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W. Donald Murray, Secretary-Treasurer
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RESISTANCE AND CHANGING APPROACHES TO MOSQUITO CONTROL

Richard F. Frolli
Kings Mosquito Abatement District, Hanford

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

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

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

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

All districts represented here have resistance to a greater or lesser degree. In some districts resistance is still at low toxicological levels, mere provocations, having only a slight impact on the total program. But resistance will grow and mature because it is chronic. It persists, demanding ever increasing attention and study both physiologically as well as economically and sociologically. We at Kings MAD are convinced that it was terminal to the body of our basic program, the spray program.

So we have changed our approach, de-emphasized spraying and re-emphasized the other avenues of mosquito control to such an extent, with such magnitude, and with such fresh thinking that we are today an entirely new district, seeking a new image, and seeking a new lease on our political life for public service.

We all know that making a change, even a minor change, in an operation or organization is very difficult to do smoothly. It requires planning, communications, consent, feedback, refining, and TIME – otherwise the change is met with misunderstanding, reluctance and is doomed.

Alvin Toffler, in articles on "future shock", deals with complexities of modern life and overstimulation of people by change or novelty. When you hear a hot rock record you climb the walls, that is overstimulation. For Toffler the shock of change manifests itself four ways; by denial of unwelcomed news or by blocking our innovations to circumvent it, or by returning to yesteryear solutions or by supersimplifying the solutions.

As you engage the problem of chemical failures, you will meet Toffler's people. First is the denyer of this unwelcomed reality, resistance. The farmer says, "You *were, too,* killing the mosquitoes." And you say, "But it took three sprayings to do it." The operator may say, "I got a kill." You say, "Only with a shotgun mixture, we can't operate that way." The operator will say, "I'm getting a kill with Baygon." You say, "Yes, but only the adults and its taking all day and night to knock them down, much longer than the 15 minute effect we had last spring." The grand jurors ask, "Wouldn't more money help?" And you say, "With 200,000 acres to treat due to repetitive spraying at $1.00 to $2.00 per acre it's not economically feasible. We can't buy our way out."

Toffler's second person, and this includes most of us, is mentally deaf. He blocks out all suggestions other than a chemical approach. He stands about flapping his arms asking, "What are you going to do now?" You say, "Pump it, dry it." He asks, "What pesticide will be next?" You continue, "Drain it, dike it." He asks, "Will garlic work?" You frustratedly add, "Punch it deeper and plant fish. Phase out the pasture, level the field, treat it with gyp, apply less water, pond the excess, recycle it, fill the pot holes." And he concludes, "Gee, I hope you get a new chemical soon, since you can't do anything."

And Toffler's "return to yesteryear" group approach and question your methods of application and materials. "You are flying too high or too wide," they will say. You say, "The chemicals don't work even on the deck and with flagmen marking the swathes." They will say, "The ULV is the problem." You answer, "It's the chemicals which don't work, not even at three gallons." They ask, "Could you return to ground application?" You say, "Pesticides are dead, what good would it do?" They ask, "Have you used oils?" You say, "Our liability is shaky." They ask, "How about DDT?" You say, "IN NO WAY – MAN, not since 1952." They ask, "Try fogging?" You ask, "What with?"

And Toffler's "supersimplifiers" with their neat equations, they say, "Get a new chemical" or, "Get going with source reduction."

We don't believe a new chemical would last very long if used extensively and intensively. Resistance is the result of chemical pressuring in the population, selecting only the physiologically hardy for survival. It is genetic in origin and pure Darwinism. We must use new chemicals which will become available with the utmost discretion and direction.

And source reduction is the most misunderstood program in mosquito abatement. How can source reduction meet our challenges when it is the most under-staffed, under-equipped, under-researched of all our mosquito control endeavors. Source reduction lends itself well to standing pond *(Culex)* mosquitoes but has very few answers for the intermittent pond *(Aedes)* mosquitoes.

So we have a crisis in mosquito control – the crisis is a mental one – a reluctance to accept change. But this crisis will break as a fever does. Someday, we'll all realize and the public as well, just how ridiculous the dependence upon repetitive spraying is as we get a clear grasp of the new realities of mosquito abatement, and define clearly new values and priorities.

When this happens, we will see funds available from chemical allocations and spray operations channeled into other avenues of mosquito abatement . . . such as, expanding the introduction of and enhancing naturalistic methods; such as, reducing and refining spraying to economically sound methods; such as, meeting head on the soil and water management problem with special equipment, special men and special procedures to get the job done.

But most important is the stimulating of the rural community to employ cultural changes in farming to improve soil and water management – which only the landowner himself can do.

We must instill an awareness of the responsibility to prevent and eliminate mosquitoes on one's own property. We must instill into the conscience of the mosquito producer the willingness to eliminate mosquito breeding and shame if he doesn't.

Control agencies have virtually taken all the responsibility of prevention and suppression away from the mosquito producer. It has been easy to spray all our troubles away, whether they were basic soil and water problems or merely poor farm management. We have treated the effects of useless water, not its causes, for too long. And, on top of this . . . districts and operators were apologetic if they failed to do so.

These attitudes must change . . . the control responsibility must be shifted to the mosquito producer and he be required to share the burden along with the district, as provided for in our Health and Safety Code.

I won't attempt to give you a packet of answers for the problems you'll encounter as you engage more resistance, for each district will do what it has to do.

We have one directive and policy at Kings: "Be polite, be firm, and do what has to do done to persuade the landowner to make the necessary corrections. Handle each as an individual person."

This is an easy policy to implement, because we have always catered to the people when chemical control was effective mosquito control and beneficial to the general public. Don't think we've gone out of business, since requesting the landowner to carry his share or because we've de-emphasized the spraying. We merely can't offer spraying as the first alternative, the easiest alternative, nor the cheapest alternative. Instead, we have a talking point for longer lasting or permanent, more superior solutions involving direct participation and sharing of costs and good effects.

We are putting the bits and pieces of mosquito technology together as we see them. We are putting years of your thinking and experience together. Nothing is forced; it's just all there for us to use when we need it.

We are molding ideas. We take our mosquitoes, our abilities, our techniques, our district, the temperament of our public and we are molding them.

There is no dogma to spray. We are free now to let our ideas flow to the better solutions. And it is an effective method. We are getting changes for mosquito control that we've never been able to obtain before.

PANEL: DEVELOPMENT AND RAMIFICATIONS OF A MOSQUITO CONTROL CRISIS

MODERATOR: Fred DeBenedetti

The University of California

E. Gorton Linsley
Division of Agricultural Sciences, University of California, Berkeley

First of all I bring you greetings from Vice President Kendrick, who heads the University's Division of Agricultural Sciences. He has asked me to express his sincere regrets at not being able to participate in the program this morning. However, he suggested that I represent him on this panel and I am pleased to be able to do so. As most of you know, I am not an expert on mosquitoes. My own experience lies in other areas of entomology. My connection with mosquito research is purely administrative, as Associate Director of the Agricultural Experiment Station, where I am responsible for research in the agricultural sciences on the Berkeley campus, and as Administrative Advisor to our Mosquito Research Advisory Committee. The committee is composed of the chairmen of departments at Berkeley, Davis, and Riverside that are engaged in mosquito research.

My remarks will be made from this particular vantage point. I cannot speak for the fine program in the School of Public Health at UCLA. There Professor Barr is pursuing studies of mosquito genetics, and Professor Work is conducting vector and virus studies in the Imperial, Coachella, and other southern and southeastern valleys. Neither can I speak for the excellent program on mosquito-borne encephalitis and related studies being carried out by Professor Reeves and his colleagues in the School of Public Health at Berkeley. Our programs, however, are intended to be complementary. In the case of the Berkeley School of Public Health we have tried, during the last five or six years in particular, to coordinate our requests for financial support of our programs.

One further word of clarification, since some of our scientists are reporting the results of their research later in the meeting sessions: I do not plan to discuss details of our research activities per se. Rather, I will respond to the broader question of the attitudes and policies of the Division of Agricultural Sciences, in particular the Agricultural Experiment Station, toward mosquito research in general. More specifically, I will discuss how the Experiment Station is responding to the present crisis in terms of current and anticipated research programs.

I need not tell this group that there is a crisis in mosquito control. You face it every day. Even if I wished to, I am sure I could not describe that crisis as eloquently and dramatically as Mr. Frolli has just done.

As a publicly supported research organization, the Agricultural Experiment Station of the University is concerned with at least three major facets of the problem. First is the tremendous capacity of mosquitoes to produce strains resistant to pesticides. These quickly replace non-resistant populations. The result is impatience and dissatisfaction of the public exposed to mosquito problems for which relief cannot be provided. Second is the fact that the sites producing very significant numbers of mosquitoes often lie outside areas under the immediate control of the most concerned people (including mosquito abatement districts, which feel the public pressure). These areas also may involve large commerical operations or projects operated by federal, state, or community agencies to meet other important public needs. Third is the concern of the general public with environmental contamination by pesticides, including suppression, control, or abatement of mosquitoes by chemical means.

It is our considered judgment that there is no short-range answer to mosquito control that will satisfy these three, largely distinct but in part overlapping, groups of citizens. Unless, in the meantime, public policy decisions solve the question of priorities, we believe that the soundest approach for University scientists is to try to work our way out of the immediate crisis while pursuing a research program with longrange goals aimed at the development of an integrated pest management program. Such a program will get us off the vicious, exhausting treadmill of trying to stay ahead of mosquito evolution by replacing one chemical with another each time resistance develops. This does not mean that we foresee a time in the near future when chemicals will not be used in mosquito control programs – unless they are completely outlawed by federal or state legislation. Rather, we look to chemicals as part of a control program that does not adversely alter mosquito genetic systems from the control standpoint, by encouraging development of resistance.

What is the present mosquito research program of the Agricultural Experiment Station and what decisions have brought it to this point? Some of our students tell us that history is irrelevant, and some history may be. But with your indulgence, I would like to recount a bit. The original work demonstrating the practicability of mosquito abatement in California was done in the Agricultural Experiment Station by Professors Quayle, Herms, Freeborn, and others at such scattered localities as Burlingame, Penryn, Oroville, and Bakersfield. These repression programs were aimed primarily at salt marsh and malaria mosquitoes. University-recommended methodology involved both chemical control and breeding site elimination or reduction. An intensive campaign of public education was carried out by the University in cooperation with the State Department of Public Health. Ultimately it led to passage of the Mosquito Abatement District Act. In the years since then university mosquito control research has continued. It received a boost after World War II when the chlorinated hydrocarbons, particularly DDT, came into prominence with the return of faculty members from war service. Some of them had participated in the use of DDT in such programs as the U.S. Public Health Service's malaria control in war areas and mosquito suppression programs of the armed forces.

Within a few years, however, it was clear that the chlorinated hydrocarbons and the organophophates that followed, which served us well in the post-war era, were no longer able to do the job. In the mid-1960's, the Agricultural Experiment Station, which had been conducting mosquito research largely with support from mosquito abatement districts, the World Health Organization, some federal funds, and limited State resources, needed a "shot in the arm". At the urging of, and with important input from, your organization, the State Department of Public Health, and other interested agencies and groups, the Experiment Station developed a plan for increasing and accelerating mosquito control research.

In the terminology of the budget document produced at that time for review at university and state levels, six major lines of interlocking effort were proposed: (1) mosquito control in water impoundments, (2) development of safer and more useful chemicals and better application techniques, (3) studies of fundamentals of behavior and biology methods of control, (5) mosquito control in relation to wildlife, and (6) extension education in mosquito suppression. The budget request involved increased support for research in increments adding up to a significant and sustained University research program. The expansion in Agricultural Extension activities was planned without additional funding. The program called for use of current personnel, including specialists in animal husbandry, agronomy, agricultural engineering, economics, entomology, irrigation and drainage, parasitology, range management, weed control, and wildlife management, as well as farm advisors in counties where mosquito problems were particularly acute.

The funding history of this program, in which your representatives and constituents have had a key role, has been as follows:

In 1965, the University prepared an expanded program for research and extension in mosquito control. This included $300,000 for the Division of Agricultural Sciences and $60,428 for the School of Public Health at Berkeley. The funds were to be provided in three successive annual increments, including $100,000 in each of the latter two years and support was to continue thereafter.

Since the initial appropriation in 1965-66, no additional mosquito research funds have been included in the state budget as finally approved, except $100,000 appropriated to the Agricultural Experiment Station by the Legislature in 1966-67 from the State Water Fund and $83,000 for the School of Public Health. Unfortunately, the $100,000 made available from the State Water Fund did not provide for salary increments. It was necessary to make up these amounts from General Fund sources. Consequently, $25,000 was added to the Division's later budget requests to offset increased salary costs.

