PROCEEDINGS AND PAPERS

of the

THIRTY-SECOND ANNUAL MEETING

of the

UTAH MOSQUITO ABATEMENT ASSOCIATION

held at

Little America Motel
Salt Lake City, Utah

October 14 – 17, 1979

edited by

BETTINA ROSAY

and

GLEN C. COLLETT

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RESOLUTIONS

WHEREAS, the Utah Mosquito Abatement Association has held its 32nd annual meeting at the Little America Motel, Salt Lake City, Utah, October 14 - 17, 1979, and,

WHEREAS the Tooele Valley Mosquito Abatement District has served as host for the organization, and,

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

THEREFORE, be it resolved that the UMAA extend sincere appreciation to the Tooele Valley Mosquito Abatement District, its Manager, Board of Directors, and to all others concerned with the success of this convention.

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

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

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

WHEREAS, we were privileged to have in attendance Glenn Stokes, President of the American Mosquito Control Association from Metairie, Louisiana, and Donald Murray, Executive Director of the American 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 conference.

WHEREAS, Lewis Fronk, Manager of the Weber County Mosquito Abatement District, who was seriously injured in an automobile accident, and,

WHEREAS, he has contributed greatly to the UMAA, serving as a Director for many years, and,

WHEREAS, he was unable to attend the 32nd annual meeting of the UMAA,

THEREFORE, let it be resolved that the UMAA extend its appreciation and sincere thanks to him for his dedicated service and that he was greatly missed in this year's conference with hope that he will be able to return in the future.

WHEREAS, Keith Wagstaff has served with distinction and devotion to the UMAA as its president for 1978 - 9,

THEREFORE, let it be resolved that the UMAA extend appreciation for his excellent service to the Association.

WHEREAS the Little America Motel in Salt Lake City has provided beautiful facilities and excellent food and services, and,

WHEREAS, the banquet was of outstanding quality,

THEREFORE, let it be resolved that the UMAA express appreciation to Little America for contributing to the success of the 1979 meetings.

WHEREAS, the Contributing Members have provided financial support and information about their products as well as displays,

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

J. Larry Nielsen, Chairman
Dennis Kiyoguchi
Rex Passey

CONTRIBUTING MEMBERS

American Cyanamid Company . . . . Princeton, NJ
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DR. F. JAMES SCHOENFELD, DVM
1979
AWARD OF MERIT

Dr. F. James Schoenfeld, State Veterinarian and Director of Animal Industry, Utah Department of Agriculture was selected as recipient of the "Award of Merit" from the Utah Mosquito Abatement Association for his great interest, support and contributions to mosquito control in the state.

Dr. Schoenfeld was born in Salt Lake City, February 10, 1918. He received his Bachelor's Degree from Utah State University and his Doctor of Veterinary Medicine Degree from Colorado State University. He served as Deputy State Veterinarian, a member of USU staff and established a large animal practice in Roy, Utah before becoming State Veterinarian in 1968.

He has been an active member of the Utah Veterinary Medical Association, serving as president and member of the board of directors. He has been president of the Western States Regulatory Veterinary Association, president of the U. S. Chief Livestock Sanitary Officials, and a member of the board of directors and chairman of the Diseases of Sheep and Goats Division of the U. S. Animal Health Association.

Dr. Schoenfeld has presented papers at numerous Utah Mosquito Abatement Association meetings. Through his effort the State Department of Agriculture has participated in sponsoring the encephalitis surveillance program conducted by the UMAA.

The UMAA is sincerely grateful for the role Dr. Schoenfeld has played in furthering the efforts of mosquito control in the state and extend appreciation for his participation in the association.

PROCEEDINGS OF THE THIRTY–SECOND ANNUAL MEETING OF THE UTAH MOSQUITO ABATEMENT ASSOCIATION

The thirty-second annual meeting of the Utah Mosquito Abatement Association convened at the Little America Motel in Salt Lake City with Keith Wagstaff presiding at the opening session. The welcoming address was given by William E. Dunn, Salt Lake County Commissioner and Trustee of the South Salt Lake County Mosquito Abatement District.

MOSQUITOES, MANKIND AND THE ENVIRONMENT

Thomas D. Mulhern (retired)
American Mosquito Control Association
Fresno, CA 93727

Mosquitoes, frail and delicate, some beautiful, others carriers of diseases that may be lethal to man, were here when the dinosaurs roamed the lush, green world. When, why, and how did the mosquitoes evolve? Where is the earliest dependable evidence dating their origin? What is their preordained role in the Great Scheme of Things?

Natural enemies abound, dry periods cause the pools to disappear, but the mosquitoes somehow manage to avoid destruction. How do they do it? "Superior Man" has directed his most potent chemicals and best technology against them but the mosquitoes persist. When man has run his course and perished from this earth, will the mosquitoes still be here?

Almost daily we are bombarded by predictions or implications that if man continues at the present rate to increase his per capita use of exhaustible resources upon which life depends, and to produce enormously increasing quantities of wastes -- some persistent and toxic -- eventually he may bury or destroy himself -- if the great radiation holocaust does not occur first! BUT I STILL HOLD TO MY OPTIMISTIC BELIEF THAT DEDICATED SCIENCE AND TECHNOLOGY COUPLED WITH GOOD SENSE AND GOODWILL BY MOST OF THE PEOPLE IN THE WORLD WILL PREVAIL, AVOIDING DESTRUCTION.

The mosquitoes must not be taken lightly; their reproductive potential is astounding. For example, Dr. T. Miura of The University of California has shown that the numbers of eggs of the irrigated pasture mosquito may be as great as 50,000 per square foot in the more suitable areas of the pastures (substantially greater than the average rate over an entire pasture). Other observations indicate that it is possible to have 15 to 20 irrigations in a single season, though 10 to 12 is more common, and each irrigation may produce a new brood of mosquitoes. Assuming 10 generations, and that each female could deposit at least 200 eggs of which 50% would be females, and that each female would survive long enough to deposit her eggs to initiate the next generation, and that there were no natural or induced mortality, the offspring from *each* first generation female theoretically could reach 100 quintillion for the 10th generation!

TABLE 1

Generation	Number of female offspring	
1	100	one hundred
2	10 000	ten thousand
3	1 000 000	one million
4	100 000 000	100 million
5	10 000 000 000	10 billion
6	1 000 000 000 000	1 trillion
7	1000 000 000 000 000	100 trillion
8	10 000 000 000 000 000	10 quadrillion
9	1 000 000 000 000 000 000	1 quintillion
10	100 000 000 000 000 000 000	100 quintillion

Calculated numerical progression in numbers of female offspring from 1 female *Ae. nigromaculis* mosquito in one season of 10 generations, assuming perfect reproduction conditions, no mortality of females prior to depositing their eggs, and that each adult female lays 200 eggs, half of them female. (In nature, losses due to physical limiting factors and biological enemies always greatly reduce all the numbers successfully completing a life cycle).

Note that under perfect conditions, each generation theoretically would have more offspring than all of the previous generation added together. Obviously no such progression is possible in nature because of the natural destruction by physical influences and by biological enemies; also, should numbers of that order occur there would be neither space nor food enough for the developing mosquitoes. However, when one considers the increase theoretically possible it is not surprising that intolerable annoyance can occur within a few weeks with an enviroment favorable for the mosquitoes, if control measures are ineffective.

HARMFUL EFFECTS OF MOSQUITOES

Much has been written documenting the enormous damage done by mosquitoes and mosquito-borne diseases: morbidity and mortality of humans, domestic animals, and wildlife; reduced productivity of labor; lessened property values; costs of providing for control; etc. These effects are well understood, so will not be described further here. However, one may accept that where pest mosquitoes are unduly numerous, the human life style will suffer proportionally, and where the mosquito population includes considerable numbers of species that are vectors of human disease, the ill-health risk to mankind increases dramatically. (For example, worldwide, the increase in malaria has been enormous in recent years since the more effective vectors have acquired resistance to residual spray chemicals). Nevertheless, enormous numbers of human lives were saved or made more productive as a positive result of the "Insecticide Era", before shortcomings of the insecticide program surfaced with extensive repetitive use and accumulated exposures. Fortunately, during this period, other control technology has substantially increased, giving promise that control can be restored as more "comprehensive" or "integrated" control measures are applied. (Table II)

ARE MOSQUITOES GOOD FOR ANYTHING?

Within the total environment, various beneficial factors have been noted:

1. Pollination of certain plants (see paper by Dr. L. T. Nielsen in National Geographic, Sept. 1979).

2. They may be part of the natural food chain of minnows and other small fish, both salt marsh and fresh water varieties. Much of the mosquito control by ditching of salt marshes is effective because the fish gain access via the ditches to the pools and other water-holding depressions where mosquito larvae and pupae develop. On the upland, in fresh water areas, clearing the shallow margins of ponds and streams of obstructing aquatic vegetation exposes developing aquatic stages of mosquitoes to predation by the freshwater larvivorous fish, and also to predatory aquatic insects.

3. Adult mosquitoes are taken in considerable numbers by dusk- and night-flying birds and dragonflies, but this

probably is not an essential part of the food of the predators.

4. Spiders entrap large numbers of adult mosquitoes (and other insects) in their webs, thereby adding to their food supply.

5. There is great concern that the human population explosion may in the forseeable future outstrip the world's capacity to produce sufficient food to sustain the increasing population, and it is acknowledged that wars, starvation, misuse of drugs, and that mosquito-borne diseases (particularly malaria, one of the world's greatest killers) tend to limit human population increase. However, I cannot accept the premise that any of these are desirable. I prefer to have confidence that scientific agriculture and aquaculture can increase production of food and fiber--albeit to do so will require that more scientific effort be diverted from destructive war-related projects to constructive food production.

6. Mosquitoes are useful as bioassay animal subjects in testing toxicity of chemicals and pesticides, and as convenient subjects for accelerated genetic research because mosquitoes have many life cycles in a short period of time.

7. Where mosquito populations and annoyance are intolerable, there is enhanced appreciation of the benefits obtained when effective mosquito control is implemented.

In the opinion of this author, none of these factors justifies allowing mosquitoes to develop in sources from which they may infest areas where people live or work or play.

MOSQUITOES AND MAN'S ENVIRONMENT

Webster's Unabridged Dictionary gives a short definition of "environment" as simply "surroundings", and a much more adequate definition for our understanding:

"Environment: all conditions, circumstances, and influences surrounding and affecting the development of an organism or group of organisms". Note that these definitions impose no limitations of space, time, or whether the factors are beneficial or harmful. To discharge our primary responsibility in serving the public, probably we must add our own qualifications and in each instance must apply the technology from our entire armamentarium of the control measures (see Table II) that can be best integrated with the primary land and water use of the landholder, in a fashion that will minimize mosquito production to protect the public, while also being most acceptable or beneficial within the primary land use objectives.

The environmental requirements for life of man and the mosquitoes have certain essential similarities; each needs water, food, shelter, and living space. The details may vary greatly, but in principle, the similarities persist. Without these four elements, the mosquito and man would, and sometimes does, perish.

The mosquito cannot change its environment, it can only seek a suitable local environment, and it exhibits great instinctive skill in doing so. In this it is somewhat similar to primitive man and to the nomads of undeveloped regions. This contrasts sharply with modern man. Wherever he settles, he changes the environment in his home, where he works, or where he plays, by employing artificially produced heat, cooling, water supply, processed foods, and artificial rain (irrigation). In the doing, all too often he inadvertently creates local environments suitable to the mosquitoes: ponds, lakes, ditches, liquid waste accumulations, carelessly deposited containers, and other water-holding items. Although mosquito species originated in natural sources, many have exhibited easy accomodation to substitute sources provided by man. Thus we note that in undeveloped areas, primary mosquito sources tend to be of natural origin, but as man takes control, a pronounced shift to man-made sources occurs. A corresponding shift in mosquito species may also occur, which in turn may demand a matching shift in control measures.

The ongoing challenge that must be met is thus one of insuring that the environment for man shall not be severely degraded by mosquitoes; and the environment for mosquitoes must be made untenable for them, without severely damaging other valuable tenants of the same environment.

Fortunately, we do have sufficient technology available to neutralize most mosquito sources and to substantially reduce most mosquito populations. Ongoing research promises to yield even more effective and more economical technology, so it appears that we may for the forseeable future assure the citizens that operational mosquito control continues to be practicable and in accord with the maintenance of a favorable environment for them.

Table II – Elements of comprehensive mosquito control performed by mosquito control agencies.

COMPREHENSIVE CONTROL (A–F)
Inclusive of all known control methodology as applicable

INTEGRATED APPLICATION (B–D)

NATURALISTIC CONTROL (A–C)
Abets natural limitation through selective use of biological and physical factors similar to those found in the natural environment

TEMPORARY CONTROL (D)

A. Natural Population Limitation

Biological factors:

Predators	Pathogens	Food productivity
Parasites	Detrimental plants	Competitors

Abiotic factors: (physico-chemical factors of the environment affecting mosquitoes, their enemies, or habitat)

Rainfall and runoff	Temperature	Sunlight and shade
Percolation	Salinity	Turbulence, currents, waves
Humidity	Alkalinity	Nature of soils substrate
Evaporation	Acidity	

B. Biologically Oriented Control

- Manipulation of living organisms to destroy or limit mosquitoes at all stages
- Environmental practices aiding populations of mosquito enemies or increasing their effectiveness
- Genetic manipulation

C. Physical Control (Source Reduction)—Elimination or Modification of Breeding Places

Water Management
- Drainage
- Impoundment
- Contour design
- Reuse
- Organic solids removal

Regulation
- Circulation
- Flow and exchange rates
- Levels and depth

Land preparation and management
- Filling
- Grading
- Drainage

Crop selection and management

Weed control

D. Chemical Control

- Ovicides (not usually practicable)
- Larvicides (small areas treated to protect large affected areas)
- Pupicides (infrequently applied)
- Adulticides (particularly useful in emergencies and in areas of chemical resistance by larvae)
- Repellents
- Growth regulators, physiological inhibitors
- Attractants (with other procedures)
- Weed Control

E. Mechanical Barriers

- Screening of buildings
- Temporary barriers as bed nets and mosquito-proof clothing

F. Landholder Motivation to Cooperate

- Public information and education
- Individual persuasion and cooperative efforts
- Legal action and enforcement
- Interagency cooperation

FROM: Training Manual for California Mosquito Control

DEVELOPED BY: Vector Control Section
California Department of Health

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Visalia, California 93277

PROPOSITION 13 AND VECTOR CONTROL IN CALIFORNIA

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On June 6, 1978, the voters of the State of California passed Proposition 13, a property tax reduction measure. There were many different reasons why supporters of Proposition 13 voted for it. This measure reduced local property tax by 60% and most local government revenue by 60%, including mosquito and vector control districts. We were fearful that our public health programs in vector control would not survive. However, one of the reasons Proposition 13 passed was to come to our rescue. There were seven billion dollars of excess tax money in the State Treasury.

When Proposition 13 passed, the State Legislature hastily passed laws that allocated this seven billion to offset the loss of revenue to local government. This money was given to the counties to be distributed by the County Board of Supervisors within certain guidelines. This money was distributed by the Board of Supervisors mandatorily to fire and police districts first and other agencies second. Mosquito and vector control agencies fared badly in this state allocation to local government.

Mosquito and vector control agencies suffered an $8,087,591 cutback in revenue due to Proposition 13. This was feebly offset by state allocation of $1,426,210 that was given to only 12 of 45 mosquito and vector control agencies. Therefore, we were faced with a very drastic cutback in manpower and services.

It was at this time that the California Mosquito and Vector Control Association decided, after consultation with legislators and our lobbyist, to take politcal action to preserve the integrity of our operations. The C.M.V.C.A. formed a task force to determine what action should be taken. The recommended action was to introduce legislation to have the state provide ongoing subvention monies through the State Health Department. This choice was made because the subvention mechanism is existing in statute and because the precedent had been set in the 1940's, '50's and early '60's by subventing most of the districts in the state to get them started.

We enlisted the help of State legislators, County Boards of Supervisors, local health officers, and anyone else we could get. We had eight legislators sponsor a bill for subvention of our local programs. This bill was heard by three legislative committees and at the fourth and final committee, it was stalled. The Governor had sent word that he would not sign the bill if it contained an appropriation in it. He also said he was tired of receiving letters, telegrams, and other information about mosquitoes and other vectors and not to send him anymore. So as it stands now, our subvention bill is still alive waiting to go over the final hurdle when we convince the Governor that vector control is important to support.

Also occurring at this time was a proposal to cut the Vector Biology and Control Section of the State Department of Health Services by 60%, which would mean a reduction from 48 to 20 personnel in this section. The philosophy behind the cut was that nuisance mosquito species, such as *Aedes nigromaculis* should not be controlled, diseases with low numbers of human cases, such as plague, would not be kept under surveillance but only handled in an emergency, and the section would concentrate only on disease-carrying mosquitoes and emergency situations.

As you can see, the concept of prevention in mosquito and vector control in California was being scrapped. Needless to say, people in mosquito and vector control in California were downhearted and dispirited.

The California Mosquito and Vector Control Association fought the reduction in the State Vector Biology and Control Section. We contacted our local legislators and legislative committees so that they would look into this matter. We also had a bill introduced that would establish the Vector Biology and Control Section in statute as well as establishing the functions. The legislative committees recommended to restore the cuts in the Vector Biology and Control Section, however, the Governor resored only 4 of the 28 positions cut. Our bill that established the Vector Biology and Control Section passed almost without opposition.

The results from Proposition 13 in terms of manpower indicate only a 10% reduction in permanent personnel and a somewhat higher percent loss in seasonal personnel. This is an average figure. At least two districts suffered a 60% reduction in permanent personnel. Mosquito control districts in California have an average of 13 permanent personnel and 13 seasonal personnel. Permanent personnel include a manager, secretary/bookkeeper/receptionist, and 10 or 11 vector control technicians. There is not much administrative fat; therefore, when we have a loss of revenue, a technician is laid off, which reduces the amount of work performed.

In terms of funding, the picture is also quite variable. Some districts are receiving bail-out money this year and others are not. We do not have the data available to report on the latest bail-out figures and which districts may have received them.

Proposition 13 has caused the serious investigation of consolidation of neighboring districts in the same county. In one case the possibility looks very good for consolidation.

As the result of all the input into the legislature and the Governor, the legislature initiated a task force to study the delivery of local vector control services and to come up with recommendations on any changes that should be made. The recommendations of the task force will be made to the legislature by January 1, 1980.

This sums up a long, arduous year of activity for our Association. From this experience several important experiences have been reinforced and should be stated.

1. Mosquito control agencies have traditionally been out of the mainstream of political action, removed from the political limelight, and this is as it should be. However, I believe that mosquito control districts have the obligation to let their local and state legislators know of their existence and the work they do. Minimum contact should be made with each legislator during the year, such as sending out annual reports or having open houses.

2. Trustees/Commissioners are very helpful in the political arena. They are influential people in the community and have access to local legislators. They can be of immense value and support to mosquito control districts in time of political turmoil. I believe we have not used trustees to the full advantage of the districts.

3. Statewide mosquito control associations that represent mosquito control agencies should have a lobbyist if for no other reason than to provide them notice and information on legislative bills that might affect district operations. In the California experience we have had a lobbyist for about five years. He started out by monitoring legislation and has evolved to proposing, writing and getting legislative sponsors for legislation for mosquito control agencies. Without the help of this lobbyist we would have been lost within the confusing pathways of the legislative process.

We have been working on a proposal for self-insurance for our agencies for three years and Proposition 13 finally forced us to move. We formed an entity called the Vector Control Joint Powers Agency, composed of 26 mosquito control agencies, that will administer insurance programs for our agencies. As of August 1, 1979, we had 26 of 47 agencies within the program self-insured for worker's compensation. In 1978, our Districts paid $375,000 premium in Worker's Compensation Insurance. In 1979, the Districts will pay the same premium to the Joint Powers Agency who will in turn purchase a policy for all the agencies for approximately $28,000. The difference will go into a fund and will receive interest of approximately 10%. On September 1, 1979, the Joint Powers Agency intitiated a multiperil policy for each agency with an average 40% reduction in premium. We estimate that within five years the interest from these funds will generate enough revenue to pay the premiums and that the Districts will have to pay no premiums for Worker's Compensation Insurance and possibly Multiperil.

INTEGRATED PEST MANAGEMENT — LIP SERVICE OR DEDICATED APPLICATION?

