the Epidemiology Bureau which is concerned with the epidemiological aspects of vector-borne disease; Laboratory Bureau Divisions of Virology, Parasitic Disease, etc., which deal primarily with causative agents; the Training Bureau which offers the popular home study course on Vector-borne Disease Control; and the Bureau of State Services with a number of vector control activities that relate to general sanitation and environmental control.

Finally, we have the Bureau of Tropical Diseases whose function includes major involvement in vector control as it relates more to members of this audience, with primary responsibility for CDC's vector control program.

The domestic component of the Bureau of Tropical Diseases is the Vector Biology and Control Division (VBCD) at Chamblee, Georgia. The tropical counterpart is the Central America Research station in El Salvador,previously mentioned. The VBCD is organized under a director with three branches including the Host-Parasite Studies Branch dealing primarily with the causative agent; the Medical Entomology Branch dealing with the vector; and the Pesticides Branch dealing with chemistry of pesticides including their effects on nontarget organisms.

Routine and emergency vector control and domestic program activities are conducted by the Medical Entomology Branch. The functions of this group include developmental activities (research), training, and consultation, usually through state or local health departments.

A review of VBCD activities for a three-year period, 1975-77, show a total of 695 direct responses to requests for some type of vector control assistance. Requests come from private citizens, industry, physicians, hospitals/clinics, federal, state and local agencies, international agencies, and Congress. The requests originated in 36 states, the District of Columbia, Puerto Rico, and the Virgin Islands and this is exclusive of training, epidemic assistance, or major consultative activity.

During the same period, the Water Resources Activity reviewed 393 Environmental Impact Statements after the transfer of that activity from Ft. Collins in the fall of 1976. These statements were submitted for comments and recommendations by originating agencies regarding the development of water resources projects that might impact on vector-borne disease.

Field training and/or technical consultation involving direct assistance and technical expertise was provided to 26 different states, Puerto Rico, Guam, and the Virgin Islands during the same three-year period and included assistance in the control of SLE, EEE, WEE, Rocky Mountain spotted fever, dengue fever, and general vector control. Major involvement was with SLE and WEE during the 1975 season, and dengue in Puerto Rico and the Caribbean in 1976 and 1977. Special assistance was rendered in vector-borne disease control to the Vietnamese Refugee Movement in 1975; to the National Boy Scout Jamboree in 1977; and to the Ft. Detrick Biological Containment Activity in 1977. Additional support was given several mosquito abatement districts and the EPA, Atlanta Region, during 1977.

The training activity in its effort to promote sound vector control practices among the vector control community organized and conducted 27 courses during the three-year period involving 553 students from state and local health departments, industry, and mosquito abatement organizations. Included were ten formal courses offered at CDC headquarters; nine field courses in various states suited to specific needs; two Peace Corps groups preparing for malaria control assignments overseas; two special courses on the safe handling of pesticides in the Pakistan Malaria Program; and two courses in Puerto Rico and the Virgin Islands in English and Spanish to vector control workers concerned with dengue control.

## III. Research and Development

Aside from routine research and development activities which include laboratory and field screening and testing of insecticides and application equipment, basic bionomics of vector species, development of survey and control methodology, and technical consultations in training and vector control, the staff participated in cooperative developmental work with various vector control entities including other CDC activities. Some examples include: vector ecology studies on the *Culex pipiens* complex in West Tennessee with Memphis-Shelby County Health Department and the Ft. Collins Laboratory in relation in SLE; the development of a contingency plan for control of dengue in Puerto Rico with the Puerto Rico Health Department and the San Juan Laboratories; the development of a systemic insecticide bait system for use in plague control in the southwest with the Ft. Collins Laboratory; efficacy studies on the use of aerial ULV against *Aedes aegypti* in urban situations with the New Orleans Mosquito Control Commission; the evaluation of new type survey tools with the Birmingham, Alabama, Health Department, with the Chatham County Mosquito Control Commission, and with the Gorgas Memorial Laboratory in Panama; insecticide susceptibility investigations with the Harris County, Texas, Health Department,and with the Memphis-Shelby County, Tennessee, Health Department.

## IV. Future Trends and Directions

The Center's future efforts in vector-borne disease control and research will continue, their character and magnitude contingent on the nature of the problems and specific needs requiring attention. Historically, one of the unique capacities of the Center has been its ability to respond to a wide range of public health needs. Numerous examples of this quality are evident in its history beginning with its efforts in malaria control in the 1940's. Following successful conclusion of that program, other needs in vector-borne disease were recognized and programs embarked upon: plague in the western United States, encephalitis, *Aedes aegypti*, dengue fever and then back again to malaria in the international context. This same ability to respond to problems is typified by the large effort and final successful resolution of the enigma of Legionnaires Disease. Throughout its better than 30 years existence, CDC has taken great care to develop and retain nuclei of competence in a spectrum of public health needs, thus enabling rapid mobilization as problems arise.

Major challenges will confront us in coping with vector-borne disease on the global front. This should not be regarded as a distraction from domestic efforts since the two are really intimately related. What we have learned about the control of vector-borne disease in the United States is now finding important application overseas and what we learn from some of the new and innovative approaches to control of vectors of trypanosomiasis, malaria, yellow fever, and other diseases will ultimately prove beneficial to our domestic needs.

On the domestic side several priority areas are identified for current and future attention. These include:

1. Establishment of preventive health standards at the community level with assurance that vector control interests are included.

2. Providing assistance to state and local governments in the identification of vector-borne disease risks and assessing local resources for dealing with them.

3. Providing continued improved technical support to local vector control programs through vigorous activities in training, research and consultation through the state health departments.

4. Provide general support to communications through conferences, workshops, special training and dissemination of technical information.

5. Attempt to secure funds for emergency control of vector-borne disease causing significant morbidity or mortality for situations not qualifying for disaster relief assistance.

# UNIVERSITY OF CALIFORNIA MOSQUITO RESEARCH PROGRAM

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I believe most of you have some familiarity with the University of California research program from annual reports and from papers presented by UC researchers at numerous meetings and conferences. In this talk I will touch on the highlights of the program, starting with some pertinent background leading up to the current position.

## Background of the Mosquito Research in California

First, I should clarify that the University involvement in mosquito research is not a recent event but represents an outgrowth of over 70 years of research, investigation, and extension activity. The first record of University involvement with mosquitoes dates back to 1905 when Professor H. J. Quayle gave technical assistance to a citizens group in San Mateo County, California in the area of San Francisco Bay on the control of the salt marsh mosquitoes. Then in 1910, University of California professors W. B. Herms and Stanley Freeborn and engineer Harold F. Gray–now immortalized for their contributions to mosquito research and control–collaborated in the organization of anti-malaria campaigns in the malarious areas of the Central Valley of California. Largely through their efforts, indigenous malaria was virtually eradicated in California by 1922.

The year 1930 marked another significant breakthrough in mosquito research in California. This was the discovery of mosquito-borne encephalitis by the staff of the George Williams Hooper Foundation of the University of California. Later in 1939, Professor William Reeves, University of California, began his productive career leading to outstanding achievement in the field of mosquito-borne encephalitis research and control.

Immediately following World War II, California mosquito control expanded dramatically because of public demand for protection against rising pest mosquito populations and outbreaks of mosquito-borne infections. Control problems were amplified and complicated by a burgeoning population accompanied by an explosive growth in irrigated agriculture, industry, and urban development. Although the availability of DDT at that time greatly simplified the execution of control at low costs, its widespread use diverted attention from the traditional methods of control by water management, larviciding by oiling, and use of mosquito fish. DDT larviciding and adulticiding became the principal, and in some cases, the only mosquito control strategy.

Then slowly but surely emerged the realization that dependence on insecticides was not a panacea. Although initially chemical control produced dramatic results, progressive reduction of mosquitoes could not be sustained because of fundamental defects in the method.

First to appear was mosquito resistance to insecticides due to intensive selection pressure from frequent and widespread sprayings. As new insecticides were synthesized to replace ineffective ones, there were accompanying cost increases. The environmental contamination problem resulting in the imposition of EPA constraints on insecticide use added further pressures to the spiraling cost problem until reliance on chemical control could no longer be justified on economic grounds in most control programs.

In California, the application of insecticides reached peak levels in the late 1950's and early 1960's. In 1962, the use of over 600,000 pounds of insecticide was reported by mosquito abatement districts. Thereafter, usage declined steadily as insecticides became less effective and more costly. By 1976, reported usage of insecticide had decreased to approximately 73,000 pounds. This nearly tenfold reduction is attributed to more selective and efficient application of pesticides and replacement by more effective oil formulations applied at low dosage rates of 2 to 4 gallons per acre instead of at 20 to 50 gallon rates for diesel oil.

What was the major thrust of mosquito research in California during the 20-year period of insecticidal dominance? The records show that UC research activities centered on laboratory screening and field testing of new chemicals combined with investigation of mosquito resistance to insecticides.

In addition, the Bureau of Vector Control, California State Health Department, pursued a comprehensive program of mosquito research involving cultural, physical, ecological, and chemical control.

Despite the shortcomings of chemical control, the availability of DDT and other insecticides contributed greatly to the rapid expansion of mosquito control seen in California after World War II. From about 1945 until 1970, the number of mosquito control agencies increased from 16 local districts covering 5,484 square miles to 60 agencies covering 57,403 square miles and protecting 16 million people. This spectacular increase was in keeping with the rapid population growth in California and the tremendous expansion of irrigated agriculture, industry, and urban development. If only traditional methods of control had been available during this period, the public demand for protection could not have been met on such a huge scale.

By the late 1960's, dependence on insecticides was no longer a viable mosquito control strategy in California for most agencies. The case for drastic revision in control practices was convincingly stated by the late Mr. Richard F. Frolli, Manager of the Kings Mosquito Abatement District, in his presentation before the CMVCA conference of 1971 (Proc. CMCA 39:1-2). A pertinent quotation follows:

> "These are crucial times – our pesticides are failing! Our basic solutions for mosquito control are dying! The resistance phenomenon has matured. The pasture mosquito and the encephalitis mosquito have triumphed over sprays in many parts of California.

"We must change our basic strategy, we must change our basic solutions, we must change our district images to ones other than spray districts if we are to be effective in mosquito abatement.

"In many counties of the State chemical sprays are no longer effective at safe, legal, economical rates. After 25 years of continuous spraying, the mosquitoes have become immune or multi-resistant to all common public health mosquitocides, including malathion, parathion, EPN, fenthion, Abate, Vapona, Dibrom, Dursban, and others.

"To the chemically oriented mosquito abatement districts of California with highly sophisticated spray programs, this is a crisis. The resistance phenomenon is no longer an embryo, it has grown and matured geographically, economically, sociologically. It is no longer an interest of the technical few, but must be reckoned with by the political many."

The high standards of mosquito control in California were threatened by deterioration and possible resurgence of mosquito-borne diseases. The crisis was serious, but practical alternatives to or replacements for pesticides were not available or perfected for operational use in considerable part due to the lag in research on biological and other non-chemical methods.

UC Research Program

In the search for a solution most mosquito control agencies in California supported a special, State legislative appropriation in 1971 to permit acceleration of mosquito research by the University of California. The research was aimed at developing new control technologies and correcting the deficiencies of existing ones. The overall objective was to pursue a balanced program of research involving biological, physical, cultural, genetic, and chemical controls needed for implementing an integrated pest management program.

The research has been underway for seven years supported by special State funds. In FY 1978-79, a sum of $478,000 was allotted to the program.

Research Coordinating Committees

The research proposals submitted annually by UC scientists for State grants are carefully scrutinized by three review committees--the CMVCA Research Committee, the UC Mosquito Research Technical Committee, and the UC University-Wide Advisory Committee on Mosquito Research. The proposals are examined for scientific merit, relevance to mosquito control, feasibility, and cost benefit factors. The approval and allocation of funds to individual researchers are based on committee recommendations.

Research Activities

Research in the following subject areas is being supported: biological control, genetic control, chemical control, physical and cultural control, and mosquito biology and ecology.

Biological control research includes studies on mosquito predators, parasites, and pathogens. The mosquito fish, *Gambusia affinis*, is the only predator being generally used in California mosquito control programs. And there is a strong demand for information on improved methods of mass rearing, management of field populations, and evaluation of effectiveness. With this object in view, research is underway to develop a bioenergetic model for evaluation of efficiency of *G. affinis*, and to determine when and where to stock and how to integrate and harmonize pesticide use with the fish. Mark, release, and recapture techniques are being developed for use in studies on population dynamics. In addition, a comparative study is being supported on the performance of various *Gambusia* stocks in California from which strains will be selected and bred for improved predator capability and suitability for intensive culture.

Two promising fungal agents, *Lagenidium giganteum* and *Coelomomyces culicivorax*, are being evaluated in the laboratory and field for rates and patterns of infections. High priority has been given to development of mass culture techniques, a prerequisite for operational use of the bioagents.

Studies on the mosquito control efficacy of two bacterial agents, *Bacillus sphaericus* and *B. thuringiensis* are being supported. Although the results would encourage continuation of the studies, there is no immediate prospect for practical use of the bioagents in California mosquito control.

Other bioagents showing possibilities for mosquito control include flatworms and mermithid nematodes. Although high mosquito infection rates have been reported with the nematodes, *Romanomermis culicivorax*, mass rearing of the organism has encountered stubborn problems.

Genetic Control

Two studies on genetic control of mosquitoes are being supported.

In one project a first attempt at incroducing a sex-linked, double translocation, heterozygote *Cx. tarsalis* population into the field was not successful, but further trials are planned. In another project, the feasibility of using the sterile male technique for control of *Cx. tarsalis* and *Ae. sierrensis* is being evaluated.

Chemical Control

Despite the growing tendency to reduce the use of synthetic insecticides, they are still essential for mosquito control in most programs. However, research emphasizes testing of environmentally safe mosquito larvicides. Consequently, the IGR compounds are receiving high priority. Pyrethroids are phenomenally effective at low dosage rates in field trials, but some non-target organisms are adversely affected. Various oil formulations widely used in California mosquito control are being evaluated for effect on non-target organisms.

Resistance

A high priority in the chemical control research involves studies of mosquito resistance to insecticides. In California the resistance problem includes more species of mosquitoes, higher levels of resistance, and a larger number of ineffective chemicals than any other comparable area. Studies include investigation of esterases as diagnostic characters associated with OP resistance, studies of the mechanisms of resistance to IGR's, examination of new N-substituted carbamates against R-strains, investigation of resistance to pyrethroids, development of procedures to delay or avoid resistance, such as the rotation of rationally selected insecticides, and selective application techniques.

Vector Diseases

Vector control research is an ongoing activity currently concerned with vector competence and genetic control of mosquitoes of public health and veterinary importance. In respect to vector competence, populations of *Cx. tarsalis* have been selected with a 100,000-fold increased resistance to WEE virus infections. The trait is polyfactorial and could be persistent in the field. Similar selection studies are being pursued on SLE virus.

Although attempts at establishing a sex-linked, double translocation, heterozygote *Cx. tarsalis* population in the field were unsuccessful, further genetic field trials are planned and preparatory studies are proceeding on measurement of *Cx. tarsalis* populations, adult daily survival rates, density-dependent responses of larvae, and cage trials of mating competitiveness.

Additional encephalitis studies in southern California are primarily concerned with elucidating the transmission of encephalitis arbovirus. As part of the basic project, information on the biology, ecology and host preference of the mosquitoes is being developed. Although high rates of WEE and SLE virus in *Cx. tarsalis* and *Cx. pipiens* mosquito pools are recorded, no clinical human infections have been confirmed.

Research on the biology and ecology of mosquitoes have been focused on *Ae. sierrensis*, *Cx. tarsalis*, *Cx. peus* and *Cs. inornata*. Studies on nutrient requirements of larval mosquitoes are providing basic information of importance to biological and ecological studies and controlled laboratory experimentation.

A unique feature of the research program is the close collaboration between University of California researchers and mosquito control agencies. Many of the research projects are being carried out in cooperation with mosquito control districts. District facilities, equipment, and personnel are provided to assist the research. Occasionally, even funds have been granted, but the deep budget cuts resulting from Proposition 13 are expected to eliminate such support.

The collaboration has been mutually beneficial and has stimulated and strengthened the program in achieving a compatible, practical, and economical research effort.

The current program is not problem free. Like other comprehensive research programs, there are many difficulties, but none are so serious or complex as to defy solution by perceptive and persistent researchers.

Through a sustained, coordinated, and adequately supported research effort, we can foresee development of feasible, economically viable, and environmentally acceptable mosquito control strategies embodying the principles and practices of integrated pest management.

# A COMMENTARY ON THE DISEASE VECTOR CONTROL PROFESSION IN AMERICA

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Stress is one of the major causes of human ailments today. The high pressure conditions associated with the rapidly changing society in which we live frequently generates mental and physical conditions which ultimately cause system failure. Stress causes failure of the human body to continue normal functions and failure of the human mind to assimilate a growing number of inputs in a rational manner. The end result being the deterioration of physical and mental well-being. Individual systems, parts of the fabric of society, buckle under the stress of modern living and the entire complexion of society changes.

Stress is also the major cause for the deterioration of our environmental systems. The ability of the present system to absorb air, soil and water contaminants is finite. The earth will always have an environment. One of the first scientific laws we learned in grade school was that matter can be neither created nor destroyed. We can, however, by stressing the environment change the interrelationships of one element to the other until the entire system buckles under the strain and the entire complexion of the environmental systems change.

Stress is the major cause of "change." Not all change is progress but all progress is change and progress will not be denied even though "the crossroads on the pathway to progress are guarded by a thousand men appointed to preserve the past." George Bernard Shaw said of them: "Progress is impossible without change, and those who cannot change their mind cannot change anything."

A population that is stressed, living in an environment that is stressed, will give birth to demands for change that would unquestionably exceed the capacity of the system to absorb them, were it not for those thousand guardsmen slowing the rate of change. They will be passed by, however, just as those who have opposed change from the beginning of time. Today, we live in an era in which time is collapsing. Expressed in a different way, we live in an era in which the rate of change is accelerating at nearly a geometric rate. This rate of change is evidenced in nearly every aspect of our lives. As an example, look at the changes we've seen in the past thirty years:

- Speed: the sound barrier was broken with the advent of the jet engine. Now rockets boost space craft travel to speeds several thousands of miles per hour.

- Communications: instant worldwide coverage of events through satellite-relayed television is an accepted "norm" while undreamed of thirty years ago.

- Miniaturization of Electronics: all of the functions of a programmable pocket calculator would have required an entire roomful of equipment to perform only a few short years ago.

- Medicine: organ transplants, open heart surgery, sophisticated chemotherapy techniques give us new hope against afflictions of many kinds.

- Chemistry: new chemical fibers for clothing, plastics, building materials, drugs, pesticides and the like, make life easier for us today than any time in recorded history.

All of these changes in these professional disciplines are going on around us and we enjoy the fruits of their progress.

How about the Vector Control profession? Is it changing too? You bet it is. Just look around at some of the changes that have, or are, taking place.

- Malaria: nearly eradicated twenty years ago, is once again the number one world health problem. Add to that, the increased problems with dengue fever and we have major changes taking place in vector-borne disease.

- *Aedes aegypti*: nearly eradicated twenty years ago from the U.S.A. now a prominent species in the southeastern and Gulf Coast states, and once again a threat to the health and welfare of U.S. citizens.

- Resistance and cross-resistance: confined to California twenty years ago, is a growing menace across the country and around the world, both resistance to insecticides and to anti-malaria drugs.

- Source reduction: indiscriminately practiced in the past, now nearly impossible in many ecologically sensitive situations because of required regulatory mandates for environmental impact statements.

- Adulticiding: while techniques and equipment have improved with the development of ULV equipment, the products to put through the equipment have not kept pace. Organophosphates remain as the principal products with the hope the list may be expanded to include the use of new carbamate formulations and perhaps the new synthetic pyrethroids.

- Larviciding: one new larvicide has been registered by the EPA during the six years I've been in the industry. One has been phased out altogether, two have become increasingly ineffective while the major U.S. larvicide, OIL, appears to be in for some very tough sledding in the near future. The problems with oil are threefold:

1. Polynuclear aromatics (PNA) are known to be ecologically disruptive contaminators. The cost of detecting and removing them from petroleum distillates destined to be

discharged into water for mosquito control is prohibitive.

2. Current legislation restricts the amount of oil that may be discharged into a navigable water to a volume that is operationally below an effective larvicidal rate. Indiscriminate spraying of petroleum distillates on coastal marshes and in surface and subterranean drainage systems is coming under increasingly close scrutiny by water quality control, wild life management and Coast Guard officials.

3. Rapidly rising oil prices have made petroleum distillates increasingly less economically attractive.

What is the "bottom line?" What is the "net effect" on our profession? We can sum it up in one word. "STRESS!" Our professional talents and capabilities will come under a greater level of stress as we change in the way we approach our professional responsibilities. The old way of doing things will become increasingly more carefully scrutinized and the new way increasingly more feasible. These attitudinal changes will be evidenced first in our industry "pace setters." They are that small number of individuals in any group that has the native intelligence to see the need for change and the self-assurance that gives them a license to fail. Through trial and error and trial again, they will hammer out the operational techniques that the majority will eventually embrace. They will take the inherent characteristics of the tools of their trade and adapt them into the best possible operational techniques to accomplish the necessary objectives. In this profession, those techniques will be called:

INTEGRATED MOSQUITO MANAGEMENT

Our government is spending more money each year to promote Integrated Pest Management (IPM) than the entire chemical budgets of all of the organized mosquito abatement districts in this country put together. Why? Certainly not because it is a new concept. After all, the Chinese practiced it 1,800 years ago, and it was a popular philosophy of pest control right here by northeastern apple and potato producers more than 100 years ago. So why all the hullabaloo now? It's simply because those in authority feel the stress. The pressure continues to mount for the most rational approach to pest control that it is possible to achieve. The stress or pressure points came from several directions simultaneously with each influence beating its own drum. Those espousing clean air, clean water, protected fish and wildlife habitats, lower taxes and at the same time a pest- and vector-free atmosphere in which to work and play. All of these factors constantly stress the professional capabilities of our industry. Couple this with the fact that we have been losing the chemical and environmental tools of our trade at a rate significantly faster than new ones come into being and you can clearly see that the profession will continue to be stressed. And our answer will be:

INTEGRATED MOSQUITO MANAGEMENT

Let's explore the meaning of this concept a bit more in depth. There are a number of definitions for IPM and here are a couple that I like. One is:

"A Pest Management System that in the context of the associated environment and the population dynamics of the pest species utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury."