In 1970, with your active support, Senate Bill No. 310 was introduced. It was described as: "An act making an appropriation to the University of California, relating to mosquito control research, declaring the urgency thereof, to take effect immediately." The act would have accomplished two things. It would have changed the source of the $100,000 already allocated to the University from the State Water Fund to the General Fund, making clear that the legislative intent was to support a continuing program. It would have provided augmentation of the research program in the Agricultural Experiment Station and the School of Public Health at Berkeley to the level originally planned.

It is my understanding that in the final budget decisions reached by the Legislature this program was included in special highway tax funds allocated to the California Department of Agriculture. We have submitted a request to that agency for funding an increase in our research program. As of now, however, the Department has been unable to respond to that request; it is not yet clear how much new money will be available for departmental programs and when it may be available. We have been cautioned that we should not anticipate permanent funding from this source.

So much for history. I have reviewed it because it indicates sustained interest on your part and our part in increasing mosquito control research. I wish to add only two postscripts. In the intervening years – years of declining support and stringent budgets with very little flexibility – where possible, we have diverted internal support within departments of the Agricultural Experiment Station to provide additional effort in mosquito research. General campus support on a contingency basis has also been provided, particularly for the School of Public Health at Berkeley, and federal funds for basic research have been substituted for state funds in some of the long-range programs. Further, the 1971-72 budget submitted by the Division of Agricultural Sciences listed as its number-one priority $325,000 for mosquito control research. The Regents' budget is privileged, as is the Governor's until the latter is presented to the Legislature. I cannot say at this time whether or not this item is included. If so, it provides for:

Replacement of salary adjustments made at the expense of the research support budget	$25,000
Replacement of the State Water Fund appropriation	$100,000
Funds available for increased research effort	$200,000
Total	$325,000

Specifically, the increased funds, if appropriated, will increase each of the present five research programs according to the following outline:

I. Development of safe and more useful chemicals and application techniques by:

- A coordinated program for rice field and pasture mosquito control, using large-scale field trials and the integrated pest management approach.
- Use of chemicals and other techniques in an integrated pest management approach.
- Evaluating substitute control methods for insecticide-resistant mosquitoes.
- Developing methods for detection and characterization of resistance in mosquitoes.
- Tree-hole mosquito control.

II. Biological control development by:

- Expanding research on biological controls, including use of fish and invertebrate predators, especially as associated with rice field mosquitoes.
- Developing more adequate methods for sampling mosquito populations.
- Determining natural mortality of mosquito eggs, larvae, and pupae, and what might be done to increase these factors.
- Investigating naturally occurring biological products and mosquito pathogens.
- Foreign exploration for new biological control agents.

III. Expansion and improvement of present programs involving fundamentals of behavior and biology that may lead to control by:

- Investigating the basis for seasonal switch in feeding habits of adult *Culex tarsalis.*
- Extension of studies on factors regulating feeding of mosquito larvae and adults.
- Studies of the biology of important mosquito species to find weak links in their life patterns.
- Physiological studies of egg-laying behavior of mosquitoes.

IV. Mosquito control and wildlife improvement, by:

- Increased effort in the study of the impact of mosquito control procedures on wildlife, fish, and the quality of the environment.

V. Habitat management and source reduction, by:

- Expansion of studies on ecology of critical mosquito species.
- Development of more adequate sampling methods for mosquito populations.
- An intensified interdisciplinary approach to the development of techniques to reduce or eliminate mosquito breeding sites (involving agronomists, agricultural engineers, water scientists, soil scientists, entomologists, and others).

One may ask "Why, in the face of the present crisis, has not the Experiment Station program changed?" It has changed in overall priorities but not in goals. More immediate effort is proposed in research on chemical control and on reduction of breeding sources. However, we would be doing a disservice to the people of California if we suddenly disbanded our team of researchers, which was assembled to come up with a long-range solution to mosquito control, and concentrated all of our resources on "fire fighting." The research program as we see it is a balanced whole. It does not readily lend itself to the elimination of any of its parts. It is under periodic review by a Joint Committee of the State Department of Public Health and the University of California concerned with "Research on Arthropods of Public Health Importance". There is an annual review by the Experiment Station Committee on Mosquito Research. To my knowledge, no member of either of these committees has advocated elimination of any part of our current program. Some differences exist as to relative support of the various program elements. However, there is no disagreement on the urgency of finding solutions for the immediate problems, especially as they relate to the pasture mosquito and rice field mosquitoes.

This, then, is the rationale and philosophy behind the present mosquito research program of the Division of Agricultural Sciences of the University of California. I thank you for the opportunity to present it in the framework of this outstanding panel.

STATE DEPARTMENT OF AGRICULTURE

Gordon F. Snow
California State Department of Agriculture, Sacramento

Whatever we may think of Bertrand Russell as a man or political thinker, there are very few who would detract from his scholarly abilities. One of his most cogent thoughts concerning man's ability to progress is one which states in essence that a people unable, or unwilling, to remember their history must, of necessity, relive it.

I think that, as a group, the people of California have forgotten their own history. Before California was invaded by the 49ers, mosquitoes were primarily a denizen of the foothill and mountainous areas where snow-fed rivulets, streams, and creeks were effectively dammed by beavers, for example, forming lakes, potholes, and providing admirable sites for mosquito reproduction. Except for large year-round rivers and lakes, the Central Valley was not particularly good haven for these creatures. However, with the coming of the trappers who were intent on beaver pelts the beaver dams gradually began to disappear. This helped reduce the number of locations where mosquitoes might multiply. The trappers were followed by frontiersmen searching for new routes through the mountains to the valleys of California, and interestingly enough, many of the routes were through and beside the streams and creeks of the high mountains and foothills. There were no freeways cutting across densely forested areas. The only routes through such heavily timbered spots were the streams and their banks.

As time passed, and the emigrant began to appear in California west of the Sierras, the pioneers turned to agricultural pursuits, and a major part of that activity remains rooted in an adequate irrigation system. California is a rich farming area, supplying over 25% of the food found on the tables of the United States. Only by adding water to previously arid land has this position become possible. Together with the irrigation practices, the potential sources of mosquitoes have been vastly increased. We see then, a movement of the mosquitoes from the Sierras and the foothills to the flat, irrigated, agricultural areas of the valleys. It sometimes comes as a surprise to many of our population, present attendance excepted, that the mosquito was not always an inhabitant of the valley areas. However, because of its annoying presence in this relatively heavily populated area of the state, the mosquito is regarded by the average citizen as a nuisance whether on the farm or in the nearby city.

The effect of mosquitoes on the rural and farm people at the present time is primarily one of nuisance. The presence in extremely high densities of adult *Aedes nigromaculis* in irrigated pastures of the Central Valley has repeatedly caused loss of many man-hours of farm labor. In the Coachella Valley and elsewhere in Southern California, the same situation has occurred with *Psorophora confinnis* as the malefactor. Heavy mosquito populations developed in rural areas may be felt in the nearby city. For example, Sacramento now has a steady low-density, year-round mosquito problem. *Anopheles freeborni* overwinters as an adult and is active on any day when the temperature is favorable.

In addition to their effects on human populations, mosquitoes may cause loss or curtailment of milk, beef, and poultry productions by their aggravating attacks on farm animals. Undoubtedly thousands of dollars of agricultural production have been lost because of mosquito activity.

There is considerable concern by many over the incidence of disease transmission historically linked to the mosquito. Yellow fever, dengue, malaria, and encephalitis have all been reported from California. Two of them, malaria and western equine encephalitis, are considered endemic in the state. Although a few cases of malaria are reported each year, case history reports indicate the disease was contracted by the individual while traveling outside the country. With increasing mobility of the population, however, and the presence of endemic malarial areas in Mexico and Viet Nam, coupled with the presence in the state of an extremely efficient potential vector, *Anopheles freeborni*, the threat of malaria continues.

Western equine encephalitis is endemic to the state and a few human cases are reported each year. The Department of Agriculture is particularly concerned about the proximity of animal handlers and horsemen in the state because of the growing interest in equestrian recreational activities.

As well as its interest and concern for the human diseases, the loss of production, and the interference with farm labor caused by mosquitoes, the Department of Agriculture is, by statute, directly involved in registering and regulating the use of pesticides to control mosquitoes. Long before the terms "ecology" and "environment" became beat-up household synonyms for "me too", and the Ecocatastrophists mounted the podium to tell us we were doomed by pesticides, the use of aircraft spreading DDT in an attempt at mosquito control was in full-scale decline. Two factors tended to proscribe, and finally eliminate aircraft applications of this pesticide. First, the mosquitoes tended to develop resistance quickly and quite dramatically to DDT; second, FDA tolerances for residues for various pesticides precluded the further use of DDT on irrigated pastures. Thus, long before the ban on DDT was loudly called for, it had already taken a secondary role in chemical control of mosquitoes.

Rice field mosquito control was seriously hampered by another problem. The impact on the ecosystem was manifest by an initial drop in mosquito populations following the application of DDT only to be followed by a dramatic increase above pre-treatment levels. This was found to be due to non-selective poisoning of other elements in the system which had tended to keep mosquito populations in check. This included invertebrate predators and parasites as well as *Gambusia*, the mosquito fish.

Organophosphate compounds have been used with success against mosquitoes. These include methyl parathion, malathion, and SD 7438, as well as several others. Some resistance to these compounds, particularly parathion was noted as early as 1958. Therefore, other organophosphates and carbamates are being screened continually so that a successful campaign against the mosquito may be continued.

The control tools used vary with the species of mosquito. The source reduction by drainage and treating is still used most effectively. Materials for treating have included DDT, oil, and many classes and types of chemical materials. At present methyl parathion at low dosage is the usual control agent. Some research is being done on other materials as well as biological controls and chemosterilants.

As I mentioned at the beginning, a people unable to remember their own history must inevitably relive it. I think we will see a classic demonstration in the next few years. Because of the free running streams in the higher altitudes, mosquitoes have not, for almost a hundred years, been much if any problem to the inhabitants. However, we have spent a lot of money, and a great deal of time carefully constructing large dams and lakes in the mountains for water supplies, hydroelectric power and as a secondary benefit, recreation. Not to be outdone, land developers usually also include an artificial, manmade lake as an attractant and inducement to buy what they euphemistically term "country estates" far from the hubbub of the city. These are almost invariably in foothill or mountainous locations. They also make ideal breeding places for mosquitoes and an area in which the mosquito was once endemic will again become a very real problem as the population in these localities rapidly increases.

STATE DEPARTMENT OF FISH AND GAME

Herb Hagen

Pesticides Investigation Section
State Department of Fish and Game

The Department of Fish and Game does not have an official policy on the use of pesticides in agriculture or in other areas. We do feel that pesticides have their place. If we are to maintain our position as a civilization today, we must use pesticides to produce food, fiber and to protect our public health. This is the position we take in our insecticide investigations. In its pesticide investigation staff, the Department has eight biologists and chemists. We do practical research and surveillance. We feel that it is our function to protect wildlife from the adverse effects of pesticides. In carrying out this responsibility, our Department has taken a leading role in cooperative inter-agency programs relating to pesticides. In the current program in the Department there are two major aspects, one is the surveillance of pest control programs and the other practical research. Each of these aspects is complementary to the other.

In our surveillance program we learn how and at what point fish and wildlife are affected by pesticides. We are often confronted with problems that cannot be answered on the basis of available knowledge, and we employ research to find the necessary answers. In addition to finding the answers to these problems, research provides us with new tools which make our surveillance program more effective. Both surveillance and research play an important role in the selection of the most effective remedial action.

At the present time most of our effort is devoted to surveillance. This program has three categories which are: 1) the investigation of fish and wildlife losses from suspected poisoning; 2) the evaluation of the effect of large-scale pest control programs on non-target fish and wildlife; and 3) contacts with other agencies and related activities necessary to keep the Department abreast of current developments in the pesticide field.

We recognize the need for mosquito control and we also recognize that there is a resistance problem in mosquitoes. We also recognize that the materials used in our mosquito abatement programs in the past and today are highly toxic, and in many instances are on the borderline as far as hazard to non-target species is concerned. We forsee, in relation to the crisis that is coming up because of resistance, some problems in increase of application rates, which seems to be the universal approach throughout pesticide applicators that if a little bit is good, a whole lot is better. I will be the first to complement Mosquito Abatement District's in their resistance to this approach.

Another problem which we feel may cause us troubles is the use of new, untried materials. I can forsee that there is a great probability that if we run into the relief of a crisis because of vector spread diseases, there is a good chance that the panic button could be pushed and anything might be tried in order to control the mosquitoes. We have usually found that when we get into the use of new and untried materials, there always seems to be things coming up that no one had forseen, and we end up having to change the use of these materials because of side effects which affect non-target species.