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The American Mosquito Control Association, at its 1979 Conference at Washington, D.C., approved officially a "Policy Statement on Mosquito Control". This was reproduced in the May, 1979, AMCA Newsletter. The Statement said that AMCA "advocates management of mosquito populations by means of integrated programs designed to benefit or to have a minimal adverse effect on people, wildlife, and the environment". One reader, a professional entomologist, wrote to the Central Office, essentially praising AMCA for developing this policy, but seriously doubting that it would be applied in a dedicated manner by most mosquito control agencies. The letter inferred that insecticide programs in vogue would continue without significant change, and that a major trend to other methods of control would be slow in coming. "Unfortunately acts of many agencies are performed without due regard for the basics." "Too frequently good intentions are more honored in the breach than in the observance."

Are these unfairly critical remarks, or are they statements based on a knowledge of what is going on? As Executive Director of AMCA I receive queries and comments from various areas relative to mosquito control.

A news clipping from Franklin County, Ohio, states "Health officials worry that mosquitoes in the county have become immune to the insecticide the county has used for 10 years to eradicate the pests during its summer fogging program."

A statement and a query from a large city: "The city of - - has been carrying out fogging exercises on an annual basis in attempts to eliminate mosquitoes. Can you provide any information which could be of value to officials in permitting a rational decision to fog the city based upon hard facts and figures?"

In a state where there is no recorded organized mosquito control agency, a letter from a person heading a committee to see what can be done to control mosquitoes comments: "Your advice is solicited on what chemicals to use, how to use them – spray or liquid – and when to use them . ."

Several years ago I heard the report that in the residential areas of cities in one of our states mosquito control was contracted between the people and one or more commercial agencies, and the *only* type of control considered was aerosol of the residential areas.

The Directory of Mosquito Control Agencies, published by AMCA in January, 1977, shows the total acreages treated with insecticides in 1975 by all agencies in the United States and Canada:

larvicided: 4,713,845
adulticided: 30,488,988

While agencies which report extensive adulticiding may carry on an active source reduction program, it is obvious that expenditures for adulticiding have no direct effect on mosquito sources. Larviciding at least identifies the sources and can direct attention to their reduction or elimination. The acreage for all agencies indicates that adulticiding covered 6½ times more acreage than larviciding.

The record for Utah:

larvicided: 169,600
adulticided: 118,700

Thus larviciding covered 1½ times more acreage than adulticiding.

The record for California:

larvicided: 882,439
adulticided: 331,659

Thus larviciding covered 2½ times more acreage than adulticiding.

The record for Delta Vector Control District

larvicided: 80,000
adulticided: 5,000

Thus larviciding covered 16 times more acreage than adulticiding. I would add that in 1978 and 1979 adulticiding in the Delta VCD was almost nonexistent.

Most of us are aware today of control agencies which place emphasis on insecticide use and which are unwilling to take a hard look at IPM. With this background of information, is it any wonder, then, that a professional entomologist has questioned the will of mosquito control people to dedicate themselves to a total program of IPM?

The IPM road can be rough! Several years ago I presented a talk to the Utah Mosquito Abatement Association about the dilemma of the Delta Vector Control District, the agency which I managed for over 31 years. All known and available insecticides had become useless against the pasture mosquito, *Aedes nigromaculis*, because of mosquito resistance to them. We had had a full-time source reduction program for over 20 years, and we had reduced many minor, low priority sources. I was determined that our mosquito sources, almost entirely artificial, the result of man's inadequate water management, could be corrected, but I was equally certain that this would require much dedicated pressure. I foresaw that the pressure would include especially direct eyeball-to-eyeball contacts with those who produced the mosquitoes. To a great extent the mosquito production was the result of a low priority placed by the mosquito producer on mosquito importance and on careful attention to water use. Our District staff began making the eyeball-to-eyeball contacts. Many growers improved their irrigation practices, but many were still not convinced, so we called some of them in to Board of Trustee hearings. These hearings were essentially educational sessions. A grower, facing 7 or 8 citizen Trustees, most of whom were farmers or farmer-oriented, was in no position to reject the appeals of the District or to get angry. Under the social pressure of the situation he would begin to understand as he had not done when our staff contacted him on his own property.

When I gave my talk on this approach to the UMAA several years ago, there was one person in the audience who objected strongly to my philosophy, stating that his district would never subject its farmers to such abuse. In my opinion our District did not abuse any farmers, but it certainly did pressure them. I ask the question: "Are people inherently respectful of or concerned about the rights of others?" The best illustration that they are not may be found on today's highways, where even on crowded freeways most cars exceed the posted speed limit, and many play the lanes as though they were football halfbacks playing a fun game, even though the stakes frequently are accidents and sometimes death. Yet a patrol car in evidence will slow the pace, sometimes resulting in an unbelievable number of cars stacked up to the rear, waiting impatiently for the patrol to move off so they can resume their illegal and irresponsible ways.

Many teachers today are disenchanted with their profession. Students these days are raised in a permissive society, and some of these permissive do-gooders have convinced the school authorities and legislators that we succeed by love, not by controlled guidance. My teacher friends know something has gone wrong, and many cannot wait to get out of their profession or retire. Frankly, a child respects a parent who provides guidance and reasonable control. A child loses both respect and love for a parent who does not provide guidance along with control.

Of course we do not want Hitler-like or communist dictatorships. If we make the right approach, people will usually go along. Where the public health and welfare are involved, the use of legal provisions may be helpful or necessary, but in the Delta VCD we achieved our goal by dedicated social pressure, not by attorneys and bona fide court cases. The pudding has now been eaten and has proven good. Mosquito spraying of field sources has been reduced by about 95%, and at the same time there has been an almost complete absence of pasture mosquitoes produced inside the District. This has been true even in 1979 under the financial stress of Proposition 13.

Our story would not be complete without noting a new problem and how it is being handled with the same difficult but satisfying IPM approach. During the 1970's Tulare County moved from an important dairy county to the greatest producer of milk of any comparable region in the world. Most of this increase was the result of the forced movement of all agriculture, including dairies, out of the Los Angeles basin. As the new breed of dairymen settled in Tulare and adjacent Kings Counties, they did things in a big way, many milking 500 to 2,000 cows. They built high, graded corrals for good drainage. The dirt for the corrals was taken from a large, deep pit, which in turn became an ideal place to dump the large amount of wash water. Not only was water used to wash the cows and the milk barn, but also the feed lanes. As much as 40% of a cow's wastes each day was washed into the pit – or holding pond. Most pits were at least 100 feet wide, 400 feet long, and 30 feet deep. Once the dairyman had discharged the manure-laden water into the pond, he usually gave it no further thought until he was forced to pump it onto adjacent land to avoid a flooding dilemma. Weeds covered the banks and spread out onto the water, creating an unusually favorable breeding source for the house mosquito, *Culex pipiens quinquefasciatus*. Manure floated to the surface of the ponds, making floating islands. Seeds of water grass, cattails and other weeds sprouted on these islands, and a weed mat several feet thick was created. The islands were interlined with open cracks, again providing prime breeding areas for the pollution-loving house mosquito.

Certainly the mosquitoes fed on the dairyman's cattle. They also fed on him and his family during the night. But they did not stay on the dairy. Because of the tremendous production, with larvae frequently 1,000 and more per dip, sheer population pressure resulted in dispersal for up to 5 miles in all directions. I observed counts of 50 adult females on the outside of my screen door on some mornings, yet there is no dairy within 2 miles of my house. There are several dozen within 5 miles.

Mosquito control on the small dairy ponds of the 1960's was carried out with Baytex and, when it became available, with Dursban. Dursban was very effective in polluted water, and when introduced as a "slug dose" at the head of the ponds was effective for a month or more. Two items changed the District's control capability: 1) the tremendous size of the ponds required such a large amount of Dursban that the cost became excessive, and 2) the house mosquito developed high resistance to Dursban.

At this point the need to consider IPM was more than evident. As with our pasture mosquito control program, our backs were against the wall. Fortunately, there was one outstanding dairy available to us for inspection which provided basic answers to our problems. The dairyman during the winter had sprayed the banks with a soil sterilant, and in the summer he took care of the minor weed growth with contact weed killer. To prevent the excessive amount of manure solids from entering the large pond, he used a small pond to accumulate the solids for one or two weeks, allowing only water to filter through to the large pond. Then he pumped and flushed the solids from the separator pond into his irrigation system where this excellent organic fertilizer was distributed over his fields. The large pond contained lots of water, but the clean banks and absence of floatage provided nothing suitable for mosquito breeding. The small pond was never permitted to stagnate and become a breeding source. No insecticides whatsoever have been needed on either of these ponds From this basic pattern we were convinced that dairies could use all the water they wished or needed to use and not produce mosquitoes. We needed to take two steps in our IPM program: 1) to educate all dairymen to recognize the value of using the manure and water on a continuous basis, and thereby to establish a workable system of manure separation, storage and removal, and 2) to provide as much social and, if need be, legal pressure to encourage the dairymen to assume their proper responsibilities to society. Fortunately, these dairymen are intelligent, hard working people. They have responsibility for multimillion dollar establishments. Basically they have been cooperative, once we show them what can be done. Up to the present time there has been no need for citations before the District Board, but we have had to be patient with some of them. Emphatically they are not negative to our program; in most cases where there have been problems to us they have simply been uninformed or perhaps thoughtless.

Before new dairies can be established today in Tulare County they must be approved by the County Planning Department. That Department submits all plans to the District for approval, and as a result all new dairies have manure separator systems. Thus our major problems today are with the large number of presently constructed dairies which do not have such systems. However, during 1979 there has been sufficient improvement in the dairy drain ponds that almost 1/3 of them did not have to be sprayed, a great savings in insecticide and labor costs, and yet with much better mosquito control.

It is obvious that mosquito control agencies must move towards water and land management if they are going to achieve relatively permanent control of mosquitoes. But now more than ever we face high level political problems. Environmentalists years ago began complaining about insecticides, and they have continued to increase pressure to reduce and even prohibit their use. More recently these environmentalists have been raising objections to physical changes in natural water and land areas. Rare plants and animals, some on the verge of extinction, become more valuable than our energy supply, our physical safety from flooding, or our health hazards from pestiferous and disease-bearing mosquitoes. The EPA, Army Engineers, OSHA, Fish and Wildlife, and other Federal agencies have been creating rules which ignore our needs and which prevent us from carrying out an IPM program of protecting the health of the citizens of this country. There are also State and local agencies which create the same havoc to our abilities to perform our health mission.

AMCA is planning to do something about this. A new position, entitled Extension Representative, has been established. As usual, we have little money to support this position, so we looked for a "young" retired person who does not command a high salary. We will pay expenses, and these may become appreciable. Richard F. Peters, recently retired from the position of Chief of the Bureau of Vector Control of the State Health Department in California, has been appointed to this position. One of his most important assignments will be to make contacts, by letter and in person, with legislators and agencies in Washington, D.C., to assure that mosquito control in the United States is kept alive, that Federal agencies are informed of our programs and needs, and that we step out of the defensive position we have experienced for many years and move into a positive, offensive position in our society. If we are to carry out a dedicated IPM program, we must be in a position of working on a cooperative basis with many arms of our government and with our society as a whole.

We must get out of the motherhood acceptance of IPM while failing to make a positive effort to make changes when needed. We must get away from a complacent insecticide program when we know that water and land management offer a more nearly permanent solution. We must get away from the philosophy that our job is to spray away the mosquitoes, or that our job is to provide personal service to everyone who complains about being bitten. Rather, we must think about mosquito sources and their total management – a total IPM approach.

INTEGRATED MOSQUITO PEST MANAGEMENT: FACTS AND FOLKLORE

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The concept of integrated pest management (IPM) has successfully emerged during the past decade as a significant advancement in dealing with management problems in agriculture and forestry. Although the concept is not new to applied entomology, philosophical discussions on the IPM approach in recent reports dealing with insect pest problems have almost reached a point of excessiveness. The concept has different connotations to different individuals. For the purpose of the present text, the term is used to denote the management of any pest with total available resources being used in a single comprehensive fashion with the objective of reducing the pest population below a defined critical level with minimal environmental impact.

A more critical definition of IPM as it relates to mosquito control programs was the subject of a panel discussion in the opening session of the recent 35th annual meeting of the American Mosquito Control Association in Washington, D.C. The content of this rather extensive discussion has been published recently (1,2,3,4,5), and should be referred to for a detailed summary on the conceptual aspects as well as a discussion of the various component parts.

With this background in delineating the definition and scope of IPM, I have prepared a list of common IPM "myths" and "folklores" and would like to take the time to comment on several of these: (A) The application of the concept is *not* new in dealing with outbreaks of infectious human diseases. The improvised manner in which the Bolivian hemorrhagic fever outbreak was dealt with had all the elements of an IPM program (6). For example, an intensive rodent population surveillance was employed and a critical threshold of infection level in rodents was determined as a basis to incorporate secondary control measures. (B) IPM is *not* simply the integration of biological, chemical and physical means of pest control. These measures are important components of IPM, but certainly not the sole basis for the concept. Among other things, a key factor is what the agricultural entomologist refers to as the economic threshold. The delineation of a critical pest population level as an integral part of the program objectives is essential for mosquito control programs. Estimates have been made for vector threshold level of mosquito vectors for western equine and St. Louis encephalitis in California (7), public tolerance levels to pest mosquitoes (8) and to economic threshold levels to pests of livestock animals (3). (C) IPM is *not* a single program appropriate for every instance and situation involving outbreaks of mosquitoes. Differences in management procedures can be cited in urban versus rural situations, natural versus man-made conditions, geographical variations, differences in cultural practices, *etc*. Even in specific crop systems, rice field mosquito problems in northern and southern Arkansas (Max V. Meisch, personal correspondence) differ as do fields in the Sacramento Valley from those in the San Joaquin Valley in California. (D) IPM is *not* a static, inflexible system, but a dynamic one. Transientness in the attitude of society with its ever-changing values (e.g., environmental concern) and crop management development (e.g., green revolution) are two examples of changes which ultimately affect practices in mosquito control. (E) IPM in mosquito control is *not* simply an entomologically oriented concern, but is dependent on social and political consideration that is obvious to many of you that have serious concerns or actually felt the consequences of Jarvis-Gann Proposition 13 and the second Jarvis Proposition in California.

To illustrate some of the points listed, I would like to refer to a study on a specific mosquito control strategy in which an operational plan was devised to alleviate the mosquito problem associated with rice culture in Colusa County, California (9,10,11,12,13). The plan was designed to contend with economic restrictions confronting many rural mosquito control agencies resulting from low population and low assessed evaluation as a basis for property tax, to cope with vast acreages of irrigated cropland as sources of mosquitoes. This scheme involved the strategy of applying low volume organophosphate larvicide to 30,000 acres of land primarily devoted to rice, three times during the summer to coincide with two larval peaks of *Culex tarsalis* and one peak in the late summer for *Anopheles freeborni* (Fig. 1). This strategy was predicated on two factors that are associated with most mosquito problem sites in the area. *First*, inspection and control of the target problem sites (e.g;, the rice fields), cannot be done economically on an individual field basis due to the magnitude of the total acreage. Since the two problem mosquitoes had been observed to occur at nearly the same time each year in three well defined peaks, it was speculated that coordinating area-wide insecticide treatment with these peaks instead of treating individual fields independently, might afford a better opportunity for success. Secondly, the rapidity and economy derived from the use of low volume technique would enable treatment of virtually the entire rice acreage, a task previously unattainable by the cost of more conventional means.

To assess the total impact of the three insecticide treatments, an intensive sampling regime was devised to follow the larval and adult mosquito and nontarget populations both within and outside the Colusa County MAD area over the entire summer period.

The first two treatments were aimed at *Cx. tarsalis* and resulted in a reduction of 87% and 77% of the larval population. In the third treatment aimed at the anophelines, a 93% reduction to a level less than 0.1 larva/dip was observed in the entire treated areas. In the untreated area during the same period, an increase of 54% to a level exceeding 1.5 larvae/dip was observed. Despite what appeared to be a somewhat impressive larviciding performance, evaluation of the adult anophelines by light trap and red box collections did show little or no reduction. Differences were not observed in the parity rates in the adult females from red box collections before and after the third application.

The results of these observations demonstrated the technologic and economic feasibility of treating large tracts of breeding sources (20,000 acres of rice + 10,000 acres of land area adjoining rice) within a large area (160 sq. mi.) over a short span of time (4-5 days) on three separate occasions to substantially reduce the mosquito larval population (87%, 77% and 93% of target species). This information is valuable since low volume technique has been considered strongly as a possible measure against epidemics of arthropod-borne disease and is also strongly considered where budget restrictions prevent a control program with a more conventional insecticide application procedure. The interpretation, however, on the more practical aspect of this study (i.e., specific benefits derived by the residents within the MAD) was quite different. A very substantial proportion of the mosquito larval population was killed in all three treatments, but a sufficient number of adult females infiltrated the treated area from the bordering uncontrolled rice field areas to prevent relief from the annoyances caused by the biting adult population. Therefore our conclusion was that the task of killing mosquito larvae was accomplished, but the real objective of the District, which is to provide relief from adult mosquito annoyances for Colusa residents, was not entirely achieved. The significance of this study goes beyond the problems of Colusa County.

Table 1 shows vital statistics of several California counties in relation to rice and organized mosquito abatement. Proportion of county land covered by MAD and total rice acreage varied considerably from one county to another. Note that from Group 1, Butte, Sacramento, San Joaquin and Yolo Counties all have 100% MAD coverage. Sutter-Yuba Counties have only 50% of their land area within the prescribed boundary of the MAD, but fortunately for the local citizens, 90% of the land devoted to rice culture falls within the District.

If larviciding success of Colusa County can be achieved in *these* areas (Table 1, Group 1), it might be speculated that in contrast to Colusa County, a substantial reduction in the adult population *might* have been observed.

In between, bordering and adjoining the previous six counties are the three counties in Group 2. Here also, considerable variation occurs in the rice acreage (i.e., from 8,000 to 126,000). The major difference is that MAD's such as the district in Colusa, are able to exert influence on less than 25% of the rice in the county. The problem becomes even more acute in Glenn County which presently has a MAD coverage of only 4.5 sq. mi. to control mosquitoes from 75,000 acres of rice in the County. In these counties, larval reduction approaching 100% (i.e., in the Colusa study) will *not* assure success in terms of real objectives (health and welfare of human population).

Group 3 is included because these counties do have little or no rice but must still suffer the consequence of mosquito problems emanating from rice fields (e.g., mainly due to the extensive flight range of the late summer anopheline females). These MADs are then examples where a Colusa-type larviciding project cannot even be considered since the major source of the problem may be many miles away from the district boundary in the next or worse, next *next* county.

Mosquito control or abatement must not be limited to operationally eliminating as many mosquitoes as can be killed and certainly the success of any MAD program cannot be gauged by the number or per cent of mosquito larvae eliminated. Operation-wise, 100% larviciding is not synonymous with 100% control of the problem as was found in Colusa.

From a research standpoint, all predators, pathogens or any new chemical larvicide has limitations under conditions encountered in Colusa (no matter how efficient). To undertake a realistic program under these conditions, any biological or chemical larvicide must be integrated *with other measures* for success. An alternative is to investigate control measures other than larvicidal. Am I advocating chemical adulticides? No, not necessarily, but I think the present usage of nonthermal adulticiding in Colusa County (Kenneth G. Whitesell, personal correspondence) is a more realistic approach to meeting the mosquito problems in areas such as Colusa.

Most items covered under control technology lead to 2 main factors regarding political-economic considerations. First is that physical gaps exist between political boundary lines of MADs, and if these gaps were eliminated, many of the existing larviciding measures (whether biological or chemical) would probably be considerably more effective. Therefore, if greater input in the districts' efforts in terms of total resources or time can be channeled into eliminating these so-called "twilight zones", would *not* the long-term benefits be well worth the effort? Are there any arguments on the comparison of, for example, the efficiency of a mosquito control program conducted on a regional or valley-wide basis versus the present program or districts on a piecemeal basis.

Another problem area in which Colusa has served as a model is more in the realm of socio-economic nature and would point to the mosquito problem (particularly the cost aspect) as an *externality*. Economists define externality as a consequence (good or bad) that does not enter the calculations of gain or loss by the person who undertakes an economic activity (14). It is typically a cost (or a benefit) of an activity that accrues to someone else. Air pollution created by an industrial plant is a classic case of an externality; the operator of a factory producing noxious smoke imposes costs on everyone downwind, and pays none of these costs himself -- they do not affect his balance sheet at all. In mosquito abatement, a rice field certainly is a classical example of externality. Solution in this approach to the mosquito problem would involve education and/or plans of either assessment or tax break inducements in relation to mosquito productivity emanating from the rice growers' economic activity.