Another definition came from the Council of Environmental Quality which defined the concept by citing three main components. They are:

"1. Maximizing natural controls predominantly by cultural methods to prevent the build-up of pests;

2. Monitoring the concentration of pests and natural control factors present to determine the need for further measures;

3. Using the most appropriate technique or combination of pest suppression techniques only when necessary to prevent economic damage."

I like this last definition for our industry because, conceptually, I believe that we can all agree that the professional mosquito control industry of this country has, from its very beginning, been an adherent to these three basic principals of integrated pest management. Let's take them a point at a time.

1. <u>Maximizing Natural Controls:</u>

   No professional pest control operation is more cognizant of this basic control measure than is the MAD manager. Source reduction, rightfully so, continues to be the preferred way to reduce, or eliminate, mosquito problems. But how many of you have tried to drain the swamp lately? How many of you have had to burn the midnight oil preparing an environmental impact statement in the hopes that you can clean out an old ditch that has become clogged and ineffective? We're not playing in the same ball game that we were a few short years ago, and source reduction is no longer a quick and easy solution to the problem in every case.

2. <u>Monitoring the Concentration of Pest and Natural Control Factors:</u>

   No one will argue, I'm sure, that most MAD's have done an outstanding job of monitoring and taxonomically classifying the mosquitoes in the area under their jurisdiction. Monitoring natural control factors such as rainfall, wind and tides is also widely practiced. We may be some way off, however, before we can accurately assess the operational impact of prey, predators and pathogens in all of the different breeding sites with which the average manager must contend. Even though accurate monitoring may be difficult to impossible, of one thing you may be very sure. The level of concern for natural control organisms in a breeding site which is to be treated will receive much higher consideration in future programs than in the past.

3. <u>Using the Most Appropriate Technique or Combination of Pest Suppression Techniques Only When Necessary to Prevent Economic Damage:</u>

Or, in the case of vector control, "only when necessary to prevent the transmission of disease or the deterioration of the quality of life of the citizenry." Number three is the bottom line of every program and project. This is where those in charge of an operation stake their professional reputation that the "most appropriate techniques and/or products" are employed to effect an acceptable level of control. That's Heavy – Real Heavy. An IPM program puts a professional responsibility on individual managers to embrace the most intelligent program possible. To continue to employ the same techniques, products and equipment that were being used in the past, is to pass professional judgment that no improvements have been made worthy of consideration. Now, the first thing that would come to my mind, were I an MAD manager, would be to get a bit upset if someone told me that I wasn't acting in a professional manner if I didn't change my program every time some new fangled idea came down the pike. Well, if I've left you with that impression, please set it aside for a moment while we discuss our industry.

Tommy Mulhern, Executive Secretary of the American Mosquito Control Association, last year described this industry as having three separate areas of influences:

Research – Operational Control – Industry Suppliers

Let's think about these three elements of our industry as being three legs of a stool. If all three legs are of equal size, length and strength, you can support a pretty hefty industry. If, on the other hand, one or more legs are less than the other, you run the risk of failure and possible catastrophe. What is the American Mosquito Control industry and what condition are its legs in? I'll give you a quick thumbnail sketch of where I see it from my vantage point as an individual representing a basic supplier with reponsibility for sales on a worldwide basis.

I see the organized mosquito control market in the U.S.A. spending in the neighborhood of $100,000,000 per year to control mosquitoes. I see about ten percent of that money being spent for chemical control agents and the balance spent largely on labor and direct operating costs. I see approximately fifty percent of the chemical budget, or five million dollars, being spent for adulticides and the remaining five million dollars being spent for larvicidal products, including all forms of petroleum distillate.

The First Leg – Research

I see state and federally funded research ability fully capable of operational evaluations of new control concepts. I see dedication of many individuals in that system to improving the techniques of vector control. I also see a hesitancy, or a reluctance on the part of others, to evaluate and perfect the operational use of new products and techniques and to openly and enthusiastically endorse their adoption by those they influence.

The Second Leg – Operations

I see a group of dedicated professional vector control ecologists who really care. People who really share a concern for the protection of the public against disease vectoring and nuisance mosquitoes, and an equal concern for the protection of the ecosystem under their direct influence. I see, also, individuals whose main philosophy would appear to be: "George was manage here at this district for thirty years before he retired last year. He never got in trouble with this program and I've got twenty years more to go to retirement. I certainly don't want to get in trouble! Do I?" I see the majority of the operational managers somewhere in between these two extremes; responsible, intelligent, concerned people who look to the other two legs of this industry to help show them how to raise their professional standards of excellence.

The Third Leg – The Industry Suppliers

I see a pragmatic group of business men who weigh the relative potential returns from investments in the mosquito control industry against the financial risks. I see skyrocketing development costs, increased time delays for new product registration due to bureaucratic indifference. Couple this with a market of very modest size and the net result is as predictable as the sun coming up in the east and setting in the west. You can bet that fewer and fewer products will be introduced for your consideration in the future. This is doubly true for the chemicals that you use, because the entire pesticide industry is in the throes of a "shake-out." Several very major chemical companies have abandoned their pesticide synthesis and screening programs during the past decade. The next five to ten years will see another whole group of companies decide that there has to be an easier way to make a buck.

Summarizing what I see in the organized mosquito control industry:

– I see an industry under stress.

– I see an industry that should have a very real concern for the fact that some dramatic changes in the way they operate may very well be imposed on them from the outside.

– I see an industry faced with the probability that tax revolts across the nation will result in more California-type Proposition 13's that will severely restrict available funds for vector control.

– I see an industry that should be pulling together in a common effort to maximize the public relations value of the task we perform.

– I see an industry that has inadequately exploited the value of good mosquito control in the control of dog heartworm. It is my understanding that the cost of prophylactic treatment of a medium sized dog costs his owner from $20.00 to $75.00 per year.

If our industry had $1.00 per year from each and every dog subjected to this dreaded disease, I would venture to guess that we could nearly double our budgets.

- I see an industry that drew 100 people to a mosquito control meeting in Indiana last week. Two years ago, this same state only had two organized mosquito districts of any size. But they are moving towards several more today. Why the sudden interest? Because three years before, that state had 258 cases of SLE confirmed. I see an industry that has not exploited the fact that there may have been, according to Dr. George Craig of Notre Dame, 50 to 200 times more than the 258 confirmed cases. Is it possible that between 12,900-41,600 Indiana citizens actually had clinical SLE in 1975?

In the entire assemblage, there was not a single representative of the press to tell that story to.

- I see an industry that has inadequately exploited a term that I heard for the first time just last week. That term is SEQUELA. (A morbid aftereffect resulting from a previous disease.)

Again, according to Dr. Craig, this is an area of public health that has never been fully explored and the results quantified. Why, I ask, if there is any reason to suspect that young children will suffer long term effects from a mosquito-transmitted disease, is this not in the province of NEED TO KNOW information for this industry?

Yes, I see the organized mosquito control industry under stress. The stressful conditions that exist will, without question, mandate changes and progress. Thousands of men guarding the crossroads on this path will not stem the tide nor alter the progression of events.

The fortunes of this industry are embodied in its people and the needs of society. As we seek the fortunes this industry offers, I am reminded of what Machiavelli had to say on the subject. He concluded that fortunes vary, but most men remain fixed in their ways because they were successful when those ways conformed to the way things were in the past, or are at the moment. Conversely, failure has been their reward when they attempted to buck, or change, the system. It was his conclusion, therefore, if it is fortune that we seek, "it is better to be impetuous than cautious, for fortune is a woman, and when it is necessary, if you wish to master her, to conquer her by force. And it can be seen that she lets herself be overcome by the bold rather than by those who proceed coldly. And therefore, like a woman, she is always a friend to the young, because they are less cautious, fiercer, and master her with greater audacity."

And so I, as a representative of the supplier leg of this industry, and an employee of a young dynamic company dedicated to perfecting new biorational insect control products, salute the young members of this organization. Not necessarily the chronologically young, but the mentally young, resilient, farsighted and self-assured individuals who can perceive the challenge of the decade ahead and conceive of all of the ways in which to advance the fortunes of this industry. They are our Pace Setters, and the control programs that they perfect for us will be called

INTEGRATED MOSQUITO MANAGEMENT

–but it won't be easy.

## PANEL PRESENTATION: AFTER RESISTANCE, WHAT?

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When faced with mosquito insecticide resistance:

- Don't panic. Mosquitoes were controlled before modern insecticides were developed and they can be controlled now.

- Know thine enemy. Maintain close surveillance to define the extent and intensity of resistance, in what species, to what chemical, and where.

- Buy time. Reexamine your district's goals, objectives, criteria, and practices to reduce pressure and so retard resistance. (This should have been done before resistance!)

- Keep an emergency contingency plan in mind in the event that a disease outbreak threatens.

- Inform and educate (1) your board, (2) the public, (3) the regulatory agencies involved, and (4) industry.

- Weigh your program alternatives, on a case-by-case basis, considering their viability, feasibility, availability, affordability, acceptibility, and all other utilities - -

  What will be the short-term and long-term effects of changing chemicals?

  What biocontrols are potentially useful?

  Can the source be eliminated or reduced? If so, (1) how? (2) by whom? (3) who will pay? (4) will legal action be needed?

  What would happen if nothing were done?

- Once having decided upon a course of action, get with it. Keep your attitude positive and be confident of success.

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Eugene E. Kauffman, Manager
Sutter-Yuba MAD
Yuba City, CA 95991

The initial impact was "Why me?"! When resistance struck, the District had a low budget, less-than-adequately trained personnel, and no source reduction program. The District's decision makers were left feeling low.

Two types of change resulted. For the short-term, we switched from one insecticide to another. The progression ended when there were no new effective and approved materials. For the long-term, the District requested additional funding, improved training of personnel, and began a source reduction program.

The numbers of resistant pasture mosquitoes were reduced as the number of problem pastures became fewer. Legal abatement procedures helped, but they were never the major approach to reducing mosquito sources.

A field technician observed in 1976 that malathion had killed larvae from a field that had produced highly resistant mosquitoes. Since that time, we have successfully controlled the adults with malathion dispersed by a non-thermal aerosol generator.

In conclusion, our initial reaction to resistance was to run into a mentally-erected stone wall. We recovered our posture when we effected changes that bettered the District's program. Our program of change is successful because we look at success as a journey, not a destination.

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When Pandora opened the box which contained all the ills that could plague mankind, odds are that the mosquito was the first to fly out. For centuries, the battle between mankind and the mosquito has been waged. If score had been kept, no doubt the mosquito would have been declared the winner. But in 1946 man sent in a new champion to combat their age-old enemy. It seemed the tide had turned. Victory was in sight. Man's new hero, "DDT", was acclaimed, exalted and extolled throughout the land. The excited gentry scurried to put an end to all pest insects. It was glorious - - revenge theirs. Earth once again would become a garden paradise. Victory was short-lived. The mosquito within three years also had found a new champion - - resistance. So the battle continued.

Shortly after chlorinated hydrocarbons had attained widespread use, resistance or tolerance became apparent. DDT resistance was first reported in California in 1949 in Kern County (Smith 1949), The innate capacity of organisms to change is an everyday confrontation.

The problem of resistance is compounded since it is often cited for control failures when actually other operational factors are the cause. It is not to be assumed that every time live larvae or adult mosquitoes are found after treating that it is due to resistance. Other considerations are that spray may have drifted or been altered by an inversion layer; the insecticide may have settled out too quickly in the water; heavy vegetation may prevent an adequate quantity of spray from reaching the water; or an improper mix may have been used. The operational problem is easier to solve than a resistance problem, so it is important that the control operator be able to distinguish the difference.

When resistance to an insecticide shows up, it is usually very spotty and rarely occurs over large areas in its early stages. However, if the population is continually pressured by the same insecticide, the resistance will spread over a large area within two or three years This does allow time to gradually introduce other spray materials or other control techniques without drastic disruptions of the agency's control program.

A sophisticated resistance surveillance program has been developed to help mosquito abatement field personnel to deal effectively with this problem. A program to monitor developing organophosphorus insecticide resistance in California mosquito larvae was begun in 1963 as a survey for both resistance and susceptibility in treated populations (Gillies 1964). In 1964 susceptibility test kits (Gillies and Womeldorf 1968) were made available to California districts. The test kit is useful in distinguishing control failures due to inadequate application or those from true resistance. It will also detect increases in tolerance and aid in anticipating control problems. If resistance is present, the test kit may be used to measure its magnitude and extent. It also aids in delineating areas where substitute control agents may be indicated.

An effective resistance-monitoring program must include a routine and thorough post-treatment inspection system encompassing most sources to which insecticides are applied. Agencies using the post-treatment inspection system will discover a failure quicker than those that rely on spot checks or citizens' complaints to discover incomplete kills.

Although DDT was not the "cure-all" long sought for, it did gain ground and gave the needed impetus for the continuing battle of man vs. mosquito. Maybe, just maybe, we'll put the mosquito back in that box.

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# THE PROSPECTS FOR EFFECTIVE CONTROL AGENTS

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Insecticide susceptibility tests on Utah mosquitoes have already given indications that resistance is a problem that can be anticipated (Hart and Womeldorf 1976, Merrell and Wagstaff 1977).

First, what is the cause of insecticide resistance in mosquitoes? RESISTANCE = SELECTION PRESSURE X NUMBERS EXPOSED TO PRESSURE X TIME. Thus, the development of resistance will occur fastest when a high selection pressure is continually placed on a high percentage of the populations. Schaefer and Dupras (1969) studied the cause of control difficulties on alkaline pastures in California; they stated: "It is apparent that there is a significant relationship between alkaline pastures and control difficulties. The alkaline pastures in question are located on hard-pan soils which have poor drainage; these lands are difficult to farm and, therefore, are usually maintained as permanent pastures rather than being rotated to other higher return crops, as occurs in other areas. The continued presence of pastures results in a given area being treated very frequently, season after season, for the control of *A. nigromaculis*. We believe that this (selection pressure) explains why insecticide resistance is the significant cause of control difficulties."

Conversely, if selection pressure is relatively low or moderate and the percentage of the total population exposed per treatment is low, then a given type of insecticide will have a much longer time of operational usefulness. The selection pressure can be reduced by not attempting to obtain complete control within a geographic area. Areas where the human population density is low can provide zones to reduce the portion of the total population which is treated; this will then help maintain a reservoir of susceptibles. In areas where such tactics can be employed, the useful life of chemical control agents will be significantly extended.

What are the future prospects for given types of control agents?

## Chemical Control Agents

A. Chlorinated hydrocarbons. The question is frequently asked whether or not it would be possible to return to the use of DDT and/or related compounds since the mosquito populations have not been pressured with them for many years. In California the use of chlorinated hydrocarbons ended about 1952 and while the populations haven't been pressured since, the resistance remains. Of course, the problems of environmental persistence and bioaccumulation would greatly influence any request for use of these compounds at the present time.

B. Organophosphorus compounds. Once organophosphorus resistance (OP-R) is established in the field it continues to spread slowly and intensify. The degree to which it spreads and intensifies is related to the degree of continued selection pressure which involves the number of applications made per season as well as the percentage of the total populations which are treated. In California some populations of *Aedes nigromaculis, Culex tarsalis* and *Culex pipiens quinquefasciatus* are now highly resistant to all commercially-available organophosphorus larvicides. What about the prospects of new organophosphorus control agents? In laboratory tests during the past 5 years, we have found that the OP-R strains show a high degree of cross-resistance to all new OP compounds. As a matter of fact, chemical companies have now all but stopped submitting new OP compounds for testing. Thus, new OP compounds do not appear to offer promise for dealing with the resistance problem.

C. Carbamates. In 1968, when OP-resistance in California became a serious problem for operational control programs, we found that Baygon (propoxur) could be used very effectively against OP-R adults at 0.05-0.07 lb AI/acre. Since that time Baygon has been used to control adults when OP larvicides fail. It is very noteworthy that carbamate resistance has not yet been documented; in fact, pressuring OP-R *Cx. tarsalis* with Baygon in the laboratory did not lead to carbamate resistance (Georghiou et al. 1974).

Baygon is the only carbamate that has been used against mosquitoes in California and it is only used for adulticiding. Carbamates are generally not effective mosquito larvicides. One exception was RE11775, a carbamate with very good efficacy against OP-R mosquito larvae (Schaefer and Wilder 1970). While RE11775 showed exceptional promise against OP-R *Ae. nigromaculis* and *Cx. tarsalis*, its use would have been limited to use against OP-R strains of mosquitoes; the compound did not offer promise against other economically important insects. Thus, its owner decided that the OP-R mosquito market by itself did not justify the large investment in costs of development. This is an economic fact of life that will continue to haunt those of us searching for new control agents for use against resistant strains of mosquitoes.

D. Other classes of insecticides which have shown promise during the past 10 years.

1. Tertiary-butyl substituted phenols. In 1971 Sacher reported on MON585, a t-butyl substituted phenol, which did not cause direct intoxication of mosquito larvae, but when 4th instar mosquito larvae were exposed they died as unpigmented (albino) pupae. Schaefer and Wilder (1972) found that aerial applications of 1.5 to 2.0 lb AI/acre of MON585 gave control of

OP-R *Ae. nigromaculis* larvae. However, Monsanto Corporation decided that the market potential of MON585, whose biological activity was limited to mosquitoes, did not justify the cost of development. In 1974, Schaefer et al. reported on another series of t- butyl phenols which Chevron Chemical Company was testing for insecticides. These compounds proved to be very effective against OP-R mosquito larvae, had no deleterious effects on nontarget organisms or on the environment but were not effective on other insect pests. Again, a marketing analysis concluded that development was not commercially justified and research on this class of compounds has been discontinued.

2. Insect hormone-type compounds. With the elucidation of the structures of the hormones which control insect molting and metamorphosis, new areas of insecticide chemistry were born. The hormones which control molting (ecdysones) were found to be steroids which are rather complex and would be very expensive to manufacture as insecticides; no compound of this type has been developed for insecticidal purposes. The hormones regulating insect metamorphosis (juvenile hormones) are much more simple in structure and hundreds of this type of compound have been made and tested for insecticides. One juvenile hormone-type compound showed very great promise against mosquitoes (Schaefer and Wilder 1972, 1973), had minimal side effects on non-target organisms (Miura and Takahashi 1974a) and was fully registered as Altosid$^R$ SR-10 by the EPA in 1975. The biological activity of Altosid is greatest on mosquitoes and flies, and these are still the only pests against which this relatively selective insecticide is marketed. Zoecon Corporation, which owns Altosid, was formed to exploit insect hormone-type compounds; they continue to develop this selective insecticide, in spite of the total market limitations, in order to have their first commercial product. It is unlikely that even Zoecon Corporation would develop such a selective product if it were to be discovered now!

3. Benzoyl urea-type compounds. Such compounds have been shown to inhibit chitin synthesis in insects. Chitin is an important component of the insect cuticle. Mosquito larvae exposed to a chitin inhibitor die at the time of the next molt when the new cuticule is being formed. One such compound, TH6040 or Dimilin or diflubenzuron, has been shown to be highly effective against mosquito larvae (Schaefer et al. 1975) when applied by aircraft at rates of 0.025-0.04 lb AI/acre. While TH6040 is not as safe to nontarget, aquatic organisms as Altosid, it is still regarded as being relatively safe (Miura and Takahashi 1974b). TH6040 is also effective against a wide variety of important insect pests of agriculture and the market potential for this compound appears adequate to justify commercial development costs. Thompson-Hayward Chemical Company, which owns TH6040, has applied for registration for insecticidal use against mosquitoes as well as use against several insects of agricultural importance. A favorable response to Thompson-Hayward's petition for registration is anticipated in late 1978 or early 1979.

   Another benzoyl urea-type compound (BAY SIR-8514), which has similar activity against mosquitoes (Schaefer et al. 1978a) and a variety of insects of agricultural importance, is currently being evaluated by Chemagro Corporation. The commercial development of this compound is now being considered.

   Thus, two benzoyl urea-type compounds show good prospects for becoming new tools in mosquito abatement programs.

4. Synthetic pyrethroids. During the past few years several synthetic pyrethroid compounds have been developed as insecticides. While these compounds have been developed for use against worms on cotton, they also offer potential as mosquito larvicides (Darwazeh et al. 1978; Schaefer et al. 1978b). The potential of these synthetic pyrethroids may be severely limited by the potential for the development of resistance. Priester and Georghiou (1978) have induced over 4,000-fold resistance by pressuring an OP-R strain of *Cx. pipiens quinquefasciatus* larvae for 18 generations with permethrin (NRDC-143). There was considerable use of permethrin on cotton during 1978 over large acreages in California. The exposure of mosquitoes to such treatments may well indeed induce resistance prior to any mosquito control attempts with permethrin or other synthetic pyrethroid compounds.

Biological Control Agents

In 1904, Smith described numerous natural enemies of mosquito adults and larvae. In the 74 years since that publication, only the mosquito fish has become an operational biological agent for mosquito abatement districts. Extensive research has been conducted on parasites (nematodes) and pathogens (bacteria, viruses, protozoa and fungi) but none of these are yet available for use in operational control activities. Furthermore, none of these pathogens are likely to be registered as mosquito control agents within the next five, and probably not the next ten, years. The EPA has ruled that the nematode *Romanomermis culicivorax*, a natural mosquito parasite, is exempt from the necessity of registration. However, the efficacy of using this nematode in operational programs has still not been demonstrated.

Thus mosquito abatement districts should not anticipate that biological control agents under current investigation will be approved for operational use within the next five years.

Cultural Control

There is no question about the virtues of source reduction and that it should be promoted whenever practical. However, it must also be pointed out that under some conditions source reduction is not practical. For example, the San Joaquin Valley of California contains a large area of good agricultural soil; it also contains areas of highly alkaline, hardpan soils which have extremely poor water penetration properties. In adverse soil areas where poor quality irrigation water is also a problem, there is no way to solve the problems by releveling, ditching or other source reduction techniques. Such conditions are difficult, or even impossible, to correct using economically feasible techniques. Attempts to improve conditions by adding soil amendments, e.g. gypsum and acid, have not proven feasible under highly adverse conditions (Schaefer and Dupras 1977). If attempted farming operations under such poor soil and/or water conditions result in large-scale mosquito production, legal abatement procedures are the only known recourse.