We have in the past and we intend in the future to work with the agencies in evaluating new materials. At the present time we are working with the public health people in evaluating, hopefully, a material that will work on at least some of the resistant species. We plan on an extensive cooperative effort this summer in evaluating the effects of this material on fish and wildlife, and we hope it will work out.

We also recognize the need for effective, non-hazardous pesticides, and we have tried to work with the chemical manufacturers in trying to influence them in their development of new materials. I know of at least two or three materials that companies have developed which were not pursued because the companies felt there would not be enough profit involved for them to continue with their evaluations necessary to get the materials registered.

One of the other problems we have is that, generally speaking, mosquito producing areas are also excellent wildlife areas. This is an unfortunate situation that is something we have to face, and we have been able, at least so far, to work very effectively with mosquito abatement people in monitoring, in looking at these areas, and so far we have been very successful in avoiding any losses on non-target species.

In conclusion, there is one thing that may cause you some problems in the future, particularly with some of the newer materials that may come out. This is section 5650 of the Fish and Game Code, which relates to the addition of deleterious materials to waters of the State.

DEVELOPMENT AND RAMIFICATIONS OF THE MOSQUITO CONTROL CRISIS

Richard F. Peters

Bureau of Vector Control and Solid Waste Management,
California State Department of Public Health, Berkeley

California mosquito control faces an organic pesticide resistance crisis, which if regarded in another organic context might be thought of as a kind of faulty program nutrition characterized by vitamin overages and shortages. There has simply been too much C for chemical control, and too little A for agronomy, B for biological control, D for documentation, E for education, entomology and engineering, G for geology, H for H_2O management, K for knowledge, M for mosquito source reduction, P for prevention and policies and X for the unknown, but sorely needed new mosquito specific control technology. This alphabetical rundown could be otherwise summarized and the needed remedy to this crisis could be stated in one letter: change the C from chemical to comprehensive mosquito control.

My tour in California mosquito control now extends well into a fourth decade, which means I associate with the Herms and Gray philosophy, that originated before the current era of organic chemicals. They advocated and practiced a balanced program of physical, biological and chemical control of mosquitoes, in that order of emphasis. This is not to deprecate chemicals, only to place their use in perspective as a vital supplement to environmental management and naturalistic methods. Unfortunately, for the past twenty-five years the use of pesticides has generally received primary emphasis, with environmental and naturalistic measures being largely ignored, or relegated to a token part in the overall program.

In 1948, during the early years of the state subvention program, our standards exhorted local mosquito control agencies to engage in:

1. public and in-service education,
2. primary measures aimed at the progressive reduction of mosquito sources,
3. larviciding as required, determined by entomological evidence, and
4. use of equipment and materials that are reliable, efficient and precise.

Had all of these components of sound mosquito control been literally observed by every local agency during the past two decades, I dare say that resistance wouldn't be as great a "bug-a-boo".

Also in 1948, Edgar A. Smith, W. Donald Murray, Jack Fowler and I brought into being the section concept of mosquito control, which covered the cartographic, entomological, engineering and operational requirements of complete mosquito control. This vital approach was only half-heartedly implemented by a small number of local control agencies. Its values are as sound today as twenty years ago and its need is even greater. It, too, could help agencies to resist resistance.

Even today, I'm not pessimistic about the dilemma we face. It might even be a blessing to cause us to now return to a more certain course of scientific mosquito control. Certainly the johnny-come-lately ecologists will welcome more selective use of pesticides.

Let us now turn to those alphabetical deficiencies which are "vital-mentionables".

AGRONOMY & GEOLOGY

A for Agronomy and G for Geology must be considered together, for they provide the basis of land management within the irrigated agricultural setting, which is the area of major resistance. This earthy opportunity for mosquito suppression has thus far been virtually ignored, but is absolutely fundamental. In this regard, I refer to crop selection as to suitability with respect to soil structure and subsequently to land preparation for the specific crop. The services of the local Farm Advisor and the Soil Conservation Service should be sought when new acreage is being develloped and when field rehabilitation or crop rotation is indicated. The mosquito production record on any parcel of land could be basis for expecting the latter.

BIOLOGICAL CONTROL

B for Biological Control invites an active employment of every naturalistic measure available and manipulable. In both respects, *Gambusia affinis* and several other predatory fish species deserve much greater utilization. The need is that of not simply planting fish and assuming they will take over; rather their control must be aided and facilitated by various environmental management means. They must also be husbanded into necessary numbers before the immature mosquito density exceeds their predatory capabilities.

DOCUMENTATION

In D for Documentation, meaningful mapping and record keeping are absolutely necessary to be able to conduct and plan effective mosquito control. Should resistance continue to manifest more widely, the need to be able to interpret the origin and destination (cause-effect) of mosquitoes and to assign definitive responsibility for abatement of mosquito sources will become even more demanding. Cost analysis, zoning of operations and accounting for program expenditures cannot be satisfactorily accomplished without proper documentation.

EDUCATION, ENTOMOLOGY AND ENGINEERING

In E for Education, Entomology and Engineering, public information about mosquito control has heretofore been broadly disseminated in the hope that diffusion would result in elevated public understanding. It would appear that not only should educational effort be targeted upon farmers, but also upon their irrigators who presently seem to be guided by "if a little water is good, a little more is that much better".

Entomologists were originally acquired in local agencies to perform a variety of technical entomological services relating to surveillance and interpretation of operational need. Gradually over the years they have evolved into Manager Entomologists, or Assistant Managers, or Administrative Assistants. No time remains for performing their intended and needed technical functions. Entomological services must be restored and intensively practiced if indeed mosquito control is to be "reliable, efficient and precise".

The past era of pesticide usage served to diminish the role of engineers in mosquito control. Suffice it to recognize that not one registered engineer is employed in California local mosquito control programs. Environmental management is (or should be) the "name of the game" and engineering is the means of achieving this end.

H_2O MANAGEMENT

H stands for H_2O management. This is perhaps the most manipulable of all the eligible areas of action needed to counter resistance. Opportunities range from water modification by additives, to various methods of application in conjunction with land preparation. This calls for control agencies to proceed before the fact, rather than only after chronic infirmity of fields sets in.

KNOWLEDGE

Our Knowledge on chemical control presently exceeds that on physical or biological control and it's high time to balance the equation.

MOSQUITO SOURCE REDUCTION

Mosquito source reduction is like Mark Twain's comment on the weather: "everybody talks about it, but nobody does anything about it." There are a few notable exceptions to this generalization; however, not one agency is at present going far enough, irrespective of what's been done to date. Every mosquito source should be regarded as reducible or modifiable to require less future need for pesticides. This critical attitude should begin with the operator and pervade every member of each local agency. Bonuses might even be considered for those operators who accomplish demonstrable source reduction with corresponding control effectiveness and economy.

PREVENTION AND POLICIES

The underlying policy of any program should be the prevention of mosquitoes as opposed to their control. This pertains principally to anticipating the mosquito consequences of artificial changes scheduled to be made in the environment and taking steps in the design and construction stages to incorporate mosquito preventive features. The control agency should be apprised of all water-related developments slated to happen and get on the inside of them before they happen. In this regard, I ponder the possible prerogative of a Board of Trustees in promulgating standards of mosquito prevention under Health and Safety Code Sections 2270 (a) "Take all necessary or proper steps" and (k) "Do any and all things necessary . . . . ." thereby obligating water users to meet design and performance conditions prescribed for mosquito prevention.

X – THE UNKNOWN

X by its very connotation of the unknown should provide every agency with a challenge to creativity. In other words, let's get out of the routine rut we've adopted and utilize our collective ingenuity to improvise better ways to control mosquitoes. A large part of the need is providing the University of California with adequate financial capability to perform needed basic and applied research and to continue to back the California Department of Public Health to enable us to provide more technical services to your agencies, particularly relating to environmental management and naturalistic measures.

In this latter regard I am pleased to inform you that the first engineer-biologist team, of the four engineers and three biologists your Association has been seeking to provide the Department, will be getting into action in approximately a month thanks to interim federal funds. The agricultural gas tax funds expected to be available for this purpose January 1, 1971, will not come into being until late this fiscal year or beginning the first of next fiscal year. This expectation should become a reality through the greatly valued and highly effective support of your Association.

Through our cooperative environmental and naturalistic control demonstration projects, to be conducted in conjunction with your agencies, we hope to be able to point up environmental remedies which may be duplicated elsewhere under like conditions. We will engage in these activities on an invitational basis, selecting specific pastures which provide opportunities to demonstrate specific solutions. The most precise kind of evaluation and cost analysis documentation will attend each undertaking, before, during and after completion. Details of this program will be provided in the future.

In another effort to assist your agencies in your transition toward comprehensive mosquito control we have begun a general mosquito control training program. Personnel of a number of your agencies have already been exposed and others are scheduled for February, March and April. In the months ahead we plan to develop seminar-type sessions for selected staff relating to the various technical areas of mosquito control.

In conclusion, while I recognize the gravity of the pesticides resistance crisis being faced by many of your agencies at this time, I remain optimistic that we, collectively, possess the capability of overcoming this obstacle. If we devote ourselves to an ecologically sound and balanced program of environmental management, naturalistic measures and selected chemical control, precisely applied, we might well achieve even greater success in the future.

PANEL: THE CURRENT STATUS AND FUTURE OF THE PASTURE MOSQUITO CONTROL PROBLEM IN CALIFORNIA
MODERATOR: CHARLES H. SCHAEFER

The Sacramento Valley Region

Eugene E. Kauffman
Sutter-Yuba Mosquito Abatement District, Yuba City

Aedes nigromaculis mosquito resistance in the Sacramento Valley has reached serious levels in the minds of many concerned managers.

In the Sacramento-Yolo District, resistance to methyl parathion became a reality in 1970. Trying just another insecticide did not produce an acceptable solution. This District has chosen to face the problem head-on by seeking source reduction solution to the problem that caused the larvae to survive, by changing to fenthion as an insecticide, and by trying to get specific advantages by the use of oils and additives.

In the Colusa District, a 40-acre field that had larval resistance to methyl parathion in 1966, failed to fenthion this year; it had a LC 50 of .008 ppm. There are now several small pockets of resistance to methyl parathion in the eastern part of the District. *Aedes melanimon* doesn't show these levels of resistance in the same area, however.

Late in 1970, there was fenthion failure in one small area of the Tehama District. Past experience indicates that six other pastures will follow in 1971. Since these were in widely separated areas, probably these will serve as foci for additional spread. The LC 90 for fenthion in the resistant area was .0015 – .01 ppm.

In the Butte County District the northern one-third is still controllable by fenthion, while the balance of the area is not. The LC_{50} for fenthion in 1970 was 0.35 ppm (in 1969 it was 0.01 ppm). There is no adequate larvicide in the southern portion of the District and Baygon is used effectively on adults. This is applied at 1/20 lb/acre. In residential areas, *Aedes nigromaculis* mosquitoes were controlled with pyrethrin in a cold fogger. Observations seem to bear-out the thought that the older adults were more susceptible to Baygon and pyrethrins, perhaps reflecting a change in physiology. During the past year 16,370 acres of totally resistant *Aedes nigromaculis* larvae were sprayed.

The failure to fenthion as a larvicide or adulticide in the Sutter-Yuba Mosquito Abatement District in 1969 covered 860 acres; in 1970 it reached a total of 10,000 acres. Due to this increase in the spread of resistance, a new emphasis in source reduction has been implemented. The initial change was in policy, that being, from multi-owner to single-owner projects. Priorities have been established to guide the District as to which property will get the earliest attention, and the amount of fund to be allocated to the project. The main values that help establish priorities are (a) how high is the resistance, and (2) how close is it (the field) to how large a residential population.

THE NORTHERN SAN JOAQUIN REGION

Stephen M. Silveira
Turlock Mosquito Abatement District, Turlock

To discuss the current status and future of the pasture mosquito in the Northern San Joaquin Region, I will briefly describe the area and the general types of pasture mosquito problems we encounter. The Northern San Joaquin Region covers the northern third of the San Joaquin Valley, roughly from Galt (on the north) to Chowchilla (on the south) and includes San Joaquin, Stanislaus and Merced counties. The five districts in the Region cover a total area of approximately 4,927 square miles, with a population of 631,455.

The entire rural area in the floor of the Valley is intensively farmed. We have a wide diversity of soils, a long, warm growing season, and an adequate supply of irrigation water at bargain prices and in one large area it is free. Approximately 90 different crops are listed by the annual crop report for this area.