Finally, how will mosquito problems and any formulated IPM programs be affected by projected trends of agricultural, political and economic factors in the coming decade? Reference will again be made to rice culture in California. A positive correlation exists between mean annual anopheline abundance and total annual California rice acreage in areas studied so that minimal rice acreage in the future would be more desirable from a mosquito abatement standpoint. Since much of the California rice is grown for export purposes and since peak rice acreage in the State coincides with crises in Asia (i.e., Korea in the 50's and Vietnam in the late 60's), continued political instability in Asia would be detrimental to us in ways which would include mosquitoes.

In California, agricultural economists tend to project greater production of rice but with less land devoted to actual planting of rice. This premise is based on the assumption that technological improvements in the future will improve yield sufficiently to actually increase total rice production despite a decrease in the acreage. This is a further extension of the green revolution and will most probably involve further manipulation of the fertilizer, herbicide and insecticide practices. As the complexity increases to enhance greater rice production, greater the need will be to integrate all of the practices into a single comprehensive system.

In conclusion, the application of the IPM concept for a mosquito control program carries forth several significant points that was clearly demonstrated in the rice field mosquito model from Colusa County. Mosquito IPM is the application of many time-tested old plus contemporary methods to control mosquitoes, and must be done so, however, with a fresh perspective that is consistent with new and everchanging values of society. The term IPM for mosquito control denotes true integration of biological, chemical and physical control, but with heavy emphasis on program objectives measured in specific terms of disease prevalence, public levels of comfort and economic benefits involving tourism and livestock production. IPM should not be a single program system for every mosquito situation but rather a flexible one unique to a given situation in a given geographic area. Finally, the holistic approach of IPM should focus on the social, political and environmental as well as the entomological concern of the mosquito problem.

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Table 1. Land Area, Rice and Mosquito Abatement Districts

	County	Land area (mi^2)	Land in MAD %	Rice (acres)	Estimated % Rice in MAD
Gr. 1	Butte	1,623	100	103,200	100
	Sacramento-Yolo	2,013	100	41,000	100
	San Joaquin	1,446	100	6,000	100
	Sutter-Yuba	1,252	50	107,500	90
Gr. 2	Colusa	1,156	13.8	126,300	22.5
	Glenn	1,322	<1.0	75,000	<1.0
	Placer	1,515	0.0	8,000	0
Gr. 3	Shasta	3,856	2.6	0	0
	Solano	901	100.0	700	0
	Tehama	2,985	15.4	1,000	0

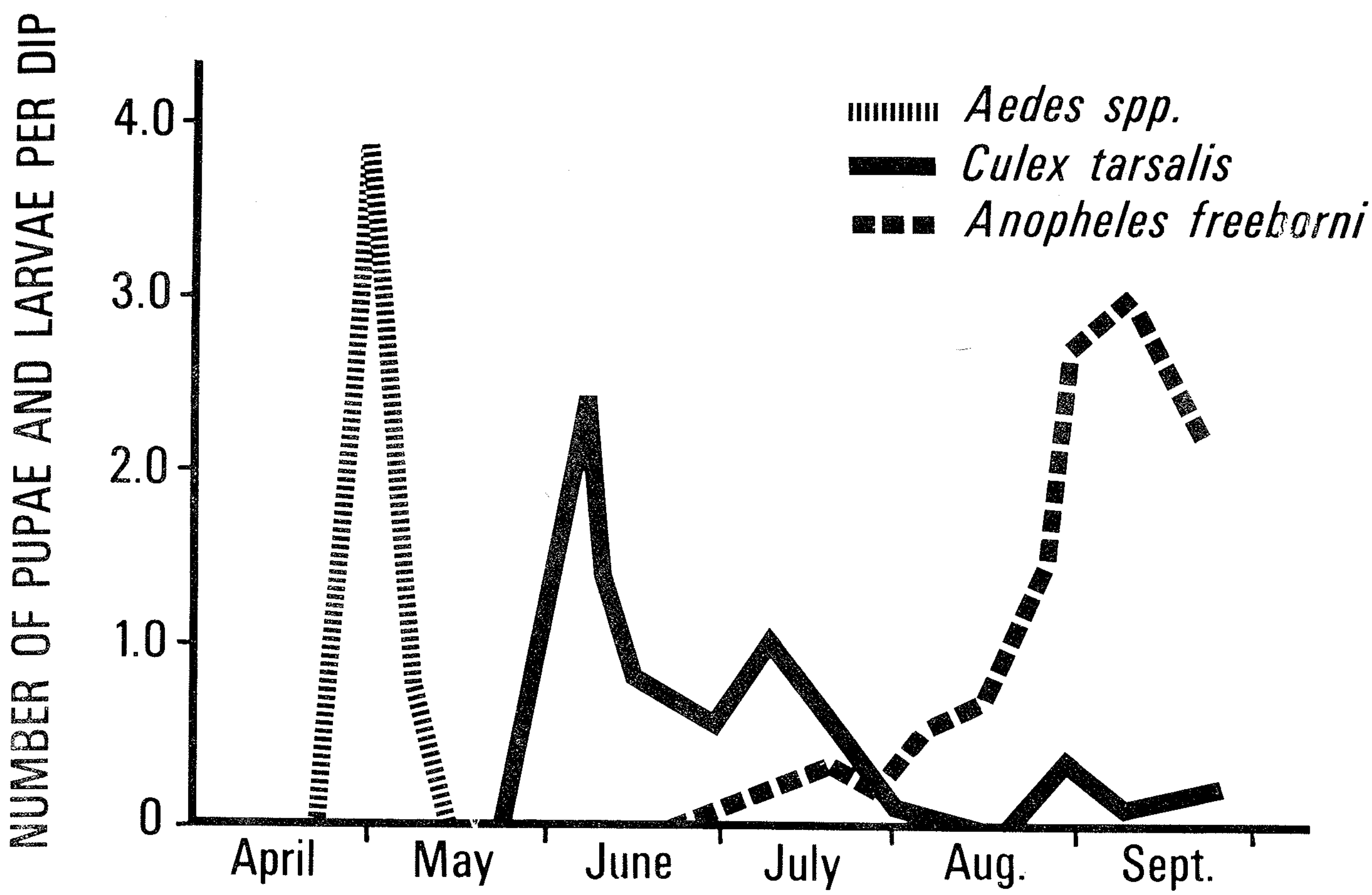

Figure 1. Semi–diagrammatic representation of the seasonal fluctuation in abundance of mosquitoes in California rice fields.

DRAINAGE DISTRICTS AND MOSQUITO CONTROL

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The great state of Utah comprises just under 53,000,000 acres. Of this, 1,138,000 are irrigated cropland now in use. Of this, only one-fourth really has an adequate and dependable water supply. At the present time there are many different projects such as the Central Utah Project that are working to improve water supplies and delivery systems.

In the State we have two major drainage systems. I am referring to the Colorado River which dumps eventually into the Gulf of California and the Bonneville System which comprises the Bear River, Malad, Ogden, and Weber Rivers. As you can see, in the State we have small streams and mighty rivers. The small and mighty waters are used to pick up the moisture necessary to sustain life. These waters vary from fresh to salty water, but all of it evenually creates drainage problems and mosquito habitat. The change that comes year-to-year in our drainage system, such as the Great Salt Lake which varies in elevation and changes the drainage around it, the same is also true with Utah Lake. The change in the water delivery down the Sevier River changes severely the mosquito habitat along its waterways. The nature of the soils and subsoils change considerably and change our drainage capabilities.

Utah is generally considered a desert land. Our rainfall varies from 5 to 60 inches in various areas of the state, with an average in our northern valley floors of about 12½ inches. There is produced annually about 53,000,000 acre-feet of water, but only about 5% of this total is used in producing crops through irrigation; 1% dry farm; 2% used by cities and towns; another 2% by industries; and only about 4.3% finds its way out of the State. Our biggest problem is getting and keeping water in the right places at the right time. Our inadequate drainage systems cause waterlogging in many areas and have resulted in causing unuseful land with many health hazards. But very little is being done to improve or develop drainage systems. Most of the work along this line is being done by the various mosquito abatement programs. Dennis Hunter, in working with me on some fact finding in connection with this paper, sent out a letter to the various abatement districts to find just exactly how much was being done in the way of managed drainage. What we found was very discouraging.

Utah County has the most drainage districts set up, and they are having some real problems. Weber County, through the mosquito abatement district, for example, has dug approximately 30 miles of drains since the district was organized. This is according to Lewis Fronk, Manager. Larry Nielsen in Box Elder County said there was no drainage district established, but they had done a great deal of drainage work as a district, especially over the last five years and were happy with the results. In Cache County, at one time there were six drainage districts operating, but most of these have now disbanded. Eleanor Murray reported that there were now over 1,100 miles of open drainage in West Millard County, that in the late 1920's nearly every farm in that area was drained by tile drains with at least one branch per 40 acres. These were so impossible to maintain that they have been abandoned. However, some are still functioning. They do have a 1¼% mill levy which amounts to approximately $24 per acre per year to help finance their drainage program. In Utah County, the four established districts have had their funds collected by the County in the past, but now funds are being turned back to the districts to make their own assessments.

In the last few years, we have had many Federal and State laws that affect the ability of the mosquito districts to do proper drainage work. I am referring to restrictions in herbicides for the control of water weeds, the concerns of wildlife habitat management, the health hazards relating to human life, 208 Water Quality requirements, etc. Let's look at how some of these things affect us.

In a discussion with Bill Geer, Biologist in charge of Resource Analysis for the Division of Wildlife Resources, we talked about the requirements of various streams, canals, and drainage ditches as to how they are classified into various types of fisheries, delivery systems, and how they should be managed. All the streams of any type in the State are catalogued and are on a computer printout and are classified in various classes from 1 to 6. The three main things that establish their classification are: the productivity of the stream for fish life, the availability to the public and private property, and the aesthetics of the area. For example, Provo River from the mouth up six miles is a Class 1 stream, is very productive, available to the public, and in a beautiful area. Below Olmstead it is a Class 2 fishery but still considered blue water. Most of the streams that are fished in the State come under Class 3, such as Big Cottonwood and parts of the Provo River. Powell Slough in Utah County, which has catfish, carp, and walleye, with some value for waterfowl production, is under a Class 3 and is possibly being considered for reclassification. Anytime that any mosquito control which requires herbicide use is applied, it should come under a close review to determine the cause and effect on fish and wildlife. There are some real concerns on who has full jurisdiction over any particular stream or drainage unit. As you know, the water, as well as the wildlife, is all owned and managed by the State. EPA now has some control through the 208 Water Quality Program, but the main health aspect of water management comes under the State Division of Health under the direction of Calvin Sudweeks with Environmental Health Services. When it comes to any physical change of any existing stream or canal, the State Engineer and the Federal Corps of Engineers would come into play. It is recommended by Mr. Geer that any treatment or change of a stream would be preceded by contacting the appropriate agency of the State or Federal Government. This review in advance would require a minimum, I would say, of two to three weeks.

Acquaint yourself with Utah Criminal Codes and the State Water Quality Act that has jurisdiction. The only financial benefits that I could find to help improve drainage comes under ASCS Cost Share for the improvement of ditch lining, land leveling, piping of ditches, or the improvement of irrigation systems such as sprinkling or drip irrigation. Other help that is available is utilizing your own abatement budgets and in securing cooperation with other departments of County Government, such as the Road Department for heavy equipment, the Weed Control to assist in weed control management along roadways and drainage areas, to work closely with agencies such as ASCS and the Soil Conservation Service for whatever funding is available through the farmers and for technical services. It is important that we maintain good relations with landowners so that they can see the advantage of drainage as a method of source reduction. Usually the landowner has much to gain if projects are properly handled.

SOIL CONSERVATION AND MOSQUITO CONTROL

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I will try to relate some of the activities of the Soil Conservation Service and the benefits they may have to mosquito control. Many of the conservation practices which have been given high priority attention are directly related to water control. Water management activities, such as land leveling, sprinkler irrigation, underground pipelines, livestock water developments and many others, all help to reduce the period of time water is left standing on the surface of the ground. This, in turn, reduces the mosquito breeding area. Many of these practices are not only planned and designed by the SCS but are also partially paid for by the Agricultural Stabilization and Conservation Service Cost Share Programs.

Of particular interest in Salt Lake County is the work I am doing with wetland wildlife habitat management groups. By channeling the water for boat access to hunting blinds, we are creating dikes to allow controlled water concentration. This reduces wetland surface water area in some places and allows deeper water for fish habitat in others. The fish provide some natural mosquito control, thus reducing the area needing sprays and dusts. One of the problems I recognized is that many of these areas do not have fish species which are efficient enemies of mosquitoes. I believe that by involving mosquito control experts in the planning of these systems, we can do the entire job much more efficiently.

I'm sure persistance is going to be required if we are to continue these programs. We will have to communicate effectively. I would suggest that each of you contact your local Soil Conservation District office.

PESTICIDE REGULATION PERTAINING TO MOSQUITO ERADICATION

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The owner of a small crossroads store was appointed a postmaster. Six months went by and not one piece of mail had left town. Deeply concerned postal authorities in Washington wrote to the postmaster to inquire. "It's simple," he wrote back, "the bag ain't full yet." Not so with the mosquito program -- our bag is full of mosquitoes. What do we really mean when we talk about pests and pesticides? Putting it at its simplest, pests are those organisms we don't like. Pests are those species that compete with us for food, inflict injury on us, or even just annoy us. Expanding just a bit further, pests are those organisms that have a negative effect on our crop plants and other desirable vegetation or on our domestic animals and favored wildlife species.

At one end of the experience spectrum pests are annoying. At the other -- as the causes of pestilence, famine and disease -- they are deadly. These pests must be eradicated or controlled, and as all of us have become increasingly aware during the past decade, they must be controlled without undue damage to the environment on which we all depend.

A pesticide is any chemical used to kill, control or diminish in some way those organisms that threaten man. Prior to World War II, American agriculture and control of pest-related diseases was largely dependent on relatively simple compounds developed in the nineteenth century. Since the early forties, however, pesticide scientists have developed increasingly sophisticated compounds with steadily improved selectivity and effectiveness. The contribution of pesticides in controlling "nuisance" pests is no small matter.

The tragedy, of course, is the toll pests can take in human life. According to the World Health Organization, in India, death from malaria has been reduced from 7,500,000 a year to about 1,500 due largely to the use of pesticides. In the U. S., pesticides constitute a prime weapon in the control of encephalitis and other dangerous diseases.

Insects with their rapid reproduction and high potential for genetic modification are an adaptable lot. Therefore, pesticide scientists labor continuously to monitor the development of insect resistance to previously effective compounds and to develop new approaches to controlling these pests.

Government has long been a vital factor in the development of suitable pesticides. A major portion of the time and expense of bringing a pesticide to market is associated with meeting government standards not only for efficacy but also for effect on environment.

Federal regulation of the sale of pesticides dates back to 1910. Throughout the years such regulation has been updated continuously. A new era of federal supervision of pesticides began with the formation of the Environmental Protection Agency. EPA now exercises the principal federal pesticide regulatory functions under authorities contained in the Federal Insecticide, Fungicide, and Rodenticide Act. EPA, whose coordinated approach to regulating chemical pest control compounds was welcomed by the pesticide industry, has several clearly designated areas of regulatory responsibility.

Every pesticide that moves in interstate commerce must receive an EPA registration. EPA has made it clear that such chemicals cannot be approved for sale unless the maker provides scientific evidence that his product is effective for the purpose intended and will not injure human beings, livestock, crops or wildlife when used as directed.

EPA continuously reviews registered chemicals in light of developing scientific data to insure continued compliance with requirements and efficacy.

EPA can suspend or terminate the registration of any product. Recent amendments to FIFRA will help insure that the United States Department of Agriculture will be able to aid in determining the economic consequences of such suspensions or terminations.

EPA conducts extensive research on all aspects of pesticides in the environment. Most experts agree that environmental damage from pesticides is almost always the result of misuse or misapplication. Therefore, both the industry and EPA as well as state regulatory agencies are focusing on better-informed, better-trained users. The State of Utah has now trained and certified approximately 6,000 applicators.

New, state-authority provisions include a section under which a state -- subject to restrictions detailed in the legislation -- could approve additional uses of federally-registered pesticides for use within the state to meet special local needs. The single-state registrations could not be granted on uses previously denied, disapproved or cancelled by EPA, or in cases where there is no federal tolerance or exemption for residues in food or feed.

The EPA could not, under the bill, disapprove a state registration on grounds of claims that the pesticide is not essential. The agency could suspend the authority of a state to register local-use pesticides, however, if the state lacked adequate controls -- but only after setting up regulations to govern such suspensions. Further, the EPA could immediately disapprove a state pesticide registration if an imminent hazard existed.

In a second state powers section, the bill gives states which meet standards set by legislation primary enforcement responsibility for pesticide use violations. The EPA, however, would retain the right to reclaim enforcement authority in emergencies when states were unable or unwilling to act. For example, Abate and methoxychlor which were obtained under Section 24C for black fly larvae in and around the Jordan River.

There are many pesticides registered that have not yet been addressed by either the generic standards program or the RPAR program and thus may not have been evaluated against the unreasonable adverse effects standard of FIFRA. EPA intends to move ahead rapidly with both programs. Nevertheless, it will be some time before a significant number of pesticides are reviewed within these systems, and an even longer time before chronic hazard studies to serve as a basis for reaching regulatory decisions are completed by registrants. During this interim period, many of the risks associated with the use of pesticides will not be identified or fully quantified. Usually, this is so because the data necessary to assess the risks have not been generated by pesticide producers. Data has been submitted in the past, but most of those studies have not been reviewed in light of current regulatory and scientific standards, a task to be accomplished with the generic standards development program.

Conditional registration of products and uses will be based on the acceptance of the existing risks both known and unknown, of pesticide products and uses already registered and in the marketplace. The agency recognizes the potential risks, but generally has no basis upon which to quantify them or to believe that they outweigh the benefits of continued use. Until the risks can be identified and addressed through the generic standards and, if necessary, the RPAR processes, little or no environmental protection is achieved by discriminating between products registered prior to 1975 and other prospective pesticide products. It will be necessary for each of us to use several products which we have in our arsenal at the present time and not put all of our eggs in one basket. That particular product may, after evaluation, be taken away from us for that particular use and we would then be in trouble.

We should be watching out for at least 4 things as we help keep pesticides available for use in Utah:

(1) The decision to cancel or continue a particular pesticide registration should be made on the overall impact to the state's economy and not by the state's relative position in the national usage list. Registrations of pesticides in smaller area states should not be revoked simply because the state usage may be only a minor part of the national total.

(2) Pesticide regulation should not be made on a state-by-state basis. Such a procedure could conceivably place the growers on one side of a border in possession of a specific pesticide while neighbors across the fence, fighting the same pests, would not have the additional tool simply because the state's total pesticide usage was deemed to be minor.

(3) Smaller states often do not have the personnel nor the finances available as larger states to develop benefit information. Thus smaller states are often at a disadvantage when regulatory decisions are made on a state-by-state basis.

(4) Active ingredient applied often is a direct function of the amount of chemical available. When pesticides are in short supply, the bulk of the available pesticide is often sent to areas where demand is significant and sales assured. Smaller states should not be penalized because their low usage figures are a result of availability.

We at the Department of Agriculture are interested and actively trying to keep all pesticides available for your use here in the state. In order to do this we will have to have complete cooperation from all agencies and users of pesticides in this state.

SUMMARY:

1. We need pesticides -- America in the twentieth century must mass-produce its food and fiber and maximize the efficiency of its disease prevention. Pesticides represent one of the many types of scientifically developed tools that make this possible.

2. Because they can be dangerous, pesticides must be used with great knowledge and care. Pesticides are poisons. They have been developed through painstaking research to do specific jobs. Over-application or other misuse is in no one's interest.

3. Scientific research must make pest control still more efficient and safe for man and the entire life chain. That is exactly what is happening. And the effort is an extension of earlier scientific explorations which have involved thousands of disciplined and dedicated researchers.

EPA AND MOSQUITO CONTROL

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What I have learned about the EPA and mosquito control in Region VIII in the past 16 months has been summarized into tables on which I will comment.