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# STATUS OF ORGANOPHOSPHORUS MOSQUITO LARVICIDE RESISTANCE IN UTAH, 1978

Keith Wagstaff[1] and Rod Merrell[2]

Merrell and Wagstaff (1978) reported on the status of organophosphorus resistance of Utah mosquitoes for 1977. This report is a continuation of that study. All procedures are the same as used in 1977. Parathion, fenthion, malathion and temephos were again tested.

Table 1 shows the results of the 1978 study. Only results where resistance or borderline resistance is indicated are included in this report, but complete results have been sent to all participating districts.

The temephos results are listed and considerable resistant activity is indicated but more study is required as temephos apparently adheres to the testing containers resulting in questionable data. It is also possible that cross-resistance is occurring (Womeldorf personal communication). Those populations where temephos resistance is indicated should be closely monitored in the field if this product is used as a larvicide on these pools to determine if resistance is actually present.

Table 2 is a summary of the study showing where resistance is occurring, species involved, and to which pesticide larvae are resistant (R) or borderline resistant (B).

All districts participating in the study demonstrate some level of organophosphorus resistance. Mosquito larval populations tested this year are mostly different from those of last year suggesting that resistance is more widespread than supposed.

A resistant population of *Culex tarsalis* was found in the Magna Mosquito Abatement District where none was found during the study last year. *Cx. tarsalis* overall is less resistant to organophosphorus this year than last.

No resistant or borderline populations of *Culiseta inornata* were tested last year. Seven districts were found to have populations where resistance or borderline resistance exists this year.

It is apparent that the trend is for more resistance to show up in future years. District managers have the responsibility to observe resistant populations and to begin to substitute some of the newer more sophisticated chemicals such as pyrethrum, juvenile hormone analogues and/or mosquito larviciding oils.

The UMAA will continue this study through 1979 and hopefully beyond.

Acknowledgements

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[2]Utah Mosquito Abatement Association

TABLE 1. Organophosphorus resistance of Utah mosquito larvae, 1978. Borderline resistant populations are underlined.

| DISTRICT | LOCATION | 1978 DATE | CHEMICAL | LC50 | LC90/ LC50 | Conf. Limits LC50 |
|---|---|---|---|---|---|---|
| *Aedes dorsalis* | | | | | | |
| Magna | 6-B Stauffer Dike | 6/29 | PAR | 0.0053 | 1.70 | |
| | 6-B Stauffer Dike | 6/29 | FEN | 0.0062 | 1.30 | 0.0055-0.0068 |
| | 6-B Stauffer Dike | 6/29 | TEM | 0.0067 | 1.50 | 0.0057-0.0076 |
| | 6-B Stauffer | 6/31 | FEN | 0.0054 | 1.70 | |
| Weber County | W. of Turkey Shed | 7/5 | PAR | 0.0045 | 1.60 | 0.0037-0.0052 |
| | W. of Turkey Shed | 7/5 | FEN | 0.0046 | 2.00 | 0.0037-0.0054 |
| | W. of Turkey Shed | 7/5 | TEM | 0.0034 | 1.90 | 0.0029-0.0040 |
| | E. of Geo. Easts | 7/5 | PAR | 0.0073 | 2.20 | |
| | E. of Geo. Easts | 7/5 | FEN | 0.0073 | 1.30 | 0.0066-0.0079 |
| | E. of Geo. Easts | 7/5 | MAL | 0.0660 | 1.80 | 0.0560-0.0750 |
| | E. of Geo. Easts | 7/5 | TEM | 0.0068 | 1.60 | |
| | E. of Geo. Easts | 7/5 | PAR | 0.0057 | 1.40 | 0.0051-0.0064 |
| | E. of Geo. Easts | 7/6 | FEN | 0.0062 | 1.20 | 0.0056-0.0067 |
| | E. of Geo. Easts | 7/6 | MAL | 0.0610 | 1.40 | 0.0540-0.0670 |
| | E. of Geo. Easts | 7/6 | TEM | 0.0049 | 1.30 | 0.0044-0.0054 |
| | W. of Turkey Shed | 7/6 | PAR | 0.0037 | 1.70 | 0.0031-0.0044 |
| | W. of Turkey Sheds | 7/6 | FEN | 0.0057 | 2.00 | |
| | Russell Wayman | 7/11 | FEN | 0.0038 | 1.70 | |
| | Russell Wayman | 7/11 | MAL | 0.0570 | 1.20 | 0.0520-0.0610 |
| | Russell Wayman | 7/13 | PAR | 0.0053 | 1.60 | |
| | Russell Wayman | 7/13 | FEN | 0.0051 | 1.60 | |
| | Russell Wayman | 7/13 | MAL | 0.0600 | 1.40 | 0.0530-0.0660 |
| | Russell Wayman | 7/13 | TEM | 0.0070 | 1.40 | 0.0062-0.0078 |
| | Perry Lynn | 7/14 | FEN | 0.0045 | 2.10 | 0.0037-0.0053 |
| | Perry Lynn | 7/16 | FEN | 0.0040 | 1.60 | 0.0033-0.0046 |
| | Perry Lynn | 7/16 | TEM | 0.0029 | 1.50 | 0.0024-0.0034 |
| | West Penmans | 7/19 | FEN | 0.0041 | 1.50 | 0.0031-0.0050 |
| Salt Lake City | Ridgeland | 7/11 | TEM | 0.0035 | 1.60 | 0.0026-0.0043 |
| | S. W. corner of Harrison | 7/26 | PAR | 0.0049 | 1.60 | 0.0039-0.0056 |
| | S. W. corner of Harrison | 7/26 | FEN | 0.0044 | 2.30 | |
| | S. W. corner of Harrison | 7/26 | MAL | 0.0510 | 1.70 | 0.0430-0.0590 |
| | S. W. corner of Harrison | 7/26 | TEM | 0.0059 | 1.30 | 0.0053-0.0065 |
| | The Hub | 8/22 | PAR | 0.0044 | 1.90 | 0.0034-0.0053 |
| | The Hub | 8/22 | FEN | 0.0048 | 3.30 | |
| | The Hub | 8/22 | MAL | 0.0610 | 1.90 | |

Table 1 (Continued)

| DISTRICT | LOCATION | 1978 DATE | CHEMICAL | LC50 | LC90/ LC50 | Conf. Limits LC50 |
|---|---|---|---|---|---|---|
| *Aedes dorsalis* | | | | | | |
| Davis County | Next to Lake Syracuse | 7/5 | FEN | 0.0054 | 1.90 | 0.0040-0.0066 |
| | Next to Lake Syracuse | 7/5 | TEM | 0.0063 | 1.60 | |
| Utah County | Sp. Fk. 5100 So. 400 W. | 6/24 | FEN | 0.0045 | 2.20 | |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 6/29 | PAR | 0.0056 | 1.40 | 0.0048-0.0063 |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 6/29 | FEN | 0.0066 | 1.50 | |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 6/29 | TEM | 0.0058 | 1.50 | 0.0049-0.0066 |
| | Provo No. 42 500 N. 2150 W. | 6/29 | FEN | 0.0048 | 1.50 | |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 7/1 | PAR | 0.0035 | 1.60 | 0.0027-0.0041 |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 7/1 | FEN | 0.0039 | 2.10 | 0.0030-0.0048 |
| | Sp. Fk. No. 10 6600 S. 5700 W. | 7/1 | TEM | 0.0026 | 2.80 | 0.0019-0.0035 |
| | Sp. Fk. No. 4 8050 S. 1200 W. | 7/19 | PAR | 0.0040 | 1.60 | 0.0034-0.0046 |
| | Sp. Fk. No. 4 8050 S. 1200 W. | 7/19 | FEN | 0.0031 | 1.70 | 0.0026-0.0036 |
| | Sp. Fk. No. 4 8050 S. 1200 W. | 7/19 | TEM | 0.0026 | 1.70 | 0.0021-0.0031 |
| | Sp. Fk. No. 4 8050 S. 1200 W. | 7/21 | TEM | 0.0028 | 2.00 | 0.0022-0.0036 |
| | Provo No. 42 500 N. 2150 W. | 7/28 | FEN | 0.0037 | 1.60 | 0.0029-0.0044 |
| | Benjamin No. 4 7100 S. 4700 W. | 8/9 | PAR | 0.0042 | 1.70 | 0.0036-0.0048 |
| | Benjamin No. 4 7100 S. 4700 W. | 8/9 | FEN | 0.0048 | 1.60 | 0.0041-0.0055 |
| | Benjamin No. 4 7100 S. 4700 W. | 8/9 | MAL | 0.0500 | 1.50 | 0.0440-0.0560 |
| | Benjamin No. 4 7100 S. 4700 W. | 8/9 | TEM | 0.0041 | 1.40 | 0.0033-0.0046 |
| | Springville No. 23 2800 S. 750 W | 8/14 | TEM | 0.0031 | 1.80 | 0.0024-0.0039 |
| | Benjamin No. 4 | 8/14 | FEN | 0.0031 | 1.60 | 0.0027-0.0034 |
| | Benjamin No. 4 | 8/14 | TEM | 0.0020 | 1.90 | 0.0017-0.0023 |
| Box Elder County | Park Stums | 7/11 | PAR | 0.0041 | 1.70 | 0.0035-0.0048 |
| | Park Stums | 7/11 | FEN | 0.0054 | 1.80 | 0.0046-0.0063 |
| | S. of Peterson Ponds | 7/11 | PAR | 0.0043 | 1.60 | 0.0036-0.0049 |
| | S. of Peterson Ponds | 7/11 | FEN | 0.0045 | 1.70 | 0.0038-0.0051 |
| | S. of Peterson Ponds | 7/11 | TEM | 0.0040 | 1.40 | 0.0033-0.0045 |
| | S. of Peterson Ponds | 7/13 | PAR | 0.0044 | 2.70 | |
| | S. of Peterson Ponds | 7/13 | FEN | 0.0051 | 1.50 | |
| | S. of Peterson Ponds | 7/13 | MAL | 0.0510 | 1.50 | 0.0440-0.0570 |
| | Park Stums | 7/13 | PAR | 0.0037 | 1.70 | 0.0032-0.0043 |
| | Park Stums | 7/13 | FEN | 0.0054 | 2.30 | 0.0011-0.0110 |
| | Park Stums | 7/13 | TEM | 0.0029 | 1.50 | 0.0025-0.0033 |

Table 1 (Continued)

| DISTRICT | LOCATION | 1978 DATE | CHEMICAL | LC50 | LC90/ LC50 | Conf. Limits LC50 |
|---|---|---|---|---|---|---|
| | Cap Ferry - Small Pond | 7/18 | PAR | 0.0044 | 1.50 | 0.0033-0.0054 |
| | Ferry Nelson Drain | 7/18 | PAR | 0.0033 | 1.90 | 0.0026-0.0042 |
| | Ferry Nelson Drain | 7/18 | FEN | 0.0030 | 2.40 | 0.0022-0.0038 |
| | E. of Peterson Knoll | 7/19 | FEN | 0.0030 | 2.10 | 0.0025-0.0037 |
| | E. of Peterson Knoll | 7/19 | TEM | 0.0026 | 1.60 | 0.0021-0.0031 |
| | Railroad Pasture | 8/22 | PAR | 0.0061 | 1.40 | 0.0054-0.0067 |
| | Railroad Pasture | 8/22 | FEN | 0.0070 | 1.60 | |
| | Railroad Pasture | 8/22 | MAL | 0.0690 | 1.80 | 0.0620-0.0790 |
| | Railroad Pasture | 8/22 | TEM | 0.0050 | 1.80 | 0.0042-0.0057 |
| | Buffalo Pasture | 8/22 | FEN | 0.0047 | 1.90 | |
| | Knudsens Pasture | 8/29 | TEM | 0.0018 | 2.00 | |
| Tooele County | Grantsville 10-9 | 8/11 | TEM | 0.0033 | 1.40 | 0.0028-0.0038 |
| | Grantsville 10-9 | 8/14 | TEM | 0.0027 | 1.80 | 0.0022-0.0034 |
| *Culex tarsalis* | | | | | | |
| Magna | 8 B Acid Lake Drain | 7/10 | FEN | 0.0046 | 2.30 | 0.0037-0.0057 |
| Utah County | 5100 S. 950 W. Spanish Fork | 7/6 | PAR | 0.0032 | 1.60 | 0.0028-0.0038 |
| | 5100 S. 950 W. Spanish Fork | 7/6 | FEN | 0.0032 | 1.80 | 0.0026-0.0039 |
| | 1600 S. State Provo | 7/16 | TEM | 0.0024 | 2.30 | 0.0018-0.0030 |
| | Pitts. Des Moines | 7/31 | TEM | 0.0039 | 1.60 | 0.0028-0.0048 |
| *Culiseta inornata* | | | | | | |
| Magna | Burts | 7/14 | FEN | 0.0056 | 1.70 | 0.0045-0.0066 |
| | Burts | 7/14 | TEM | 0.0043 | 2.40 | 0.00009-0.0120 |
| | Burts | 7/16 | TEM | 0.0031 | 2.10 | 0.0024-0.0038 |
| Weber County | Stake Farm | 7/9 | PAR | 0.0036 | 1.80 | 0.0029-0.0043 |
| | Stake Farm | 7/9 | FEN | 0.0043 | 1.50 | 0.0035-0.0051 |
| | Stake Farm | 7/9 | TEM | 0.0030 | 1.80 | 0.0024-0.0038 |
| Davis County | D & D Ranch | 6/28 | TEM | 0.0031 | 2.40 | 0.0020-0.0043 |

Table 1 (Continued)

| DISTRICT | LOCATION | 1978 DATE | CHEMICAL | LC50 | LC90/ LC50 | Conf. Limits LC50 |
|---|---|---|---|---|---|---|
| *Culiseta inornata* | | | | | | |
| Salt Lake City | 17th. N. & Beck Street | 6/26 | PAR | 0.0071 | 2.40 | 0.0056-0.0089 |
| | 17th. N. & Beck Street | 6/26 | FEN | 0.0060 | 1.40 | 0.0052-0.0067 |
| | 17th. N. & Beck Street | 6/26 | MAL | 0.0560 | 1.70 | 0.0470-0.0650 |
| | 17th. N. & Beck Street | 6/26 | TEM | 0.0081 | 2.10 | 0.0033-0.0290 |
| | 17th. N. & Beck Street | 6/30 | PAR | 0.0052 | 1.60 | |
| | 17th. N. & Beck Street | 6/30 | FEN | 0.0061 | 1.40 | 0.0054-0.0069 |
| | 17th. N. & Beck Street | 6/30 | MAL | 0.0690 | 1.50 | 0.0590-0.0820 |
| | 17th. N. & Beck Street | 6/30 | TEM | 0.0069 | 1.40 | 0.0036-0.0078 |
| South Salt Lake | 12-36 | 6/28 | PAR | 0.0041 | 2.00 | 0.0026-0.0056 |
| Utah County | Springville | 7/29 | PAR | 0.0031 | 1.40 | 0.0027-0.0036 |
| | Springville | 7/29 | FEN | 0.0043 | 1.80 | 0.0035-0.0050 |
| | Springville | 7/29 | TEM | 0.0032 | 1.70 | 0.0026-0.0038 |
| Box Elder County | Mantua Reservoir | 7/12 | PAR | 0.0037 | 1.70 | |
| | Mantua Reservoir | 7/12 | FEN | 0.0047 | 2.00 | 0.0038-0.0056 |
| | Mantua Reservoir | 7/12 | MAL | 0.0520 | 2.10 | 0.0420-0.0620 |
| | Mantua Reservoir | 7/12 | TEM | 0.0053 | 1.40 | 0.0046-0.0060 |
| *Aedes nigromaculis* | | | | | | |
| Weber County | Huntsville No. 100 | 7/3 | PAR | 0.0038 | 2.50 | |
| | Huntsville No. 100 | 7/3 | FEN | 0.0030 | 2.70 | |
| | Huntsville No. 100 | 7/3 | TEM | 0.0023 | 2.90 | 0.0017-0.0031 |
| | Johnson's Pasture | 7/15 | PAR | 0.0055 | 2.40 | 0.0044-0.0068 |
| | Johnson's Pasture | 7/15 | FEN | 0.0057 | 1.80 | 0.0048-0.0066 |
| | Johnson's Pasture | 7/15 | MAL | 0.0820 | 2.10 | 0.0680-0.0990 |
| | Johnson's Pasture | 7/15 | TEM | 0.0072 | 1.80 | 0.0061-0.0085 |

Table 1 (Concluded)

| DISTRICT | LOCATION | 1978 DATE | CHEMICAL | LC50 | LC90/ LC50 | Conf. Limits LC50 |
|---|---|---|---|---|---|---|
| *Aedes vexans* | | | | | | |
| Weber County | Englands | 8/1 | FEN | 0.0030 | 2.00 | 0.0024-0.0036 |
| | Englands | 8/1 | TEM | 0.0042 | 1.80 | 0.0035-0.0050 |
| | Englands | 8/3 | TEM | 0.0021 | 1.90 | 0.0016-0.0026 |
| | Strangers 700 S/Freeway | 8/7 | PAR | 0.0034 | 2.20 | |
| | Strangers 700 S/Freeway | 8/7 | FEN | 0.0036 | 1.50 | 0.0030-0.0042 |
| | Strangers 700 S/Freeway | 8/7 | MAL | 0.0670 | 2.00 | 0.0570-0.0790 |
| | Strangers 700 S/Freeway | 8/7 | TEM | 0.0055 | 1.50 | 0.0048-0.0063 |
| | W. of Cannery - Plain City | 8/8 | FEN | 0.0032 | 1.60 | 0.0026-0.0039 |
| | W. of Cannery - Plain City | 8/8 | TEM | 0.0050 | 1.40 | 0.0043-0.0056 |
| | 700 S & Freeway Stranger | 8/9 | TEM | 0.0021 | 1.70 | 0.0018-0.0024 |
| *Culex pipiens* | | | | | | |
| Salt Lake City | 744 Douglas Street | 6/25 | FEN | 0.0043 | 1.50 | 0.0034-0.0051 |
| | 744 Douglas Street | 6/25 | MAL | 0.0580 | 1.30 | 0.0490-0.0680 |
| Utah County | Provo 700 S. 900 W. | 7/31 | PAR | 0.0048 | 1.50 | 0.0040-0.0055 |
| | Provo 700 S. 900 W. | 7/31 | FEN | 0.0038 | 1.80 | 0.0030-0.0046 |
| | Provo 700 S. 900 W. | 7/31 | MAL | 0.0590 | 1.70 | 0.0490-0.0700 |
| | Provo 5th. S. 1800 W. | 8/3 | PAR | 0.0038 | 1.60 | 0.0029-0.0046 |
| | Provo 5th. S. 1800 W. | 8/3 | FEN | 0.0041 | 1.90 | 0.0031-0.0050 |
| | Provo 5th. S. 1800 W. | 8/3 | MAL | 0.0840 | 2.00 | |
| | Sp. Fork 2nd. So. 2nd. E. | 8/6 | FEN | 0.0030 | 1.70 | 0.0025-0.0036 |

Table 2. Summary of data showing where resistance is occurring and species involved.

| DISTRICT | PESTICIDE PARATHION | FENTHION | MALATHION | TEMEPHOS |
|---|---|---|---|---|
| *Aedes dorsalis* | | | | |
| Magna | B | B | – | R |
| Weber County | B,R | B,R | B | R |
| Salt Lake City | B | B | B | R |
| Davis County | – | R | – | R |
| Utah County | B,R | B,R | B | B,R |
| Box Elder County | B,R | B,R | B | B,R |
| Tooele County | – | – | – | B,R |
| *Culex tarsalis* | | | | |
| Magna | – | R | – | – |
| Utah County | B | B | – | B,R |
| *Culiseta inornata* | | | | |
| Magna | R | R | – | R |
| Weber County | B | B | – | R |
| Davis County | – | – | – | R |
| Salt Lake City | R | R | B | R |
| South Salt Lake County | B | – | – | – |
| Utah County | B | B | – | R |
| Box Elder County | B | B | B | R |
| *Aedes nigromaculis* | | | | |
| Weber County | B,R | B,R | B | B,R |
| *Aedes vexans* | | | | |
| Weber County | B | B | – | B,R |
| *Culex pipiens* | | | | |
| Salt Lake City | – | B | B | – |
| Utah County | B | B | B | – |

# EFFECTIVENESS OF CHLORINE BLEACH IN REMOVAL OF SELECTED PESTICIDES FROM TWO WORK CLOTHING FABRICS[1]

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Removal of pesticides from workers' clothing is a practical necessity with potential adverse effects on health if not effectively accomplished. In one case in Utah, death resulted from the wearing of parathion-contaminated work clothes, even though the clothes had been laundered. Pesticide contamination can arise by many different means, such as accidental spills, or from the return of the worker to the pesticide work area wearing the same clothes. This is a common likelihood for at least two reasons: Having several sets of work clothes is expensive and washing them daily is laborious; and often there is a lack of appreciation for the toxicity of pesticides, so that the individual may not be concerned about the contamination.

The purpose of this study was to investigate various laundering techniques, readily available to the public, to determine a reliable and practical method of decontaminating clothing of pesticides so that they could be worn again without jeopardizing health. Initially, it was planned to investigate approximately seven pesticides, two fabrics and several treatments, such as anionic an cationic detergents, alkaline soaps, and chlorine bleaching. Early analyses indicated that bleaching alone was quite effective at removing some pesticides. With this indication, it was decided to examine the effect of two variations of chlorine bleaching treatments on two fabrics contaminated individually with four pesticides.