The pasture mosquito is found primarily in the irrigated pasture and to a lesser extent in corn, alfalfa and orchards. Irrigated pasture is produced on almost every soil in the area for which water is available. Clover pasture, however, is shallow rooted; therefore, the largest areas of irrigated pastures are grown on the shallow hardpan, saline soils. In most instances, these soils have a thin, fine, sandy loam surface which rests abrupty on an impermeable hardpan cemented with lime and silica. Sub-drainage is imperfect or nonexistent. These soils are not suited for cultivated crops unless the undesirable saline alkali conditions are corrected and drainage is improved. In some areas, one can drive for miles and see no other crop except irrigated pasture.

Many of these pastures are improperly leveled, with inadequate surface drainage and poor sub-drainage. On poorly managed pastures, water is applied in large amounts every 7 to 14 days, depending on the weather, with the cattle in the field. It is common to find water standing for at least four days and as long as 14 days in these sub-marginal pastures. These become ideal sources for the pasture mosquitoes.

The pasture mosquito was first reported in this area in 1938. Chemical insecticides were first applied against this mosquito in 1945. The pasture mosquito is highly pestiferous. Control efforts by the districts have kept it under heavy insecticide pressure up to the present time. In its effort to survive, this mosquito has been most successful. It has methodically shot down every chemical our modern technology has created for its destruction.

Control programs in the Northern San Joaquin Region utilize the organophosphorus compounds as larvicides almost exclusively. Ethyl parathion and malathion were the first organophosphorus compounds used, beginning about 1953. The first laboratory-demonstrated high parathion tolerance in pasture mosquito larvae occurred in the San Joaquin MAD in 1964; high malathion tolerance – East Side MAD in 1966; high methyl parathion tolerance – Turlock MAD in 1966; high fenthion tolerance San Joaquin MAD in 1966 (Womeldorf, Gillies, and White 1968).

Insecticide resistance in pasture mosquitoes progressively increased in our Region until the high point was reached in a small area (two square miles) west of Turlock in June 1970. At that time and place both adult and larval pasture mosquitoes were found to be highly resistant to all currently available organophosphorus compounds (including ABATE® and Dursban®) which had never been used operationally. Control was attempted with Baygon at 0.05 lb/acre as an adulticide. Two adulticide applications were made on two separate adult populations near the end of the season. Baygon® 70% WP was applied by fixed wing aircraft at the rate of 0.05 lb/acre in one-half gallon of water. The adults were treated approximately 24 hours after emergence. Results were disappointing. Field observations indicated a mortality of approximately 75%. Considering the large numbers of adults present before treatment (100+ per pant leg), a 75% kill was barely noticeable. The reasons for our apparent Baygon failure have not been determined. We plan to fully investigate this particular population during the coming season.

In our continuing attempts to cope with a highly resistant pasture mosquito population, FLIT® MLO was field tested at one and two gal/acre by aircraft. We learned that the FLIT mode of action on mosquito larvae and pupae is quite different from what we are accustomed to with chemical insecticides. Techniques currently in use to evaluate chemicals do not apply to FLIT MLO; therefore, our field evaluations at Turlock were incomplete. Our present plans are to apply FLIT MLO to the highly resistant population within the two square mile area mentioned previously. This area is conveniently isolated from other pasture mosquito sources. By starting FLIT MLO applications at the beginning of the season, we hope to develop measurement techniques which will assist us in viewing the entire spectrum of activity of FLIT MLO against a population of resistant pasture mosquitoes.

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THE LOWER SAN JOAQUIN VALLEY

W. Donald Murray
Delta Mosquito Abatement District, Visalia

Harold Gray, Manager of the Alameda County Mosquito Abatement District for about 25 years, and one of the stimulators of the formation of the CMCA, wrote a memorable paper for presentation to the 18th Conference of this Association held in Berkeley in 1950. The title was "Which Way Now?"

At that time two of the districts in the southern part of the San Joaquin Valley, the Kern and the Delta MAD's, had experienced high resistance to DDT by the pasture mosquito larvae. Gray presented the logic stressed by Professor William Herms, namely, that effective and economical mosquito control must be based on reduction, to the lowest practicable extent, of mosquito production water. Larvicides and adulticides were considered to be merely supplementary means, necessary but to be secondary in value and usefulness.

In the rest of his presentation, Gray stressed the need for mosquito abatement districts to move into a strong source reduction effort. Again referring to Herms, Gray stated "He believed that men are generally reasonable and will act for the general welfare, if only they understand what is required. He did not expect men to come to him; he went to them." Gray finally stated that in those residual cases where persuasion and appeals failed, we should not hesitate to invoke legal remedies.

The presentation was superb, the material contained therein was correct and sound. Why, then, after 21 years, has no real change occurred in the control programs of mosquito abatement districts in California so that many of the districts now are in a greater dilemma than in 1949?

Shortly after Harold Gray's presentation "Which Way Now?", the Delta MAD began looking seriously at this "motherhood" program of mosquito source reduction. The result was the employment of an operator to work full time on reduction of mosquito sources. Records of mosquito breeding sources had been kept since 1947, and contacts were made with all the major mosquito producers to discuss the possibility of correction or reduction of mosquito problems. These producers were generally agreeable and cooperative. Very frequently they asked "What can I do?" The District had no practical answer. It was not enough to respond "don't raise mosquitoes."

By 1953 the Delta MAD realized the need for more information, so made the decision to employ a University-trained graduate in some phase of agriculture related to the mosquito problem. A graduate in agronomy was employed that year. A priority list of problems was set up, and an effort was made to contact the major producers and to obtain corrections. Talks were given to service clubs and to schools, using kodachrome slides to let the audiences see what the problems were. Several movie films were prepared to help tell the story and to sell the program. All these acttivies provided many interesting contacts and resulted in many interesting programs to service clubs, etc., but they resulted in no significant changes in the top priority problems. The District bought heavy equipment, and has been using it fulltime ever since, but this, too, has had no significant effect on the top priority problems.

What was wrong? Were the recommendations of Gray just oversimplified truisms? Did the District fail to carry out its program properly? It can be said that failures to achieve goals can lead to frustrations, which can lead to ulcers and heart attacks. The Delta District's source reduction specialist experienced the entire list of potentials. The conclusions reached quite some time ago were that the climate – or environment – was not right. The source reduction program corrected a lot of mosquito problems, but it did not do much good on the top priority problem in the District, namely, the irrigated pasture mosquito.

One of the almost – but not quite – disheartening developments was that, after struggling, fretting, beating our heads, spraying, and being frustrated for some years because of a given pasture, the farmer would eventually plow up the field and the mosquito problem would immediately drop to zero. All that was necessary, therefore, was to get all the farmers to plow up their pastures and put them into other crops. So long as they have pastures, they will produce mosquitoes. While greater care in land preparation, in irrigation, in animal management and in drainage may help, all such improvements simply will not solve the problem. In recent years the District has philosophically accepted this situation and has developed an effective spray program which largely ignored the practices of the farmer – if he produced mosquitoes, the District sprayed.

On repeated ocassions it looked like the District had reached a dead end because of insecticide resistance, to DDT, to toxaphene, to parathion, to methyl parathion. But on each occasion a substitute was found which kept the program going effectively. In 1970, however, the string ran out. In test situations Baytex was used two and three times in one irrigation cycle, with inadequate control. The rate per single application was doubled – with full legal approval. The use of Baygon to kill adults was adopted late in the season, with temporary benefits but nevertheless with anticipated unsatisfactory results.

Early in 1970 the Delta MAD sent a report to each 1969 mosquito producer, explaining the anticipated dilemma, and urging consideration of changes in crops. The irrigated pasture is the unquestioned villain. The July monthly report of the District was mailed to each mosquito producer, with the urgent appeal to make changes in crops or patterns. In late September the trustees of the Tulare, Kings and Delta MAD's held a joint meeting, in part to assure themselves that mosquito control districts did have a future, and that they should not be classified simply as "spray" districts. Newspaper publicity was stressed. The Kings MAD employed a "Public Information" Specialist who developed radio and television announcements, pamphlets and leaflets, etc.

The September monthly report of the Delta MAD illustrated the status of the pasture mosquito – the greatest light trap counts since 1954, and one of the highest complaint years since 1954. The year 1971 is not awaited with anticipation!

The U. S. President established a council on Environmental Quality. The Chairman, Russell F. Train, has stated: "What we do with our own land is <u>not</u> just our business. Society has an interest in proper land <u>use</u>. We do not really <u>own</u> any land – it has been here for millions of years, and <u>will</u> be here long after we are gone. We merely have a short term trusteeship of that land."

What we are seeing is a gradual change in attitude – in environment. We could not previously, and we can not now, call the mosquito producers "criminals". We have refused to bring out the Health and Safety Code as a lever, since we fear it will set up an unwise barrier, certainly at least in the early developments. Parents who raised large families some years ago were considered helpful both to themselves and to society. Already a stigma is being attached to those who wantonly overproduce onto a finite, limited world. The environment is now right for MAD's to stress mosquito production as an environmental pollution.

In 1971 the Delta MAD will carry out limited spray activities. It will carry out complete inspections. It will produce maps of breeding areas on individual properties, and will mail these records daily to the property owners, lessees or caretakers. Personal contacts will be made. If the populations become excessive, and public pressure demanding, further, more drastic action, may be necessary. Above all, the District's program will be flexible to meet the situation as it develops.

CURRENT RESEARCH ON THE PASTURE MOSQUITO PROBLEM

Charles H. Schaefer

Mosquito Research Laboratory, University of California, Fresno

While discussing the pasture mosquito problem at last year's California Mosquito Control Association Annual Conference, I stated, "The combination of chemical control, improved water and land management and the possible use of soil amendments appears to be the most realistic course for the next few years. It is also possible that this approach will not be adequate, under some circumstances, and that only a political solution will remain." (Schaefer 1970). I believe that this statement is still true; and I will discuss what our research program is doing along these lines to provide practical information on the pasture mosquito problem.

<u>Chemical Control</u>. During the past 20 years, mosquito abatement districts have had many highly effective and economic insecticides which have provided a simple method of "cleaning up" one of agriculture's by-products: *Aedes nigromaculis*. If the outlook for new chemical insecticides

was still bright, it would be possible to continue with the same approach. However, insecticide resistance has become more and more widespread and severe in California; and there is no apparent prospect for new, effective, inexpensive insecticides. While mosquito control cannot continue to rely so heavily on chemicals as it has in the past, chemical insecticides still remain as one of the most important tools. No matter how well we are able to promote source reduction, there will always be occasions where unexpected events, e.g., breaks in irrigation ditches, lead to intolerable populations that must be readily suppressed. Even the best source reduction methods will not prevent large-scale mosquito production during seasons of unusual flooding, such as occurs periodically in California. Thus, there is a very definite need for us to continue our chemical testing program. Due to the current resistance situation in *Culex tarsalis*, there is an urgent need to find an effective insecticide that could be used in case of an encephalitis crisis.

While we are continuing to test all new organophosphorus and carbamate compounds which we receive, industry has greatly reduced its effort on these types of materials, and relatively few are being submitted for testing as candidate insecticides. Several companies are now showing interest in pyrethrum type compounds, but the doses required for larviciding are coupled with high costs.

Studies on the new carbamate insecticide RE11775 were continued throughout the 1970 season; this compound gave excellent control of organophosphorus-resistant strains of *Aedes nigromaculis* and *Culex tarsalis* when applied by aircraft at 0.1 lb/acre. Ultra-low volume application of RE-11775 (0.1 lb in 3.1 ounces) gave excellent control of an organophosphorus-resistant *Culex tarsalis* strain in Kern County. RE11775 was found to be much less stable under field conditions than the common organophosphorus larvicides. We are now working in cooperation with Chevron Chemical Company to obtain registration of this compound for mosquito control in California.

During 1970 we again participated in field evaluations of FLIT®MLO; aerial applications were made to more than 20 pastures by the Tulare Mosquito Abatement District for the control of *Aedes nigromaculis* larvae and pupae. The results were quite variable; and we concluded that it was not operationally feasible to use FLIT MLO, by aircraft application, in the same type of control program that mosquito abatement districts have been using. Details of this evaluation will be published shortly (Schaefer and Ramke 1971).

One new chemical mode of action, which appears to have practical potential for mosquito control, is the use of juvenile hormone mimics; these compounds have biological activity that mimics that of natural insect juvenile hormone. The presence of juvenile hormone, or its mimics, at times during the life cycle when little or none would normally be present, interferes with metamorphosis. Juvenile hormone mimics have little apparent effect on mosquito larvae, but larval treatment results in abnormalities in the pupal or adult stages. One juvenile hormone mimic, which we tested during 1970, has biological activity in the range of that of organophosphorus larvicides, e.g., treatment of larvae with .003 ppm resulted in a final mortality of about 50%, under laboratory conditions. Field tests were conducted with some of the more active compounds; one compound showed promising activity against an organophosphorus-resistant strain of *Aedes nigromaculis*. Further field tests will be conducted during 1971, but it appears that this type of compound has practical potential for mosquito control.