Mosquito pest species. State lists and my own collecting indicate that there are 27 pest species among some 39 mosquito species that have at one time or another been found in large numbers (Tables 1 & 2). The eight most pestiferous species all breed in irrigation water and other temporary pools that are often related to careless management of water. The top three species are also listed as vectors of encephalitis: *Aedes dorsalis*, *Aedes vexans* and *Culex tarsalis*.

State management systems. Each state has a mosquito management system that has developed in direct response to the trend in the mosquito pest populations, the exposed human population, and the resulting illness or annoyance (Figure 1). The element of preventative planning found at the state level rarely occurs at the community level with the exception of organized mosquito districts such as those in Region VIII. Such districts are capable of carrying out long range plans related to water management and source reduction such that a minimum use and misuse of pesticides can occur.

Legislation and regulation. A minimum use and misuse of pesticides is the charge Congress has given the EPA through a stormy legislative and regulatory history. The current goal, in the case of mosquito control, is to have each community program use the methods that would be selected if it were under the direction of a resident professional manager. The legislative results (Table 3) at present represent a return of control and enforcement to the states. The professional judgement of district managers that is required in the selective use of pesticides in IPM programs is again being recognized. The EPA will continue to oversee the total pesticide program and to refine label directions.

Justification of use. The burden of justifying use is being shifted back to the states and district managers, "Application in accordance with label directions or commonly recognized practice should not pose an unreasonable adverse effect to humans or the environment." The risk of use should not be greater than the benefit of use. Should *Aedes dorsalis* and *vexans* be controlled as vectors or as nuisances? The justification of use for mosquito control is based on a number of factors not just one, as for a field crop (Table 4).

Larviciding produces the minimal human pesticide exposure when pesticides are used. The emergency use of adulticides for public health reasons is fairly easy to justify. The routine use of adulticides for nuisance control, especially as the area treated increases in size is more difficult to justify. And, even more so if adulticiding is the only control being used. As an option in an IPM program, the frequency of adulticiding is reduced and human exposure minimized, a typical situation in mature organized districts in Region VIII. For this reason the EPA is trying to work the concept of IPM into labeling. This may also prevent a ban on use by a state regulatory agency (acting under proposed rules) in response to pressure from an environmental action group. The EPA is relatively immune to state action groups.

Recent EPA memos suggest that the justification for use of pesticides over large areas will no longer rest with managers. One possible label change is that public notice must be given prior to application over a large area. Another is that a barrier zone must be left between the treated area and sensitive areas (residential, wildlife). Spraying (by ground rig or aircraft) for mosquito control involves a serious paradox. The droplet size that is most effective for impinging on the pest and for floating about through vegetation does so because of its excellent drift properties. Because of this paradox, ULV application is under review by legislative demand.

The final justification of use is that it works. Under proposed rules it will be possible for states to require application records to include mosquito counts prior to and after the day of application as a means of obtaining effectiveness data, an integral part of IPM. Lack of quality control is what perpetuates faith in poor control practices.

Community training and education. If, as indicated above, the minimum use and misuse of pesticides occurs in mature professionally managed mosquito districts in Region VIII, it follows that labeling and training programs that spread this type of management should be given the highest priority by the EPA. The importance of training and effective public relations is apparent in the activities of a number of organizations in Region VIII (Table 5). The EPA is now funding the development of a training program in Integrated Mosquito Management.

Professional management services can also be sold in small packages to supplement community efforts in source reduction and water management (Table 6). The increasing cost of highly trained personnel doing work that local residents could do restricts the application of sound mosquito management. Everett Spackman concluded last year's meeting with a slide-tape program on a project in Wyoming ranch country in which the ranchers did the scouting, not hired professionals. I am rewriting the traditional literature into a series of projects as a means of injecting mosquito control activities into existing community programs, 4-H, Scouts, and biology classes.

Summary. In summary, good practice in mosquito management can be encouraged by training, by the sale of professional services to unorganized communities, and by law. It was because the public did not get the first two that certain elements of the public insisted on the last one. This produced the EPA. Today there is still a need to balance these three components. Over-regulation is as self-defeating as walling up professional mosquito management services inside organized districts. Training and public relations (education) now have a high priority with control districts, the AMCA, and the EPA.

TABLE 1
TWENTY-SEVEN PEST SPECIES IN REGION VIII
(TARGETS OF CURRENT CONTROL OPERATIONS)

Pest Ranking	Species	Pest Status	State Ranking CO	UT	WY	MT	SD	ND
1	*Aedes dorsalis*	WN, V	1	1	1	1	1	1
1	*vexans*	WN, V	1	1	1	1	1	1
3	*Culex tarsalis*	WN, V	1	1	x	2	1	1
4	*Aedes nigromaculis*	LN	1	2	2	1	2	2
5	*increpitus*	WN	2	1	2	1	x	–
6	*idahoensis*		1	–	1	1	x	x
7	*melanimon*	LN	2	2	1	2	–	–
8	*campestris*	LN	x	2	2	x	2	2
11	*cataphylla*	LN	2	2	1	x	–	–
11	*nevadensis (communis)*	LN	2	2	1	x	–	–
11	*pullatus*	LN	1	2	2	x	–	–
11	*trivittatus*		1	–	x	2	x	2
11	*Culiseta inornata*	LN, V	x	1	x	2	x	2
14	*Aedes fitchii*	LN	2	2	2	x	x	x
17	*excrucians*		2	x	2	x	x	x
17	*hexodontus*	LN	2	2	x	x	–	–
17	*spencerii*		–	x	2	x	x	2
17	*sticticus*		2	x	x	2	x	x
17	*Anopheles freeborni*	LN, V	2	2	x	x	–	–
20	*Culex pipiens*	WN	x	1	x	x	x	x
24	*Aedes cinereus*		x	x	x	2	x	–
24	*flavescens*		x	x	x	x	x	2
24	*impiger*		x	x	2	x	–	–
24	*niphadopsis*	LN	–	2	–	–	–	–
24	*Anopheles punctipennis*		2	–	x	x	x	x
24	*Culex erythrothorax*	LN	x	2	–	–	–	–
24	*Culiseta incidens*	LN	x	2	x	x	x	–

State Ranking: 1 = annual pest, 2 = commonly a pest, x = can be a pest
Pest Status: LN = local nuisance, WN = widespread nuisance, V = vector

TABLE 2
BREEDING SOURCES COMMONLY INHABITED BY PEST SPECIES

Pest Ranking	Species	Distribution	Pest Breeding Sources: Classi-fication	Pest Breeding Sources: Comment
1	*Aedes dorsalis*	P, V	A, B, C	
1	*vexans*	P, V	A, B	Irrigation waste water
3	*Culex tarsalis*	P, V	A, B, C	Irrigated meadows
4	*Aedes nigromaculis*	P	A, B	
5	*increpitus*	P, V, M	A, B	Grassland pools
6	*idahoensis*	P, V,	A, B, C	Overflow pools
7	*melanimon*	P, V	A, B	Temporary pools
8	*campestris*	P	A, B	
11	*cataphylla*	V, M	B, C	Mountain (temporary)
11	*nevadensis (communis)*	M	B	snow-water and
11	*pullatus*	M	B	woodland pools
11	*trivittatus*	P	B	Overflow pools
11	*Culiseta inornata*	P, V, M	B, C	Permanent pools
14	*Aedes fitchii*	P, V, M	A, B, C	Irrigation
17	*excrucians*	M	B, C	Mountain
17	*hexodontus*	M	B	
17	*spencerii*	P, V	A, B	Irrigation
17	*sticticus*	P	B	Overflow pools
17	*Anopheles freeborni*	P, V	C	Marshes
20	*Culex pipiens*	P	C, D	Marshes & containers
24	*Aedes flavescens*	P	A, B	Irrigation
24	*cinereus*	V, M	B, C	
24	*impiger*	M	B	Mountains
24	*niphadopsis*	P, V		
24	*Anopheles punctipennis*	P	C	
24	*Culex erythrothorax*	P	C	Marshes
24	*Culiseta incidens*	P, V, M	B, C	Mountains
27				

Distribution: P = plains, V = valleys, M = mountains (above 6000 - 7000 ft)

Pest Breeding Source Classification:
A = irrigation related
B = temporary natural pools
C = marshes
D = containers, tires & junk

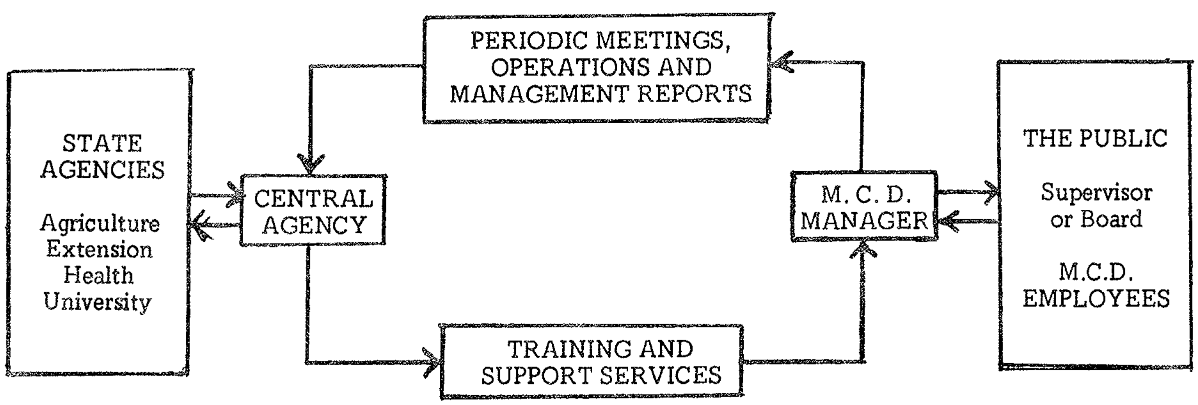
FIGURE 1

STATE MOSQUITO MANAGEMENT SYSTEM

Within each state, a self-supported system exists composed of a central agency with personnel interested in mosquito control and the control district managers. These two groups are bound together by training sessions, periodic meetings, and annual reports. This is the functional core of a state system. It requires an annual training program for control and management personnel as a significant portion of these people are new each year.

The core interacts with two other subsystems. The central agency is supported by several state agencies which generally includes a University. This subsystem is typically the repository of technical expertise and the source of new control methods.

The third subsystem is composed of the mosquito control district (MCD) manager, supervisor or board, employees, the public, and the interactions between. The public is composed of mosquito breeders and mosquito feeders. Often the mosquitoes are being raised by the very person concerned about their presence.



In general, the three subsystems do not respond to the same goals or with the same timeliness. The uninformed mosquito ridden public is interested in nuisance control today. It is much less interested in measures that require long lead times characteristic of methods championed by integrated pest management principles. Application of these principles is more closely related to the interest of state agencies in predicting and preventing vectored disease outbreaks and abnormal pest populations. This places the MCD manager at the center of opposing forces unless long term IPM methods such as water management and source reduction can be demonstrated to the public to have a cost advantage in the long run. This requires local research (pilot) demonstrations and a convincing public education program.

TABLE 3

RECENT LEGISLATIVE RESULTS RELATED TO MOSQUITO CONTROL

1. Less than label dosage is now considered consistant with the label.
2. States with Cooperative Enforcement Agreements now have primary use enforcement responsibility. The state has 30 days to act on uses in violation of the label.
3. Proposed rules will shift registration and regulation of pesticides to the individual states.
4. The ultimate responsibility to protect the public and the environment from misuse of pesticides will rest with the EPA.
5. Test questions on IPM are specifically prohibited on applicator tests for certification.
6. Documentation of the effectiveness of pesticides other than those used on health related pests may be waived by EPA. However, the states are encouraged to obtain such information.
7. Any method of application not specifically prohibited by the label can be used with the exception of ULV.
8. ULV can only be used if so stated on the label.

TABLE 4

MOSQUITO CONTROL OPERATIONS, PESTICIDE USE PATTERNS AND CONTROL STRATEGIES

A. Control Operations Stated on the Label

1. Larval control
2. Adult control
3. Large area control
4. Mosquito control

Use Patterns Not Directly Stated on the Label but Implied by the Statement of Who Can Apply the Product for Adult Mosquito Control, " . . . trained personnel of public health organizations, mosquito abatement districts or pest control operators."

B. Use Pattern	Risk		Benefit (Adulticides)
1. Agricultural	residues	/	reduced production costs
2. Public Health (emergency use)	human exposure to pesticide:		
a. Vector Control	1. directly	/	disease reduction
	2. residues		
b. Severe Biting	on urban produce	/	disease reduction increased productivity
3. Nuisance control (routine and emergency use)	as above	/	annoyance reduction increased property value
4. Large area control (any of the above)	Disruption of IPM programs using parasites and predators	/	increased effectiveness of control
C. Control Strategy			
1. Pesticide only	all of the above	/	emergency response
2. IPM option	minimize above	/	reduced frequency of use

TABLE 5

SAMPLES OF TRAINING AND EDUCATIONAL ACTIVITIES THAT APPLY TO REGION VIII BEYOND THOSE CARRIED OUT BY ORGANIZED MOSQUITO DISTRICTS

A. Accomplished

1. State and Association training sessions for seasonal employees.

2. Mosquito Control in Utah, slide-narration program, Extension Service, Reed Roberts

3. Mosquito Control in Wyoming, slide-tape program, Extension Service, Everett Spackman.

4. "Mosquitoes and Their Control in the United State" by AMCA, $2.00 + .28 cents tax for a single copy.

5. "Mosquitoes of Public Health Importance and Their Control" by CDC, both the 1976 and 1977 editions.

B. Soon to be Accomplished

1. AMCA Bulletin No. 1 – The Use of Aircraft in Mosquito Control
   No. 2 – Ground Equipment for Mosquito Control
   No. 6 – Biocontrol of Mosquitoes
   No. 7 – Identification of North American Mosquitoes

2. Mosquito Control in Texas and Louisiana, slide-tape-narrative script program by AMCA. (Number one priority)

C. In Progress

1. Public Relation Guidelines to help districts to better advertise their programs and enlist public support by AMCA. (Number two priority)

2. Integrated Mosquito Management, slide-tape public education/training aids program by Montana Department of Health and Environmental Sciences, Van Jamison and Kenneth Quickenden. (EPA funded)

3. "Project Manual on Mosquito Management", for teenagers, biology classes and community action groups, EPA, Richard Hart (IPA assignee, NWMSU)

TABLE 6

CHECK LIST FOR A COOPERATIVE COMMUNITY MOSQUITO REDUCTION PROGRAM

I. Mapping

A. Large area program map (on one sheet) with sufficient detail to draw in the boundaries of:

1. Protected area – that area in which a minimal mosquito population is desired.

2. Barrier zone – that area around the protected area (about 1 mile across) in which control operations are carried out in normal years.

3. Outlying area – major breeding areas beyond the barrier zone and areas that are in neighboring control programs.

B. Small area control maps (one sheet per ¼ section, 8 inches to the half mile) on which to plot survey results and control operations.

II. Adult Survey

A. Landing rates, biting collections, and light trapping.

B. Determine:
1. Density and species of pest populations
2. Community tolerance threshold
3. Effectiveness of control operations
4. Breeding areas

III. Larval Survey (number of wigglers per dipper of water)

A. Identify actual breeding sites and plot on small area control maps.

B. Classify breeding sites for type of control and priority of control.

IV. Control Program Management

A. Coordinator of volunteers, maps and records.

B. Liaison with a state or regional mosquito authority.

C. Individual owners responsible for small breeding sites.

D. Large breeding areas require:

1. Cost estimates for possible control options;

a. water management
b. drain, fill, or deepen
c. mosquito fish
d. larviciding
e. adulticiding

2. Cost sharing of control with owners.

3. City, county or contracted program operation.

SOME PROBLEMS ENCOUNTERED IN DRAFTING OPERATIONAL MANUALS FOR THE THIRD WORLD

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1. Introduction. To fulfill its purpose an operational manual must serve all staff involved in vector control, that is a wide spectrum audience ranging from the ministerial level to field staff.

Since the level of general knowledge that we take for granted is frequently lacking in the Third World, a functional manual (apart from dealing with organizational and operational methodologies) must also give the biological and natural parameters which condition the execution of control techniques and must further indicate the availability, range and sources of equipment and materials used in vector control. Such "trade information" may seem to be out of place in such a manual, but in view of the frequent lack of this type of information it is considered vital for the resident staff to make intelligent choices and by so doing accept the responsibility which is frequently carried by International Aid Agencies to adventurous salesmen, or – fortuitous local agencies.

In the final analysis a useful manual is an exercise in communication, thus its reading audience and the parameters which condition their attitudes are of prime importance in attempting to produce a significant document and these will be considered herein.

2. The Reading Audience. This can be subdivided into management, supervisory and field staff.

a. Management. This is traditionally entrusted to a medical practitioner who frequently is the only university-trained member of staff.

While in no way wishing to denigrate from the earlier efforts and successes achieved by the medical discipline in the field of vector control, the post–DDT era of second generation insecticides, with their attendant difficulties and changing methodologies of treatment, have demonstrated that vector control is rapidly approaching the status of a discipline *per se*, and if anything it has gravitated from the medical to the entomological discipline.

This concept has not yet reached the Third World where the medical entomologist is a *rara avis*, often a self-trained technician, unlike his graduate counterpart in crop protection whose status is recognised and who is usually a respected professional civil servant.

Medical management is best noted in the often encountered emphasis placed on the collection of epidemiological data with the complete disregard of the vector. Thus, one country where control led to eradication of the vector and malaria still stresses surveillance by haematological monitoring with complete disregard for the mosquito vector and its possible reintroduction.

In consequence, the few qualified medical entomologists encountered usually limit themselves to taxonomy and testing for resistance rather than playing an important part in planning campaigns and introducing new methodologies. In part the blame for this lack must be attributed to these individuals. On the other hand they cannot rise to a position where their ideas can be voiced, heard and knowledge implemented.

b. Supervisory Management. Like petty officers on a ship, middle management is the strength of any organization, especially when senior management is ever-changing. Many supervisors are "lifers" who have gained seniority through long years of service and who received their vector control training in the 1950's during the heyday of the DDT eradication campaigns. They have made little technological advance since then. Even those who have received refresher courses are limited by their actual exposure and thus the Leco HD, Swingfog SN 11, Dynafog 99 and 180 or the Fontan backpack are the limit of their choice of equipment as only these machines were "taught" at the courses they attended.

In one case a foreman complaining of a lack of Fontan's was unaware that the available Solo backpacks could also be used. Similarly when it was pointed out that a mini-Leco might be more suitable than a Leco HD the director and senior foreman insisted on a Swingfog as they were in ignorance of the existence or capabilities of the mini-Leco. In this respect one frequently hears blame passed on the International Agencies "for not telling us", an all too prevalent attitude absolving the national management of any responsibility.

c. Field Staff. This is usually a faceless "army" of laborers receiving social security payments rather than an organized, salaried force. They can range from illiterates to high school graduates usually lacking transportation or even basic equipment (torch, sucking tube, vials, pipettes, etc.,) but usually in possession of a ballpoint pen, comb and transistor radio.

They often respond when given individual attention and supervision, otherwise gravitate to "la dolce vita".

This is not necessarily a reflection on their capability, but rather on their poor leadership and motivation. Frequently, management is housed in good offices in the ministry, removed from their field staff who are found in a crowded dilapidated building, pinch-hitting for stores, laboratory, staff quarters and garages all under one roof.

Social and geographic separation between management and the operational staff is frequently carried to the extreme where even equipment manuals are kept for "safekeeping" in the supervisor's office. Thus on requesting a manufacturer's manual for a given piece of equipment it is not uncommon to be told that the foreman keeps it locked in his desk a few miles away at the office. This attitude cannot be ascribed solely to a respect and a wish to protect the "written word" but frequently demonstrates an element of "snobbishness" which does not improve the maintenance of equipment or field staff performance.

3. Traditionalism. The "DDT/pressure pump era" produced two attitudes which continue to plague and seriously hamper the efficiency of vector control in the Third World.

   a. Diminishing Priority. The early successes of these campaigns undoubtedly revolutionized health and socio-economic conditions in most of the Tropics. In spite of today's recrudescence of vector-borne diseases, vector control has been degraded in the priority plans of governments, leading to lower budgets and an erosion of staff and their standards. A notable exception to this is the vector control organization of the Government of Singapore.

   b. The "Residual Spray" Syndrome. Owing to the initial successes of this technique management has failed to evolve with the new methodologies of control which have been dictated by increasing environmental awareness, changing vector biology and increasing urbanization and sophistication of the *populus*, which in many cases have made residual sprays impractical if not impossible (as where residual spraying has met 60% refusals by householders).