## MATERIALS AND METHODS

### Materials

The four pesticides chosen for the study were parathion (0, 0-diethyl 0-p-nitrophenyl phosphorothioate), diazinon (0, 0-diethyl 0- [2-isopropyl-4-methyl-4-pyrimidinyl] phosphorothioate), lindane (1, 2, 3, 4, 5, 6 hexachlorocyclohexane, gamma isomer), and carbofuran (2, 3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate). Parathion and diazinon were selected because they are representatives of the organophosphate class of insecticides. There is also a sharp distinction in toxicity between these compounds, parathion having an acute oral $LD_{50}$ in the rat of 3-30 mg/kg bodyweight, as contrasted with 66-600 for diazinon. Lindane is one of the few remaining widely used organochlorine insecticides, which family of pesticides is characterized by physico-chemical inertness, persistence in the environment and significant acute and chronic toxicity problems. Carbofuran is a representative of the carbamate group of insecticides and differs from the most common member of that group, carbaryl, in that it is approximately 50 to 100 times more toxic than carbaryl.

Purified standards of these four pesticides were obtained from Health Effects Research Laboratory, Environmental Protection Agency, Research Triangle Park, North Carolina. These were used to verify the identity and concentration of the pesticides in the commercial preparations used in treating the cloth. The commercial preparations[2] used were: Best 4 Servis Brand Parathion, 41%, Colorado International Corporation, Commerce City, Colorado; Diazinon 4E 47.5%, Geigy Chemical Company, Ardsley, New Jersey; Ortho Lindane Borer and Leaf Miner Spray, 20% gamma isomer of benzene hexachloride, Chevron Chemical Company, Richmond, California; and Chemagro Furadan[R] 4 Flowable Insecticide, 40.64% carbofuran, Chemagro Division, Baychem Corporation, Kansas City, Missouri. Parathion and diazinon cloth-dosing solutions consisted of 50 mg/ml in acetone. The lindane dosing solution was 50 mg/ml in hexane. The carbofuran solution was 100 mg/ml in acetone. Aldrin was used as an internal standard for parathion and diazinon, while benzene hexachloride (alpha isomer) was the internal standard for lindane and carbofuran. The two internal standards were made up in methanol at approximately 1mg/ml.

The two cloth materials selected were 100% cotton denim and 50/50% polyester/cotton. These are representative of the majority of work clothing that is likely to be worn by persons using pesticides. The cloth was cut into patches 10 cm X 10 cm.

The stock bleach solution was 5.25% sodium hypochlorite laundering bleach, manufactured by Thatcher Chemical Company, Salt Lake City, Utah. The concentration of chlorine was verified several times throughout the project and did not vary. The treatment solution was made by diluting the stock solution 100 times with water for a final chlorine concentration of 0.05%. This is approximately equivalent to commercial chlorine bleach label recommendations for heavily soiled clothes.

The solvents used were hexane, methanol, and acetone, all of pesticide or nanograde quality.

### Methods

1. Preparation of cloth.
   The cloth, cut in 100 $cm^2$ patches, was stretched across a frame, and the particular dosing solution was applied in sufficient volume to add 100 mg of pesticide. Three treatment replications were prepared and three replications of the recovery/positive control (RPC). The RPC replicates were subjected directly to the extraction phase to determine percent recovery from the cloth. A blank having no pesticide was carried through the entire protocol. Each patch was allowed to air dry for 15 minutes.

2. Soak and rinse.

   Patches were soaked individually in 1,250 ml of 1% bleach solution for specified time periods. All four pesticides were subjected to 1% bleach solutions for 1 hour and 24 hours, and on both fabrics, for a total of 16 experiments. The patches were soaked without agitation. At the end of the time period, the patches were removed, immersed in 500 ml of water and agitated 10 minutes. This was repeated, with the rinse being decanted and discarded. The patches were air dried for 2 hours.

3. Extraction.

The patches were cut into small pieces and extracted in a separatory funnel for 5 minutes with 2-125ml aliquots of extracting solvent (hexane for parathion, diazinon and lindane, and methanol for carbofuran). The extract was drained through a 3-inch layer of anhydrous, hexane-washed sodium sulfate and collected for gas chromatography.

4. Gas Chromatography.

The instrument was a Hewlett Packard 5830A with flame ionization detector, equipped with a microprocessor/integrator. All separations were performed on 3% OV-17 on Chromosorb W, 100/120 mesh, 2mm i.d. by 3 feet in length. Instrumental operating conditions were:

| | | |
|---|---|---|
| Carrier gas | ......... | nitrogen, 30 cc/min |
| Injection port temperature | ...... | 250° C |
| Column temperature | ... parathion | 180° C |
| | diazinon | 170° C |
| | lindane | 160° C |
| | carbofuran | 155° C |
| Detector temperature | ......... | 300° C |

The concentrations of the dosing solutions were determined by comparison to pesticide/internal standard area ratios of purified standards. After verification of concentrations of commercial solutions, the commercial solutions were used in the calculations of percent pesticide removed. Gas chromatography was performed on the extracts of all recovery/positive control, treatments and blanks by the addition of 0.1 ml of the appropriate internal standard solution to 1.0 ml of the extract, vortexing, and injecting from 3 to 4 ml into the instrument. All experimental blanks were negative. Percent removal was adjusted for recovery differences using the mean of the recovery/positive controls for each experiment. Area ratios were fitted into the following formulas:

$$\%\text{ removed} = \left[\frac{\%\text{ added} - (\%\text{ remaining})\left(\frac{100}{\%\text{ recovery}}\right)}{\%\text{ added}}\right] \times 100$$

Where % added = 100

$$\%\text{ remaining} = \frac{\text{Unknown area} \div \text{internal standard area}}{\text{Standard area} \div \text{internal standard area}} \times 100$$

$$\%\text{ recovery} = \frac{\text{Recovery/positive control area} \div \text{internal standard area}}{\text{Standard area} \div \text{internal standard area}} \times 100$$

(Mean of 3 replicates)

Statistical Methods

The experimental design was a three-way factorial, 4 X 2 X 2 (4 pesticides, 2 cloth types and 2 soak times). Analysis of variance was performed according to the general linear models procedure in the statistical package, SAS, supplied by the SAS Institute, Raleigh, NC (Barr et al. 1976). Differences between treatment means were determined using Duncan's Multiple Range Test, and possible outliers were examined and kept or rejected, using the least squares multiple regression analysis ($P < .01$) from the above reference. Variability in the group mean was expressed in terms of standard deviation and coefficient of variation. In the tables statistically significant difference is indicated with an asterisk (* at $P < .05$ and ** at $P < .01$ levels).

## RESULTS AND CONCLUSIONS

All experimental data are presented in Table 1, along with the mean, standard deviation, and coefficient of variation for each data group. Throughout the study using the described protocol, good to excellent precision was obtained. The mean coefficient of variation for all treatments was 8.4, with a high of 26.7 and a low of 0.2. As indicated by the mean values of the recovery studies, the particular organic solvents used (methanol for carbofuran and hexane for all others) were essentially 100% effective in extracting the respective pesticides from the fabrics.

Comparisons among pesticides

Table 2 displays the mean of all treated replicates for all pesticides with a given cloth and soak time. These same data are graphically presented in Figures 1 and 2. With a 1-hour soak and 100% denim, all pesticides are significantly different from each other ($P < .01$) in the percent removed. Parathion and diazinon appear similar, but there is a statistically significant difference due to tight within-treatment precision. The 1% bleach soak for 1 hour removes the organophosphates to the greatest extent, followed by carbofuran, and significantly less lindane is removed. At 24 hours, only lindane is statistically significant ($P < .01$) from the remaining three pesticides in percent removed.

At one hour on the 50/50 material, all pesticides are significantly different from each other ($P < .01$), as was the case with the denim material. At 24 hours, parathion, diazinon, and carbofuran are quite effectively removed by the 1% chlorine bleach soak, while over 90% of the lindane remains in the 50/50 cloth.

Two factors are suggested to explain the differences in percent removed among the pesticides. They are chemical structures and water solubility. The sodium hypochlorite bleach solution is a strong oxidizing medium. By oxidation potential, it is stronger (in equal concentrations) than the permanganate ion. As illustrated in Table 3, the organophosphate and carbamate insecticides used in the experiments contain phosphoric and carbamic acids ester linkages. These bondings are relatively less stable and more susceptible to oxidation than the chlorine-carbon and carbon-carbon bonding in the lindane molecule. Parathion and diazinon would be attacked by hypochlorous acid in solution to yield phosphoric acid derivatives and substituted phenolates. The heterocyclic carboxylic acid bonding in carbofuran would produce a carbamate chloride, with a benzofuranyl leaving group. Attack by hypochlorous acid on lindane (at the acid strength used in the experiments) does not affect the strong saturated cyclic bonding of cyclohexane, and a medium rich in chlorine would not be expected to destroy the chlorine-carbon bonding. If this were to happen, it is possible that the compound could pick up another chlorine ion from the milieu and retain its structural integrity. The second factor (also listed in Table

3) is degree of water solubility. There is a fair correlation between water solubility of the pesticide and the percent removed, although by water solubility alone, it would have been predicted that nearly all of the carbofuran would have been removed in the one-hour treatment, rather than the 31% that was actually removed. The highly apolar nature of lindane further protects it from attack and removal in an aqueous medium.

Comparison between one- and 24-hour soaking periods.

The contrast between the two time periods used is best seen graphically in Figures 1 and 2 for 100% denim and 50/50 polyester/cotton, respectively. There is a statistically significant difference ($P < .01$) for all pesticides between one hour and 24 hours, again with the exception of lindane. This statistical difference holds for both types of fabric. Although the 24 hour treatment removes greater than 90% of the pesticides for all compounds tested except lindane, this still may not be adequate for those pesticides having high toxicity. For example, parathion was 96.4% removed from the 50/50 material at 24 hours, yet, because of its high toxicity (3-30 mg/kg) sufficient residue might remain to produce either a chronic effect, or an acute effect in an individual whose cholinesterase activity has been previously reduced to a low level. In the 24-hour treatment, the highly toxic carbofuran was essentially 100% removed. No detectable carbofuran residue was found.

Comparisons between fabrics

The comparison between fabrics is seen in contrasting the data from Figure 1 with the data in Figure 2 for the same time period. No statistically significant differences were observed between fabrics at one hour, with the notable exception of carbofuran, which was significantly different ($P < .01$). More than twice as much carbofuran was retained by the 100% denim than by the 50/50 fabric. No significant differences are seen between fabrics at 24 hours. However, as previously mentioned, the 5% of carbofuran remaining in the denim could be dangerous, because of its high toxicity.

An early preliminary experiment was performed on both fabrics that had been bleached in chlorine solution prior to pesticide treatment. It was found that approximately 95% of the parathion was removed by a one-hour soak in 1% chlorine bleach solution from these materials, contrasted to the 41% removed by the same treatment on new material. It is possible that the dyes and sizing chemicals in new cloth have a protecting effect on the pesticide. This would suggest that there might be a significant difference in the same fabric as a result of the previous laundering history. Although not statistically significant, the data suggest that it is consistently easier to remove all of the pesticides tested (except lindane) from the 50/50 fabric than from the 100% denim. This would indicate that the affinity is greater between the pesticide and the natural fiber.

Conclusions

From the experiences and data of the project, the following conclusions appear to be justified:

1. The percent removed of the pesticides used in this study at one hour soak in 1% chlorine bleach solution varies with the structure and water solubility of the pesticide. The one hour, 1% bleach treatment alone is not sufficient to remove serious contaminations, particularly of the more toxic pesticides.

2. The percent removed at 24 hours in 1% bleach is quite good, with the exception of lindane. If lindane is a consistent model for the organochlorine compounds, then this treatment would be totally inadequate for their decontamination. It may also not be adequate for those compounds with high toxicity having a small percentage remaining in the cloth. Undoubtedly, the longer soaking period would weaken the fabric and shorten its lifetime, but this economic factor should be secondary to concerns about the health of the wearer.

3. Fabric differences do occur, as seen with the compound carbofuran and in the new cloth versus pre-bleached cloth comparison (parathion only).

4. On the strength of the pre-bleached differences, and the fact that alkaline soap materials are known to hydrolyze organophosphate compounds, it is quite likely that combinations of bleaching and soap laundering techniques would be more effective than bleaching alone at removing pesticide residues from clothing. Such treatments could be investigated in further research.

LITERATURE CITED

Barr, J., J.H. Goodnight, J.P. Sall, and J.T. Helwig. 1976. A User's Guide to SAS, 1976. Sparks Press, Raleigh, North Carolina. pp 108 and 127.

[1]This study was supported through a contract with the Epidemiologic Studies Program, Human Effects Monitoring Branch, Technical Services Division, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460. EPA Contract No. 68-01-3264. The views expressed herein are those of the investigator and do not necessarily reflect the official viewpoint of the Environmental Protection Agency.

[2]The use of brand names does not signify endorsement of same.

Table 1. Data and statistics of all treatment replicates and recovery/positive controls by experiments.

| Exp. No. | Pesticide | Cloth | Treatment | | %Recovery[a] | %Removed |
|---|---|---|---|---|---|---|
| 1. | parathion | 100% denim | 1% bleach, 1-hour soak | | | 48.8 |
| | | | | | | 41.4 |
| | | | | | | 43.8 |
| | | | | $\bar{x}$ | 100.0 | 44.3 |
| | | | | s | 1.6 | 4.3 |
| | | | | cv | 1.6 | 9.8 |
| 2. | parathion | 50/50 | 1% bleach, 1-hour soak | | | 41.2 |
| | | | | | | 48.7 |
| | | | | | | 40.0 |
| | | | | $\bar{x}$ | 99.9 | 43.3 |
| | | | | s | 2.8 | 4.7 |
| | | | | cv | 2.8 | 10.9 |
| 3. | parathion | 100% denim | 1% bleach, 24-hour soak | | | 71.4 |
| | | | | | | 81.1 |
| | | | | | | 26.9[b] |
| | | | | $\bar{x}$ | 100.0 | 76.3 |
| | | | | s | 1.6 | 6.8 |
| | | | | cv | 1.6 | 9.0 |
| 4. | parathion | 50/50 | 1% bleach, 24-hour soak | | | 97.5 |
| | | | | | | 95.8 |
| | | | | | | 95.8 |
| | | | | $\bar{x}$ | 99.9 | 96.4 |
| | | | | s | 2.8 | 1.0 |
| | | | | cv | 2.8 | 1.0 |
| 5. | diazinon | 100% denim | 1% bleach, 1-hour soak | | | 49.7 |
| | | | | | | 50.0 |
| | | | | | | 49.7 |
| | | | | $\bar{x}$ | 103.5 | 49.8 |
| | | | | s | 1.3 | 0.2 |
| | | | | cv | 1.2 | 0.3 |
| 6. | diazinon | 50/50 | 1% bleach, 1-hour soak | | | 69.6 |
| | | | | | | 54.2 |
| | | | | | | 59.0 |
| | | | | $\bar{x}$ | 100.2 | 60.9 |
| | | | | s | 2.3 | 7.8 |
| | | | | cv | 2.3 | 12.9 |
| 7. | diazinon | 100% denim | 1% bleach, 24-hour soak | | | 89.1 |
| | | | | | | 95.2 |
| | | | | | | 96.4 |
| | | | | $\bar{x}$ | 103.5 | 93.6 |
| | | | | s | 1.3 | 3.9 |
| | | | | cv | 1.2 | 4.1 |

Table 1. (Continued)

| Exp. No. | Pesticide | Cloth | Treatment | | %Recovery[a] | %Removed |
|---|---|---|---|---|---|---|
| 8. | diazinon | 50/50 | 1% bleach, 24-hour soak | | | 98.5 |
| | | | | | | 98.4 |
| | | | | | | 98.8 |
| | | | | $\bar{x}$ | 100.2 | 98.6 |
| | | | | s | 2.3 | 0.2 |
| | | | | cv | 2.3 | 0.2 |
| 9. | lindane | 100% denim | 1% bleach, 1-hour soak | | | 19.0 |
| | | | | | | 22.3 |
| | | | | | | 22.6 |
| | | | | $\bar{x}$ | 107.2 | 21.3 |
| | | | | s | 3.4 | 2.0 |
| | | | | cv | 3.2 | 9.3 |
| 10. | lindane | 50/50 | 1% bleach, 1-hour soak | | | 24.6 |
| | | | | | | 28.2 |
| | | | | | | 27.2 |
| | | | | $\bar{x}$ | 109.4 | 26.6 |
| | | | | s | 11.4 | 1.9 |
| | | | | cv | 10.4 | 7.0 |
| 11. | lindane | 100% denim | 1% bleach, 24-hour soak | | | 15.3 |
| | | | | | | 14.1 |
| | | | | | | 20.2 |
| | | | | $\bar{x}$ | 107.2 | 16.5 |
| | | | | s | 3.4 | 3.2 |
| | | | | cv | 3.2 | 19.7 |
| 12. | lindane | 50/50 | 1% bleach, 24-hour soak | | | 10.0 |
| | | | | | | 10.1 |
| | | | | | | 6.0 |
| | | | | $\bar{x}$ | 109.4 | 8.7 |
| | | | | s | 11.4 | 2.3 |
| | | | | cv | 10.4 | 26.7 |
| 13. | carbofuran | 100% denim | 1% bleach, 1-hour soak | | | 33.0 |
| | | | | | | 29.4 |
| | | | | | | 32.8 |
| | | | | $\bar{x}$ | 97.9 | 30.9 |
| | | | | s | 9.6 | 2.2 |
| | | | | cv | 9.8 | 7.1 |
| 14. | carbofuran | 50/50 | 1% bleach, 1-hour soak | | | 72.1 |
| | | | | | | 69.9 |
| | | | | | | 67.9 |
| | | | | $\bar{x}$ | 98.4 | 70.0 |
| | | | | s | 11.4 | 2.1 |
| | | | | cv | 11.6 | 3.0 |

Table 1. (Continued)

| Exp. No. | Pesticide | Cloth | Treatment | | %Recovery[a] | %Removed |
|---|---|---|---|---|---|---|
| 15. | carbofuran | 100% denim | 1% bleach, 24-hour soak | | | 97.8 |
| | | | | | | 97.4 |
| | | | | | | 91.4 |
| | | | | $\bar{x}$ | 97.9 | 95.5 |
| | | | | s | 9.6 | 3.6 |
| | | | | cv | 9.8 | 3.8 |
| 16. | carbofuran | 50/50 | 1% bleach, 24-hour soak | | | 100.0 |
| | | | | | | 100.0 |
| | | | | | | 100.0 |
| | | | | $\bar{x}$ | 98.4 | 100.0 |
| | | | | s | 11.4 | — |
| | | | | cv | 11.6 | — |

[a] % recovery indicates the percentage of pesticide extractable from the given cloth, not subjected to the soak treatment (see materials and methods for calculation formula). In several of the experiments, all six values for a given cloth and pesticide were pooled, and the mean (depicted in this table) was used in calculating the % removed.

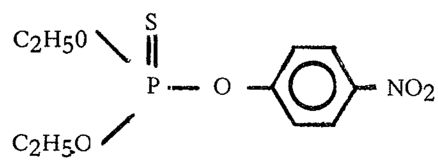
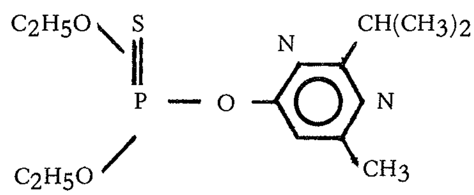
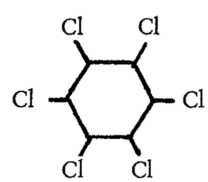
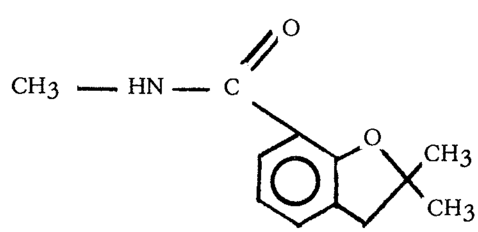
[b] Rejected ($P < .01$) by least squares multiple regression analysis.

Table 2. Percent pesticide removed grouped by cloth and soak time.

| CLOTH AND SOAK TIME | PESTICIDE PARATHION | DIAZINON | LINDANE | CARBOFURAN |
|---|---|---|---|---|
| 100% denim, 1 hour | 44.3** | 49.8** | 21.3** | 30.9** |
| 100% denim, 24 hours | 76.3 | 93.6 | 16.5** | 95.5 |
| 50/50 polyester/cotton, 1 hour | 43.3** | 60.9** | 26.6** | 70.0** |
| 50/50 polyester/cotton, 24 hours | 96.4 | 98.6 | 8.7** | 100.0 |

**Indicates statistical significance ($P < .01$)

Table 3. **Toxicity, structural formulas, and water solubility of parathion, diazinon, lindane, and carbofuran.**

| Pesticide<br>$LD_{50}$<br>(acute oral, rat, mg/kg) | Structural formula | Solubility in water, ppm |
|---|---|---|
| parathion<br>3-30 |  | 20 |
| diazinon<br>66-600 |  | 40 (20°C) |
| lindane<br>76-200 | <br>(gamma isomer) | insoluble |
| carbofuran<br>8-14 |  | 700 (25°C) |

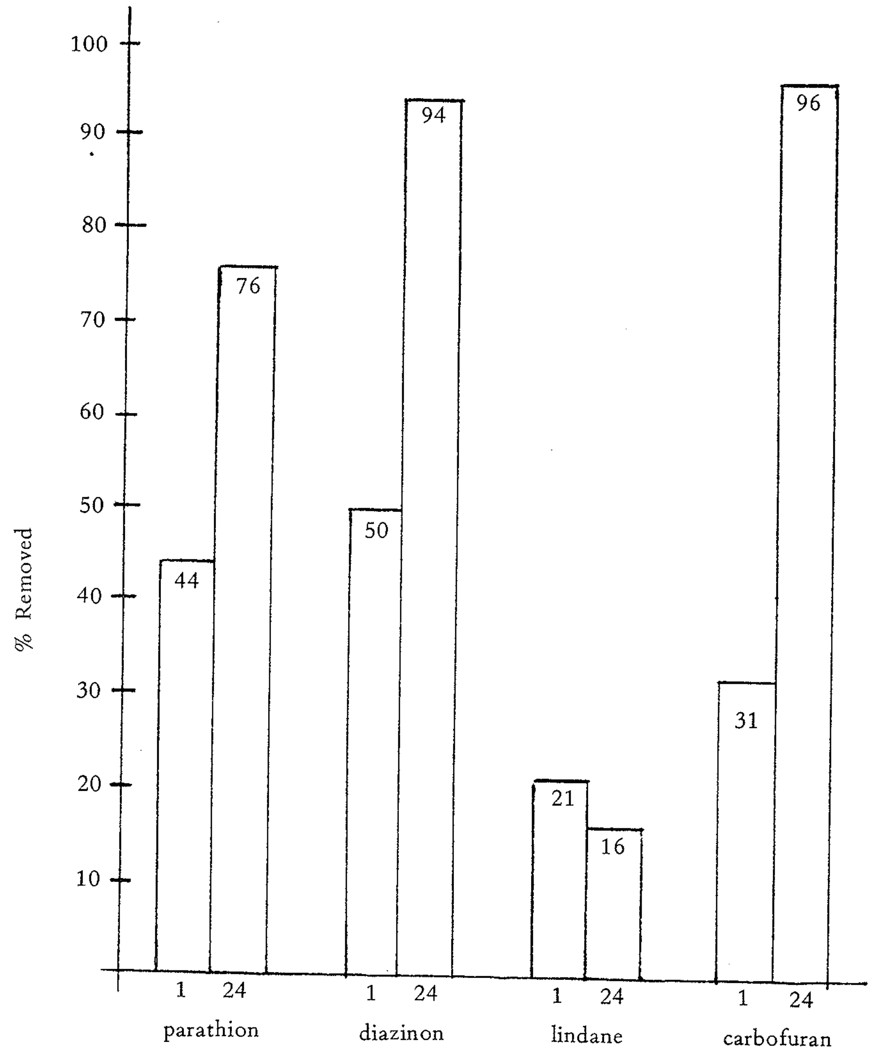



Figure 1. Comparison of percent removed among pesticides between 1 hour and 24 hour soak periods, 100% denim.