Water and Land Management. The conditions associated with large-scale breeding of pasture mosquitoes are generally poor for agriculture, e.g., over-irrigation of pastures; it is also true that careful management of water and land is not conducive to mosquito production. Thus, promotion of good agricultural practices is a positive way of improving agriculture and public health simultaneously; however, in order to do this, those of us in mosquito control must become more knowledgeable about farming operations. Source reduction personnel of mosquito abatement districts have been taking this type of approach for many years. In view of our current mosquito problems, it is important that this effort should become more intensive and also more technical.

After a severe pasture mosquito problem becomes apparent, correction is usually both long-term and expensive. One of the best ways to prevent such problems from occurring is through working directly with farmers who are in the process of establishing pastures; this approach is not new, but is one in which better technical information would be of great value. Figure 1 shows some of the factors that need to be considered when constructing pastures. Unfortunately, the economics of these considerations are unknown for many, and probably most, of the soil types where the pasture mosquito problem is worst. For example, how much improvement in water penetration will result from applying given amounts of various soil amendments into the upper foot of Traver fine, sandy loam and how long will it take before improvement of water penetration is apparent?

Of the various soil amendments which are available, e.g., gypsum, sulfuric acid and sulphur, gypsum appears to offer the best possibilities; but the amount of gypsum and the depth of incorporation required to significantly improve water penetration on specific soil types is largely unknown. We have established field plots and applied gypsum at several rates on two soil types, where the pasture mosquito problem is severe. This effort is only a beginning and we hope to establish similar experimental plots on other soil types in 1971. In some cases, it is likely that we will find that it is not economically feasible to improve water penetration through the use of soil amendments; however, this information would still be very important.

Of course, progressive farmers are quite knowledgeable about agricultural problems and generally utilize good meth-

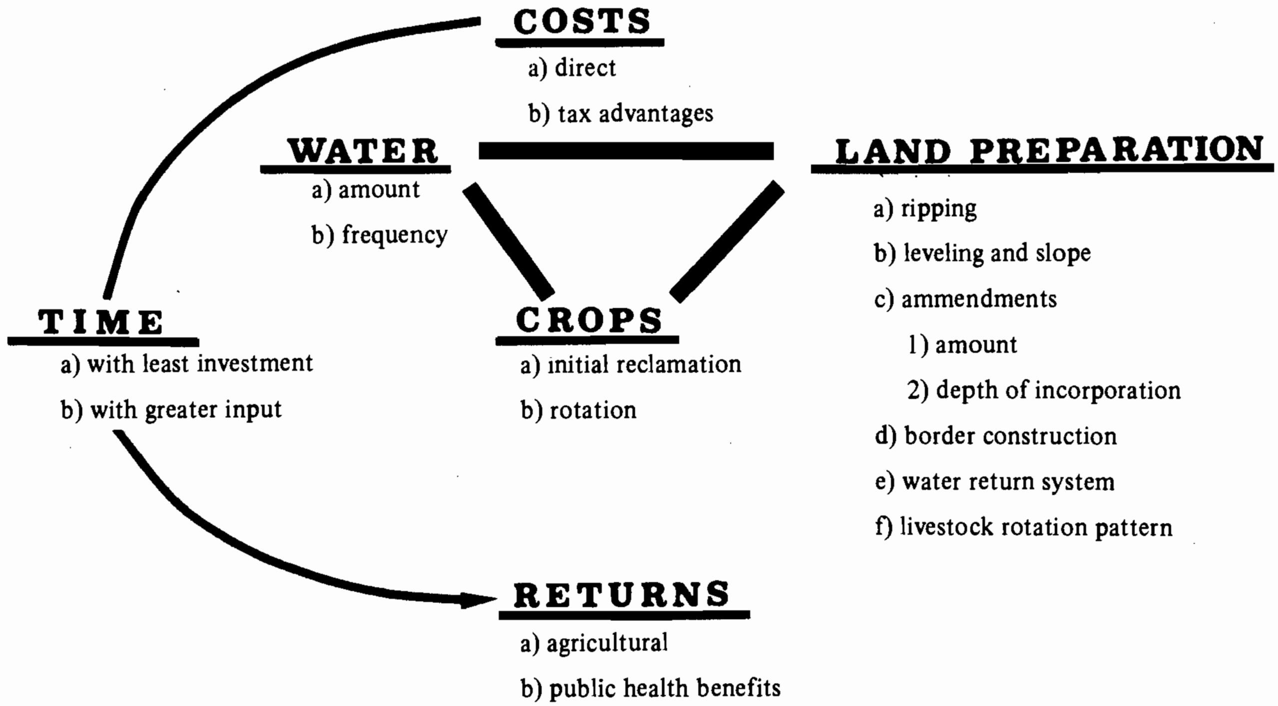

Fig. 1.–Considerations in the development of land for, or via, pastures.

ods of water and land management. However, there are numerous farming operations, particularly on lands which yield only marginal returns, where serious mosquito problems have resulted. In some cases, attempts have been made to improve conditions but with no real effect, e.g., installation of a tail-water return system without improved care in the amount of water applied. One of the worst fields that I have seen is a case where the owner had invested a substantial amount of money, in attempting to improve conditions, with the result of greatly worsening the problem. The latter case is worthy of further consideration as an example of what can happen without careful evaluation of the numerous factors involved. This pasture is on an alkaline soil (Traver soil series) in Tulare County. We decided to sample the soil in the field, which is a severe mosquito producer, to determine how much gypsum would be needed to improve water penetration. Figure 2 shows the pH and gypsum requirement of soil samples taken from the north, center, and south sections of eight checks; each check is 60 feet wide and one-fourth mile long. The gypsum requirement is over 15 tons/acre across the northern part of the field and about one-half of that amount across the center. But there is little, if any, requirement across the southern part. The north-south gradient in pH and gypsum requirement was not understood until the owner described the "improvements" he had made: in 1964 he decided to change the direction of the natural drainage, which was from north to south, so that the cattle would not have to walk back through tail water in order to get to the barn. As the barn was south of the field, he cut 12-14 inches of soil from the north side and graded the field to slope toward north; also he constructed a return ditch along the north side, which drains to the west and then south to a sump. Unfortunately, the owner did not realize that he was removing all of the shallow topsoil from the north part of the field and that the very poor subsoil would be exceedingly difficult and slow to reclaim. He was concerned with how to keep cattle out of the tail water, because of disease problems that he had experienced earlier, and not that he should keep cattle off wet fields. From 1965 to 1969 each irrigation of this field resulted in massive breeding of *Aedes nigromaculis*, while growth of pasture grasses was minimal (particularly on the north side of the field). After the 1969 growing season, the owner disbanded his attempt to use this property for pasture and decided to sell out. In this case, a positive attempt was made to improve conditions of the property, but the techniques used resulted in an agricultural failure and the production of a

9.8	10.2	10.0	9.8	10.2	10.2	9.7	9.7	pH
16.9	19.4	18.8	17.9	17.7	19.2	13.4	16.5	G.R.*
8.8	8.8	8.1	8.8	8.6	9.8	9.5	9.6	pH
6.3	8.3	6.8	6.9	3.0	11.9	12.6	17.4	G.R.
8.4	8.8	8.8	8.6	8.2	8.2	8.9	8.6	pH
1.3	1.3	0.8	3.8	1.8	1.5	2.8	5.8	G.R.

N ↑

Fig. 2.–Soil samples from Evans' Ranch, Tulare County, March 1969. (Traver fine sandy loam)

*G. R. = gypsum requirement in tons/acre of 85% gypsum per acre foot of soil.

severe mosquito problem. In cooperation with the Tulare MAD, we studied the efficacy of using gypsum to improve penetration on this same property. No improvement was apparent two years after incorporation of up to 15 tons of gypsum per acre. It appears that it is not economically feasible to develop such land for pasture.

Another question of current concern is how much soil depth above a hardpan is sufficient for land reclamation? We are studying this problem in cooperation with the Delta MAD, on a large field where the owner is attempting to convert native land (Fresno soil series) into irrigated pastures. The field involved has a soil depth which varies from one to seven feet above a hardpan. The owner has successfully developed similar fields and expects that this land will be reclaimed after it has been in pastures for six to eight years. During the reclamation period, the land is certain to produce mosquitoes. How can the reclamation period be shortened? Should land where the soil depth is only one foot above a hardpan layer be reclaimed? There are many other related questions that can be raised about land reclamation; but, in any event, we need to obtain specific data to determine what can be done, what should (and should not) be recommended, and what should be prohibited. Unfortunately, progress on this type of research is necessarily slow, so we should not waste time in getting started!

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A FORCE FOR RATIONAL ENVIRONMENTAL ACTION

Nicholas Pohlit
National Environmental Health Association, Denver, Colorado

Mosquito control, like all environmental control activities, demands judicious use of natural resources, judicious use of technology, and decisions based on the most reliable knowledge available on needs for human health.

The world today is a complicated milieu filled with frustrated people, and organizations, and businesses, and industry, and interest groups, all fighting for identity. Emotions are running rampant across the nation and throughout the world, and many people are panicking because the scare mongers have gotten the word out.

The word they have gotten out is that the world is doomed . . . that there are too many people now, and there will be still more millions in a few short years . . . that the air and the water and the land are hopelessly and forever poisoned so that the people on earth will be gasping their last breath before the century is over . . . that the oil and coal and wood and everything else is going to run out and the earth will be a dark, cold chunk of space rock.

Now, we know that we are polluting the land, and the air, and the water, and that there are a lot of people on this earth, but WE ARE NOT DOOMED. It will take rational action and clear thinking by many people to reverse, or at least to slow down, some of the actions that are causing these disturbing phenomena. It will take education and research and some extra dollars, either public tax funds or individual investments, to find the answers to environmental problems.

Recently there was some action on the detergent front. Just when some manufacturers had begun making phosphate-free products to quiet the cry against detergents, it was discovered that the products might possibly be more harmful than the phosphates. It appears that more research is needed in substitute formulas, water treatment, or systems for denutrifying waters that have been overnourished.

In the case of mosquito control problems, you already know that the use of DDT has been curbed and the results of substitutes have not been spectacularly successful. You already know that mosquitoes become resistant to pesticides and continue to breed and to grow and to "bug" people and animals. You already know that you are trying water management as a means of controlling mosquitoes, and that you have to work with other people, for instance farmers, to achieve any measure of success.

That brings me to the point of our being together. The professional organizations that are concerned with public health and with environment are going to have to work together to bring environmental control into focus and to achieve a respectable, healthful environment here in this country and to help other countries that want to benefit by the expertise we have achieved.

The National Environmental Health Association was actually started in California in 1937 when men working in such areas as solid waste disposal, vector control, housing, and food sanitation joined together to develop a professional organization. Their purpose was to set standards for education and excellence in performance, to promote professionalization, and to obtain better salaries. In 1956, the organization achieved national status and was moved from the UCLA campus to the University of Denver campus for a more centralized location. For the first time, a full-time executive director was employed. After eight years at the University of Denver, the offices were moved, and we "went out on our own". The national office has established liaison with government and industry as a means of accomplishing professional goals on a nationally effective basis. And, we work closely with educational institutions across the nation in producing professional manpower.

Today we are working with national, state, and local legislators and with industry to gather and disseminate information regarding environmental accomplishments and needs. A great part of our work is devoted to education and manpower for environmental health work. As you may or may not know, there is a critical shortage of qualified environmental health personnel. We have projected needs of environmental health workers from the current 252,000 to a need of 537,000 in 1980. There are presently 33 existing schools of environmental health leading to a bachelor's degree. These schools are producing 150 environmentalistis annually, and we need 10 times this number.

The National Environmental Health Association has established a National Accreditation Council for Environmental Health Curricula in four-year colleges and universities and is presently reviewing schools across the nation. Several have been approved for accreditation under this program. The Association also sponsors an internship and residency program for graduate programs in specialty fields. These programs turn out administrators who will guide the nation's significant environmental health decisions. Although too few of these specialists have been turned out so far, the programs are scheduled for expansion as soon as funds are available.

To meet the need for 1,500 graduates per year from environmental health programs, it will take $4½ million per year, plus an increase in facilities for another 33 schools, which is estimated conservatively at $33 million, just for the construction. Staffing these new schools is placed at a minimum of $75,000 per year for each school. Stipends are needed for many students, and we estimate that need at $1,650,000 annually. As an organization, we are working with federal legislators to obtain funds through the Health

Training Improvement Act of 1970, and to date have been able to squeeze out about $400,000 for upgrading existing programs. This is not much when we need $6¾ million per year, plus the construction funds. We have a long way to go to produce those needed environmentalists.