   This resistance to new ideas is in part attributable to conservative management, in part politico-administrative since the new techniques are not labor-intensive and in part due to a fear or inability to request or obtain initial high capitalization costs required for the new methodologies (e.g., compare the cost of pressure pumps vs. foggers and spray aircraft).

   However, the economics of vector control in practice are relatively unchanged *in toto* as residual campaigns are based on low equipment and high labor costs while the newer methodologies reverse this ratio but not necessarily the total expenditure.

   The latter is reflected in present annual budgets for *Aedes* control in the Caribbean (Tonn et al. 1979) which though based on residual and focal treatments, compare favorably with those from mosquito abatement agencies (Challet 1977) using modern mosquito control methodologies.

4. The International Agencies. In my opinion the International Agencies are partly responsible for fostering the traditional techniques of control and remiss in not introducing new concepts to the Third World.

   Furthermore, national staff frequently sheds its responsibility onto roaming regional advisors or special consultants passing the "buck", rather than attempting to solve local difficulties and failures.

   In one case the International Agency had estimated a 3-year eradication programme. When this failed after 3 years of sporadic effort, local support ceased forthwith with government showing little or no concern since in essence they had remained divorced from this effort since its inception.

5. A Manual. From the foregoing it becomes obvious that no manual can serve, let alone solve, the many and in some cases deep-rooted ailments of vector control agencies in the Tropics. However, the challenge is there and any solution, no matter how deficient, is better than none.

6. Methodology of Manual. The most hopeful solution to this dilemma is to make the manual as visual as possible while retaining a full supporting text with tabulations of specifications, formulations, etc.

   Even the prolific use of diagrams has to be carefully considered. While these should provide easily assimilated information, they should also include terse written statements of known facts. The purpose of both diagrams and short written statements within the individual plate is for orientation and in the hope of stimulating the reader to look further in the text and also to encourage local studies to verify the applicability of these facts and figures to varying local conditions.

   Figure 1 portrays the results of the philosophical approach using the life history of *Aedes aegypti*.

   At first glance it is noted that this diagram is pictorially much more informative than the standard life history. Furthermore an effort has been made to keep true proportionalities where these are important (e.g., larval instars). Similarly basic entomological information such as inter-instar growth is shown and no phase or subject is taken for granted (e.g., rotation of male terminalia) but portrayed in detail with its known chronology and time lapse.

   A wide range of breeding places is given to stress the variety of household containers used by this species, encouraging field staff to make thorough searches and hopefully add other types of containers not portrayed. In a way it is hoped that the diagram will set a blueprint on which local variance can be added in the spirit of "beat the diagram" one-upmanship.

   Minimum time intervals are stated in writing to emphasize the need for this information and the need to check the given values under the local seasonal conditions of each country. In the final analysis the periodicity of control measures (e.g., adulticidal sprays) is dictated by the duration of the whole or component parts of the life history.

   Figure 2 shows the more practical side of the manual for those without access to vector control literature and trade advertisements. It shows, at a glance, various types of portable ULV equipment with an approximate scale allowing prime selection to be visual though further reference is also given in performance tables, etc.

   In conclusion an attempt is made to handle the whole subject within one plate with accurate portrayals of each action and phase in order that the observer can identify his conditions and problems, and hopefully relate to the visual and written impact included in the diagram and thus be stimulated to investigate further by reading the supporting text.

   For these same reasons each section of the manual seeks a self-explanatory, to-the-point title; thus "Larval Surveys" becomes "How to Determine Mosquito Densities" and in this respect we follow the format "How To Do It" books. However, as Fig. 1 implies, there is no attempt to gloss over facts, but rather to portray them in full detail for in no way should a manual talk down to its audience, nor is it intended as *"le dernier mot"* on the subject but an attempt to demonstrate the complexity of the subject and stress the ecological interrelations which should be the basis of tactical vector control. On the other hand, for example while accurate maps are the basis of good planning, their use in vector and epidemiological planning cannot be assumed when dealing with an audience which for the most part has not been educated or accustomed to their use. Thus both deficiencies have to be made up for in such a manual, which in the words of Kinglake means that the author is frequently: "striving for the impossible while shadowing the unobtainable".

7. Distribution and Availability of Manual. Lastly, when the manuals are available especially if produced under the aegis of International Organisations there is a strong tendency to use only what is given gratuitously and not order more. Needless to say the few free copies end up in private or semiprivate libraries and the whole purpose of the exercise is defeated. Ideally each organization should receive at least ten copies and then hopefully one or two copies will percolate down to the field staff for whom the manual is partly designed.

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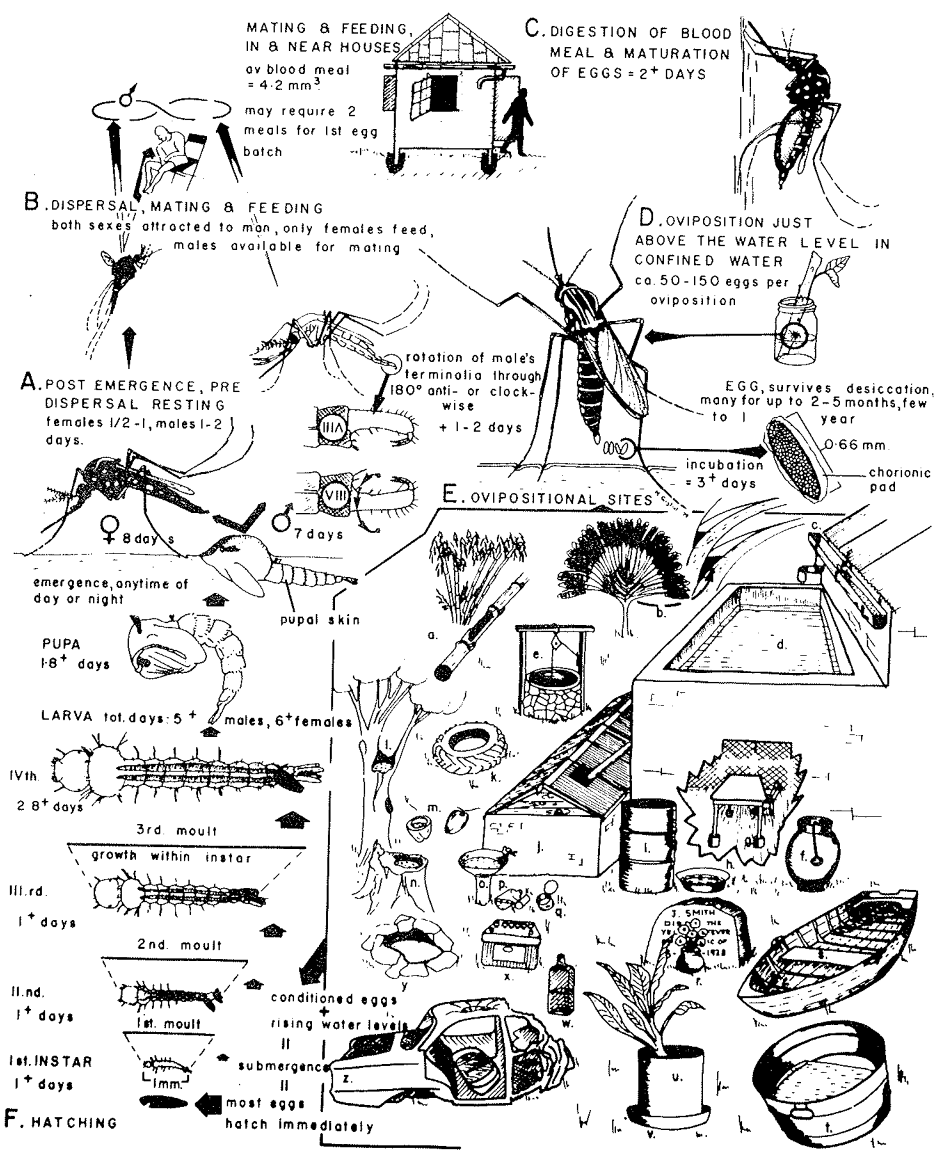

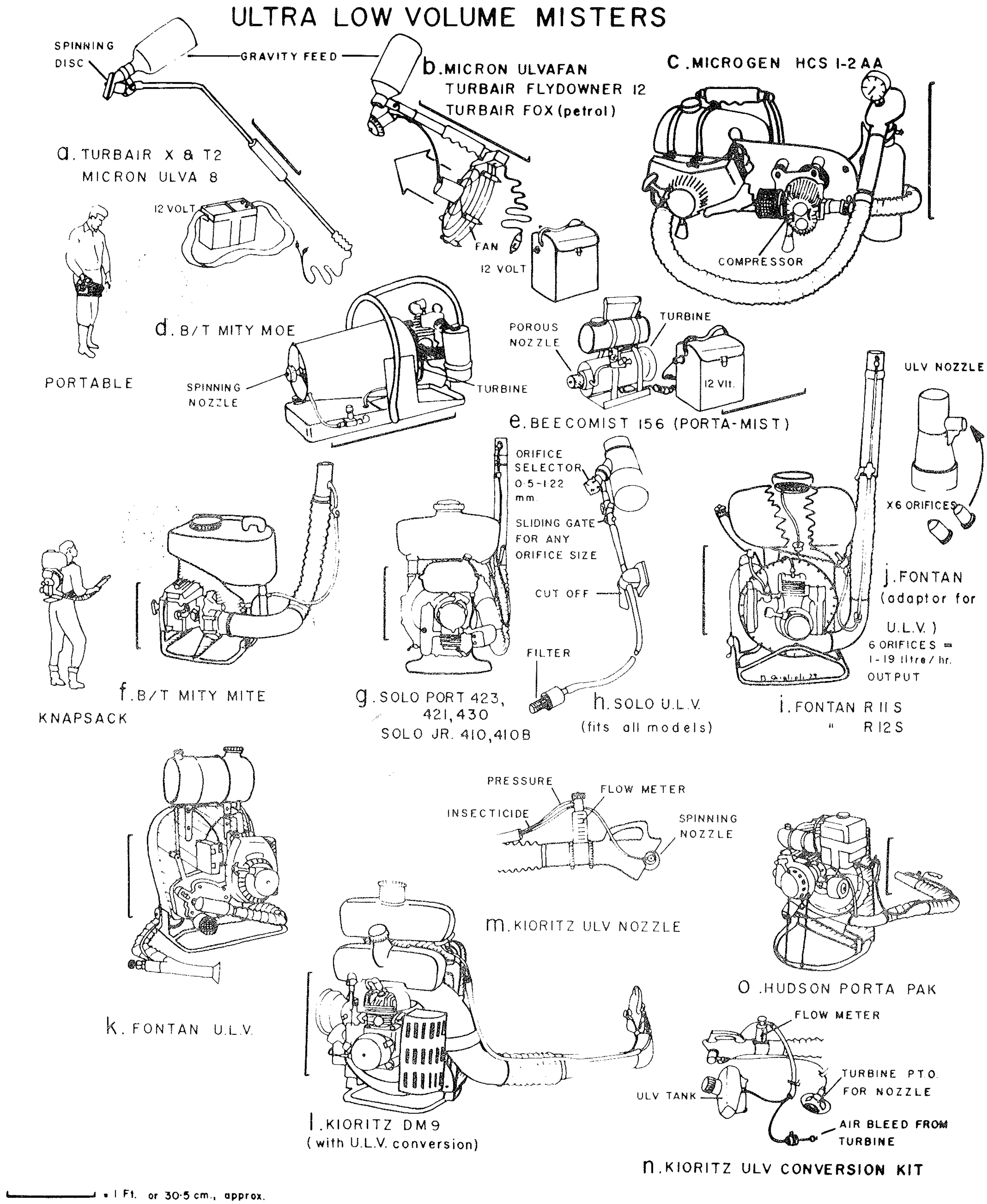

Fig. 2. Some portable ULV misters (after PAHO draft: "Manual for the emergency control of *Aedes aegypti*-borne diseases").

MERMITHIDS FOR MOSQUITO CONTROL

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The mermithid *Romanomermis culicivorax* is the nematode most commonly used for mosquito control. It can be mass produced *in vivo* and applied by methods in regular use for insecticides. It is effective in a reasonably wide range of mosquito habitats and a reasonable range of warm climate mosquitoes are susceptible to it. However, as a control method it is expensive and in order to popularize its use as a biocontrol agent and make it competitive with chemical larviciding agents cost must be reduced.

The cost is high for two reasons: First, the *in vivo* method is labor intensive, although production costs in the long-term could be reduced if an *in vitro* system could be developed. Secondly, at the end of existing *in vivo* production methods the preparation for use in the field is formulated in sand. The ratio of sand to the effective ingredient, the nematode eggs themselves, is high and the relative weight of sand increases transport costs enormously. Not only are sand cultures expensive to transport to a laboratory or a field testing site but they are also inefficient. There may be some loss of the nematodes and their eggs due to grinding mechanical damage by the shifting sand. If condensation occurs within the plastic wrapping around the culture, the extra water may cause the eggs to hatch prematurely, as the preparasites are short lived they will probably die before they can be used. In addition there is the danger of fungal infection thriving in such a situation. Preliminary investigations have been made towards an alternate formulation for *R. culicivorax*.

After the nematodes had been passaged through the laboratory host, *Aedes aegypti*, the emergent post-parasites were collected. Instead of placing them in trays of damp sand, they were put into clear plastic dishes half filled with water. The nematodes in the dishes molted, mated and laid eggs. Using this method the eggs could be mass collected and aged precisely. The latter was achieved by removing the females, on a daily basis, from the dishes where they had laid their eggs. This procedure made it possible to observe egg development and hatch more closely. At 27°C the eggs developed from the one cell stage to the pre-hatch coiled stage in 1 week. However, at 17°C the developmental time was extended to 1 month. After the coiled stage of development had been reached the eggs could be stored for at least 1 month at 5°C. Alternatively, eggs transferred to 5°C immediately after oviposition developed over a much longer period of time. They have been kept for 2½ months so far without reaching the coiled stage.

For sand cultures mass hatching is induced by flooding them with water when they are 11-16 weeks old. In contrast, a small percentage of eggs held in water alone at 27°C will hatch after the coiled stage has been reached. While the vast majority will normally remain at the coiled stage for an extended period of time, hatching occurs intermittently at a slow rate. If, however, a homogenate of *A. aegypti* larvae was added to the eggs at this stage, synchronous hatch was obtained. Definition of the hatching factor is under investigation and will be reported elsewhere.

In summary, *R. culicivorax* can be cultured through its free-living stages in the absence of sand. The basis exists for mass collection, storage and synchronous hatch of the egg stage. After further investigation it is hoped that these processes can be scaled up for mass production purposes and that in the not too distant future it will be possible to transport masses of eggs of *R. culicivorax* in a relatively small and light container. This will clearly be far more economical than before, since it avoids the weight problem and other difficulties inherent in transporting sand cultures.

HISTORICAL DEVELOPMENT OF OMWM IN NEW JERSEY -- EQUIPMENT AND TECHNIQUE

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The development of open marsh water management (OMWM) in New Jersey has been a continual process since the early 1900's (Smith (1902). Clark (1977) defined OMWM as "a connected system of ponds and open channels developed to provide habitats for mosquito-eating fish and give them access to all temporary standing water areas." This definition should also include the concept that the physical management for mosquito control is on an open salt marsh, which is subjected to normal tidal fluctuations. This separates this type of physical management from impoundments which have altered salt marshes through the construction of dikes to eliminate the normal tidal fluctuations.

In OMWM there are two principal types of salt marshes. First is the marsh system that has been altered in the past, usually in the form of the old parallel ditch systems. The application of the OMWM management technique in this type of marsh must take into consideration the existing ditches and drainage patterns. The second type of marsh is the natural marsh where there has not been any type of alterations. The development of an OMWM system on a natural salt marsh has to consider several natural characteristics associated with the estuarine ecosystems. Provost (1976) stated that as the tide range increases the amount of high marsh decreases. Generally the increase in high marsh will indicate more mosquito breeding habitat. Gooley and Lesser (1976) showed that in salt marsh areas subjected to less than 0.3 m of tide swing, approximately 68% of the marsh breeds mosquitoes while in marshes subjected to more than a meter had only 16% breeding.

Another consideration is the tidal energy associated with tidal ranges. Provost (1977a) suggests that in areas of insufficient tidal amplitude to energize the flow of water through the connector channels, impoundments should be utilized. The same results can be accomplished through increasing the amount of water on the high marsh through the construction of ponds and pond radials, or stop ditching (Shisler 1978a).

Another major consideration is the texture and depth of peat of the marsh material. The older marsh is usually a deep and solid marsh that will hold water and maintain the configuration of the ditches. In general, newer marshes have a shallow depth of peat and are not as firm as older marshes. Smith (1904) reflects that the marshes along the Barrier Island should not be ditched because of the shallow peat. All the prior considerations have to be evaluated to determine the type of physical alteration required in the control of mosquitoes.

Development of OMWM

The first reference to the type of management we have termed OMWM is found in Smith (1903) where he discusses the construction of ponds and ditches and filling in holes that breed mosquitoes instead of treating the area with oil. This also sounds like the foundation for our Integrated Pest Management (IPM) systems of today. Smith (1904) also recognized the fact that all marshes do not breed mosquitoes, while others that do not breed yearly have to be continually watched in order to assess their potential as mosquito breeders. Smith's main interest was the utilization of natural predators to control the mosquito populations. He placed wooden barrels in the marsh as reservoirs for fish (Smith 1909). Smith (1904) was the first to recommend parallel ditches for mosquito control, however he would vary the distance between parallel ditches according to the amount of mosquito breeding and would utilize the hole-connecting plan when isolated breeding areas were found. Headlee (1945) states that this hole-connecting plan of Smith's could not work because of the personnel and economics. Therefore the trend was to promote parallel ditching systems. Also another important component was that Smith recognized the value of fish in these manipulated habitats while Headlee was concerned with fish in natural ponds only and not the construction of new fish habitats. The parallel system's drawing power decreases in time as the percolation characteristic of the marsh is lost and previously drained mosquito breeding depressions regenerated themselves as mosquito breeders.

Clarke (1938) introduced new terminology "Champagne Pools" at the New Jersey meetings as a method in upland situations which was similar to the early work of Smith. In the 1930's and 1940's long verbal battles originated between wildlife biologists and mosquito control personnel over the ditching of the marsh causing a decrease in the waterfowl habitat (see discussions in the Proc. of the N. J. Mosq. Exterm. Assoc. Mtgs. 1930 through 1940). Bradbury (1938) constructed weirs in the ditches during migration of waterfowl to flood the marsh and create the valuable standing water habitat for migrant waterfowl. In the early 1950's an effort was made to create additional fish and wildlife habitats that would control mosquitoes through impoundments (MacNamara 1952, 1957; Chapman and Ferrigno 1956; Darsie and Springer 1957). Finally it was in the 1960's that Ferrigno and Jobbins (1968) demonstrated that fish and wildlife habitat could be created on the open marsh through the techniques known today as open marsh water management. The work of Ferrigno and Jobbins (1968) in OMWM reinitiated the concept of creating wildlife habitats on the salt marsh that will control mosquitoes without damaging the "fragile" salt marsh-estuarine ecosystem.

Objections from landowners to work on their land and the development of new equipment has led to the naturalist approach (Candeletti 1979). This approach decreases the linear footage of ditch while increasing standing water through irregular ponds and meandering ditches.

Another method that increases the valuable standing water habitat of the marsh while utilizing natural elevations of the marsh is stop ditching (Shisler 1978a). This is a present use of the concept developed by Bradbury (1938) and similar to that presently being utilized in Louisiana where weirs are used to hold the water level in tributary creeks and ponds (Chabreck 1967). The major difference is that the ditches are permanently blocked off and there is an upland water source that continually feeds the area with fresh water. The vegetational

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succession yields a variety of species that offer ideal food for waterfowl, such as, dwarf spikerush (*Eleocharis* sp.), three square (*Scripus* sp.), Walter's millet (*Echinochloa walteri*) and smartweed (*Polygonum* sp.).

Recent research on our small salt marsh fishes include species previously considered rare or absent (Able et al. 1979). The commonly recognized fishes in mosquito control were the killifish (*Fundulus heteroclitus*) and the sheepshead minnow (*Cyprinodon variegatus*) and, until recently, almost no one considered the value of the Stickleback (*Gasterosteus aculeatus*) or Luci's killifish (*Fundulus luciae*) for mosquito control. These fish are found in great numbers with larvae stickleback in the spring throughout the high marsh while Luci's killifish, although almost absent from open tidal waters and ditches, is probably the most common fish in the potholes and on the marsh surface in the fall (Able et al. 1979).