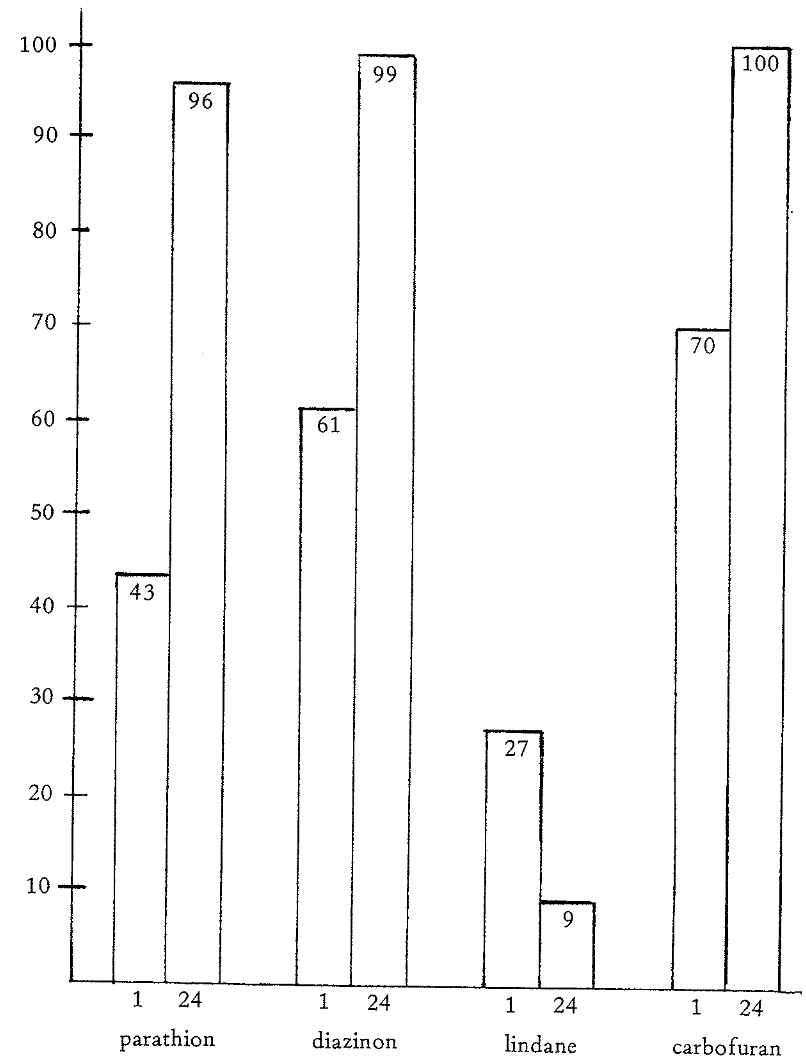



Figure 2. Comparison of percent removed among pesticides between 1 hour and 24 hour soak periods, 50/50 polyester/cotton.

# ST. LOUIS ENCEPHALITIS VIRUS ACTIVITY IN FLORIDA DURING 1977 and 1978

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Florida—that wonderous land of sunshine, sandy beaches, orange trees, and mosquitoes that extends a few hundred miles into the Caribbean Sea with the warm Gulf of Mexico on one side and the Atlantic Ocean on the other side. The earliest explorers and settlers of Florida were well acquainted with the mosquito. They named lagoons, inlets, and even large portions of the State for the infamous insect. Orange County and several adjoining coastal counties were once all lumped into a huge county called "Mosquito County."

As early as 1842, the Count de Castelnau, in his "Views and Recollections of North America," described the area around Tallahassee as a beautiful spot marred with tragedy. He wrote, " . . . in opposition to the numerous advantages there are the greatest plagues that can afflict a new settlement . . . every year bilious fevers of a most dangerous nature spread consternation in the whole region . . . the comparative extent of the huge cemeteries is a sad warning for one who, charmed by the beauty of the site, would want to establish himself in this region."

When Congress was debating the statehood of Florida in 1845, John Randolph of Virginia rose to state that Florida could never be developed, nor would it be a fit place to live. He called Florida a "land of swamps, of quagmires, of frogs and alligators and mosquitoes."

In 133 years, that land of swamps, quagmires, alligators and mosquitoes has become the eighth most populous state in the nation. It is the vacationland of millions of visitors, well known for its favorable climate and pleasant living. But it was not always a delightful or easy place to live.

The birth of the Florida State Board of Health is a dramatic incident in the history of yellow fever and its control in the State. The dread yellow fever was introduced to the port cities of Pensacola, Fernandina, Key West, Tampa, Port St. Joe and finally Jacksonville and through the 1800's took thousands of lives. In 1887, panic stricken residents of Tampa staged such a hurried exodus from the city that it is reported lamps and stoves were left burning. In 1888, over 10,000 of Jacksonville's 26,800 residents fled. Among those who remained, there were 5,000 reported cases of yellow fever with 400 deaths. It was in these circumstances that Dr. J. Y. Porter of Key West began his career in Jacksonville as the first State Health Officer.

The early 1900's were the end of an early era; for it was during the years 1900-1902 that the practical significance of the discovery of the mosquito as the vector of yellow fever and malaria became known. There has not been a case of yellow fever in Florida since 1905. Beginning in 1919 with an experimental malaria program in Taylor County, a State-wide malaria control effort developed which in 1941 became a model for the nation. In 1948, the last indigenous case of malaria was reported in the State.

Florida was well on its way into the great post-war development period. Major efforts were devoted to controlling pest mosquitoes during the 1950's and Florida's booming tourist industry reflected success in these efforts.

St. Louis encephalitis received its name from the initial epidemic in St. Louis, Missouri, in 1933. Modern virology was then in its infancy. The earliest reported case of SLE in Florida was from Dade County in 1952. In 1959, a number of suspected cases of arbovirus illness was observed in elderly patients in the St. Petersburg area. This outbreak was the first to be clinically recognized in the State and included 68 cases and 5 deaths. In 1961 from late October thru early December, 25 cases were reported. The disease was more severe than in 1959 as 7 deaths were recorded.

These two smaller outbreaks were followed by a general epidemic which occurred in 1962 in the four counties surrounding Tampa Bay. There were 222 confirmed cases with 43 deaths giving a fatality rate of 19.4%. St. Louis encephalitis virus was recovered from 4 humans and 42 mosquito pools, predominantly *Culex nigripalpus*.

The epidemic was most severe in Pinellas County where the clinical attack rate was 42.6 per 100,000 population. In the other three affected counties, the attack rates were: Manatee 21.3, Sarasota 17.8, and Hillsborough 4.8.

In Pinellas County, age specific rates varied from 9.4 per 100,000 in the 0-14 age group to 94.9 in the 65-84 age group, a pattern characteristic of rates reported in previous epidemics in the United States. In Hillsborough County, the rate was highest in the 25-44 age group. Hillsborough County is much more rural than neighboring Pinellas. Although an intensive surveillance program including sentinel chicken flocks, special mosquito trapping, trapping and bleeding of wild birds and mammals was carried on in Florida and the Tampa Bay area, no SLE was detected in Florida until 1969 when there was one confirmed human case and three positive mosquito pools from Polk County. Also in 1969, SLE virus was isolated from a raccoon in Hillsborough County. Additional virus isolations were made from an opossum in February of 1972 in Escambia County and in 1973 from an impala at Busch Gardens in Hillsborough County.

In 1977, there were 110 confirmed and presumptive cases of SLE in 19 counties in a band across Florida from Lee County and Dade County on the south to Pasco and Volusia Counties on the north. The first presumptive case was reported the week of August 12th. The number of cases peaked during the week of October 21st with cases through the week of December 9th. As in 1962, the attack rates were highest in the age groups over 55 years of age except the rate for the 15-25 age groups which had an attack rate of 16.8%. The high attack rate in this age group is interesting and probably resulted because of the large number of cases in the more rural Central Florida Counties.

A number of mosquito pools were positive for SLE. In Lee County there were 21 positive mosquito pools out of 472 tested. Back yard chicken flocks from several counties were checked, and 171 out of 342 chickens tested were positive.

Additional arbovirus surveillance data was as follows:

| Source | No. Positive SLE / Total Tested | % Positive |
|---|---|---|
| Urban bird sera | 18/1438 | 1.25 |
| Back yard chicken sera | 25/544 | 4.6 |
| Sentinel chicken sera | 19/102 | 18.6 |
| Mammal sera | 12/58 | 20.7 |
| Mosquito isolations | 28/571 (Pools) | 4.9 |

As in 1962 the primary mosquito vector in 1977 was *Cx. nigripalpus*. It is doubtful that any other mosquito species in Florida has been found breeding in such a great variety of habitats—from cypress swamps to open salt marshes freshened by summer rains, lakes, shallow, temporary rain pools, epiphytic bromelaids and, occasionally, artificial containers and tree holes. Ditches, grassy swales and rain pools seem particularly favorable.

*Cx. nigripalpus* populations exist in many areas of Florida at a very low level during the period of January through March. A slow buildup occurs during April, May, and June coinciding with seasonal increases in rainfall, reaching a peak during July, August, and September. The decrease in production and in female numbers from October to December is slower than the increase between June and July.

The species is a nocturnal mosquito. While light is the prime regulator of its flying activity, *Cx. nigripalpus*, like most mosquitoes, respond to many other environmental factors. Flying is greatly diminished when the temperature drops below 20°C (68°F). Winds above 5 mph inhibit activity. Humidity is extremely important as very little flight activity takes place when the relative humidity falls below 90%. On the other hand, flight activity increases with humidity above 90% to reach a peak during rain.

Studies indicate that in rural areas, man is not particularly attractive as a host to *Cx. nigripalpus*, while cattle are very attractive. It has been learned that host selection of *Cx. nigripalpus* changes abruptly from birds to mammals in May and June and is mostly mammals until November or December when it changes back to birds for the winter and spring.

1978 has been a year of great concern. An extensive statewide surveillance system was established under the guidance of Health and Rehabilitative Services, including sentinel chickens, trapping and testing of mosquito pools, testing sera from wild birds and mammals, and checking human sera from CNS cases. The Florida Legislature provided approximately $150,000 additional funds for the Jacksonville and Tampa laboratories and increased surveillance activities by Health and Rehabilitative Services personnel. To date, sentinel chicken flocks are located in 31 counties and there have been 51 chickens in 10 counties with positive antibody reactions for EEE and none positive for SLE. There have been 113 mammal sera out of 537 tested positive for either SLE and/or EEE. The mammals "positive" for SLE probably have antibodies from previous infection and not this year. Virus isolations have been made from two mosquito pools out of 738 tested. One mosquito pool from Hillsborough County was positive for EEE and California encephalitis virus was isolated from one mosquito pool from Pinellas County. Thru September 15, there have been four human cases of EEE throughout the State resulting in one death. There has been no SLE activity detected throughout the State.

Public health and mosquito control officials in Florida are extremely concerned about the future. Changes in the methods of handling stormwater runoff and wastewater disposal in cypress heads and wetlands could provide additional ideal *Culex* breeding habitat. We must guard our surveillance program against the errosions of time and negative results which cause funding to be diverted to other more visible programs such as occurred following the 1962 epidemic so that we may meet the problems of the future head-on. The availability of safe and effective pesticides and an emphasis on source reduction procedures are important to the protection of the health and well-being of our citizens and tourists.

I wish to thank Dr. Flora Mae Wellings, Director of the Epidemiology Research Center, Department of Health and Rehabilitative Services, Tampa, and Dr. A. J. Rogers, Director of the Office of Entomology, Department of Health and Rehabilitative Services, for the use of their slides and for furnishing surveillance data and assistance.

# WESTERN EQUINE ENCEPHALITIS IN EASTERN UTAH, 1978

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The equine encephalitides constitute a group of horse diseases characterized by nervous disturbances and generally high mortality. Symptoms of the disease are fever, irregular gait, wandering, circling, yawning, grinding of teeth, pendulous lower lip, inability to rise when down. There may be signs of impaired vision, reduced reflexes, incoordination, drowsiness. Termination may be paralysis and death. Diagnosis is based on clinical signs, history, and seasonal occurrence. Demonstration of typical histopathological lesions of viral encephalitis strengthens the diagnosis. Further support is from the positive results of virus neutralization or hemagglutination-inhibition tests on acute and convalescent sera.

On 1 August 1978, Dr. Daniel S. Dennis, veterinary practitioner of Roosevelt, Duchesne County, received reports of four cases of suspected equine encephalitis. Within a few days he was informed of 12 more sick horses. During that time, Dr. Ed Oscarson saw four suspected cases in the Vernal-Jensen area of Uintah County.

On 8 August, Dr. Cecil John VMO and I went to the Uintah Basin to investigate the problem. With Dr. Dennis and two mosquito abatement district directors, Dr. Steven Romney and Mr. Rod Clark, we visited several premises where there were sick horses. We took blood samples from five of the horses. The bloods were sent to Dr. Althea Bailey, Bureau of Laboratories State Division of Health. Three were positive for WEE.

By 14 August, Drs. Dennis and Oscarson had 11 new cases of suspected equine encephalitis.

I met with Dr. Taira Fukushima, State Health Division Epidemiologist, Mr. Keith Wagstaff, South Salt Lake County MAD Field Supervisor, and Mr. Glen Collett, Director of the Salt Lake City MAD, to discuss the public health aspects of the outbreak. There was concern throughout the State about how far the disease might spread and what precautions should be followed. A letter was sent to Dr. Kenneth Creer, State Commissioner of Agriculture, requesting that he approach Governor Scott M. Matheson about obtaining $10,000 from the Governor's emergency fund to help control the possible epizootic threat in the Uintah Basin. The money was granted to the mosquito abatement districts.

Through 29 September, Drs. Dennis and Oscarson saw 56 cases of suspected encephalitis in Duchesne and Uintah Counties. There were six reported deaths. A total of 3500 doses of encephalitis vaccine was used in that area.

Suspected horse cases were reported from other parts of the State. Blood samples from 17 horses located in Cache, Carbon, Millard, Utah, Wasatch, and Weber Counties tested by the State Division of Health laboratories were negative for WEE, VEE, and SLE.

# WESTERN ENCEPHALITIS ACTIVITY IN UTAH IN 1978

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Encephalitis surveillance is an ongoing program established in 1974 with the cooperative efforts of various agencies as an early warning system of possible pending encephalitis outbreaks in potentially critical areas (Marrott 1974). Funding for the program is from the Utah mosquito abatement districts, Utah State Division of Health, Utah State Department of Agriculture, and the University of Utah. Through donated services, the program functions adequately on a modest budget. Each year, goals and services are expanded as time and funds permit.

The following table shows the number of mosquito pools processed and tested by species per district. Generally, one pool from each collecting location was checked with the emphasis on *Culex tarsalis* pools.

| DISTRICT | Culex tarsalis | Culiseta inornata | TOTAL |
|---|---|---|---|
| Box Elder | 5 | – | 5 |
| Weber | 9 | – | 9 |
| Davis | 40 | 2 | 42 |
| Salt Lake City | 10 | – | 10 |
| Magna | 4 | – | 4 |
| Utah | 15 | 3 | 18 |
| Duchesne | 4 | – | 4 |
| Uintah | 18 | 2 | 20 |
| TOTALS | 105 | 7 | 112 |

On 3 August 1978, the Utah Mosquito Abatement Association held its monthly meeting. At that time encephalitis virus surveillance and vector population levels were discussed and evaluated. The consensus was that the overall mosquito populations were generally lower than in the past years, with the *Cx. tarsalis* population below normal. At that time approximately 66 pools of *Cx. tarsalis* collected from along the Wasatch Front since the first week of June had been tested. There had been no positive isolations of virus nor had any equine cases been reported.

Shortly after the 3 August meeting, an encephalitis outbreak occurred in the Roosevelt and Vernal areas. The remainder of the State showed no virus activity in the 112 total pools processed. Surveillance ended the first week of September. There were no additional reports of cases in other locations. It is commendable that many horse owners vaccinated their animals for the disease, especially in the Uintah Basin.

Thanks are given to all persons who have helped to make this surveillance program successful.

## REFERENCE CITED

Marrott, L. 1974. The establishment by the Utah Mosquito Abatement Association of an encephalitis surveillance program. Proc. Utah Mosq. Abate. Assoc. 27:25.

# PANEL DISCUSSION: TRUSTEES' ROLE IN A MOSQUITO ABATEMENT PROGRAM

Moderator: Robert K. Washino, Trustee
Sacrament-Yolo MAD;
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My discussion will be in three different parts. First, a simple story; second, a brief list of what I consider to be prime responsibilities of a trustee; third, several questions that might integrate the story and the list.

The story concerns an illness called Bolivian hemorrhagic fever. The virus was originally thought to be arthropod-borne. In the late 1950's, in the town of San Joaquin in Bolivia in South America, there was a major outbreak of this disease. There was much human illness and misery, and at least 300 persons died. A group from the National Institutes of Health, called MARU for Middle America Research Unit, conducted investigations. The source of the virus was determined to be a mouse-like rodent, but the virus could not be isolated in mosquitoes, ticks, mites, or such. The researchers decided to control the disease by initiating control of the rodent, and they considered use of house cats. The old-timers said there used to be many cats, but in recent years they had largely disappeared, the 12 noted being the last. It was found that the cats would get sick, linger for just a few days, and die, and it was soon determined that they were dying from DDT poisoning. Several years before the problem started, many of the walls were sprayed with DDT for malaria control, explaining the source of the DDT. Presumably the cause of the Bolivian hemorrhagic fever was the elimination of the cats and the resultant movement of the wild rodents into the village and into close contact with the people. The source of the infection was eventially found to be mouse urine.

If the story ended here, we would just have a story of the environmental impact of a particular insecticide. However, some of the people initiated control measures. The health science group found that infected mice had a characteristic swelling in the posterior area, and a high percentage of mice had this swelling. The control team set out a great many traps in the village and followed up with a poison campaign whenever infected mice were found in the trapping program. These measures proved very effective and the disease was stopped.

Those who serve as a trustee or as a manager should relate to this story. It is a simple but good example of integrated pest management. The control of the disease outbreak was achieved by simple and direct measures exerted only when the situation called for it. The fact that the malaria spray was involved emphasized the need to consider the environmental impact of whatever mosquito control measures are taken by a control agency. Research activity was supported, and the knowledge from that research was applied directly to control measures. The concept of an economic and a disease threshold was blended into the concept of integrated pest management, making this one of the first times that the conceptual part of integrated pest management was applied to a vector-borne disease problem.

The list of basic responsibilities includes political, policy, fiscal and technological matters. I note the political because the next national meeting of AMCA is in Washington, D. C. We should become much more aware of federal legislation and what this can mean to local programs. Some have recommended that we take a much more aggressive stand on the Boggs Bill. One district has emphasized that we should have a week designated as "Mosquito Control Week." Others recommend that we take a much stronger stance with the Department of Health, Education and Welfare. These issues should be discussed by the board members and their managers.

One of the first things the trustees should ask of their manager is "Does the district have a mission?" "Is there a master plan?" "What will we be doing five years from now?" "Is there a ten-year projection plan?" "Do we have a policy manual which delineates precisely the responsibilities of the board, the manager, the various employee positions?" "Is there a contingency plan? How well prepared are we for an emergency?" We have international travelers, immigrants, migratory workers, etc., continuing to arrive in the United States. They come from such areas as India, which in 1976 recorded six million cases of malaria and perhaps an additional six million unrecorded. In Pakistan in 1976, possibly one out of every five persons had malaria. Who will be blamed for not knowing that this kind of immigration is taking place.

On fiscal policy, I note the considerable discussion in California about Proposition 13. Yesterday's panel on insecticide resistance illustrates our concern about technological matters.

I now wish to ask the board members here, the panel, and the audience a series of questions. Some of these questions were taken from the presidential address at a recent meeting of the American Society of Tropical Medicine and Hygiene.

1. When a mosquito-borne disease epidemic or a large scale mosquito outbreak occurs, and it is found that the vector or pest is resistant to the usual insecticide that is available, who will be blamed for not knowing that this has happened and for not having an alternative material developed, evaluated and available?

2. When a mosquito-borne disease epidemic or pest outbreak occurs that requires a large scale use of an insecticide that has not been licensed, and it has been declared illegal to use the material, who will make the decision to use it, and what action groups will arise to oppose the decision?

3. With the increased difficulties in financing the cost for development and evaluation of biological and chemical agents for the control of infectious diseases or pest outbreaks, who is to assume the development costs and legal responsiblity now that industry is increasingly unwilling to risk the investment or responsibility?