As one means of alleviating the manpower shortage, the profession has slowly sanctioned the use of technicians — persons with two-year degrees — to handle the myriad details of sampling, laboratory tests, and other tasks in air and water pollution control, water treatment, and other areas where these people can be useful. This frees the true environmentalist for more responsible, more decision making positions. To this end, the National Environmental Health Association has developed, and published in the Journal of Environmental Health, a two-year technical curriculum. There are a number ot two-year schools that are turning out water technologists and other laboratory people, and more and more programs are being developed in junior and community colleges throughout the nation.

These technicians are being accepted and employed as beginners in the career ladder and some states are helping them to progress. These technicians are valuable to the profession and are now being admitted to state professional associations. We are encouraging all environmentally allied workers to join our National Environmental Health Association because these people will strengthen our ranks and make our membership a more rounded and adaptable body of environmental workers. Through a broad field of environmental endeavors, we will be able to spread the work for environmental sanity to an ever widening segment of the general public.

The U. S. Department of Health, Education, and Welfare has issued a report calling for 600,000 technicians and auto mechanics by 1975 for installing and maintaining air pollution control devices. They have indicated that training funds will be made available for persons interested in this field. This is only one example of the many technical fields that will be opening up as environmental control progresses.

In order to use personnel and resources effectively, unified effort is necessary to prevent confusion, duplication of facilities, personnel, effort, and travel, controversy, program imbalance and haphazard priorities. An effective system for environmental management should be action oriented, and organized to insure visibility, ease and speed of action, adequate funding, sensible reaction to public and environmental needs. Since traditional programs for environmental control have not always been outstandingly successful, we must all reevaluate and consider regrouping of activities.

The National Environmental Health Association has created a Management Evaluation Service through which health departments and agencies can get an evaluation of their departments by a team of proven successful environmental health personnel in the various areas of concern — environmental planning, management, staff development, community affairs, program implementation, and analytical evaluation. Through this service, solutions to management problems will be proposed in both oral and formal written reports in accordance with the wishes of those who subscribe. Persons who will do the evaluating are all members of our organization — an environmentalist with 20 years experience in environmental management, including all levels of government . . . . a nationally recognized environmental health educator . . . an industrial management consultant with 25 years experience in environmental technology . . . a specialist environmental manpower development . . . a communicator with 15 years experience as a sanitarian and health educator . . . and many more. All are superbly qualified to be judges of other systems and agencies and to make recommendations for improvement. We hope that through this service, the quality of delivering environmental health services throughout the nation will be measureably improved.

One field of environmental health that this Association is especially active in is accidental injury control. One reason that we are active here is that accidents are the fourth leading cause of death in this nation. We can think of no better reason. The Association has conducted four workshops this past year in accidental injury control, in conjunction with our state affiliates where the workshops were held, and under a grant from the U. S. Public Health Service. These workshops were held for the purpose of training environmentalists to start programs in accidental injury control in the United States, and it is imperative that they be developed now in every neighborhood, in every industry, in every school, and that the message be carried to the general public and be carried out by the general public.

This is one area where the mosquito control personnel can help environmentalists — that is, in the safe use of pesticides and in draining unnecessary and unhealthful bodies of water which may be pools for drownings, or for mosquito breeding. As you know, the desired end result of your activities is to control insects which attack crops and livestock and at the same time to protect the health of livestock and humans on a long-range as well as a short-term basis.

The use of chemical pesticides has contributed greatly to the increase in agricultural productivity and has been an important factor in the control of disease vectors. The use of DDT, which is still the only economically feasible pesticide in underdeveloped parts of the world, has made agriculture possible in areas where it was formerly out of the question. It has made living bearable in the tropics and has reduced the incidence of malaria in India, for example, from 100 million cases per year with 750,000 deaths to only about 15,000 cases with 1,500 deaths. And yet, the use of this pesticide has caused other problems . . . . . .

It stores up in animal tissue and causes birds' eggs to have weak shells or no shells at all. Large doses of it have killed fish in this nation's waterways and in Europe. Now federal legislation has restricted its use. More research is needed. Meanwhile the use of other pesticides with short-term effects are being used, and those who use them must be made aware that safe use is essential. They may be immediately more harmful than DDT if they are used improperly. VISTA volunteers have decried the use of any pesticides because a few tragic cases of persons being sprayed, or of persons swallowing pesticides have been reported. These cases were clearly the result of not knowing how to use the products or the possible effects of direct contact with these pesticides.

Such incidents must be reduced or eliminated altogether. Education on their use is necessary, and in many cases where these substances are being handled by migrants, the education should be bilingual. We all know that many farm workers are non-English speaking persons from Mexico and other Latin American countries. We believe that all farm workers should be trained in the safe use of pesticides and other farm chemicals. The message should also be transmitted to private citizens in urban areas as well as rural because pesticides and fertilizers are used extensively in private homes and gardens.

The National Environmental Health Association conducts an Annual Educational Conference in Environmental Health. This year, the conference will be held in Portland, Oregon, June 26 through July 2. We invite the California mosquito abatement people to attend this meeting and to participate in the program. We have exhibit space available if you have display material and/or literature that would be educational to our conference. Last year we had an excellent presentation on mosquito control in India and Ethiopia by Larry Cowper who has been working with USAID in malaria eradication since 1959. He is now providing consultant and technical services to eight U. S. assisted country malaria programs in Africa, Asia, and the Near East. We are sure that mosquito control personnel here in our own country could provide some interesting information about the home front action. We urge you to attend the AEC and to bring along your knowledge and any audio-visual presentations you might have.

The National Environmental Health Association operates through a number of active committees. This year, all committees have been charged with drafting model legislation which can be used as a guide for states and local governments that are adopting environmental legislation but do not have the necessary facts on which to base their action. Some of the committees involved are the Disaster Committee, the Noise Committee, the Pesticides Committee, the Solid Wastes Committee, the Air Pollution Section, the Injury Control Section. We became especially aware of the need for such model legislation while attending hearings in a state senate committee where they were attempting to set air pollution regulations for emissions from manufacturing plants and to set fines for violations. The legislators involved were not sufficiently informed to draft enforceable, workable, and yet effective legislation. Later we found this to be true in other environmental areas. Therefore, as a national professional organization with people who work constantly with such problems, we decided to provide this type of service. We believe it will lead to better, more effective environmental legislation.

Also, we believe as professional environmentalists it is our duty to inform the United State Congress and their staff members regarding needs for environmental health programs –– both on the educational and the action fronts. We have a number of outstanding members of our Association who are working in government, and they help us to get the message to the right people. In order to call attention to our work, our members and our long-standing position in the field of environmental control, we were directly in contact with President Nixon during 1970. A resolution was adopted at our 1969 convention commending Nixon for his environmental awareness, and in March, 1970, we were able to meet with the President in the White House and to present our citation to him. Several of our members attended the presentation, and we were well received as environmental professionals.

During 1970, NEHA headquarters made several statements to congressional committees in the areas of housing, education, and accident prevention. Other members of our Association made statements on housing and minority problems and on lead poisoning control. We were active in the detergent phosphate controversy and called for rational action and further research in this area.

We are actively studying the population question and recently released a statement saying that production of enough food for growing populations is not a problem but that the equitable distribution of food is a problem. Recently, we heard an interesting talk by Professor R. W. Behan of the University of Montana in which he described the panic exploded by Dr. Paul Ehrlich in the Population Bomb. Professor Behan theorizes that new natural resources are created from the now and then useless material on earth. He illustrates his remarks by progression of man through the Stone Age, the Iron Age, the Bronze Age, the Steel Age . . . . and suggests that there is enough deuterium in the sea water to power the world until our sun has been dead for six billion years. He suggests not a withdrawal from technology but research and development expenditures of substantial and permanent nature from both public and private sectors. His is the first expression of hope for mankind that we have read in many a moon.

The National Environmental Health Association believes that through education, application of technology, and rational action, environmental problems can be solved and that we can have a respectable and healthful world to live in. We solicit your support and your cooperation in our endeavors.

PANEL: CALIFORNIA WILDLIFE MANAGEMENT–MOSQUITO SUPPRESSION COORDINATION COMMITTEE

MODERATOR: Eugene E. Kauffman

The Role Of The Wildlife Management–Mosquito Suppression Committee, Its Activities And Personality

Frank M. Kozlik
Wildlife Management Branch, California Department of Fish and Game, Sacramento

It is always interesting to check into the history of an organization, agency or as in this case, a committee, to see how it got started. Most of the time beginnings start in a small way and gradually expand into an all encompassing organization. In our case we find that we got our start at the top and that we moved downward to do our best work at the grassroots level.

Our Committee was conceived at the national level through the instigation of the National Mosquito Control-Fish and Wildlife Management Coordination Committee. This National Committee had been formed as an outgrowth of the Symposium on the Coordination of Mosquito Control and Wildlife Management that was called in Washington, D. C., in April, 1959. Just as the conference had been used as a means of promoting suppression agencies, it was felt that a permanent committee could carry out these objectives on a continuing basis.

Since the Washington Symposium had been well received, the National Committee felt that along with its other objectives there was a need to sponsor another symposium. They also recognized that the Washington Symposium had been eastern oriented, so it was decided that the next conference would deal with western problems and programs and that it be held in the west. As a result the conference was at Yosemite National Park in October, 1962. This conference proved to be so successful that another one was held at the same location in May, 1964. It was at this second conference that the National Committee requested that a local committee be formed to coordinate activities in California.

Those in attendance agreed and the late Oscar V. Lopp was designated as acting chairman to form the committee. It was also decided that the committee should be comprised of representatives from the five agencies that had programs or an interest in mosquito suppression and wildlife management. These were the California Mosquito Control Association, California Department of Public Health, University of California, U. S. Fish and Wildlife Service, and the California Department of Fish and Game. Later, because many of its programs affect mosquito control and fish and wildlife management, the California Department of Agriculture was added to the participating agencies. Just as Oscar Lopp was a driving force in putting on the national conferences at Yosemite, so he was in getting the coordinating committee organized and the representatives designated from the various agencies.

Since its inception there have been personnel changes on the Committee, but at present these are the members:

From the CMCA there is Eugene Kauffman. Gene is Manager of the Sutter-Yuba Mosquito Abatement District and as all of you know takes an active part in your Association. Gene is also a member of the Association's Wildlife Committee thus providing good liaison between our two groups.

The State Department of Public Health is represented by Richard Peters, who is the Chief of the Bureau of Vector Control and Solid Waste Management. Dick needs no introduction to this group as he has worked closely with your Association for many years. Dick's position covers a variety of jobs. He is now in solid wastes with its related vectors such as flies, cockroaches and rodents. He also has dealings with such venomous animals as rattlesnakes, wasps and scorpions, but the important thing is that he still spends the largest share of his time on mosquito control.

The University of California is represented by Dr. John E. Swift, who is extension specialist in entomology and Special Assistant to the Director of the Experimental Station. Most of you know Ed from contacts in the field or as a regular participant at these conferences. Ed deals with many other insects than mosquitoes, but of most importance to our Committee is his work in the pesticide field.

The State Department of Agriculture has Harry E. Spires as its representative. Harry has been involved with pesticide registration and has presented material on this subject at your conferences. In his capacity as special assistant to the Chief of the Bureau of Inspection Services he deals with special projects. Thus, he is in a position where he could handle any special problem involving mosquito suppression or wildlife management.

The U. S. Fish and Wildlife Service is represented by David J. Lenhart, who is their staff pesticide specialist for the western region. Dave is a native Californian and worked here for the Service before moving to their regional office in Portland.

And finally, I represent the State Department of Fish and Game. My specialty is waterfowl so that I am in a position to resolve any conflict that might occur between mosquito suppression and wetlands management. I am also a part of your Association's Wildlife Committee, thus assuring further liaison between our committees.

One of the first items of business for the Coordinating Committee was to come up with a set of objectives that would achieve coordination. The first objective states that the Committee shall stimulate interest at the state and local level in mosquito control, wildlife management and related agricultural policies. This is being done through informational activities such as publications, training programs and at meetings and conferences similar to this one.

The second objective is to coordinate action programs between mosquito abatement agencies, wildlife management and agriculture. The next paper on this program concerning rare and endangered species is an example of how our Committee, the CMCA Wildlife Committee, and agencies can work together on an action program. At one time on our wildlife areas we paid little attention to mosquito control. We raised tons of food for wildlife, but we also produced hordes of mosquitoes. Now we use proper water management to help control mosquito production. When mosquitoes do get out of hand the local abatement district comes in and handles the problem. To be ready for such action our areas now regularly budget funds to pay for necessary abatement measures.