Procedures in the application of OMWM techniques (Hansen 1979) to a typical salt marsh system needs to be clarified again. What we are going to do is to develop a management plan as if we are doing an actual project on a salt marsh.

1. After referring to several years of mapping locations of previously larvicidal applications (Gooley and Lesser 1976) it is determined that certain areas receive repeated applications of a larvicide on a yearly basis.

2. The areas are evaluated to obtain the necessary permits and right of entry agreements from the landowners.

3. Once all necessary permits are obtained, a professional biologist and/or entomologist walks over the entire area locating all mosquito breeding sites and marks each site with a 1 meter plaster lath.

4. Once all mosquito breeding sites are thus identified in one or two acre plots, the stakes are realigned into a series of tidal ditches, ponds or pond radials, in order to connect all mosquito breeding habitats.

5. Following the stakes a rotary ditcher or other suitable equipment is utilized to construct the type of alterations determined by the professionals.

The construction of ponds has gone through a series of changes over a period of years because of research and the development of equipment (Ferrigno et al. 1976; Shisler et al. 1978). Today ponds take the shape of the mosquito breeding areas and vary in size from several square meters to approximately 0.25 ha. The ponds average less than 0.3 m in depth to allow light penetration to stimulate benthic vegetation, growth such as Widgeongrass, *Ruppia maritima* (Ferrigno et al. 1976). Fish reservoirs approximately 1 meter in depth are placed in the ponds to serve as places of refuge during drought conditions. Ponds and adjacent mosquito breeding depressions are connected by radial ditches approximately 1 meter in depth.

Spoil from these ponds and radials is deposited and spread out over the adjacent marsh to fill in additional mosquito breeding depressions and not impeded the natural flow of high tides over the marsh. The spoil is also maintained at an elevation of less than 0.1 m above existing marsh elevation to discourage undesireable vegetation from colonizing the spoil.

Tidal ditches are constructed similar to radial ditches but are connected directly to older tidal ditches or a natural tidal creek and the spoil is handled in the same way. The application of OMWM alterations to a marsh depends upon the previously mentioned characteristics of the marsh and how the marsh is going to be utilized by the landowner or public.

The labor and effort put into water management on the marshes often go unnoticed whereas fogging trucks and helicopters gain wide public exposure (Clark 1977). Recent research has shown that water management is the most effective and economical method of mosquito control when compared with chemical measures (Hansen et al. 1976; Provost 1977b; Shisler 1978b; Shisler et al. 1979), and we believe it will continue to be when properly integrated in a mosquito control program.

Equipment

The initial ditching equipment consisted of hand equipment. e.g. spades, potato hooks, and bog saws. The spades were altered in such ways that they required two or three men to effectively utilize them in the construction of ditches. The most recognized spades were the "Skinner Spade", "Monahan Spade" and the Eaton Spade (see Shisler 1979). Hand equipment was still being employed in New Jersey until the 1950's. The machine driven ditcher, the True Ditcher, made its first appearance in New Jersey during the 1903 season to ditch a section of marsh in New Jersey (Brooks 1929). A series of alterations to the machine driven ditchers through the next 30 years produced the Eaton Ditcher, Reiley Plow, several State Ditcher Diggers and the Scavel Plow (see Reiley 1928; Mulhern 1941; Shisler 1979).

The development of amphibious equipment greatly changed the thinking of the permanent mosquito control methods in New Jersey salt marshes. The amphibious dragline was the first type equipment utilized on the marsh. The dragline was followed by a series of rotary ditchers developed by Quality Marsh Equipment in Louisiana in conjunction with suggestions from Professor D. M. Jobbins and other mosquito control workers (Shisler 1979; Candeletti 1979). The rotary ditcher solved the problems of spoil piles adjacent ditches by chopping up the spoil and distributing the spoil over the marsh in a thin layer. The first rotary was mounted on amphibious skids and pulled behind an amphibious marsh buggy. The combination of the two machines offer very little maneuverability on the marsh surface. Later the rotary section was mounted on the amphibious marsh buggy and driven by the same motor. Problems associated with the fact that the ditcher speed was directly proportional to the track speed developed in the form of cutting ditches, distribution of spoil and overheating the motor. Hydraulic driven motors allow for rotary speeds to differ from track speeds. The first one of the hydraulic driven rotaries was in a fixed position behind the marsh buggy. This rotary was then followed by the backhoe-mounted rotary bucket that moves across the back of the marsh buggy increasing maneuverability of the rotary (see Shisler 1979; Candeletti 1979).

Today we are looking at the new rotaries by Maletti for their applicability into our source reduction programs. These machines cost approximately $4,000 to $8,000 which is different from the present cost of a Quality Marsh Rotary of $125,000. The Maletti rotaries have to be driven by a three point power take off from a tractor or some other power source, plus these new rotaries have the capability of working on our upland water management programs.

Provost (1977) makes a closing statement that we will end with. "One must conclude that because people will not tolerate the salt-marsh mosquito infestations arising from untreated salt marsh, those mosquitoes will continue to be controlled. Economically and ecologically, the method of choice will surely be source reduction."

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REDUCED USE OF PESTICIDES THROUGH OPEN MARSH WATER MANAGEMENT

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Our Commission, in 1973, took a long, hard look at the efficacy and cost of pesticides and decided to put more time, effort and money into water management. This was our turning point into open marsh water management. We had experimented on one 548-acre tract along the Atlantic coastal marshes from 1967 to 1969, the Seaville Marsh, with a great deal of success. I am going to relate to you, now, the history and the line of progression of an ongoing project that we call the Tuckahoe Marsh Management Project.

This marsh is an Atlantic coastal marsh, inland along the Tuckahoe River. The Tuckahoe-Corbin City Fish and Wildlife Management Area makes up most of the land area, well-used by hunters and for recreation and boating along the river. Some land along this river is privately owned but most of the heavy mosquito-breeding areas are on State-owned lands. The Wildlife Management Area comprises 9,320 acres of marsh (72% of the total State-owned area of 13,000 acres) and 3,680 (or 28%) of upland located in two counties, Atlantic and Cape May. Approximately 24% of the acreage is in Cape May County. This is part of the Egg Harbor-Tuckahoe drainage system of 19,503 acres of tidal marsh and open water. Although emphasis is on wildlife management, this a multiple use area. Wildfowl hunters spend over 2,000 hunter-days and harvest over a thousand ducks and hundreds of Canadian geese. Thousands of upland hunters utilize the area in their quest for quail, pheasants, grouse, woodcock, rabbits, and deer. Trappers harvest between 10,000 and 20,000 muskrats annually. Boy Scouts and other outdoor enthusiasts enjoy camping at man-made lakes and in remote forest areas. Thousands of bird watchers and sighseers appreciate the large numbers of waterfowl, shorebirds, wading birds and other wildlife that abound in the area. Excellent freshwater fishing is found in the impoundments. Saltwater fishing and crabbing are available in the tidal creek, rivers and bay. The famous Jersey shore is only 4 miles east of the meadow. A State-owned boat ramp is located on the Tuckahoe River. A bathing beach and several campgrounds are also along the river. The marshes provide tons of nutrients to the rivers and to Great Egg Harbor Bay that provides important recreational and food sources to man.

Prior to beginning this project, the last work accomplished on the Tuckahoe Marsh was in the 1930's by the CCC. One section of the marsh has never been subjected to mosquito control. The Tuckahoe River, winding through a wide tidal marsh, marks the northern boundary of the tract in Cape May County. Of the total State-owned land area in Cape May County of 3,079 acres, 30% is upland, 59% tidal marsh, 11% waterfowl impoundment, and there is a 17-acre freshwater lake. The general distribution of major vegetational types from the bay to the upland ridges commences with salt marsh cordgrass, changes to a mixture of salt marsh cordgrass and salt meadow cordgrass or salt hay, drops slightly in elevation to a threesquare zone adjacent to the upland, then into the red maple, gum, and upland swamp to a pitch pine lowland, and finally to the white oak-scarlet oak highlands.

Many of the ditches installed in the CCC days are clogged and holding water. For the most part, these ditches will be abandoned as the non-mosquito breeding threesquare zone is again expanding. Only those ditches in salt marsh cordgrass that are breeding mosquitoes are maintained. The cleaning of ditches is based solely on the need to eliminate breeding and not on a routine maintenance of old ditches.

Open marsh water management consists of three basic techniques:

1. Tidal ditches are used whenever practical. Each breeding depression is ditched to a tidal source, either a natural tidal creek or another tidal mosquito ditch. These ditches will insure daily tidal inundation of the depressions and access for larvivorous fish.

2. Where breeding depressions occur near a pool which is capable of sustaining a population of larvivorous fish throughout a season, radial ditches are dug from the pool to the depression. A tidal ditch near such a pool might lower the water table in the pool and reduce fish numbers. Radial ditches maintain the integrity of these pools.

3. Sometimes numerous depressions are found close to each other over a large area. In these instances a pond is dug to encompass the depressions and to maintain a permanent reservoir for fish. Shallow ponds are dug (6 inches to 1 foot) and outlined with a 3-foot deep ditch as a reservoir for fish when the marsh dries. Shallow ponds are most beneficial for shorebirds and wildfowl.

Before any actual management is done, all potential mosquito-breeding depressions are staked in a section of the marsh. A determination is then made for how best to apply management. These methods have been shown to be very effective for source reduction. Virtually all mosquito breeding is eliminated in those areas to which open marsh management has been applied. Mosquito breeding existing in a managed area appears to result from the failure to locate breeding depressions or the failure to recognize a section of marsh as one which breeds mosquitoes. The work is staked out by a mosquito control worker and a wildlife biologist.

Our management team consists of two men and a rotary ditcher. The older model rotary ditchers are unable to dig ponds, and the use of an amphibious dragline is necessary. The newer ditcher can dig ponds as well as ditches. A "marsh buggy" and/or a boat with outboard motor is also needed for transportation to and from the machines. Boston Whalers are used by our Commission for transportation up and down the Tuckahoe River which becomes rough at times.

After the initial survey to determine the location of mosquito-breeding depressions, funds were solicited. After a year of discussion and budgeting, a joint project between the County Mosquito Commission and the Interdepartmental Committee of the State Mosquito Control Commission was approved. A total of $156,500.00 was budgeted, $77,350.00 being the State's share and $79,150.00 the Commission's share. Having been planned three years in advance and with the rising rate of inflation, needless to say, the cost was higher. The rotary ditcher was budgeted for $60,000.00 but cost $73,500.00 at a bid price. Salaries increased and parts cost skyrocketed. When the project is completed, it is estimated that the total cost will be in the neighborhood of $175,000.00. However, we still have a rotary ditcher that will be used for other work, so the entire cost of the machine should not be charged off to this project alone.

Obtaining permits was time-consuming and it took approximately two years to complete and receive them. In New Jersey, Mosquito Extermination Commissions are exempt from the Wetlands Act. However, it was necessary for us to apply for a riparian permit from the N. J. Department of Environmental Protection and a Corps of Engineers permit. The riparian permit was received in July of 1975 and the Corps of Engineers permit was received in July of 1976. An additional year was needed for acquisition of the custom-made rotary ditcher, which had to be assembled after it was received, and to complete the funding arrangements for the machine. Work finally started 25 July 1977. To date, we have completed approximately 1,000 acres and have had 12 months of actual digging time.

In that 12 months we constructed 18 ponds with average size of 200 X 90 X 1 feet, recleaned 9,000 lineal feet of ditches, dug 300,000 feet of new ditches, and eliminated approximately 1,000 acres of mosquito breeding territory. At the present time, this is 1,000 acres that we do not have to treat with pesticide.

Cost figures on larviciding in 1976 averaged $8.62 per acre including administrative overhead. One-third of this figure is administrative costs. In 1979 costs can be increased by 20%, making a cost per acre of $10.00 including administrative overhead. Excluding administrative costs, a price of $6.50 per acre would be more accurate. An average of four applications of pesticide for the mosquito-breeding season per acre would result in a yearly cost of $26.00. This would change as the number of broods on the marsh increase or decrease accordingly.

Open marsh water management is difficult to evaluate as far as economics go. It depends on the type of marsh, the number of mosquito-breeding depressions, the ditches needed, and the equipment used. Our cost for the Tuckahoe Project, to date, averages out to approximately $39.00 per acre of control, excluding the cost of the machine. The first project we undertook in 1967, the Seaville Marsh, averaged $29.18 per acre, and another project completed in 1975 averaged $63.45 per acre, the latter being a restoration of a salt hay farm to a tidal marsh on the Delaware Bay side of our County.

In summary, open marsh water management definitely and significantly reduces the use of pesticides on the open salt marsh as continued evaluation and monitoring reveals. It is an environmentally acceptable technique that has the support of the New Jersey Department of Environmental Protection and the Corps of Engineers. The initial cost is high but the long-term cost is less expensive.

The first area we completed in 1969, the Seaville Marsh, has not needed even one pesticide treatment in 10 years. Ditches and ponds are still in excellent condition. Another project on the Delaware Bayshore eliminated 1,000 acres of salt hay breeding waters and has not needed treating since 1975. Additional projects on that marsh are continuing, and we expect to eliminate another 3,000 acres from pesticide treatment.

When the Tuckahoe Project is completed in late 1980 or early 1981, over 2,000 acres of breeding marsh will be free of mosquitoes and pesticide contamination.

MOSQUITO CONTROL TRENDS IN THE MIDWEST

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Public awareness of the importance of mosquitoes, their role in disease transmission, effects on daily lifestyles and human activity patterns, is growing in the Midwest. Improved medical surveillance has revealed the existence of markedly higher levels of arbovirus transmission than had been previously recognized. Widespread western encephalitis virus activity in 1975 and 1977 initiated the formation of an Arbovirus Surveillence Advisory Committee which resulted in improved communication with the medical practitioners and the recognition of 64 human California (LaCrosse) encephalitis cases in southeastern Minnesota and western Wisconsin in 1978 (Sjogren and Washburn 1979) and approximately 83 cases in the same region in 1979.

The increased public awareness of mosquito-transmitted disease has also led to greater public interest in the effects of mosquito pest annoyance on daily lifestyles in the form of denied time for favorite activities. These insights have led to greater citizen interest in mosquito control methods, costs and environmental safety margins. Outcomes of this trend have included the formation of the Saginaw Bay Mosquito Control District in Michigan in 1977, the LaCrosse County Mosquito Control District in Wisconsin in 1978 and planning to substantially increase the program of the Metropolitan Mosquito Control District. These developments are communicating the fact that effective and environmentally compatible mosquito control technology exists to make our communities more enjoyable. Once understood, public opinion is strongly in favor, even in these inflationary times, of increased taxes for effective mosquito control.

Midwest control methods parallel closely those of the Western U. S. with emphasis on larval control (Sjogren 1976) to combat the 50-odd mosquito species in the region. The predominance of *Aedes* species, notably *Aedes vexans* with its 15-mile flight range, make for widespread, high mosquito annoyance problems. The dense, hardwood forest vegetation, rolling terrain and higher relative humidity levels in the region combine with approximately 18" of summer rainfall to produce favorable breeding and adult survival conditions.

Breeding site densities average 20-25 per square mile and run as high as 140 locations per square mile in certain areas due to glacial moraine deposits. The inability to drive to each mixed grass and woodland depression make inspection and control labor intensive. Rainfall of 1½" or more enables enough surface runoff to collect in depressions to produce major floodwater *Aedes* broods. The number of broods per year varies with area and year, ranging from 2 to 14 with an average of six.

Conservation and natural resource agencies strongly discourage source reduction work on breeding sites due to wildlife interests. Biological control efforts have been limited to the use of fish in some areas and noninterference with natural regulating mechanisms in others. The intermittent nature of most prolific mosquito breeding areas prevents the establishment, survival and reproduction of mosquito predators.

Chemical control of mosquito larvae remains the primary control method due to the above limitations. Granule formulations of Abate and Dursban predominate due to the need to penetrate dense vegetation growth in breeding sites. Use is being made of Dursban 10 CR and Altosid by some districts where environmental and economic conditions permit.

Use of adult control measures by ground nonthermal aerosol machines by districts varies considerably from street-to-street community-wide spraying, to only spraying of parks, recreation areas, special group functions and adult harborage areas within communities. Malathion, resmethrin and pyrethrum are the adulticides in most common use.

Control programs vary depending on the size of contiguous area under larval control and funding levels. Optimally, large land areas are controlled to provide buffer zones beyond urbanized areas to reduce adult mosquito influx. As the area under control increases, the cost of community-wide adult control measures rises substantially and efforts are placed primarily on larval control.

In small communities the optimum control measures, as developed by John Clarke in Illinois, include a combination of larval control within and 1 mile around the community boundary and nonthermal aerosol adult control applications whenever New Jersey light trap counts exceed 20 females per night. Conducting larval control measures reduced the average number of adult control applications by half.

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EFFICACY OF OIL SOLUTION AND WATER EMULSION FORMULATIONS OF FENTION AGAINST PASTURE MOSQUITOES AND EFFECT ON SELECTED NON–TARGET INSECT SPECIES

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Introduction. – Fenthion larvicide was first used by the City of Laramie in 1975 for control of floodwater mosquitoes in nearby pastures. In recent years total acreage sprayed by the City was:[1]

1975	3,000 acres
1976	3,696 acres
1977	5,760 acres
1978	7,666 acres
1979	12,104 acres

In more remote areas of Albany County, Wyoming, governmental agencies have expressed concern over the mosquito problem. Small groups of landowners have organized for mosquito control and in 1976, for the first time, 35,000 acres of land near the Little Laramie River received two applications of fenthion.

Prior to 1978, fenthion larvicide was applied in 1 to 2 qt. of oil per acre. In 1978 a water emulsion formulation was utilized. Due to undetermined problems with this new formulation, questions arose concerning the efficacy of this formulation as well as safety to non-target organisms.

The objectives of the experiment discussed in this report were: to compare the efficacy against mosquitoes of water and oil base formulations of fenthion applied at 1 qt. of total material per acre and to determine the effect of both formulations on populations of selected non-target insect species, particularly insects that were important in the diets of birds in the meadow habitat.

Materials and Methods. – The experimental design consisted of 3 treatments which were: 1) diesel oil solution of fenthion; 2) water emulsion formulation of fenthion; and, 3) no treatment. On June 16, 1979, both fenthion formulations were applied to separate meadows of the Carroll Farm, which is located west of Laramie. The Paradise Farm, ca. 5 miles away, was untreated. Mosquito larvae collected from both ranches were primarily *Aedes dorsalis* and *Ae. melanimon.*

Both fenthion formulations were applied at 0.05 lb. actual/acre to the meadows by an air tractor fixed-wing aircraft equipped with 8, No. 4666 nozzles. Airspeed was 193 km/h. and delivery was 378 liters/min. at a boom pressure of 2.8 $kg/cm.^2$ over a swath width of 38 meters. Altitude was about 38 m. The area treated with oil solution was 3120 acres, and the water treatment area was 640 acres.

Floating mosquito larval cages were constructed from 1 qt. plastic ice cream containers. Areas of the sides and top were removed and replaced by cloth screen, and the entire container was placed within a styrofoam float that permitted approximately one-half of the container to be submerged. These cages were placed in areas of standing water in the meadows with sufficient water depth to keep the cages afloat. Twenty-five, field-collected larvae were placed in each cage.

The first set of four floating cages with larvae was placed in the field prior to spraying. To test for residual activity, four cages were placed in each meadow every 24 hours post-spray, and these were observed 24 and 48 hours later.

Larval mortality was also determined by means of standard pint dipper samples of areas within the treated meadows. The same areas, identified by flags, were dipped before and after spraying.

One additional floating cage received 15 adult Dytiscidae, probably *Hygrotis* spp. The dytiscids remained in the cages under daily observation and were fed a diet of untreated mosquito larvae.

Pitfall traps baited with fresh cattle dung were used to assess the impact of the treatments on dung beetles. This group of insects was selected because it appeared to be abundant (1/3 of species) among the diet items of the Wilson phalarope. Five traps were placed in each meadow. One trap was placed approximately in the center of the treated meadow, and the remaining four were placed approximately halfway between the midpoint and the edge. The traps were placed on higher land that was not submerged by flooding. Traps were baited at 1- to 3-day intervals and all beetles collected over a 24-hour period were removed, identified and counted.