4. When political, social and economic priorities dictate the passage of legislation such as the Jarvis-Gann Proposition 13 in California, who will be blamed for not knowing that this could happen and for not having alternate measures prepared?


### Lynn Thatcher, Trustee
### Salt Lake City MAD
### Salt Lake City, UT 84116


I did not have to create any interest of my own when I was assigned to be a trustee, because I had been in a program of environmental health and had a good appreciation of what mosquitoes are and the bad effects they create, the political and technical problems which exist, and particularly how important they are in the field of public health. I was honored and pleased for the opportunity to participate more closely in mosquito control. I had known of the district's activities and also of other districts in Utah, and I was also well aware of the manager and his program in the Salt Lake District. I found that being on the board was a little different than being on the outside and calling for advice when I needed it in connection with my other environmental health activities. When I came on the board I found we had a good cross section of trustees: a retired environmental specialist with the same type of training as I had; an ecologist who had work experience in wildlife resources work for the State; a pharmacist; a city engineer. This group provided a good, balanced view to carry out the responsibilities that the trustees have. Wanless Southwick had been running our pesticide program, largely a federally financed research program aimed at determining the human effects of pesticide use. He had to have close contacts with mosquito abatement districts because their activities constituted one of the important uses of pesticides.

To put the question of the board's function and the trustee's responsibility in the primitive perspective which I have, I would say that the trustee is expected to do what the citizen wants him to do and to do it efficiently, and to spend the least possible amount of tax money. The purpose of our program is the control of mosquitoes. However, one cannot always be certain that the average person in our community has had enough contact with mosquitoes to know very much about them. He might think that the situation on his patio today, where he has never seen a mosquito, is normal, and that the money spent for mosquito control is merely to supply jobs. If we do too good a job we can destroy the evidence, and this may be hard to cope with. The average citizen can easily find out how much money a district is spending. If he should have difficulty doing this directly, he can go through legal channels and get the information. The average citizen is not impressed by plain statistical figures, but if we put a dollar sign on it he will listen. He may be concerned about what our spending will do to his taxes. The work of mosquito control today is so complex that I believe we must give up all hope of clearly impressing on this citizen just how hard it is to do.

We renegotiated a contract for air spraying. Costs for this work have increased greatly, perhaps faster than the general inflation. We had to consider whether we should increase the mill levy or just not spray so much. In cooperation with our adjoining districts we combined this work into a bigger contract and obtained one bid for the entire area including three districts. We came out almost as low on our contract price as we had two years ago. Unfortunately, the average citizen will not know about this and will not even listen when we explain to him that this is one of the things we do to save district funds.

Keeping an eye on construction is another thing we do. A freeway system is underway in our district. It has dragged along piecemeal longer than was expected. People who design these highways do not normally spend a lot of time considering to whom they should talk to assure their design is not going to create problems for others. A mosquito abatement district must be aware of what is going on and not wait for the planners to come to it. On one of the highway projects the design guaranteed entrapment of water which could be a prolific breeder of mosquitoes. The only way to correct it was to change the design. This was accomplished as a result of contact by our district, but if the district had not taken the initiative I doubt if the correct job would have been done.

We should keep in mind what the different types of weather can do to us. We should be prepared for unusual weather which requires a bigger control effort than normal. We will be blamed if we haven't taken this into consideration.

Identifying mosquitoes is a technical job we must do but the public will not understand why. The percent of kill is another technical job which requires expertise. I do not understand it, but I would like to know more so that I could have a better appreciation of how the experts do it. The average citizen, however, knows nothing and is not interested in learning or even whether it costs money to have this kind of talent.

I have come to several conclusions. A district must get good personnel and do what it has to do to keep them. It must know what it is doing – it must know how to get the technical information it needs, and how to put it to work. In these days of inflation and tax revolt this will be very difficult.

Two new things we face now. One is consolidation. Eventually we must answer, "Should we support combining the Salt Lake County mosquito abatement districts into one large district, or should we fight to keep them as they are?" This is a technical as well as a political matter. The tax revolt is another thing we are facing now, although we may be a little behind California. With the trustees we have, and with the knowledgeable people we have, I am optimistic that with all the problems facing us we will make out all right.


### Leland Cunliffe, Trustee
### South Salt Lake County MAD
### Midvale, UT 84047


Each mosquito abatement district is different. The first thing we trustees do is represent the people from our respective communities. Part of our program is to assure control in our communities and that calls are given an intelligent, responsible answer. If an emergency should occur, as we had in 1958, we should have established an emergency fund. This fund will not be used by the district manager unless he comes to the board and explains the situation, then receives the conclusion of the board. No district should overexpend for equipment it does not need but should have enough respect for the taxpayer's money that it buys only the equipment it needs and then maintains it to assure it is ready to do the job of protecting the public.

There are many do's and don'ts in a board member's responsibility. The first thing he should not do is take the job if he is not going to do the job. It has been said that many board members do not have a high school education, but there is nothing to stop them from reading and asking questions. I think board members should take time to go in the field and get to understand their district. Their ultimate goal is to represent the people. Each board member in our district has an area which he represents, and at every meeting he gives a report on his area, while our manager gives a report on general conditions.

W. Donald Murray, Manager
Delta VCD
Visalia. CA 93277

I have been a manager for 31 years and I enjoy working with the board which I have. It has not always been that way. There were times many years ago when I approached the board meetings with considerable fear and uncertainty. However, in recent years I have come to the board meetings feeling that I would have an enjoyable time, a profitable one because there would be accomplishment. Some of these meetings, however, have not been easy. This year I have had repeated meetings which last two hours or more because there were difficult matters to be considered. Board members are private citizens who are not paid to do this job, and I do not wish to impose on them, otherwise they might not stay.

What can a manager do to get and to keep a good board? What is ethical and proper for a manager to do? Board members in California are appointed by city councils and county supervisors. My position has been to go to the appointing agency and point out the type of board member that I felt I needed. Sometimes I have suggested three or four or five names, but I have never asked the appointing agency to put a specific person on my board. By following this procedure I have been able to attract the appointment of top quality persons, so that today I have a board I respect and am proud of. I have played a part in the appointments, but I believe I have been correct and ethical in the procedure to get good board members.

Who is to be blamed for any problems or undesirable developments? When Proposition 13 was approved by the voters in California, there were some MAD managers who were ready to quit, to blame it all on the public. There have been other managers who have accepted it as a traumatic challenge but they are not going to give in and quit. This is the position I have tried to take. As of October 2, five of my employees were laid off. Will this break up the district program? No! We will still have a program, although it may not be quite so good. On the other hand, the forced sharpening of our procedures may provide for some improvements. Will I blame the public? Only if we cannot make it after a valiant effort. In that case, I will blame the public and will tell them they got what they asked for. Many people have told me: "We were not thinking of your mosquito program when we voted for Proposition 13; we know this is good local program and we need it. But we had to cut down on welfare and give-away programs and a lot of other waste in government." Nevertheless, they hurt us and they haven't touched most of the things they were after. Yes, I blame the public to a degree, but I am not really going to be in a good position to be critical unless our program fails, and I do not think it will because there are many things we can do.

The question was asked about insecticides – what if we do not have any that are effective? My position has been to ask Dr. Charles Schaefer for help. Fortunately today we still have materials that work. I believe we may be able to continue to use them for sometime if we do not abuse them. For years my district has attempted to avoid abusing insecticides. We have reduced the acres treated with insecticides by 95% in the past 10 years. This to me is the best solution to an insecticide resistance problem. Eventually we may be able to achieve adequate control by precision use of minimal amount of insecticide, so that resistance will not again destroy our program as it did in 1972 when we had populations of pasture mosquitoes at counts of up to 50 per pant leg inside our cities, 3 to 6 miles from the producing sources. And even more recently we have had swarms of house mosquitoes in our houses when Dursban failed.

I think each district must act aggressively to move ahead, but how do we do this? The manager can do only so much, then he must rely on his board. The manager is the professional arm; he supplies the technical information and carries out the administrative program. The board is the policy-making and political arm. There is no question but that the best approach in the political area is by the board member, not by the manager. When needed legislative or fiscal action is involved, the board president or perhaps each board member individually may need to contact their legislators, both state and federal, in which case the response of the legislators may be very significant. The way we can win in politics is by the common, down-to-earth, local autonomy politics, not big government politics. Mosquito control in our government is truly but a small, but we believe an important, part of government. By the right kind of input, in which the manager develops the information, provides it to the board, and the board members carry it to the proper level of government. we will all play an important part in our democratic form of government.

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QUESTION: If a district were to use an illegal insecticide, who would make the decision about using it?

WASHINO: I asked the question in such a manner that I expected you to ponder over it, not answer it. What about situations in which a particular insecticide which had been legal was declared illegal?

RAY DOWNS: Utah State Department of Agriculture. We are very concerned that pesticides be used properly and that only those that are authorized be used. We do have a certification program in Utah, and we hold training sessions including tests. The mosquito abatement district managers are concerned that their employees be properly certified. We license individual operators, not a district. The person who is doing the direct application is the one who is licensed, the one who is liable if there is any problem. We must look at the label on the containers and use these pesticides according to the label directions. As our materials are becoming more restricted, it is up to all of us to know which we can use and for which purposes. There are laws relative to this and which provide penalties for improper uses. We do have occasional violations on which we must take action. The managers of MAD's should know what material may be used and only these should be purchased and used in the programs.

CUNLIFFE: A board member or manager should uphold the statutes of the state and federal governments. I as a board member would not give any sanction to anything that was not certified.

THATCHER: I have no quarrels with the law. Once a law has been established and upheld in the courts, we cannot give the slightest consideration to breaking it. I believe the trustees, being partly in the political arena, do have the obligation to fight, by any means at their command, rules and regulations that are unreasonable. We have all types of rules, some very reasonable, some in the middle, and some very unreasonable. If they are unreasonable, we need to go through whatever channels we have to fight them and to try to restore balance to the decisions at the Federal and State levels.

WASHINO: Under normal conditions, a material might be used in one particular manner. Under emergency conditions, where one cannot predict the precise use, one might run into problems he does not anticipate. This is my concern rather than an excess concern over legality.

REED ROBERTS: Extension Entomologist, Utah State University, Logan. If we have a situation with an outbreak of a disease and no registered chemicals that were effective, we could call EPA and ask for emergency approval via telephone and advise them that we could not wait for a meeting in Washington, D. C. We would then be in a position that if the material were OK'd, we would use it. If EPA did not OK it, we could tell our people that EPA won't let us save your lives – the agency really does not care about you!

THOMAS D. MULHERN: Trustee, Fresno MAD, Fresno. The first thing I had to appreciate when I became a trustee was never to encroach upon the province of the manager, otherwise he creates confusion. On only one occasion have I disagreed with my manager and that was because I knew he was misinformed.

I hope board members will not be led into false economies. Many trustees, at least in California, have not come to appreciate the full values obtained by attending meetings such as this and the AMCA meetings. A few years ago I was asked to act as a technical person to go to Iran in the name of the World Health Organization to find out why mosquitoes there were not being controlled and malaria was becoming rampant. I drew on information that had come to me from attending meetings and dealing with people. I found that the National Iranian Oil Company was giving the mosquito control people all the oil they wanted free, and the people in charge of the program were accepting it and using it, but it was not working. They were transporting it in some cases 800 miles and applying it at rates up to 200 gallons per acre, but it was not killing the mosquito larvae. Because I was familiar with information gathered from meetings such as this, I was able to guide these people to using effective materials. The people who think it is economical to deny their managers the relatively small cost of coming to meetings where they can find new and additional information may in the long run be costing their program money, not saving it.

# NOTES ON THE BIOLOGY AND BEHAVIOR OF THE ROCK POOL MOSQUITO, *AEDES EPACTIUS*

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An extensive investigation was conducted treating the bionomics of the rock pool mosquito, *Aedes epactius* Dyar and Knab (=*Aedes atropalpus nielseni*), with a survey of associate flora and fauna. That research was the first of its kind to have critically examined the unique rock pool habitat occurring in the deserts of the southwestern United States. Throughout the course of the research, data were regularly gathered from a total of 43 rock pools located within three principle geographic areas in the desert regions of southeastern Utah. These included sites within Canyonlands National Park (San Juan County), Arches National Monument (Grand County) and, adjacent to the Colorado River, the Dewey Bridge pools, 22 miles northeast of Moab (Grand County). The study was of an extended overall seasonal nature, begining September 1968 and ending March 1971.

All rock pools studied are located exclusively within massive sandstone strata of a common physical nature. The surfaces of such "slick rock" formations are smooth or gradually rounded, and rarely angular or highly porous. Surrounding desert vegetation is sparse or entirely absent and thus runoff from intermittent precipitation is brief, but often torrential and abrasive. Great surface areas are usually drained by a few, deeply gouged lines of erosion. The formation of the majority of rock holes with the capacity for holding significant quantities of water takes place along such established drainage lines. Due to their common occurrence along those lines, rock pools are often encountered in linear series through the length of a given drainage, often with great variation in shape, depth and diameter occurring among the holes within that series. Of the rock pools which were found to regularly support populations of *Ae. epactius*, dimensions varied from narrow crevices 3 in. wide X 9 in. in length X 5 in. deep, to water-carved sinks 10 ft. in diameter and 2½ ft. in depth. The average size of a typical *Ae. epactius*-producing rock pool was approximately 3 ft. in diameter by 1 ft. deep.

The great majority of all rock pools studied held water on a temporary basis only, and through the summer months they commonly retained water for a maximum of 12-15 days from having been filled to capacity. Those factors governing the rate of drying, and many other physical and chemical parameters common to that environment are the degree of exposure, air temperature, basin shape and depth, substrate depth and porosity and the total surface area per unit volume of water. Due to the great variability of these factors, even adjacent rock pools often have widely contrasting physical and biotic profiles. A given rock hole may remain completely dry for several months before being refilled by a desert storm. To its biotic components, this desert rock hole environment is a stressful and demanding one, typified by the cyclic alteration of prolonged periods of desiccation and extreme heat. Summer surface temperatures often exceed 130° F. with relatively brief periods through which the rock hole remains flooded.

Chemically, the rock pool aquatic system is extremely oligotrophic, characterized by greatly reduced organic loads, with limited quantities of available nitrogen and phosphorous.

The cumulative biosurvey of those rock pools yielded the following plant and animal taxonomic determinations:

| Planktonic And Sessile Algae & Fungi | Invertebrate Animals |
|---|---|
| 155 Species, representing | 80 Species, representing: |
| 7 Divisions | 7 Phyla |
| 8 Classes | 13 Classes |
| 14 Orders | 28 Orders |
| 54 Families | 44 Families |

Of all aquatic plant and animal species occurring within the desert rock pools studied, including associated mosquito species of the genera *Culex, Culiseta* and rarely *Psorophora*, only *Ae. epactius* was determined to be completely endemic to that very severe habitat type.

The following data are representative segments only of observations made on the bionomics of the rock pool mosquito, *Ae. epactius* in the desert regions of southeastern Utah.

## Gonotrophic Cycles and Longevity

For the determination of the longevity and maximum number of gonotrophic cycles for *Ae. epactius*, regular laboratory ovarian dissections (Detinova 1962) were conducted upon active, field-collected, blood-seeking adult females. Field collections at the sites of adult emergence and subsequent dissections were made at intervals as regularly as possible and in all instances were commenced upon the first post-emergent appearance of blood-seeking adults and continued through that period in which older biting females from any given brood could still be located.

The data for *Ae. epactius* substantially indicates that this species is capable of completing only one gonotrophic cycle throughout the natural life span of the adult female. In all dissections of field-collected biting females, 58 total of oldest locatable biting adults, only nulliparous specimens were encountered. Supporting field observations as well as studies of laboratory colonies established from locally collected desert *Ae. epactius* offer substantial evidence that the natural life span of adults of this species compared to that of most Culicidae is extremely brief. At no time, under optimal conditions, in 2½ seasons of continued field observations did the researcher encounter resting or actively biting females later than two weeks after any massive emergence of adult populations from those rock pools being investigated. Also, under optimum conditions, encounters with biting two week post-emergent females were very rare. Biting and mating adults were still relatively common in the vicinity of the rock pools up to 8-10 days following their emergence. As observations of post-emergent flight habits indicate, normal geographic dispersal of a given population does not in this instance account for the observed depletion of numbers, in that the movements of adult *Ae. epactius* are noted to be essentially restricted to the close proximity of the rock pools from which they emerge.

On the basis of those field and laboratory data gathered, a projection may be made of the maximum probable longevity and approximate effective biting period of adult *Ae. epactius*. All observations suggest a maximum natural life span for females of that species of no more than 20 days. An average effective biting period of no more than 10-12 days is indicated. Laboratory-colonized populations will though, under optimal conditions of temperature and humidity, persist for significantly greater periods of time.

### Oviposition and Fecundity

Adult oviposition activities, involving the attachment of ova to a sandstone rock hole substrate are accomplished in intimate association with the existing waterline of the contained pool. Eggs are individually cemented to selected surfaces within that narrow zone extending from the waterline to the maximum vertical extension of the moisture front, having percolated up the rock hole walls by way of surface absorption. Successive depositions by other females progress downward with continued evaporation and recession of water levels. Embryonation of eggs begins immediately upon their deposition. The moisture-dependent stages of that process and conditioning of the eggs are thus usually completed immediately prior to the onset of complete drying of the rock hole, with the accompanying elevation of temperatures. As previously noted, exposed substrate temperatures in excess of 130° F. are a common rock hole phenomenon.

Field collections of *Ae. epactius* eggs from dry rock holes and supportive laboratory observations indicate that the great majority of ovipositing females of that species cement eggs upon the surfaces of well-sheltered alcoves within incuse seams and in association with other protective recesses and irregularities presented by the surrounding rock hole walls. A favored, repeated oviposition site in one larger rock hole which was regularly monitored, was the ceiling of a linear, overhanging ridge protruding from an otherwise smooth, sheer wall. These preferred oviposition sites were most often located well within the inner confines of those selected rock holes. The direct incidence of light upon those surfaces occurs, if at all, for limited durations and at shallow angles of incidence. Viable eggs, thus deposited, would therefore be spared the direct inimical effects of excessive desert heat and depressed relative humidities.

In the field, the maximum of large separate adult broods to emerge from any series of rock pools throughout a given breeding season (May-September) was five. The approximate average number of larvae per brood of all complete broods to develop within rock pools that consistantly produced *Ae. epactius* was 300 per pool. The normal high was 425. The normal low was 125.

### Post-Emergent Flight Habits

The post-emergent behavior of adult Utah *Ae. epactius* is markedly divergent from that of the majority of other non-container breeding mosquito species. Cumulative field observations of the adults of that organism indicate that extreme limitations are imposed upon the movements of naturally occurring populations. Numerous observations were made under optimal conditions for adult activity. The researcher never encountered adult male or female *Ae. epactius* at distances in excess of 100 feet from established breeding sites. Contacts at that distance were rare. During evening and early morning hours, the approach of the researcher to within the immediate vicinity of a productive series of rock pools would, depending upon the date of emergence of the most recent brood, result in his attack by numbers of biting females. Considerable adaptive advantage is gained by adult *Ae. epactius* in remaining within the immediate vicinity of the pools from which they emerged. In the desert environment, rock pools often constitute the primary source of available water for vertebrates common to that area. As with the parasite *Ae. epactius,* potential hosts are active during the cool, humid early morning and evening hours. The frequent approach of several species of warm-blooded vertebrates to those pools for water concomitantly results in their parasitism by *Ae. epactius*. With the water-lured, induced concentration of otherwise widely dispersed hosts, extended flight by adult *Ae. epactius* from those points of regular host concentration are unnecessary, if not totally impractical in the desert environment. Conveniently, when daytime temperatures and humidities are most harmful, adult *Ae. epactius* are thus afforded shelter in more humid locations in the proximity of, or in some instances, within the actual confines of moist rock holes. Upon the successful parasitism of a suitable host, engorged females are thus assured the ready availability of favorable oviposition sites.

### Adult Mating and Feeding Behavior

Extensive observations of laboratory colonies of Utah *Ae. epactius* indicate that that form is strictly anautogenous.

The response to the host organism of naturally occurring adult populations of *Ae. epactius* is an unusual and efficient one, resulting, in many instances, in the simultaneous satisfaction of copulatory and nutritional requisities. Unlike most mosquito species, adult male *Ae. epactius* demonstrate distinct affinities for those prospective host organisms sought by the female. Characteristically, males directively seek and remain within the immediate proximity of a suitable host and mate with females attempting to parasitize that host.

In the field, adult *Ae. epactius* would begin to approach the researcher immediately upon his early morning or evening arrival at a series of rock pools from which a population had recently emerged. Males, though not always, were usually the first to establish an association with the researcher-host. This association began with the loose aggregation of two or three males with additional individuals progressively entering the group. A given male normally assumed a hovering attitude within a more or less compartmentalized space at a variable distance from and facing the body of the researcher. The usual distance from the host as established by hovering males was about 12 inches. The most conspicuous action was an arrhythmic backwards, forwards, side-to-side flight. The velocity of vertical movement was considerably less than that for horizontal displacement. Males would occasionally alight briefly upon the researcher and then resume their hovering habit. The approach to the host by females was directive, rapid and usually unhesitating. As a given female approached the potential host, several males would rapidly abandon their previous positions and attempt to intercept the female. Upon her capture by a male, the initial, tumbling copulatory stages were effected aerially, venter to venter. Complete insemination occurred either aerially, or the attached male was carried to the host by the female, where the act was completed during the initial stages of host parasitism. In the event of the failure to capture a given female, pursuant males resumed their position in relation to the host, to repeat their previous actions upon the arrival of another female.

The behavioral mechanism described, though obviously efficient, undoubtedly does not represent the sole mode of female insemination in the natural environment. On numerous occasions in the field, females unquestionably parasitized the researcher in the complete absence of associated males. With most anautogenous *Aedes* species, insemination is necessary to elicit a blood-feeding response in females. This is not the case for *Ae. epactius*. In the laboratory, virgin females will avidly engorge upon an adequate host. In those instances infertile eggs develop and are oviposited in an otherwise normal manner. For selective reasons, the widespread oviposition of infertile eggs by virgin females most certainly cannot occur in natural populations of *Ae. epactius*. Recently emerged males and females may be maintained in breeding cages for several days in the complete absence of a potential host and generally high frequencies of insemination will still result via male response to the in-flight wing pitch of the females. It is therefore indicated that in naturally occurring populations of *Ae. epactius*, insemination occurs in a significant number of instances in male-female encounters totally divorced from a feeding situation involving a host organism.