The third objective is to stimulate interest and support cooperative research programs among all agencies and organizations. A good example of how this can be accomplished was the low volume aerial spraying in Colusa and Kern counties. The results of this experimental program were reported at your 1969 Conference by the cooperating agencies. We are also supporting the U. S. Fish and Wildlife Service's research plans at the Kern National Wildlife Refuge where a series of ponds will be used to develop compatible practices.

The fourth objective is to develop a procedure for review of mosquito abatement, wildlife management and related agricultural programs where conflicts may occur. While no formal procedure has been developed for handling such conflicts, they are taken up at Committee meetings. But of more importance is the fact that Committee members can immediately get in touch with each other and they know whom to contact to help resolve any forthcoming conflicts.

The fifth objective is to sponsor regional meetings. Here we have probably carried on our greatest activity in bringing personnel from the various agencies together, so that they can get acquainted and understand each other's programs and problems. Meetings have been held at Willows, Fresno, and Bakersfield, and a future meeting is being planned for southern California.

Our final objective is to integrate regional programs into an acceptable statewide program for research, education and action. Since we are still concentrating our efforts at the regional level we have not as yet developed any statewide program.

In conclusion, I feel that the Coordinating Committee's greatest accomplishments come about by being able to take quick action where conflicts might arise. Each of us knows whom to contact and in most cases a few quick telephone calls can prevent issues from developing or getting out of hand. I think here is where you are seeing the true meaning of the word coordination –– action in a smooth concerted way.

ENDANGERED WILDLIFE

Howard R. Leach

California Department of Fish and Game, Sacramento

I think Jean Delacour's foreword to Greenway's "Extinct and Vanishing Birds of the World."(Greenway 1958) is the best way to introduce the subject of California's endangered wildlife:

"We are now witnessing the most tremendous changes in the world, and one of the saddest consquences is the awful threat to the existence of many forms of wildlife. Human populations increase; weapons are improved; new poisons are found and used; and remote areas, so far inaccessible, are penetrated more and more easily. As a result, plants and animals are fast decreasing and some may eventually disappear altogether."

During the past 2,000 years the world has lost through extinction about 106 known forms of mammals of which 77 were species. Such losses have accelerated in recent times. Since 1600 some 64 mammals and 94 birds have become extinct. We now recognize, worldwide, over 223 mammals and 287 birds as being threatened with extinction. The list of fish, amphibians and reptiles is undoubtedly equally impressive.

Since 1900, here in California, five mammals and one bird have become extinct and 24 native animals are now on the federal endangered species list and face extinction. This month the Department submitted to California scientists a list of 129 wildlife forms, the status of which we are not certain. These included 52 birds, 27 mammals, 21 fish, 19 reptiles, and 10 amphibians. We are in the process of reviewing these in an authoritative manner and compiling a list of what we believe are truly California's rare and endangered animals.

The preservation of the remaining animal life of the world –– especially those species which are rapidly approaching extinction –– is one of the most urgent problems facing biologists and conservation agencies today. Until recently, this concern was seemingly shared only by zoologists and naturalists –– the world at large seemed to care less. But now with the question of man's own survival in doubt –– faced as we are with weaponry (nuclear war), over population, food shortage, environmental degradation, pollution and all the social problems of the world –– we suddenly find people expressing increasing concern about vanishing wildlife. They are demanding that these animals be given adequate protection and assured a place to exist. Times are changing; we are entering an era of compassion for our fellow creatures as evidenced by recent legislation, rather than an era of exploitation.

Federal Legislation

In 1966 Congress passed an Endangered Species Preservation Act. This Act gave authority to the Secretary of The Interior to publish a list of native animals threatened with extinction and to provide federal programs of research and protection. To accomplish this the Secretary appointed an Endangered Species Committee and solicited the assistance of many conservation organizations and scientists in compiling the "Red Book" (U. S. Dept. Interior 1968) which now contains 101 rare and endangered species and subspecies native to the United States.

Definitions used in the Red Book are: Endangered – An endangered species or subspecies is one whose prospects of survival and reproduction are in immediate jeopardy. Rare – A rare species or subspecies is one that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens.

In 1969, Congress extended to the Secretary authority to deem endangered world-wide animals faced with extinction and to prohibit their importation into the United States without permit. This act further covers all vertebrate life, plus mollusks and crustaceans. It places a high penalty on those who are convicted of illegal importation of endangered wildlife or engaged in interstate traffic in wildlife through amendments to the Lacey Act and Black Bass Act. The federal listing of endangered wildlife native to the United States is found in Table 1, and wildlife native to California in Table 2. The Secretary's listing of worldwide endangered species is contained in the Federal Register issued June 10, 1970 (Vol. 35, No. 112).

Despite the best intentions of federal acts, endangered wildlife's fate, for the most part, rests with the states. Unless these species are covered by the Migratory Bird Treaty Act or the Bald Eagle Act, federal jurisdiction is superseded by the state. State laws are required to assure survival of most all of the endangered wildlife.

State Legislation

In response to this need, the California Legislature passed the California Species Preservation Act and the Endangered Wildlife Act in 1970.

The California Species Preservation Act directs the Department to inventory all threatened fish and wildlife, develop criteria for rare and endangered, and report to the Governor and Legislature every two years on the status of these animals. Recommended measures for their protection and enhancement are also to be included in these biennial reports.

The Act made additions to the state's listing of fully protected birds and mammals and established categories of fully protected amphibians, reptiles, and fish. A heavy fine of a maximum of $1,000 and/or a year in the county jail was levied for those convicted of violation. Table 3 contains a listing of California's fully protected animals, taken from Article 1, of the California Fish and Game Code.

The Endangered Species Act expresses legislative concern about California's threatened wildlife, defines rare and endangered wildlife, and gives authority to the Fish and Game Commission to deem what animals in California are rare and endangered. It further prohibits importation of these animals except by permit.

Wildlife Stewardship

Let there be no doubt as to whom responsibility for wildlife rests. Wildlife is the property of the people, the sovereignty of which they have vested with the state to be conserved and managed for the benefit of all people. Such is the law of this land and has been defended in court since the early colonists adopted the principles of the Magna Carta.

As we well know, responsibility is shared by state and federal government for which they have established agencies to administer this public trust. Through the laws established by the Legislature and rules and regulations promulgated by the Fish and Game Commission, the California Department of Fish and Game is given responsibility for stewardship of the state's fish and wildlife, including both game and nongame species. The Fish and Game Code is explicit:

"Section 1600. The protection and conservation of the fish and wildlife resources of this state are hereby declared to be of utmost public interest. Fish and wildlife are the property and provide a major contribution to the economy of this state as well as providing a significant part of the people's food supply and therefore their conservation is a proper responsibility of the state."

Table 1.–Endangered species of native fish and wildlife.

MAMMALS:

Indiana Bat	*Myotis sodalis*
Utah Prairie Dog	*Cynomys parvidens*
Delmarva Peninsula Fox Squirrel	*Sciurus niger cenereus*
Eastern Timber Wolf	*Canis lupus lycaon*
Texas Red Wolf	*Canis rufus rufus*
San Joaquin Kit Fox	*Vulpes macrotis mutica*
Black-footed Ferret	*Mustela nigripes*
Florida Panther	*Felis concolor coryi*
Caribbean Monk Seal	*Monachus tropicalis*
Guadalupe Fur Seal	*Arctocephalus philippi townsendi*
Florida Manatee or Florida Sea Cow	*Trichechus manatus latirostris*
Key Deer	*Odocoileus virginianus clavium*
Columbian White-tailed Deer	*Odocoileus virginianus leucurus*
Sonoran Pronghorn	*Antilocapra americana sonoriensis*
Hawaiian hoary bat	*Lasiurus cinereus semotus*
Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*
Salt marsh harvest mouse	*Reithrodontomys raviventris*

BIRDS:

Hawaiian Dark-rumped Petrel	*Pterodroma phaeopygia sandwichensis*
California Least Tern	*Sterna albifrons browni*
Hawaiian Goose (Nene)	*Branta sandvicensis*
Aleutian Canada Goose	*Branta canadensis leucopareia*
Tule White-fronted Goose	*Anser albifrons gambelli*
Laysan Duck	*Anas laysanensis*
Hawaiian Duck (or Koloa)	*Anas wyvilliana*
Mexican Duck	*Anas diazi*
California Condor	*Gymnogyps californianus*
Florida Everglade Kite (Florida Snail Kite)	*Rostrhamus sociabilis plumbeus*
Hawaiian Hawk (or Io)	*Buteo solitarius*
Southern Bald Eagle	*Haliaeetus l. leucocephalus*
American Peregrine Falcon	*Falco peregrinus anatum*
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*
Masked Bobwhite	*Colinus virginianus ridgwayi*
Whooping Crane	*Grus americana*
Yuma Clapper Rail	*Rallus longirostris yumanensis*
Light-footed Clapper Rail	*Rallus longirostris levipes*
Hawaiian Gallinule	*Gallinula chloropus sandvicensis*
Hawaiian Coot	*Fulica americana alai*
Eskimo Curlew	*Numenius borealis*
Hawaiian Stilt	*Himantopus himantopus knudseni*
Puerto Rican Plain Pigeon	*Columba inornata wetmorei*
Puerto Rican Parrot	*Amazona vittata*
American Ivory-billed Woodpecker	*Campephilus p. principalis*
Northern Red-cockaded Woodpecker	*Dendrocopus b. borealis*
Southern Red-cockaded Woodpecker	*Dendrocopus borealis hylonomus*
Hawaiian Crow (or Alala)	*Corvus tropicus*
Small Kauai Thrush (Puaiohi)	*Phaeornia palmeri*
Nihoa Millerbird	*Acrocephalus kingi*
Kauai Oo (or Oo Aa)	*Moho braccatus*
Crested Honeycreeper (or Akohekohe)	*Palmeria dolei*
Molokai Creeper (or Kakawahie)	*Loxops maculata flammea*
Akiapolaau	*Hemignathus wilsoni*
Kauai Akialoa	*Hemignathus procerus*
Kauai Nukupuu	*Hemignathus lucidus hanapepe*
Maui Nukupuu	*Hemignathus lucidus affinis*
Laysan Finch	*Psittirostra c. cantans*
Nihoa Finch	*Psittirostra cantans ultima*
Ou	*Psittirostra psittacea*
Palila	*Psittirostra bailleui*
Maui Parrotbill	*Pseudonestor xanthophrys*
Bachman's Warbler	*Vermivora bachmanii*
Kirtland's Warbler	*Dendroica kirtlandii*
Dusky Seaside Sparrow	*Ammospiza nigrescens*
Cape Sable Sparrow	*Ammospiza mirabilis*
Brown pelican	*Pelecanus occidentalis*
Arctic peregrine falcon	*Falco peregrinus tundrius*
California clapper rail	*Rallus longirostris obsoletus*
Large Kauai thrush	*Phaeornis obscurus myadestina*
Molokai thrush	*Phaeornis obscurus rutha*
Hawaii akepa	*Loxops coccinea coccinea*
Maui akepa	*Loxops coccinea ochraceu*
Oahu creeper	*Loxops maculata maculata*

REPTILES and AMPHIBIANS:

American Alligator	*Alligator mississippiensis*
Blunt-nosed Leopard Lizard	*Crotaphytus wislizenii silus*
San Francisco Garter Snake	*Thamnophis sirtalis tetrataenia*
Puerto Rican Boa	*Epicrates inornatus*
Santa Cruz Long-toed Salamander	*Ambystoma macrodactylum croceum*
Texas Blind Salamander	*Typhlomolge rathbuni*
Black Toad, Inyo County Toad	*Bufo exsul*
Houston Toad	*Bufo houstonensis*

FISHES:

Shortnose Sturgeon	*Acipenser brevirostrum*
Longjaw Cisco	*Coregonus alpenae*
Piute Cutthroat Trout	*Salmo clarki seleniris*
Greenback Cutthroat Trout	*Salmo clarki stomias*
Montana Westslope Cutthroat Trout	*Salmo clarki*
Gila Trout	*Salmo gilae*
Arizona (Apache) Trout	*Salmo* sp.
Desert Dace	*Eremichthys acros*
Humpback Chub	*Gila cypha*
Moapa Dace	*Moapa coriacea*
Colorado River Squawfish	*Ptychocheilus lucius*
Cui-ui	*Chasmistes cujus*
Devils Hole Pupfish	*Cyprinodon diabolis*
Comanche Springs Pupfish	*Cyprinodon elegans*
Owens River Pupfish	*Cyprinodon radiosus*
Pahrump Killifish	*Empetrichythys latos*
Big Bend Gambusia	*Gambusia gaigei*
Clear Creek Gambusia	*Gambusia heterochir*
Gila Topminnow	*Poeciliopsis occidentalis*
Maryland Darter	*Etheostoma sellare*
Blue Pike	*Stizostedion vitreum glaucum*
Lahontan cutthroat trout	*Salmo clarki henshawi*
Mohave chub	*Siphateles mohavensis*
Pahranagat bonytail	*Gila robusta jordani*
Wondfin	*Plagopherus argentissimus*
Kendall Warm Springs dace	*Rhinichthys osculus thermalis*
Tecopa pupfish	*Cyprinodon nevadensis calidae*
Warm Springs pupfish	*Cyprinodon nevadensis pectoralis*
Pecos gambusia	*Gambusia nobolis*
Unarmored threespine stickleback	*Gasterosterus aculeatus williamsoni*
Fountain darter	*Etheostoma fonticola*
Watercress darter	*Etheostoma nuchale*

Table 2.–Listing of California fish and wildlife – extinct, endangered, or rare[a] – December 14, 1970.