Results and Discussion. – On June 16, prior to spraying, we placed a row of paper cups containing 10 mosquito larvae each, across both meadows perpendicular to the flight path of the airplane. Each cup contained 100 ml. of water, and the cups were spaced 10 meters apart. Thirty-two and 59 cups were placed in the Carroll water and oil areas, respectively. Between 6 and 7 hours post-spray all cups contained at least 9 dead larvae. Twenty cups placed in the untreated Paradise Meadow all contained live larvae. From this we assumed there were no skips in the application.

The results of the fenthion applications are given in Table 1. The percent reduction of mosquito larvae, based on dipper counts, was much greater in the oil solution treatment. Larval counts were not continued in the treated fields because water movement in the water emulsion-treated field changed drastically, and areas marked for dipping either dried up or flooded excessively. There was a large reduction in numbers of larvae in the untreated area. However, this was due to pupation of those larvae and not mortality.

There was no observable residual efficacy due to either formulation of fenthion (Table 2). High mortality was observed in one area (cage no. 1) of the oil solution-treated field beginning on June 19. We are rather certain that this was because predaceous flatworms became established in these cages, and they were killing the larvae. Fairly high mortality was observed in cage number 1 in the water emulsion-treated area also. This particular area was different than the others in either Carroll meadow because it was not receiving additional irrigation water during this part of the study. Actually this spot was uphill from the remainder of the areas where cages were located, and the water level kept receding so that the cage could be used no longer on June 21. We suspect that the fenthion remained concentrated in this one area and therefore produced some residual mortality.

A fairly high mortality was observed among caged mosquito larvae in the check area on June 19. We can suggest no explanation for this.

In order to determine the extent of larval mortality resulting from fenthion that might have adhered to floating cages in the treated areas, an additional four cages were placed in the treatment areas prior to spray application. Between 1 and 2 hours after spraying these cages were moved to an area that received no treatment. Twenty-five larvae were then placed in these cages and observed for mortality at 24 and 48 hours. The results indicated insignificant mortality due to contamination of cages.

The effect of the two fenthion formulations on caged adult dytiscids can be seen in Table 3. Only about 50% mortality resulted from the two treatments.

Figures from annual report, "Mosquito Control Program, City of Laramie", 1975 through 1979.

The dominant insect species attracted to cattle dung was *Aphodius vittatus* followed by *Sphaeridium scarabaeoides.* There did not appear to be any depression in numbers of beetles attracted to the fresh cattle dung in the areas treated with oil and water formulations of fenthion (Figure 1). The fluctuations in population appeared to be a function of air temperature. The highest maximum air temperature, 85°F, occurred on June 13. Maximum air temperature then dropped to 72°F on the 15th then increased to 76°F on the 16th. The colder temperatures around the time of spray application may have had some survival value since the insects were less active at that time.

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Table 1. Effectiveness of fenthion oil-solution and water-emulsion formulations against mosquito larvae based on pint dipper survey of standing water.

		Oil Solution				H_2O Emulsion				Untreated			
Days post-spray	Date	Trans. No.	No.. dips	Live larv. /dip	% red.	Trans. No.	No. dips	Live larv. /dip	% red.	Trans. No.	No. dips	Live larv. /dip	% red.
−2	6/14	4	31	0.66	-	7	69	1.39	-	1	61	5.38	-
		5	133	4.64	-	8	54	1.70	-	2	50	17.56	-
		6	99	12.34	-	9	63	0.79	-	3	89	2.87	-
1	6/17	4	29	0	100	7	65	0.11	92	1	75	2.31	57
		5	89	0.06	99	8	65	0.40	76	2	25	15.52	12
		6	100	0.01	99+	9	64	0.11	86	3	90	0.74	74
2	6/18	4	22	0	100	7	65	0.15	89	1	79	1.23	77
		5	77	0.01	99+	8	52	0.33	81	2	28	7.39	58
		6	95	0	100	9	66	0.09	89	3	97	0.38	87

% reduction is based on pretreatment counts.

Table 2. Residual effectiveness of fenthion oil solution and water emulsion formulations against 3rd and 4th instar mosquito larvae exposed for 2 days in floating cages, Carroll (treated) and Paradise (untreated) Farms, 1979.

		Cumulative number of dead mosquito larvae (out of 25/cage) (Examination date in parentheses)					
		Oil Sol'n.		H_2O Emul'n.		Untreated	
Days post-spray	Cage No.	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr
		(6–17)	(6–18)	(6–17)	(6–18)	(6–17)	(6–18)
1 & 2	1	25	25	25	25	0	1
	2	25	25	0	0	0	1
	3	24	24	0	0	1	1
	4	18	19	25	25	0	0
		(6–18)	(6–19)	(6–18)	(6–19)	(6–18)	(6–19)
2 & 3	1	1	16	20	25	1	4
	2	0	0	0	1	0	4
	3	1	1	0	0	1	6
	4	6	6	0	0	0	4
		(6–19)	(6–20)	(6–19)	(6–20)	(6–19)	(6–20)
3 & 4	1	22*	23	2	9	19	21
	2	2	3	0	1	5	6
	3	0	0	0	2	7	7
	4	0	2	0	0	1	2
		(6–20)	(6–21)	(6–20)	(6–21)	(6–20)	(6–21)
4 & 5	1	24*	25	2	4	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	1	0	1
		(6–21)	(6–22)	(6–21)	(6–22)	(6–21)	(6–22)
5 & 6	1	25	25	0	-	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	1
	4	0	0	0	0	0	0

*Numerous flatworms had entered cage and appeared to be responsible for larval mortality.

Table 3. Effect of fenthion on adult Dytiscidae in cages, 1979.

Days After Spraying	Cumulative Percent Mortality		
	Oil Solution	H_2O Emulsion	Untreated
1	33	47	0
2	40	53	0
3	47	53	0
4	47	53	0

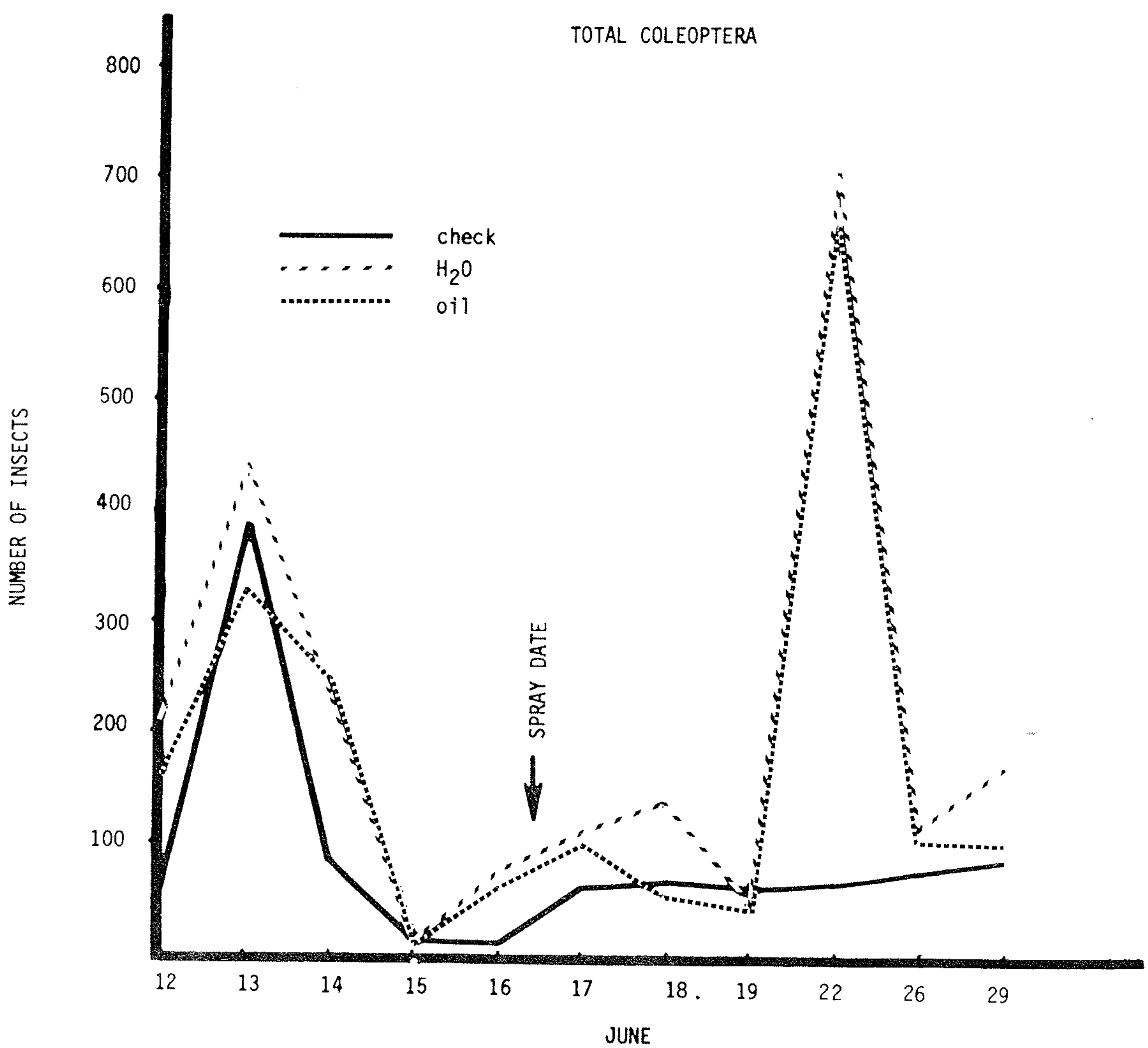

Figure 1. Effect of fenthion oil solution and water emulsion on Coleoptera attracted to fresh cattle dung. Insecticides applied to flood irrigated meadows June 16, 1979.

THE MOSQUITOES OF SOUTHWEST MISSOURI

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INTRODUCTION

The mosquitoes of Missouri have received mention several times in general works (Dyar 1922, 1928; King and Bradley 1941; Adams 1942; Jenkins and Carpenter 1946; Bohart 1948; Carpenter and LaCasse 1955; and Carpenter 1968, 1970). Adams (1934) was the first to present a specific report on the mosquito fauna of Missouri, recording 19 species of seven genera. Day (1943) listed 30 species of eight genera from St. Louis County, Missouri. Adams and Gordon (1943) published a list of 30 species of seven genera for the state.

Two important mosquito surveys were conducted in 1942-43 by U. S. Army entomologists. Gurney (1943) coordinated a mosquito survey of Camp Crowder, located in the southwest corner of the state. In this survey 31 species of nine genera were collected. Olson and Keegan (1944) in a collecting program of the Seventh Service Command (North Dakota, South Dakota, Nebraska, Iowa, Minnesota, Colorado, Wyoming, Missouri, and Kansas) listed 35 species of eight genera for the state of Missouri.

Carpenter (1942) and Roth (1945) both added new records to the state list. An anonymous report by CDC (1951) listed four new records. Smith (1955) recorded 51 species of nine genera, giving distribution and ecological notes on the species of Missouri. Enns (1958) was the first to provide a key to the larval species of the state. He listed 57 species of nine genera for Missouri. However, this list included several species that have not been found in the state, but which he believed should occur in the state.

Recent studies include an investigation by Smith and Enns (1967) of mosquito populations associated with oxidation lagoons in central Missouri. They stated that the mosquito populations associated with oxidation lagoons consisted of 12 species. Smith (1969) reported 22 species of eight genera collected in or near Columbia, Missouri. The most recent list of mosquitoes of the state was reported by Smith and Enns (1968). They reported a fauna of 51 species for the entire state.

However, the ecology and distribution of the mosquito fauna of southwest Missouri had not been thoroughly studied. Therefore, it was the purpose of this study to determine the species composition of the fauna and to describe habitats and associations of all species found in Greene County. Greene County is located in the southwestern part of the State of Missouri, about 40 miles from the Arkansas state line on the south and about 60 miles east of the Kansas-Oklahoma state lines. Area of the county is approximately 677 square miles, with elevations ranging from 1,350 to 1,700 feet.

METHODS AND MATERIALS

Collections of larvae and adults were made during the months of April through October 1977. Emphasis was placed on collecting fourth instar larvae in order to determine the ecological preferences of the species. Collecting routes were mostly determined by the network of roads throughout the county with different routes being taken for every day of collecting in an attempt to sample uniformly throughout the study area.

Larval collections were made by use of a long handled dipper. The dipper was used to obtain visible larvae as well as those interspersed in aquatic vegetation and debris. Specimens were transferred to pint-sized cups containing water from the breeding place and were transported to the laboratory in a styrofoam cooler.

From collections containing more than 10 larvae, representative fourth instars were preserved in alcohol. The remaining larvae were reared in the laboratory. For most collections, slides of larvae and male terminalia and pinned female adults were made available for identification. The specimens have been placed with the Department of Life Sciences, Southwest Missouri State University, Springfield, MO, for further reference

RESULTS AND DISCUSSION

As a result of this study six genera and 20 species of mosquitoes were collected in Greene County, Missouri. They included:

Anopheles punctipennis (Say)
Anopheles quadrimaculatus Say
Uranotaenia sapphirina (Osten Sacken)
Culiseta inornata (Williston)
Psorophora ciliata (Fabricius)
Psorophora columbiae (Dyar and Knab)
Psorophora cyanescens (Coquillett)
Psorophora discolor (Coquillett)
Psorophora howardii Coquillett
Aedes atropalpus (Coquillett)
Aedes canadensis (Theobald)
Aedes thibaulti Dyar and Knab
Aedes trivittatus (Coquillett)
Aedes vexans (Meigen)
Culex erraticus (Dyar and Knab)
Culex pipiens complex
Culex restuans Theobald
Culex salinarius Coquillett
Culex tarsalis Coquillett
Culex territans Walker

Four additional species have been reported from Greene County (CDC 1951) but were not collected in this study. They are: *Anopheles barberi*, *An. crucians*, *Ae. triseriatus*, and *Cx. peccator*. *Aedes atropalpus*, *Ae. canadensis*, *Ae. thibaulti*, *Ps. ciliata*, *Ps. discolor*, and *Ps. howardii* appeared to be new county records. *Aedes thibaulti* was collected not only for the first time in Greene County but for the first time in this area of the state. It was previously known only from the southeastern portion of the state. *Aedes canadensis* larvae were collected for the first time in this area. However, Gurney (1943) reported taking one adult in southwest Missouri.

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Psorophora howardii, whose total range throughout Missouri is not well known, was taken from two collections.

A total of 146 collections was made. Table 1 summarizes the number of times each species was collected from each habitat, the total collections from each habitat, and the total number of times each species was collected.

Anopheles punctipennis, *Ae. vexans*, *Cx. restuans*, and *Cx. salinarius* were collected more than any other species. Collections containing these species often contained numerous larvae, and I believe these species to be the most abundant in Greene County. *Anopheles puntipennis* was found in a greater variety of habitats than any other species of the study. However, it was taken over 50% of the time from a riparian-type habitat. *Aedes vexans* was also taken in a wide variety of habitats but was mostly taken from drainage ditches and other temporary water sources. *Culex restuans* and *Cx. salinarius* were both commonly taken from drainage ditches and rain puddles but appear to readily accept artificial containers as breeding sites.

Psorophora columbiae, *Cx. pipiens* complex, *Cx. tarsalis*, and *Cx. territans* were found in several collections, but only in a few collections were they found in large numbers. *Psorophora columbiae* was found almost exclusively in rain puddles and ditches filled with rain water. The *Cx. pipiens* complex has been reported to occur in almost any type of water and frequently in artificial containers, but it was mainly taken from rain puddles and ditches in this study. *Culex tarsalis* was also taken primarily from drainage ditches. *Culex territans*, like *An. punctipennis*, showed a preference for the stream environment. In 15 collections *Cx. territans* and *An. punctipennis* were collected together.

Five species were taken in only one larval habitat: *Cs. inornata* (drainage ditches), *Ps. cyanescens* (rain puddles), *Ps. howardii* (rain puddles), *Ae. atropalpus* (rock holes), and *Cx. erraticus* (permanent ponds). These as well as the remaining species of this study were collected in too few numbers and collections to be certain of habitat preferences. Further studies are needed to better determine habitat preferences and abundance of these species in southwest Missouri.

ACKNOWLEDGEMENTS

I thank my major professor Dr. Steven L. Jensen for suggesting and helping design this project and for his continuing ideas. Many thanks go to Drs. Russell G. Rhodes and Robert F. Wilkinson, Jr. for critical reading and suggesting ideas. I am appreciative of the 14th Preventive Medicine Unit, U. S. Army Reserve for collections made in the study area. I thank Dr. Lewis T. Nielsen for helping with the manuscript. Thanks go to Dr. Jay Linam for his continued encouragement. A special thanks to my wife Roxann for her encouragement and help in early collections.

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Table 1. Summary of larvae collected, with number of collections taken from each habitat.

SPECIES	HABITATS: DRAINAGE DITCHES	PONDS: TEMPORARY	PONDS: SEMI-PERMANENT	PONDS: PERMANENT	STREAMS	STREAM BEDS	ROCK HOLES	SINK HOLES	RAIN PUDDLES	LOW MEADOWS	ARTIFICIAL CONTAINERS	TOTAL TIMES SPECIES COLL.
An. punctipennis	8	2			16	10	2	1	3	1		43
An. quadrimaculatus	1			2							1	4
Ur. sapphirina				1	1							2
Cs. inornata	4											4
Ps. ciliata	3	1							5			9
Ps. columbiae	10	1			1		1		9	1		23
Ps. cyanescens									6			6
Ps. discolor	3	1							1			5
Ps. howardii									2			2
Ae. atropalpus							1					1
Ae. canadensis	1				1						1	3
Ae. thibaulti					1						1	2
Ae. trivittatus					1				4			5
Ae. vexans	25	1	2		4	1			6	2		41
Cx. erraticus				2								2
Cx. pipiens complex	9				1				6	2	2	22
Cx. restuans	18		3		5		1		9		10	46
Cx. salinarius	16			1	3	3			6	1	7	37
Cx. tarsalis	10				1		1		2		1	15
Cx. territans	6				8	6	2		4			26
Total collections from each habitat*	48	2	5	2	25	13	2	1	23	4	12	

*Total collections from each habitat do not equal the total of the columns because in most collections two or more species were present.

WESTERN UTAH LAGOMORPHS AND CALIFORNIA ENCEPHALITIS VIRUS[1]

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ABSTRACT

During October 1979 a total of 139 blood samples was collected from lagomorphs at Blue Lake and near Fish Springs in western Utah. Of the 94 selected specimens which were assayed, 53 exhibited significant levels of California encephalitis neutralizing antibodies. This result of 56 percent positive specimens represents a high incidence of antibody and correlates with previous high levels of virus isolations from mosquitoes of the area. Blue Lake had a high level of California encephalitis virus isolated from mosquitoes and a high level of neutralizing antibody, particularly in the blacktailed jackrabbit, *Lepus californicus*. The role of lagomorphs as potential hosts for California encephalitis virus was discussed.

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CHANGES IN RESISTANCE OF UTAH MOSQUITOES TO ORGANOPHOSPHORUS LARVICIDES

Chad Merrell[1] and Bettina Rosay[2]

Resistance studies supported by the UMAA were continued during the summer of 1979. Standard procedures were used for tests with parathion, fenthion, and malathion and included observations on larvae of six mosquito species.

During limited testing in 1965-7, no resistance to parathion was found (Womeldorf 1967). In 1971, Shinney and Havertz found no resistance to malathion in controlled areas of Weber County. From 1976 to the present, more intensive, routine assays have been done for larvae from most of the organized mosquito abatement districts in the State (Hart and Womeldorf 1976, Merrell and Wagstaff 1977, Wagstaff and Merrell 1978).

Some changes in resistance have been noted that, in part, may be due to using mosquito populations from different areas, involvement of different personnel, and other variables such as transportation of larvae and rearing of early instars to the testing stage.

There seems to be no firm definition for the limitations of resistance. For a re-evaluation of past years' results of resistance surveillance on Utah mosquito larvae, we have used:

<u>Resistance</u>	<u>LC_{50}</u>	
parathion, fenthion	>0.0050 ppm	accompanied by
malathion	>0.1000 ppm	$LC_{90/50} > 2.0$

<u>Borderline</u> - only one of couplet

For the re-evaluation of the last four years' work, not all data were available for 1977 and 1978. Except for unusually low numbers of *Cx. tarsalis* this past summer, there were remarkable similarities for 1976 when 124 populations were tested, and 1979, with 98 populations. Listed below are the numbers of tests for each species followed by the total number of resistant tests for all chemicals and, in parentheses, borderline results.