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# *ROMANOMERMIS NIELSENI* FOR THE CONTROL OF MOSQUITOES IN CANADA

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A prime aim of the Research Unit on Vector Pathology, St. John's, Newfoundland, is the mass production of mermithid nematodes which are naturally parasitic in biting flies, so that they can be introduced into biting fly habitats in sufficient numbers to regulate host populations. At present the only in vivo culture of a mermithid parasite of mosquitoes capable of providing sufficient nematodes for field trials is at USDA, Lake Charles, Louisiana and is of *Romanomermis culicivorax.* Galloway and Brust (1976, 1977) showed by both laboratory and field experiments that the thermal tolerance of *R. culicivorax* preempts its use against mosquitoes in Canada.

It became essential that a suitable mermithid of mosquitoes be found for use in northern climes. *Romanomermis nielseni* was an obvious choice. This mermithid was first described from a collection of larval, pupal and adult mosquitoes made at an elevation of 8,000 ft. near Lone Tree, Wyoming, in May and June of 1965-1966. The infection level of the hosts was reportedly high and in addition several species of mosquitoes found infected in Wyoming are common to Canada.

Two collections have been made so far. In May 1977 the primary aim was to collect as many infected mosquitoes as possible, find ways of keeping as many emergent nematodes as possible alive through their free-living stage with a view to finding a suitable laboratory host for the nematode by testing the susceptibility of several species of mosquito to the preparasitic stage.

The mass collection was brought back to the laboratory in Salt Lake City. Over a four-day period some mermithids emerged, and these were separated out but the bulk of the infected mosquito larvae were transported back to Newfoundland. The rest of the post-parasitic mermithids emerged over a two-week period. On a daily basis they were separated out and set up in petri dishes where their development was monitored. The nematodes were kept at 17° C. At this time one-half to one-third of the nematodes developed an infection with the fungus *Saprolegnia* and were totally lost, which event drastically curtailed the chances of success in 1977-1978. The surviving nematodes molted to the adult stage, mated and eggs were laid. According to Tsai (1967) the eggs laid would go into diapause over the winter. However, Petersen (1976) who looked at the biology of *R. nielseni* found that at 17° C the peak hatch of the eggs occurred within 18-20 weeks, with small hatches extending over 10 months. In this series of experiments initiation of egg hatch fell into three groups at 4 weeks, 8-9 weeks and over a year after deposition. The duration of hatching in each case was several months. This process of hatching and phenomena of diapause in the eggs of this nematode are to be investigated further. Synchronous hatch of the eggs is of paramount importance in order to initiate a culture. Small egg hatches over an extensive period of time preclude good infection rates in a host and as the sex of a nematode is determined by the number of nematodes harbored by an individual host this subsequently affects the emergent male:female post-parasitic ratios essential to good egg production.

Considerable difficulty was encountered in trying to find a suitable host for *R. nielseni*, primarily because there are few mosquitoes that are known hosts for this particular mermithid that can be easily reared in the laboratory and secondly none of the natural hosts of *R. nielseni* would likely be good for in vivo culture as their life cycles are too protracted for rapid buildup of their numbers and the nematodes that are subsequently passaged through them. The susceptibility of several possible mosquito hosts to *R. nielseni* was determined as far as was possible at this time. After exposure to the pre-parasitic stage infections were obtained in *Aedes aegypti, Wyeomyia smithii, Aedes atropalpus* (Belleville, Ontario strain) and *Culiseta inornata.* Development of the parasitic phase to the post-parasitic emergence was complete in all hosts except *Wy. smithii.* Of the emergent nematodes from the other hosts all were females which failed to molt completely to the adult stage.

In May 1978 a collection was made again at Lone Tree and brought back to Newfoundland as described previously. None of the nematodes succumbed to fungal infection so that a larger number was available for experimentation. The nematodes developed normally to adulthood and eggs were laid. To date one large synchronous hatch of the eggs has occurred which allowed attempted infection of *Culex restuans, Ae. aegypti* and *Ae. epactius* (=*atropalpus nielseni*). Both *Ae. aegypti* and *Cx. restuans* were found to be highly susceptible to infection and the subsequent collection of a large number of healthy post-parasitic nematodes which emerged from them endorsed their use as possible laboratory hosts. At this point in time (September 1978) the post-parasites which emerged from *Ae. aegypti* have molted, mated and produced eggs which are developing normally. None of the *Ae. epactius* exposed to the parasite became infected.

The availability of a number of *R. nielseni* in the laboratory throughout the year will allow further investigation of the biology of the nematode and of certain facets of the host-parasite relationship which will lead to the eventual improvement and expansion of the culture. This together with the input of a mass field collection in 1979 will make the possibility of full establishment of an in vivo culture of *R. nielseni* a more immediate probability.

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# CHANGES IN MOSQUITO CONTROL PRACTICES IN CAPE MAY COUNTY, NEW JERSEY

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

I am happy to be here in Utah today to speak to you about mosquito control in Cape May County, New Jersey. Our terrain is much different than yours; our highest point is 10 feet above sea level and that point is on top of a sanitary landfill. I would like to tell you of our methods of mosquito control and the changes that have taken place.

I was taught from an early age that the art of being a good orator is making deep noises from the chest sound like important messages from the brain. Not having a deep voice, I hope that I will be able to give you the latter without the vocal disguise. But before discussing our methods of mosquito control, as compared with those of the past, I would like to give you an idea of what our county is like, its terrain and economic structure, along with a short history of the Cape May County Mosquito Extermination Commission.

Cape May County is 267 square miles of land area, largely undeveloped. It is bordered on the east side by the Atlantic Ocean and on the west by the Delaware Bay and is, in fact, more than 40% woodland. These extensive woodlands and the tidal marshes which account for another 30%, give a visitor the impression of wide-open space, an aesthetically pleasing sight in these days of traffic jams and high-rise apartments that we see so much of in the middle Atlantic area.

Some 90% of our economy is based on tourism, making mosquito control a necessity for both economic and health reasons. In 1978, from May to September, our county had a record number of 6,500,000 tourists. The winter population is 80,000. Business generated by tourists in the county totaled $500,000,000. last year, and the indirect assessed tourist related property valuation was 90%. Direct assessed value was 60%. Even after several years of inflation, high unemployment and tight money, the resorts had their two best years ever because of their proximity to all the large metropolitan areas of the northeast and because a good many people are now taking shorter, less expensive, closer-to-home vacations. In addition, in 1978, we are close to the beginnings of casino gambling in neighboring Atlantic City.

In New Jersey all mosquito extermination commissions operate under Title 26 of the law (Health and Vital Statistics), and in Cape May County this gives us a budget based on one quarter mill of every dollar of assessed valuations. Title 26 also provides for a freeholder option for additional operating or equipment expenses. The Board of Chosen Freeholders in Cape May County looks favorably on mosquito control and has generally provided adequate funding for a well-balanced program. Additional assistance has come from the State Mosquito Control Commission in the form of equipment loans, monies for water management projects and aerial spraying for adult and larval mosquito populations. Such assistance has been a tremendous help for a small county such as ours with low ratables and a large people population during the mosquito breeding months.

The Cape May County Mosquito Extermination Commission was organized on Friday, October 15, 1915, in the county seat, Cape May Court House, at the Bellevue Hotel. Six members were appointed to the Commission by a justice of the Supreme Court of New Jersey. The Commission remained a six-member body until December, 1972, when the law was revised, making a seventh member mandatory. The seventh member was to be a member of the Board of Chosen Freeholders of the county. The members of our Commission range from a wildlife biologist to fishermen and farmers, to medical doctors and local health department members.

The commissioners hire a superintendent to run the Commission, and we have a staff of 20 full-time, year-round employees. Summer help ranges between 15 and 20. Our personnel are represented by a union and by the New Jersey Civil Service. Some of our titles are bookkeeper, clerk-typist, account clerk-typist, foreman, equipment operators, heavy equipment operators, pesticide applicators, inspectors, mechanics, mosquito identification specialists, biologists; and we are now working on a description for the title of marsh management specialist. Many of our personnel have been with the Commission for more than 10 years, and we highly value this experience as it is one thing that you cannot get on the easy payment plan. Incentive programs and in-house training sessions make our positions more attractive and interesting.

Commission headquarters is situated on 17 acres of land in Dias Creek in Middle Township near Cape May Court House and is only a short distance from the Delaware Bay. We have 9 buildings on our property. They include offices, a shop, storage for vehicles and pesticides, locker and cleanup facilities for personnel and a fine research laboratory. We maintain all of our own equipment.

The object of our Commission is to control mosquitoes in Cape May County through an effective, well-balanced, environmentally sound, economic, integrated mosquito control program. In order to do this we have established the following in the order of their priority.

1. To accomplish water management on the salt marsh through the use of the open marsh water management technique wherever possible and compatible with the environment and to eliminate the use of pesticides on the open salt marsh.

2. Establishment in 1974 and improvement upon a helicopter larviciding program properly monitored, calibrated and recorded.

3. Establishment in 1968 and continuance of a weekly marsh larval survey program delineating all breeding areas in the County, eliminating those properly managed and no longer productive, while adding newly created or newly discovered breeding areas.

4. Close liaison with all municipalities and campgrounds in the County doing their own fogging or spraying, training and educating operators in the proper use of pesticides and application techniques while passing along the recommendations of the Agricultural Experiment Station as to the recommended pesticides.

5. Continuance of a county-wide light trap and bite count surveillance operation.

6. Research and monitoring of our own programs; experiments in cooperation with the Mosquito Research Group at the Experiment Station and cooperative endeavors with the Division of Fish, Game and Shellfisheries and the County Health Department.

7. Educating the public as to the part it plays in mosquito control, as well as informing it of our role.

8. Training of our own personnel through courses given at the Commission on mosquito control and related subjects as well as training from the State Experiment Station, Rutgers University and other schools in the needed training field.

9. Requiring all personnel to be Certified Pesticide Applicators even those not handling pesticides on a daily basis.

10. Adulticiding only when justified by landing rates or parous mosquito rates when vector potential is high.

With these objectives in mind I would like to tell you a little about our specific programs.

Our Open Marsh Water Management unit consists of two rotary ditchers and an amphibious drag line with two boats and a Swamp Spryte for transportation to and from the machine work site. This program requires the services of four operators along with supervisory personnel and inspectors for staking the breeding habitats. A wildlife biologist stakes the breeding areas to be ditched along with mosquito commission personnel. Once a project is conceived, permits and funding obtained, work proceeds. There are appoximately 8,000 acres of breeding salt marsh in Cape May County that could be subjected to open marsh water management. This would largely control the number one nuisance mosquito - *Aedes sollicitans*.

Our upland water management unit consists of a 5-ton Schield Bantam crane with a 3/8 yard bucket that belongs to the State Mosquito Control Commission and is on loan to us and a John Deere crawler-dozer-tractor with an interchangeable backhoe and rotoboom attachment. We hope, in 1979, to obtain a new tractor with a backhoe. Because of the unavailability of parts, the rotoboom attachment has become obsolete. Men with shovels, drags and axes are used in upland situations removing blocks from ditches and removing brush that impedes the flow of water and creates pockets and mosquito breeding.

Our pesticide program consists of larviciding by helicopter. Our Commission leases a Bell G5A helicopter equipped with an aerial granular Simplex seeder, Model 1610. The system is basically a hydraulic system consisting of two hoppers, a blower assembly, two-four inch diagonal cross tubes and one flexible air duct tubing. The hydraulic system is attached to the helicopter frame and engine. The dry-seeder unit is interchangeable with a liquid applicator. It is possible to drop the drums and air blower and put on a wet pump in a matter of 3 to 4 hours. We do not use a liquid insecticide from a helicopter in our program so it has not been necessary to change from one to another in the course of the operation but we do have the capability of doing this. The unit was designed for disbursing tree seed and grass seed mixtures of up to 15 to 18 pounds per acre. As the seed is lightweight and bulky, dropping this volume into the airstream, it is immediately carried away and does not clog the tube. The 2% Abate granular on a celatom carrier that we use is also light in weight and bulky; however, we apply it at a rate of five pounds to the acre. This is used on both salt marsh breeding areas and woodland upland sites. As stated previously, approximately 8,000 acres of salt marsh and 3,000-4,000 acres of freshwater impounded marshes are treated for mosquito breeding. Each year we find new breeding areas that we did not know existed and other breeding habitats are eliminated. Upland and urban mosquito breeding sites are treated by our pesticide applicator crews inspecting and treating known breeding locations routinely. The county is divided into three regions – North, Central and South. A crew inspects and treats breeding areas weekly. Newly discovered areas, either newly created or as a result of complaints, are added to the list each year. Each complaint is answered personally by an inspector and measures are taken to eliminate the breeding by source reduction. If this is not possible, the location is put on our weekly treatment schedule and checked weekly throughout the breeding season. Again the pesticide used by the application crew is Abate but in liquid form (4E) mixed with water.

The catch basins in the county are treated with the same mixture of Abate and water with excellent results. We have also used Altosid briquets in basins experimentally with good success. Only basins that produce mosquitoes are treated. Of the 20,000 catch basins in the county, approximately 3,000 contain larvae, as determined by previous surveys. Tidal basins do not breed mosquitoes. The basins are marked at the beginning of each season; therefore, it is feasible and economical for one catch basin unit to complete the circuit of the basins in the county within the 10-day period needed for the control of *Culex pipiens* larvae. In 1978 the catch basins in two towns were treated using Altosid briquettes. The data is not all collated; however, it appears to have been successful.

We began our helicopter program in 1974. Based on our surveillance program, drastic reduction of mosquito populations have been achieved in areas that we have larvicided. We have, to date, found no resistance to Abate in repeated bioassays.

Adulticiding by air is accomplished through the use of the State Airspray Program coordinated by the Mosquito Research and Control group at the Experiment Station in New Brunswick. Several different chemicals are used: Dibrom 14 and HAN with one ounce of Dibrom plus two ounces of HAN to the acre, malathion ULV application at a rate of three ounces to the acre or another option, which our county hasn't used in several years, low volume spraying of one to two ounces of 91% malathion in one quart of no. 2 fuel oil per acre. In 1978 our Commission adulticided only once, approximately 8,000 acres with Dibrom and HAN mixture with good results. We do not do any ground adulticiding; however, we coordinate the programs for the municipalities and campgrounds in Cape May County. Cape May County is a resort area and has 48 campgrounds with over 30,000 campsites within its 267 square mile area. Each campground has its own spray machine. These machines are calibrated and checked by us, and they must have an approved program from the State Department of Environmental Protection in order to carry out the program. We also assist the municipalities with the same type of program. We check and calibrate their equipment for them before any spray program is attempted. We feel that it is a better utilization of the county monies to do increased source reduction and a limited amount of adulticiding. When adulticiding is carried out, it is on upland areas. In Cape May County, no marshes are treated with an adulticide.

We have an extensive surveillance program. A marsh larval dipping survey consisting of over 100 dipping stations with 650 staked breeding depressions is carried out weekly from April 1 to November 1 each year. The survey began in 1968 and the statistical data from these surveys has been invaluable in determining priorities for control. The helicopter is used for checking 30 of the inaccessible stations in addition to the actual granular pesticide application. A network of 30 New Jersey light traps are spaced strategically throughout the county and are picked up and identified daily. Four summer personnel are assigned to this duty. As they pick up the trap collections, they also take landing rates in pre-selected areas. The landing rates are used again to justify adulticiding or to judge the effectiveness of larviciding. The light trap program has been in effect since 1960 and has yielded some very significant data that show that there has been a steady yearly decline in our county-wide mosquito populations. Data on these populations are maintained and graphs are kept using the Williams mean. CDC portable light traps are used periodically to determine migratory directions of broods. Pigeon traps are used in areas where *Culex* mosquitoes are prevalent.

The Commission's equipment consists of 26 vehicles, 6 trailers, 5 boats with motors, 3 tracked marsh vehicles, 1 John Deere backhoe with wide track assembly, 1 amphibious rotary ditcher on loan from the State Mosquito Control Commission, 1 amphibious drag line, 1 amphibious rotary excavator, 1 Thiokol Swamp Spryte and 1 5-ton Schield Bantam Crane and assorted pumps, sprayers and mowers. To service this equipment we have two mechanics and a thoroughly equipped shop including a painting room and emissions testing equipment. Routine maintenance and all major repairs and welding are carried out in our shop. In addition, our mechanics are certified pesticide applicators and are responsible for calibrating the spray equipment brought to us from municipalities and campgrounds throughout the country.

In the early part of 1974 we started renovation of an unused building which is now a five room laboratory, as a result of a grant for equipment and furnishings from the State Mosquito Control Commission and our Commission funds for renovation. Research, experimentation and assessment of some of our programs are the major reasons for this laboratory. It is staffed with three full-time personnel in the winter time and in the summer two additional biologists are hired. An identification specialist does taxonomy in the laboratory, identifies the light trap catches and samples from the larval surveys, does age-grading work with the mosquitoes and maintains an established mosquito colony. We do resistance tests with bioassays during the course of the breeding season as well as calibration of the helicopter granular applications by weighing the granules collected in strategically positioned containers. A Mettler balance in our laboratory is used for the weighing process. A good deal of work has been done with fish, experimenting in biological control in woodland pools by stocking certain breeding areas instead of treating with pesticides. Twenty glass aquarium tanks are used for experiments with fish species such as gambusia, mudminnows, killifish and menhaden. Three large 50-gallon tanks are used for public education and tours of school children who are frequent visitors to the Commission grounds. Two out-of-door stock ponds are on the premises.

There is a cooperative ongoing project between the Cape May County Health Department and the Mosquito Commission for taking water samples in tidal streams to determine dissolved oxygen content, pH and salinity. We use this information in the decision-making process before larviciding a salt marsh or adulticiding areas adjacent to a marsh. The Commission has had an ongoing study of one particularly troubled area, specifically the Bidwell drainage system, where numerous fish kills have occurred in the past seven or eight years. The County environmental laboratory analyzes samples that we collect. An extensive assessment of the area has been undertaken and the water samples tested for oxygen content, salinity, pH, ammonia, nitrates, hydrogen sulfide, sulfates and phosphates.

At this time we have a joint project with the New Jersey Department of Fish, Game and Shellfisheries, Division of Marine Services, the United States Geological Survey in order to do a comprehensive study of this drainage system and come up with an answer to the predominatly menhaden fish kills. Originally we started this research as a defensive mechanism because of the bad press we were receiving from the fish kills in regard to our pesticide program. However, we know, and the research data has proved, that low oxygen is the primary cause of the fish kills. After repeated urging, other agencies are interested in the data we have collected and will now join us in a joint research program. The more agencies included in the research, the more data will be widely accepted and published. We have not adulticided in the vicinity of these fish kills since 1970 but still receive adverse publicity after each kill.

We have established a mapping system of all projects, both water management and pesticide applications, that bring all of our programs into focus and enable us to coordinate all facets of the program. These are put on USGS maps along with aerial maps of our wet lands. Extensive records are kept on all pesticide applications.

Finally, we have established in-house training sessions for personnel from November 1 to April 1 each year. The Commission passed a resolution in 1977 that all personnel working for the Commission be certified pesticide applicators, not just supervisory personnel as the law requires. We have training courses for these personnel both before and after they are certified and short training courses for summer personnel. The Experiment Station in New Brunswick sponsors seminars and training sessions throughout the year and our employees attend those when available. Several employees have attended courses at CDC in Atlanta, Georgia, at the County Extension Service, and some of the nearby universities. The Commission has established a policy of paying for classes for employees if it is for the benefit of mosquito control and the employee shows promise. We have been asked by the County Extension Service and the Pesticide Project at Rutgers to participate in the recertification programs for pesticide applicators as far as holding training sessions and training applicators for mosquito control in Cape May County.

Effort has been made in the past to inform the public of the role played by the Mosquito Commission in the control of mosquitoes. More effort is needed. We have increased our public relations endeavors. We have increased our talks to civic organizations. We conduct tours for school children, we go to schools for lectures; we supply information and literature to the schools and to local libraries. We appear on local television and radio stations regarding mosquito control. We participate in annual meetings, conventions and local fairs to get our message across.

Cape May County has evolved into a County of people who are definitely interested in the environment. They do not want their environment destroyed by our overuse of chemicals. We have endeavored to change our image as strictly a pesticide organization. We spray pesticides, especially adulticides, only when necessary. We no longer have the reputation of doing just fogging and notning else. Water management is our main concern and this concern is stressed, especially in public relations programs.

In 1979 we will have a 20 minute video tape movie with sound that has been put together for us by the Cape May County Public Relations Departi ient depicting many of our control operations. It will be used by us and by the County Public Relations Department throughout the next several years.

We are fortunate to have the financial support of the Cape May County Board of Chosen Freeholders to carry out our program each year.

Mosquito Control in Cape May County is important. Tourists like to spend time out-of-doors in a seashore resort. Mosquito control is necessary and important both for nuisance and for vector control. We have changed our program considerably in the past several years. We have evolved to quality control; to integrated control. In the past we used grid ditching systems where we now use the open marsh water management systems. The grid ditching helped control mosquitoes but it did not control them completely so that it was still necessary to use pesticides in an area. Open marsh water management controls mosquitoes and completely eliminates pesticides from that particular former breeding habitat. That's one change. Another change is that we do not do any ground adulticiding. We help coordinate campgrounds and municipal programs who have sprayed on their own in the past, and we do see that each applicator is trained and certified and that the pesticides they use are recommended.

Source reduction is our main concern and we have accomplished much changing our image from a pesticide-oriented Commission to an ecologically concerned agency.

In conclusion, and in order to summarize in a few words the status of mosquito control in Cape May County after 63 years of operation, I would say that we are continuing to progress and change in all aspects of control. We have evolved into a new environmentally acceptable type of water management. We have become very specific and monitor closely any pesticide applications that we make. We are oriented toward research and are always open for suggestions and experimentation for new improved methods. We have excellent communication with all federal and state agencies and with all of this our records show that the mosquito populations in Cape May County are on a downward trend.