	1976 TOTAL TESTS		1979 TOTAL TESTS	
Ae. dorsalis	100	5 (12)	102	7 (58)
Ae. nigromaculis	18	4 (6)	12	2 (4)
Ae. vexans	40	0 (16)	54	3 (28)
Cx. pipiens	38	1 (9)	49	0 (18)
Cx. tarsalis	49	1 (5)	11	0 (5)
Cs. inornata	44	1 (13)	37	5 (18)
	289		265	

The magnitude of results for 1979 is given in Table 1.

Through the recent years of surveillance, there has been no resistance to malathion for any species. In 1976, about 20% of the tests showed borderline resistance which increased to about 50% in 1979. Observations in California indicate that a failure threshold for malathion can occur when the LC_{50} reaches 0.1 ppm. In 1979, our highest concentrations for LC_{50}'s were 0.081 ppm for *Ae. dorsalis* in Box Elder County and 0.097 ppm for *Cs. inornata* in Davis County. Most of the LC_{50} dosage rates have been very low. However, half of the 1979 tests had $LC_{90/50}$ ratios equalling 2.0 or greater and as high as 5.2. Even though the larval populations are still susceptible to malathion, the heterogeneity shown by the $LC_{90/50}$ ratios is evidence of the wide range of insecticide concentrations required to kill the larvae, a warning of impending malathion failures.

The total resistance to parathion and fenthion has been relatively low with only a slight increase over the past four years. In 1979 there were three times as many borderline results for fenthion as in 1976. For parathion, the increase was one and a half times.

There were a comparable number of tests with *Ae. dorsalis* for each of the four years and very little resistance has been demonstrated. In 1978 borderline cases for fenthion greatly increased, and in 1979 those comprised 80% of the tests on that species.

Relatively few tests have been done with *Ae. nigromaculis.* The results have remained the same over the four years, about half the tests being resistant or borderline.

In 1976 no resistant *Ae. vexans* were found. A single population resistant to parathion was tested in 1977, and one to fenthion in 1978. In 1979, only three parathion-resistant populations were found. Interestingly, for 1979 there was a decrease from previous years in the proportion of tests borderline for parathion but an increase for fenthion borderline.

Very few tests have shown resistance for either *Culex* species. Proportionately, borderline results for *Cx. tarsalis* and all three chemicals rose in 1979 but only 11 populations were tested.

Cs. inornata has demonstrated virtually no resistance to parathion or fenthion, none at all in 1977. There has been only a slight increase in the borderline results.

By judging the results of the past four years' tests on a common basis and re-evaluating each year's data, there is evidence that overall resistance to the test chemicals has increased only slightly but borderline resistance has doubled.

1/ Utah Mosquito Abatement Association

2/ South Salt Lake County MAD

REFERENCES CITED

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Shinney, C. L. and D. S. Havertz. 1971. Comparison of susceptibility trends of *Culex tarsalis, Culex pipiens,* and *Anopheles freeborni* to malathion in areas under control within Weber County, Utah. Proc. Utah Acad. Sci., Arts, Lett. 48:37-8.

Wagstaff, K. and R. Merrell. 1978. Status of organophosphorus mosquito resistance in Utah, 1978. Proc. Utah Mosq. Abate. Assoc. 31:21-7.

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Table 1. Magnitude of tests – 1979.

	PARATHION		FENTHION		MALATHION	
	TOTAL NO. TESTS	NO. RESIST. TESTS*	TOTAL NO. TESTS	NO. RESIST. TESTS*	TOTAL NO. TESTS	NO. RESIST. TESTS*
Ae. dorsalis						
Box Elder	14	2 (5)	14	3 (10)	15	(5)
Davis	2	0	2	(2)	2	(2)
Tooele	1	0	1	(1)	1	(1)
Uintah	2	0	2	(2)	2	(2)
Utah	5	(4)	5	1 (4)	5	(2)
Weber	10	1 (5)	9	(7)	10	(6)
TOTAL	34	3 (14)	33	4 (26)	35	(18)
Ae. nigromaculis						
Salt Lake City	2	(2)	2	2	2	(2)
Weber	2	0	2	0	2	0
TOTAL	4	(2)	4	2	4	(2)
Ae. vexans						
Box Elder	2	0	2	(1)	2	(1)
Salt Lake City	2	1 (1)	2	(2)	2	(1)
South Salt Lake	2	(1)	2	(1)	2	(2)
Tooele	1	0	1	(1)	1	0
Utah	4	(3)	3	(1)	3	(2)
Weber	8	2 (3)	8	(5)	7	(3)
TOTAL	19	3 (8)	18	(11)	17	(9)
Cx. pipiens						
Box Elder	1	0	1	(1)	1	(1)
Magna	1	(1)	1	0	1	0
South Salt Lake	4	(2)	4	(2)	4	(3)
Utah	12	(3)	10	(4)	9	(1)
TOTAL	18	(6)	16	(7)	15	(5)
Cx. tarsalis						
South Salt Lake	1	0	–	–	1	0
Uintah	3	(1)	3	(2)	3	(2)
TOTAL	4	(1)	3	(2)	4	(2)
Cs. inornata						
Davis	2	1 (1)	2	(2)	2	(1)
Magna	4	(3)	1	(1)	3	(2)
Salt Lake City	3	2 (1)	3	2 (1)	2	(2)
South Salt Lake	2	(1)	–	–	1	0
Utah	7	0	2	(2)	3	(1)
TOTAL	18	3 (6)	8	2 (6)	11	(6)

*Borderline in parentheses

ACQUISITION AND USE OF LANDSAT IMAGERY

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The Aerial Photography Field Office (APFO) is administered for the Department of Agriculture by the Agriculture Stabilization and Conservation Service. The purpose of the APFO is to disseminate and encourage use of remotely sensed imagery relevant to functional responsibilities of the Department.

The APFO is the archive for remotely sensed data collected by USDA, NASA aircraft, Landsat, Skylab, Apollo, and Gemini spacecraft. APFO archives all pre-February 1979 Landsat data and purchases past February 1979 Landsat data (identified for Agriculture requirements) from the EROS Data Center in Sioux Falls, South Dakota. APFO sales for FY 1978 amounted to over 2.5 million dollars, of which 3% was for Landsat data ($750,000).

Agriculture has identified routine applications of remote sensing: changes affecting production and quantity of renewable resources; land-use classification and measurement; renewable resources inventory and assessment; land productivity estimates; conservation practices.

Landsat (formerly known as the Earth Resources Technology Satellite (ERTS)) consists of the earth orbiting observatory, a data collection system, command and tracking facilities, and a ground data handling facility for processing.

Landsat 1 (ERTSA) was launched July 23, 1972; Landsat 2 (ERTSB) was put into orbit July 22, 1975; and Landsat 3 (ERTSC) was launched March 5, 1978.

The satellite moves in an almost perfectly circular orbit at an altitude of 500 nautical miles inclined at 81° relative to a plane passing through the earth's equator. The near polar orbit is also sun synchronous, crossing the equator on the day side of earth 14 times every day at approximately 9:30 a.m. local time in each transit. Each successive orbit shifts westward about 1,785 miles at the equator. On the following day, the next 14 orbits parallel those of the previous day, but each one is offset westward by about 99 miles.

Two imaging sensor systems operate on the Landsats. One is a television camera system (Return Beam Vidicon). The RBV was shut down early in the Landsat 1 operation due to a switching malfunction.

The second system is a multispectral scanner which produces a continuous image strip built up from successive scan lines extended perpendicular to the forward direction of the satellite's orbital motion. Reflected light from the ground is transferred by an oscillating mirror in the MSS to a recording system after passing through filters that select different wavelength intervals of this light. Each of the four wavelength channels processes a predetermined spectral interval or band. One principal use of this multispectral capability stems from a basic property of materials. Because various classes of features found on the surface reflect differing amounts of light at different wavelengths or wavelength intervals, they can be separated and identified by their own characteristics, reflectance patterns or spectral signatures. (Examples: many dry soils, by contrast, reflect less light in the green than in the red and, moderately more so in the infrared; wet soils show similar patterns of relative reflectance in the four bands, but the magnitude or intensity of light reflected in each band is reduced by the general light-absorbing characteristic of water.)

The light reflectance data obtained by the MSS on board Landsat are first converted to electrical signals, which vary in proportion to the intensity measured for each band. These analog signals then are converted into a digital form and transmitted to one of the receiving stations (U. S. (3), Canada, Brazil, Italy, Chile).

The digital video data can be re-formatted into computer compatible tapes and analyzed by users through a variety of computer based programs. The digital data can be reconverted at ground processing facilities into sets of black-and-white photo images.

Color images are made from combinations of individual black-and-white images by projecting each given band through a particular filter. The usual combination consists of band 4 (green), projected through a blue filter; band 5 (red), projected through a green filter; and band 7 (infrared), projected through a red filter. This produces a false color infrared image which is equivalent to the standard false color infrared product of conventional color infrared photography. Growing vegetation will appear in various shades of red, rocks and soils will normally show colors ranging from bluish through yellows and browns, water will stand out as blue to black, depending on depth and amount of suspended sediment, and cultural features (towns and roads) will usually be recognized by bluish-black tones arranged in characteristic patterns.

Landsat 4 is scheduled for launch in the fall of 1981. Sensors aboard are planned to be the MSS and the Thematic Mapper. The Thematic Mapper is an improved version of the MSS. The resolution will be 30 meters instead of 80 meters. There will be seven bands instead of four, ranging .45-.52, .52-.60, .63-.69, .76-.90, 1.55-1.75, 2.08-2.35 and 10.4-12.5. The orbit will be west to east due to the lower altitude of the spacecraft and adjoining scenes will be on 8-10 day intervals instead of the present next-day swath. The turn-around time is looking for a big improvement. Using communication satellites to relay images to White Sands and back to GSFC within 8 hours and Domsat to relay tape information to EROS Data Center within 48 hours makes a total of 56 hours before the information is in the public domain. The tape recorders are planned for use only as a back up. There will also be changes made to the worldwide reference system.

Slides were shown to illustrate the uses of Landsat imagery.

REVISED CONSTITUTION OF THE UTAH MOSQUITO ABATEMENT ASSOCIATION

Adopted at the 8th Annual Meeting of the Association
Revised at the 13th Annual Meeting
Revised at the 25th Annual Meeting
Revised at the 28th Annual Meeting
Revised at the 30th Annual Meeting

ARTICLE I. NAME

The name of the organization, an unincorporated association, shall be "UTAH MOSQUITO ABATEMENT ASSOCIATION".

ARTICLE II. OBJECTIVES

The objectives and purposes of the Association shall be to promote close cooperation among those concerned with, or interested in, mosquito control and related work, to increase the knowledge and advance the cause of mosquito abatement in an efficient and effective manner compatible with the goals of a sound environment. The Association may also encourage and undertake such other insect control problems as the Association may determine.

ARTICLE III. MEMBERSHIP

Section A. The membership of the Association shall consist of three classes: Members, Contributing Members, and Honorary Members.

Section B. Members shall consist of two categories: Agency Members and Individual Members.

1. Agency members shall be any active mosquito abatement program supported with an annual budget from public funds.
2. Individual members shall be any person interested in or concerned with mosquito abatement who desires affiliation with the Association.

Section C. Contributing Members shall be any commercial or other organization which desires affiliation with the Association.

Section D. Honorary Members shall be any individual who has performed outstanding service in the interest of mosquito abatement and who has been elected to honorary membership for life by two-thirds majority vote of voting members present at the time of voting.

Section E. Approval of Membership. All applications for membership shall be subject to approval by a majority of the Board of Directors at any meeting of the Board of Directors at which a quorum is present.

Section F. Voting. All trustees, commissioners and designated permanent employees of agency members shall have one vote at Association meetings. All individual and honorary members shall have one vote. Contributing members shall have no vote.

ARTICLE IV. REVENUES

Section A. The revenue of the Association will be derived from dues paid by members, from the sale of publications, from donations and contributions and from such other sources as may be approved by the Board of Directors.

Section B. The dues for members and date of payment shall be established annually by the Board of Directors of the Association. All mosquito abatement districts and organizations sponsoring members shall be notified one month prior to the annual meeting of the Association of any changes in the amount of dues from those assessed the previous year and approved by the Board of Directors.

ARTICLE V. OFFICERS

Section A. The elective officers of the Association shall be President, President-Elect, Vice President, and a Secretary-Treasurer. The officers shall be elected at the annual business meeting by a majority vote, except for the President-Elect who automatically ascends to the office of President. A director shall be appointed by the governing body of each unit in Utah engaged in mosquito control and which is a member of the Association. The elective officers and the duly appointed directors shall constitute the Board of Directors.

ARTICLE VI. DUTIES OF OFFICERS

Section A. The President shall preside at all meetings of the Association, annual and special, and at all meetings of the Board of Directors. He shall maintain and exercise general supervision over the affairs of the Association, subject to the authority of the Board of Directors, and shall discharge such other duties as usually pertain to the office of President. He shall name members of the committees with consent and approval of the Board of Directors at their first meeting during his term of office. In the absence of the Secretary-Treasurer, the President may sign checks to pay for bills approved by the Board of Directors.

Section B. The President-Elect shall exercise the powers and perform the duties of the President in the absence or disability of the President. In case of a vacancy in the office of the President, the President-Elect becomes President for the balance of the term of the office. He shall function as Program Chairman for the Annual Meeting held during his term of office. The Board of Directors shall appoint by a majority vote an Acting President-Elect, when the office becomes vacant, to serve until the next election of officers by the Association.

Section C. The Vice President shall assist the President and the President-Elect with the duties of these offices as directed.

Section D. The Secretary-Treasurer shall keep full and correct minutes of all meetings of the Association and of the Board of Directors. He shall be responsible for the maintenance of all membership records, conduct the correspondence of the Association, and issue all notices of meetings. He shall collect and receipt for all dues, assessments and other income. He shall deposit promptly all funds of the Association in such depositories as shall be approved and designated by the Board of Directors. Checks in payment of obligations of the Association shall be signed by the Secretary-Treasurer. He shall, under the direction of the Board of Directors, pay all bills of the Association and make such other disbursements as are necessary and incidental to the operations of the Association. He shall, at the annual meeting of the Association, and if directed by the Board of Directors at special meetings, make full and true report of the financial condition of the Association. He shall perform such other duties as are usually incident to the office of Secretary-Treasurer and as may be assigned to him by the Board of Directors. The Secretary-Treasurer with the approval of the Board of Directors and with the assistance of the Publications Committee, shall publish and distribute the Proceedings and other publications of the Association. In the absence or disability of the Secretary-Treasurer, the Board of Directors shall appoint a member of the Association to serve in this capacity as required or until the next election of officers by the Association.

Section E. The Board of Directors shall meet upon the call of the President, or upon the request of three (3) or more members of the Board of Directors directed in writing to the Secretary-Treasurer. At least five (5) days prior notice in writing shall be given by the Secretary-Treasurer to all members of the Board of Directors as to any meetings of the Board of Directors: the time and place of such meetings shall be designated by the President. A majority of the members of the Board of Directors shall constitute a quorum for the transaction of business, and action by the Board of Directors shall be upon the vote of a majority of those members present at any meeting of the Board of Directors at which a quorum is present. The Board of Directors shall manage the affairs of the Association and shall have power:

(a) to fill any vacancy among the elected officers of the Association,

(b) to appoint the following standing committees each to consist of not less than three (3) members: Publications, Auditing, Program, and Nominating. Special procedures for the Nominating Committee are included in Article VII. The Secretary-Treasurer shall be an ex officio member of all committees,

(c) to appoint such other committees as it may deem to be necessary or useful in conducting the business of the Association,

(d) to prescribe the duties of officers of the Association not otherwise prescribed in the Bylaws of the Association,

(e) to prescribe rules and regulations for the conduct of the affairs of the Association, as are not inconsistent with the provisions of the Constitution of the Association,

(f) to determine the number and price of each publication which shall be distributed to the various members of the Association, and to others; to approve lists of nonmembers who may receive publications without charge,

(g) to accept or reject applications for memberships in the Association, except Honorary Membership, and to prescribe rules and procedure in relation thereto.

ARTICLE VII. NOMINATION AND ELECTION OF OFFICERS

Section A. At least 15 days prior to the annual meeting of the Association, the President shall appoint, subject to approval of the Board of Directors, a nominating committee consisting of five (5) members of the Association naming one of the five to serve as Chairman.

Section B. The Nominating Committee shall determine its nominees for elective officers of the Association. It shall present the names of the nominees selected in the opening session of the annual meeting of the Association. It shall also present at this time, on request, any nominations made in writing and signed by three or more members of the Association. Election of officers will be conducted in a business meeting where nomination for officers may be made from the floor.

Section C. Officers of the Association shall be elected by majority vote at the annual meeting of the Association, and shall serve until the next annual meeting.

ARTICLE VIII. MEETINGS

Section A. There shall be an annual meeting of the Association, for the election of officers, the presentation of papers and discussions on mosquito abatement and related subjects, and such other business as may be properly considered. Such meetings shall be held at such times and places as the Board of Directors shall prescribe. At least 7 days prior notice shall be given to all members as to the time and place of the annual meeting.

Section B. Special meeting of the Association may be held whenever the Board of Directors deems such meetings necessary, or whenever ten or more Members shall make a written request thereof, presented to the Secretary-Treasurer. Such request shall be presented to the Board of Directors, which shall designate a time and place for such special meeting. The Secretary-Treasurer shall give written notice of all special meetings of the Association to all members at least seven (7) days prior to the date of such special meeting.

Section C. A simple majority of Members of this Association shall constitute a quorum for the transaction of business at any annual or special meeting and any actions taken at such meetings shall be by majority vote.

ARTICLE IX. REPORTS AND PUBLICATIONS

Section A. The Association shall publish an annual report. The report may contain the proceedings, papers, and business transacted at the annual meeting. It may also include any other matter deemed by the Board of Directors to be essential to the general welfare.

ARTICLE X. PARLIAMENTARY PROCEDURE

In the absence of rules in this Constitution of the Association the proceedings of the Board of Directors' meetings, as well as the Association meetings shall be conducted in accordance with established parliamentary procedure.

ARTICLE XI. AMENDMENTS

This Constitution may be amended at any regular business meeting of the Association at which there is a quorum, by a two-thirds vote of the members present, provided the Board of Directors has previously considered the merits of the amendment.

ARTICLE XII. FINANCIAL RESPONSIBILITY

Except by the specific direction of the Board of Directors under their personal individual financial responsibility, no debt or other financial obligation of this Association shall be incurred by this Association beyond the amount of the funds (over and above all liabilities) then in the hands of the Secretary-Treasurer.

TITLES PUBLISHED ONLY

"Relevance of IPM to Mosquito Abatement Programs." Richard C. Axtell, Department of Entomology, North Carolina State University, Raleigh, NC.

"Highway Design Can Cooperate in Mosquito Prevention." Glen S. Baldwin, Utah Department of Transportation, Salt Lake City, UT.

"Utah Encephalitis Surveillance Report." Lewis Marrott, Utah County Mosquito Abatement Department, Provo, UT.

"Mosquito Abatement Authority Under Utah Law." Fred Nelson, Utah State Office of the Attorney General, Salt Lake City, UT.

"Mosquito Problems in Scandinavia." Lewis T. Nielsen, Department of Biology, University of Utah, Salt Lake City, UT.

"Hazardous Waste Control." Dale D. Parker, Bureau of Solid Waste Management, Utah Division of Health, Salt Lake City, UT.

"Landing Strip Design and Construction." Rex Passey, Davis County Mosquito Abatement District, Kaysville, UT.

"Economics of Plane Spraying." Gerald Purdy, Davis County Mosquito Abatement District, Kaysville, UT.

"Report of the Utah Mosquito Control – Fish and Wildlife Management Coordinating Committee." Reed S. Roberts, Extension Entomologist, Utah State University, Logan, UT.

"Costs/Benefits of Mosquito Control – An Extension Viewpoint." Reed S. Roberts, Extension Entomologist, Utah State University, Logan, UT.

"The American Mosquito Control Association Today." Glenn M. Stokes, President AMCA, Metairie, LA.

"Public Relations in Mosquito Control: An Obligation." Glenn M. Stokes, Jefferson Parish Mosquito Control Department, Metairie, LA.