Our personnel are active and participate in the state associations. I was interviewed on a recent television program and was introduced at that time as an expert in mosquito control. An expert? I don't think so. What is an expert? I read somewhere that the more a man knows, the more he knows he doesn't know; so I suppose one definition of an expert would be someone who doesn't admit out loud that he knows enough about a subject to know he doesn't really know much.

And with that note I'd like to thank you for asking me to participate in your program today.

# THE DEVELOPMENT OF MOSQUITO CONTROL IN NEBRASKA

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Mosquitoes have existed in Nebraska for many years. Lewis and Clark reported that great hordes of mosquitoes were encountered along the Missouri River. Prior to World War I we know of some mosquito problems in western Nebraska, especially in the early Bureau of Reclamation irrigation projects. However, it was not until World War II, when the United States Public Health Service established Malaria Control in War Areas that any systematic surveys were made in Nebraska. These surveys were under the direction of Dr. John A. Rowe. It may be of interest to note that Dr. Rowe was a native of Utah who had received his early entomological training at Utah State University. During World War II there were at least 15 military establishments, airfields, prisoner of war camps, etc., in Nebraska which were surveyed one or more times. Since these military establishments were widely distributed throughout Nebraska, they pointed out that pest mosquito problems existed in all areas of Nebraska. It is interesting to note that Malaria Control in War Areas was principally interested in *Anopheles*; however they found few in the areas surveyed. The one exception was around Fort Crook in Sarpy County where an *Anopheles* control program was established.

In 1944 the Army requested Dr. John A. Rowe to make a pest mosquito survey at the prisoner of war camp located approximately five miles east of the city of Scottsbluff. The Army had reported that the mosquitoes were so bad that they interfered with guard duty at the camp. As a result of the survey, Dr. Rowe pointed out that the problem was principally an *Aedes* problem related to irrigation practices. A large scale control program was proposed, but because the camp was abandoned in 1945, no control was carried out.

In the early 1940's there was a lot of interest in mosquitoes. Much of this interest was related to the war effort, but also it had been recently established that mosquitoes were the vectors of western equine encephalitis and St. Louis encephalitis. In 1938 Dr. H. Douglas Tate joined the Department of Entomology, College of Agriculture, University of Nebraska. Tate was interested in medical entomology, especially mosquitoes. In 1942 Tate and W. W. Wirth published in Entomological News some notes on Nebraska mosquitoes. In 1944 Tate and Doris Gates published as Research Bulletin 133, "The Mosquitoes of Nebraska." This work was based upon material collected in light traps operated at 12 areas. During World War II the Seventh Service Command, U. S. Army Medical Laboratory was located in Omaha. Two entomologists, T. A. Olson and H. L. Keegen, were attached to this laboratory and in 1944 they published two papers on Nebraska mosquitoes.

Thus by the mid 1940's, thanks to Tate and his students, Olson and Keegen, and Malaria Control in War Areas, a good picture of the mosquito problems in Nebraska had been established. In addition, during the early 1940's Drs. W. McD. Hammon and W. C. Reeves did field work in Nebraska on western equine encephalitis and established that both the proper mosquitoes and the virus were in the state.

With the development of the Pick-Sloan Plan following World War II, the Public Health Service, through the newly established Communicable Disease Center, had the Missouri River Drainage Basin Office in Kansas City make a detailed mosquito survey of the Republican River Basin in southern Nebraska under the direction of Dr. Rowe. This study showed the relation between irrigation, drainage, and mosquitoes. The report published in December 1951 made a number of recommendations which would reduce mosquito breeding in the project.

In 1950 the Water Resources Branch of CDC established a field station at Mitchell in Scotts Bluff County. This location was picked by Dr. Rowe based upon his earlier work at the Scotts Bluff Prisoner of War Camp. Dr. Rowe felt that the North Platte River Valley of Nebraska, because of high mosquito populations, was the ideal area to study the relationship between irrigation practices and mosquitoes. Assigned to this laboratory were Leslie Beadle, George Keener, G. Allen Mail, and Lafe R. Edmunds. These entomologists all contributed publications which increased the knowledge of mosquito problems in western Nebraska.

Municipal mosquito control started in Nebraska about 1947. George Derkensen obtained a Tifa franchise and started selling Tifa "fogging" machines to Nebraska municipalities. Derkensen was an outstanding salesman and by 1952 about 30 municipalities had Tifa machines.

In 1952 I joined the Nebraska State Department of Health. Basically, I was to wear two "hats" . . . mosquito control and aquatic biologist for stream surveys. Six weeks after joining the State Health Department I was placed in charge of the sewage treatment plant program, but I was told that I could work on mosquito control programs when and if I had time! Truthfully, this change in programs was beneficial to developing mosquito control programs. The sewage treatment plant work was mostly making one or two inspections per plant per year, but it gave me excellent opportunity to meet municipal officials. In the spring of 1952 the last major flood on the Missouri River occurred and with the prodding from the Kansas City office of the USPHS, the State Health Officer instructed me to devote full time to studying the effect of the Missouri River flood on mosquitoes.

With this background, in 1953 we published "Recommendations for Fly and Mosquito Control in Nebraska." This was mailed to all of the major communities in Nebraska, together with a letter offering to help establish a good mosquito or fly control program.

"Recommendations for Fly and Mosquito Control" became an annual publication and today we distribute approximately 500 copies principally to Nebraska municipalities. This publication has been of value in two areas. First, it has allowed us to tell communities that mosquito control is more than just running a "fogging" machine up and down the streets of a village and that a good control program requires source reduction. Second, with this publication we have been able to recommend good insecticides. For many years Nebraska was the operating area for many so called "fly-by-night" salesmen.

Since the late 1950's we have held one-day training schools for municipal employees. These schools are held in March and April in various areas of the state, and municipalities are invited to send the employee who will be in charge of mosquito control. We also encourage the mayor or councilman to attend. At these schools we have stressed that mosquito control programs which include source reduction are the most economical as well as the most efficient. We have also included material on safety, maintenance of equipment, and the buying of insecticides. In the past 20 years approximately 300 municipalities and better than 1,000 men have attended these schools.

The question is always asked, how many municipalities in Nebraska have mosquito control programs? This a difficult question to answer because there are great variations in mosquito problems from year to year. In western Nebraska, where ditch irrigation and pasture flooding are practiced, there are major mosquito problems every year. In the eastern part of the state mosquito problems are directly related to rainfall; there are years when a municipality does no control and there are years when $10,000 to $15,000 is spent on mosquito control. To the best of our knowledge, there are approximately 225 communities equipped to do some type of mosquito control. However, our survey indicates that in any given year probably less than 150 municipalities do control work. We have attemped to determine how much Nebraska municipalities spend on mosquito control. Unfortunately, this has been difficult because many municipalities keep poor records or charge the program off to the street department or utility department. It has been especially difficult to obtain labor costs. Based upon the data that we have been able to obtain, plus some educated guesses, it appears that municipal mosquito control in Nebraska costs approximately $250,000 to $300,000 per year. We believe that these figures are conservative because of recent increases in salaries paid to municipal employees.

What constitutes a mosquito control program in Nebraska? We have villages that once a year take out the fire truck the night before the annual firemen's picnic and spray the town for mosquitoes, and cities which have well organized source reduction programs, including biological control with *Gambusia* and adulticiding programs. Between these two extremes, there is everything. To be very truthful, the majority of programs are limited to adulticiding. In many cases, because of legal restraints, this is all a municipality can do. *Aedes vexans* is the major problem mosquito in Nebraska. Often times these breed eight to ten miles from the municipality and under proper conditions migrate into the municipality. Since we do not have mosquito abatement districts, adulticiding is the only method to obtain relief.

Nebraska has had a mosquito abatement law on the books since 1959 but has yet to establish the first district! Why? First, although our law is patterned after the Utah law, there is one section that really hurts. The irrigation interests were strongly opposed to the mosquito abatement law. However, the mosquito abatement bill was introduced into the legislature by a very powerful senator, the late Terry Carpenter from Scotts Bluff County. Through vote buying and politics, the method of establishing a mosquito abatement district was changed so that a two-thirds majority vote, based upon the last gubernatorial election, is required to establish a district. This factor, plus the fact that a district cannot cross county lines, has resulted in no mosquito abatement districts.

In recent years there has been very little interest in the formation of mosquito abatement districts. Without doubt there is conflict of interest between irrigation districts, drainage districts and municipalities. In Nebraska, for many years there has been a strong reluctance to establish new tax-levying political subdivisions. At the present time in Nebraska, the irrigation districts, reclamation districts, and the natural resource districts are better organized and more powerful than the municipalities. This fact makes any changes in the mosquito abatement law very difficult.

At the present, the majority of municipalities are satisfied with their present mosquito control programs. Many have developed well-rounded programs which include source reduction. As tax problems become more acute, there is the possibility that we will see the formation of small mosquito abatement districts around some of the larger municipalities. At present, a municipality can do mosquito control work under a state zoning law which allows a municipality to work in a three-mile limit around the community. However, the zoning area does not contribute tax dollars, and they are needed in local government.

In closing I would like to summarize by saying that in any given year approximately 150 Nebraska municipalities have some type of mosquito control program and spend approximately $250,000 to $300,000 per year.

# MOSQUITO CONTROL IN WYOMING

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Mosquito control in Wyoming is what I would call the non-traditional program not having the benefit of a law providing for an enabling act to develop abatement districts. Without the enabling act there have been some cities and towns where the administrators have found it necessary to take some measures to control the annoyance. These control measures have generally been to apply an adulticide by ground equipment and sometimes having the town treated by using aircraft. The ground equipment being used are such things as the Buffalo turbine, Leco and the London Aire ULV Aerosol Generator and thermal foggers. The product used as an adulticide usually is malathion and at least one city uses a combination of malathion and pyrethrum.

It seems that the cities and towns are often suckered into purchasing an insecticide from a firm selling custodial supplies and with the purchase they are given a thermal fogger of a sort. These ready-to-use products have a low percentage active ingredient and so are an expensive way to purchase an insecticide in a large volume The degree of effectiveness, I am sure, is low and the treatment must be done on a weekly or perhaps in some cases biweekly basis. Perhaps we have not done an effective job of educating the officials responsible for making purchases for city or local governments. How do we make inroads on this situation?

Since 1971 I have had an opportunity to talk mosquito control with various towns and a few county governments. Some of these have developed a program but most are just spraying without much thought to it. One of my frustrations in contacting these communities is how do you finance a program where the population or property or tax base is rather small? There is no way to set a tax to support a program.

Perhaps you can justify the arrangement as they have done for Laramie, Cheyenne or Casper. Usually the city sanitarian and/or some of his help work full-time on mosquito control during the months of May, June and July. Another possibility is to do as some of our ranching communities have done, and that is with some guidance from the Extension Service, conduct larval surveys on which to base control activities.

During 1976,1977 and 1978 two ranching communities have conducted a larval control program by applying fenthion (Baytex), 2/3 fl.oz. of the 93% material on an acre basis. The insecticide was applied in a one-quart mixture of diesel fuel, except the first application in 1978 where water was used as the carrier. The percent kill was not acceptable when water was used as a carrier. Three other areas or communities decided in 1978 to try the area approach for larval control. In the Snake River Valley (Baggs, Dixon, and Savery) 10,000 acres were sprayed by helicopter. The Elk Mountain area was also sprayed, and 1500 acres around Jeffrey City were treated.

The three areas, like the Big Laramie and Little Laramie communities are high mountain meadow country. The method of irrigation is one of flooding as water becomes available in late April and May. They usually cut hay during late July. Most of the ranchers hold the water on their land from May until mid-July. This, needless to say, provides extensive larval habitat for the *Aedes* mosquitoes. The programs for these mountain meadow areas are directed by a community board which I have trained to survey for mosquito larvae. These boards get the sign-up from the ranchers and town property owners and seek assistance in financing from the weed and pest control districts and their respective county commissioners. They make the contact with the aerial applicators to obtain bids to apply the chemical. In some communities they have a meeting after the treatment to hear comments on the evaluation of the treatment.

The cost for the ranching community program has been about $.90 to $1.00 per acre to the rancher while the remaining costs have been absorbed by the weed and pest control districts as well as the county commissioners.

This type of organized effort seems to be a possible answer for communities whether there is a population of 125 or 45,000. Of course we are speaking of those communities with the typical *Aedes* breeding areas which are surrounding the area and not within the city.

In Albany County the most common mosquitoes are *Aedes campestris, Ae. cinereus, Ae. dorsalis, Ae. fitchii, Ae. flavescens, Ae. idahoensis, Ae. melanimon, Ae. nigromaculis, Ae. vexans Culex tarsalis,* and *Culiseta inornata. Ae. melanimon* and *Ae. dorsalis* constitute 90% of the mosquito problem in Wyoming.

# FUTURE DIRECTIONS IN MOSQUITO AND GNAT CONTROL IN THE TOOELE VALLEY MOSQUITO ABATEMENT DISTRICT

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Tooele Valley MAD
Grantsville, UT 84029

The title of this report does not necessitate that our future directions of mosquito and gnat control will be limited to the topics discussed here but these primary concerns influence our success of a comprehensive control. It is to be assumed that basic ground control, including proper water management and source reduction, is being implemented in the Tooele Valley MAD with increasing efficiency.

The Tooele Valley is located west of the Salt Lake Valley and is bordered by the Great Salt Lake to the north, the Oquirrh Mountains to the east, and the Stansbury Mountains to the west. The presence of alkali mudflats, desert vegetation, open skies, and the Great Salt Lake typifies the scenery that the freeway traveler sees of the Valley although a number of small, chiefly rural communities lie a few miles south of the I-80 freeway. These communities experience, at times, extreme mosquito and gnat problems that require the services of a professional mosquito abatement district.

Approximately 3 miles south of the Great Salt Lake, Terracor, a Salt Lake City developer, began construction in 1969 of a planned residential, recreational community which included a 110-acre sailing lake and marina, an 18-hole PGA-approved golf course, and other facilities such as tennis courts and an AAU-sized swimming pool. This community, Stansbury Park, currently has 112 single family dwellings and 48 condominiums. Projected population growth of this "village" is estimated to reach 22,000. To maintain the desired lifestyle at Stansbury Park it became imperative for a mosquito control program to function. Even as early as 1971, one year before the first house was built, Terracor began serious efforts to eliminate the mosquito nuisance. Control was limited to adulticiding with ground equipment, but eventually it expanded to larviciding breeding sites with 2% parathion granules and some liquid chemicals. In 1973 aerial adulticiding began and virtually took over as the sole control measure.

This area, including the communities of Lake Point and Erda, is bounded on the north, west, and south by fields, ponds, swales, and flatlands of saltgrass – prime *Aedes* habitat. Water accumlates here in late winter as a result of snow melt, raised water table, and increased flow from nearby springs and wells. Water accumulations of over 100 acres are common in spring, all producing mosquitoes. By mid-June only a few small pools are left after the water supplies are cut off. Irrigation contributes very little to our mosquito problem in midsummer as watering is mostly done by sprinkler systems. Precipitation may pose a threat by refilling low areas but generally these pools dry up within a week.

Basically, this describes the geography here and introduces our problem – that of frequent migrations of *Aedes* species into Stansbury Park, Erda, and Lake Point. Excepting our spring migrations, the sources of our adult mosquito invasions are not known. This past season, 1978, we experienced migrations beginning April 20th, July 24th, August 30th, and October 10th. Except for *Aedes campestris* on April 20th, all migrations involved *Aedes dorsalis* and struck with varying severity. Frantic inspection of the District failed to locate any positive source within a 5-mile radius of the area of infestation.

The migration on July 24th was the most severe and involved approximately 25 sq. miles which resulted in numerous complaints. Our New Jersey light traps collected about 25 *Ae. dorsalis* per night at Stansbury Park and Erda. Four days later the collections dropped to 13 per night. Eight days afterwards we were unable to trap *Ae. dorsalis* as the nuisance had disappeared.

Experience has taught us that this district is extremely explosive and is apt to give us repeated migrations in each future year. Our direction is to inspect ever-so-closely our known larval sources and extend inspections further out. Especially after thunderstorms it will be imperative to inspect thoroughly this area for temporary pools that may trigger a situation to induce migration. As irrigation can contribute to this kind of excitement, we will carefully watch all fields and pastures during the summer months. We will provide adulticiding services to reduce the impact of migrations but will not rely on this control method as a panacea for the problem.

Five miles south of Tooele City lies the secluded, rural town of Stockton. The source of Stockton's mosquitoes is almost exclusively limited to Rush Lake which is about one mile southwest of the town. It would actually be easier to restrict our control to adulticiding in town rather than attempt larviciding around the lake. Rush Lake renews itself every year beginning in mid-winter which the accumulation of snow melt, recharged spring flow east and south of the lake, high water table, and high mountain water runoff when warmer weather comes in late spring. There is no outlet to the lake and water depth in the deepest part probably does not exceed 5 feet at peak season. The water spreads out over more than 3 sq. miles and approximately 1000 acres of saltgrass surrounding the lake is inundated with water. By late summer, due to the reduction of water sources, the lake bed becomes dry with only a few springs and wells remaining as permanent mosquito sources. Control of larvae in the spring could easily be accomplished by aerial applications of chemicals, yet as so few people would be affected by such a costly program, this would be economically impracticable. With greater pressures being exerted to use less pesticide, we would like to see this area developed so the water could be used in a beneficial way. Presently it does little but produce mosquitoes. This past summer we attempted a larviciding program around the lake edge beginning in May. Due to the extent of the water, our inspectors were instructed to spray along the edge of the lake for 1/8 mile if larvae were present at densities of 10 or more per dip. Thus we limited our control to those places that produced the most. Accompanying this larviciding we also adulticided fields that sheltered mosquitoes. *Aedes* species were found in abundance in the spring and early summer. Later, *Culex tarsalis* became the primary species in this locale.

With our present budget it is impossible to carry out a complete larviciding program let alone an extensive water management project. As the lake bed is under BLM control, it is our intention to work with that organization in hope of improving water management or possibly developing the lake for recreational use. Whether or not we will be able to improve the mosquito problem at Rush Lake depends on help from other government agencies. In the meantime we will continue larviciding and step up adulticiding to give the people some relief from mosquitoes.

Another topic is perhaps our most difficult. This interest, gnat control, has been voiced by the residents for a number of years and has been pushed into the political arena. Historically, Grantsville is the worst place in the state, according to Grantsvillites, for *Leptoconops kerteszi*. Attempts by various agencies have failed to produce enough knowledge for practical control.

The adult gnats make their appearance in the County in early spring and often persist for 6 to 8 weeks depending on various indeterminate climatic conditions. Some research has been done on this issue but it was mostly directed toward understanding gnat biology and identifying larval habitats. In 1970 Rees and Winget concluded a research project which provided us with some pertinent data. Part of their work was done in Tooele County. They found that *L. kerteszi* larvae preferred a habitat of alkaline sandy soil mixed with clay and silt. Preference was 12-16% moisture content but larvae were found in 5% to saturation. Vegetation characteristic of such a habitat primarily included greasewood, saltgrass, and glasswort from 0-75% cover. Such conditions are extensive along the southern shore of the Great Salt Lake, and vast acreages are in close proximity to Grantsville and other Tooele County communities. It is not unlikely that a severe biting gnat problem can be found in these towns in late spring.

Little actual work was done this past spring to alleviate gnat problems in the District because of lack of funds, time, personnel, and knowledge regarding their sources. We did, however, get residents' responses as to where and when gnats seemed to be worst. Whether or not our mosquito reduction efforts have an indirect effect on the suppression of the gnats has not been determined. It is felt though, that ULV adulticiding in some places with mosquitoes as the target species may have helped reduce the numbers of gnats. Comments from people ranged from "no gnats" to "more than usual".

Our challenge in the Tooele Valley MAD will be to isolate specific larval sites, observe emergence, and learn more about the biology and capabilities of this pestiferous insect. Experimental control has been done by Rees and Winget (1970) and others, and some actual control was done by the Salt Lake City MAD at the Salt Lake Refining Company in 1948-52. Because of stricter pesticide laws, cost, and a greater degree of desired control, we are somewhat shackled to produce an immediate control program in Tooele County. Be it understood that our sights are set in that direction where some control will eventually be developed in the County. We must have the cooperation of Valley residents and hope that they will be patient as we learn more about this and consequent control measures. The problem must be further researched and surveyed.

As a closing thought, it should be brought out that the crux of our problem is in the springtime. About one-third of our positive sources occur from March through May and are generally 10 or more acres. Although we have more places producing larvae in the summer, very few are larger than one acre.

After completing two seasons of mosquito control with the Tooele Valley MAD, it is apparent from our past that the future looks good. As we become more and more familiar with the territory, that light at the end of the tunnel grows bigger and brighter.

## LITERATURE CITED

Rees, D.M. and R.N. Winget. 1970. Current investigations in Utah of the biting gnat *Leptoconops kerteszi*. Mosq. News 30:121-7.

# MOSQUITO CONTROL IN LOGAN, UTAH

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In July of 1978 the mayor of Logan announced that funding had been approved for mosquito control in Logan City. I was given the opportunity, or challenge, to develop and operate the program.

Historically, mosquito control in Cache County has been, and still is, somewhat controversial. Nevertheless we proceeded to program for mosquito control. The preliminary survey work that had been done in previous years was used as a basis for procedures.

Having some prior knowledge of the Logan area and access to the survey information, I began larval studies and mapping of breeding sources. Daily light trap collections were taken for assessment of adult activity.

When a source was found it was treated with 2% parathion granules at a rate of 2 lb/A. Adult populations were treated with a Leco fogger using 3 oz. of malathion ULV per minute.

Public relations and educational activities will be used to develop an awareness of, and individual responsibility for, mosquito control. We are preparing a slide presentation and lecture that will be available to schools, service clubs, and other organizations.

We hope to be able to offer some mosquito control services to the neighboring communities next season with the intent of eventually extending service to the whole county.

## TITLES PUBLISHED ONLY

"Flies and Flowers," Robert E. Elbel, University of Utah, Salt Lake City, UT

"Waterfowl Management and Mosquito Control," Jack R. Fowler, Sacramento-Yolo MAD, Sacramento, CA

"Water Management Problems on the Great Salt Lake Marshes," Lee Jenke, Westside Gun Club Association, Salt Lake City, UT