Extinct in California	Year
Amargosa meadow vole	1917
Mexican jaguar	1860
California grizzly bear	1922
Plains wolf	early 1920's
Big-eared kit fox	1903
Columbian sharp-tailed grouse	late 1940's or early 1950's

Endangered	Rare
Santa Cruz long-toed salamander	Limestone salamander
Blunt-nosed leopard lizard	Black toad
San Francisco garter snake	Kern rainbow trout
Piute cutthroat trout	Southern sea otter
Lahontan cutthroat trout	Tule elk
Mohave chub	California bighorn sheep
Tecopa pupfish	Peninsular bighorn sheep
Unarmored threespine stickleback	Prairie falcon
Colorado River squawfish	Greater sandhill crane
Owens River pupfish	California black rail
San Joaquin kit fox	Gray whale
Morro Bay kangaroo rat	Guadalupe fur seal
Salt marsh harvest mouse	
Southern bald eagle	
American peregrine falcon	
California condor	
California least tern	
Yuma clapper rail	
Light-footed clapper rail	
California clapper rail	
Brown pelican	
Blue whale	
Humpback whale	
Pacific right whale	

[a]Reference: "Rare and Endangered Fish and Wildlife of the United States", Resource Publication No. 34 (amended 1968 ed.). Compiled by the Committee on Rare and Endangered Wildlife Species, Bureau of Sport Fisheries and Wildlife, Washington, D.C. December 1968.

"Section 1000. The Department shall expend such funds as may be necessary for biological research and field investigation for the collection and diffusion of such statistics and information as shall pertain to the conservation, propagation, protection, and perpetuation of birds and the nests and eggs thereof, and of mammals and fish."

"Section 1580. For the purpose of protecting rare and endangered wildlife or aquatic organisms or specialized habitat type both terrestrial and aquatic, the Department, with the approval of the Commission may obtain by purchase, lease, gift, or otherwise land and water for the purpose of establishing ecological reserves. Such ecological reserves shall not be classified as wildlife management areas pursuant to Section 1504 and shall be exempt from the provisions of Section 1504"

Since the inception in 1937 of the Federal Aid in Wildlife Restoration Act –– commonly referred to as the Pittman-Robertson Act –– there has been over $300 million spent in the United States for the conservation and management of game animals; $18 million by the California Depart-

Table 3.–Listing of California's fully protected birds, mammals, reptiles and amphibians and fish[a] – January 1971.

BIRDS:	
American peregrine falcon	*Falco peregrinus anatum*
California black rail	*Laterallus jamaicensis coturniculus*
California clapper rail	*Rallus longirostris obsoletus*
California condor	*Gymnogyps californianus*
California least tern	*Sterna albifrons browni*
Greater sandhill crane	*Grus canadensis tabida*
Light-footed clapper rail	*Rallus longirostris levipes*
Southern bald eagle	*Haliaeetus leucocephalus leucocephalus*
Trumpter swan	*Cygnus buccinator*
White-tailed kite	*Elanus leucurus*
Yuma clapper rail	*Rallus longirostris yumanensis*
MAMMALS:	
Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*
Bighorn sheep	*Ovis canadensis*
Northern elephant seal	*Mirounga angustirostrits*
Guadalupe fur seal	*Arctocephalus townsendi*
Ring-tailed cat	*Bassariscus* sp.
Pacific right whale	*Eubalaena sieboldi*
Salt-marsh harvest mouse	*Reithrodontomys raviventris*
Southern sea otter	*Enhydra lutris nereis*
Wolverine	*Gulo luscus*
REPTILES and AMPHIBIANS:	
Blunt-nosed leopard lizard	*Crotaphytus wislizenii silus*
San Francisco garter snake	*Thamnophis sirtalis tetrataenia*
Santa Cruz long-toed salamander	*Ambystoma macrodactylum croceum*
Limestone salamander	*Hydromantes brunus*
Black toad	*Bufo boreas exsul*
FISH:	
Colorado River squawfish	*Ptychocheilus lucius*
Thicktail chub	*Gila crassicauda*
Mohave chub	*Gila mohavensis*
Lost River sucker	*Catostomus luxatus*
Modoc sucker	*Catostomus microps*
Shortnose sucker	*Chasmistes brevirostris*
Humpback sucker	*Xyrauchen texanus*
Owens River pupfish	*Dyprinoden radiosus*
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*
Rough sculpin	*Cottus asperrimus*

[a]Source: California Fish and Game Code, Article 1, Sections 900-903; 3511; 4700; 5050; and 5152.

Table 4.–Summary of Special Wildlife Investigations Program and Accomplishments 1968–1970.

Study	Completed	Under Study	On Going	Output
Peregrine Falcon Nesting Study	X			Herman S. (1970).The Peregrine Falcon –– a vanishing Californian, Outdoor California Jan-Feb. 1970. Herman, et al. (1970) The Peregrine Falcon decline in California Aud. Field Notes vol. 24 no. 4 1970. Job Completion Report, 1970.
Seabird Breeding Ground Survey	X			Osborne T. and J. R. Reynolds (1971).California seabird breeding ground survey 1969-70. WMB Adm. Rpt. 71-3 Osborne T. (1971) Survey of bird use of Coastal rocks of northern California–WMB Adm. Rpt. 71–4 Job Completion Report, 1971.
Humboldt Bay Mud Flat Study	X			Job Completion Report – 1971.
Coastal Wetland Survey	X			Mudie, P. (1969). A survey of the coastal wetland vegetation of north San Diego Co. WMB Adm. Rpt. 70–4. Job Progress Reports 1968-69.
White-tailed Kite Study	X			Waian, L. B. and R. C. Stendel (1970). The White tailed kite in California with observations of the Santa Barbara population. vol. 56 no. 3. Job completion rept. 1970.
California Brown Pelican Study	X			Gress F. (1970). Reproductive status of the California brown pelican in 1970 with notes on breeding biology and natural history. WMB Adm. Rpt. 70–6 1970. Job Completion Rept. 1970.
Island Fox Study	X			Job Completion Rpt. – 1970.
California Condor Study			X	Sibley, F. C. (1969).California Condor Surveys 1968 CFG vol. 55 no. 4. Mallette R. D. (1970) California Condor Surveys 1969. CFG vol. 55 no. 4. Job Progress Repts. 1968, 1969, 1970 California condor survey. Operational Management plan for California condor 1970.
Statewide Heron Rookery Study				Job Progress Rpts. 1968, 1969, 1970.
Raptor Survey				Job Progress Rpts. 1968, 1969, 1970.
San Joaquin Kit Fox Study		X		Laughrin, L. (1970).San Joaquin kit fox, its distribution and abundance. WMB Adm. Rpt. 70–2 Job Progress Rpts. 1969, 1970.
Statewide Shorebird Survey				Job Progress Rpts. 1968, 1969, 1970 California Shorebird Survey, 1969-70 DFG 1971.
Shorebird Research				Job Progress Rpt. 1968, 1969, 1970.
Prairie Falcon Nesting Study	X			
Lake Earl Wildlife Evaluation	X			
Anaheim Bay Estuary Study	X			
South San Francisco Bay Habitat Evaluation	X			
California Least Tern Study	X			
Assess Nongame Problems			X	Progress report on wildlife affected by the Santa Barbara Channel Oil Spill––Jan. 28 – Mar. 31, 1969 DFG Second Progress Rpt. on wildlife affected by the Santa Barbara oil spill, Apr. 1 – May 31, 1969. Leach, H. R. and L. Fisk (1969) The Gopher Tortoises. Inland Fisheries Inf. Leafl. No. 26.

ment of Fish and Game. These funds have contributed immeasurably to the knowledge we game managers possess and to the success of our game management programs. Few people, indeed, can quarrel with the statement that we now have more game than existed in the 1930's because of the years and years of research, management, and protection afforded these animals. However, as we delve deeper into the problems of nongame wildlife, we find the task to be unpleasant. I mentioned here in California, alone, we have some 129 wildlife forms in short supply whose status is undetermined. Essentially nothing has been done to determine their life history and habitat needs. We know virtually nothing of their distribution and abundance other than occasionally someone has reported their occurrence and we know they are about. Unpleasant, too, is realization that man's use of the land and water is seriously affecting these animals and hastening their way to extinction and we have neglected to take notice. Because of this the Department initiated a program to be responsive to the needs of nongame wildlife. California became one of two states to set up such a program financed with wildlife restoration funds.

Special Wildlife Investigations

Initiated on July 1, 1968, Special Wildlife Investigations was staffed with a Wildlife Management Supervisor and an Associate Wildlife Manager-Biologist, provided with $56,400 and put to work. Funding since then has been $84,800 and $82,000. Program objectives are those of the Department: (1) To maintain all species of fish and wildlife for their intrinsic and ecological values as well as for their direct benefits to man. (2) To provide for diversified recreational use of fish and wildlife. (3) To provide for an economic contribution of fish and wildlife in the best interests of the people of the state. (4) To provide for scientific and educational use of fish and wildlife.

Project goals are essentially (1) determine the current status of California's threatened wildlife and develop programs for their preservation and enhancement, and (2) become knowledgeable of nongame wildlife and put this knowledge to work to assure these resources do not become threatened.

Appended is a summary of Special Wildlife Investigations (Table 4) program and its accomplishments over the three years it has been in operation. Of the 20 research projects or "jobs" undertaken seven have been completed, nine are currently under study and four are ongoing programs. Our primary thrust is short-term studies directed towards resource inventory rather than academic research. Our goal is to determine the current status of California's threatened resources, provide continued surveillance, and develop programs to protect and conserve these resources.

References Cited

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ENVIRONMENTAL CONFLICTS

Earnest E. Lusk

Bureau of Vector Control and Solid Waste Management
California State Department of Public Health, Redding

I doubt that there is much value in recounting a list of environmental conflicts. If you read the newspapers, listen to the radio, or watch TV you know that new ones are being added each day. However, for the purpose of initiating a discussion of the subject I would like to describe a few situations and discuss a somewhat different point of view for some of them.

Until recently pesticides have been receiving most of the publicity but there is a growing awareness that many of man's activities may result in "conflicts". The term "environmental conflict" does not necessarily denote ecological damage.

Webster's definition of conflict is "a strife for mastery" or "a struggle occasioned by incompatible desires". Many times because of our need to produce food, fiber, shelter, or usable energy we must necessarily enter into conflict with nature. I'm not sure we could classify these needs as "incompatible desires" but they may at times lead us into a "strife for mastery" over nature.

Many of our "conflicts" develop as a result of our creation of specialized ecosystems. We cultivate massive areas of a crop which provides a habitat specifically suited to certain species. Often these species present either a hazard to the continued production of this crop or to the health of the people living in the area and we are faced with the task of trying to control what we have produced.

As an example, the production of rice in the Sacramento Valley is of considerable economic benefit to the area but the cultural methods we use provide great expanses of warm, rich, protected, shallow water. What is a poor gravid *Culex* or *Anopheles* female expected to do? The production of enormous numbers of mosquitoes in such a habitat is a perfectly normal response of nature. Our perfectly normal response, since we also want to live in the valley, is to attempt to prevent this, so you might say this is the beginning of a conflict with nature.

It is in the choice of weapons and the methods we use to carry on this conflict that we must exercise great care. The development of a technology which will allow us to produce the desired results on the specific target without damaging side effects is the final goal.

Generally man "treats" or "manipulates" the environment in some manner which he believes will produce desirable results. A subdivision developer includes a lake in his plans because he wants to enhance the beauty of the area and provide recreational benefits to the people who purchase homes there. One side effect of this, of course, is that the lots sell faster and for a higher price – a good effect from his point of view.

The newly filled reservoir may turn out to be an ideal habitat for a variety of gnats and midges and later on for aquatic weeds and mosquitoes – a good effect from their point of view. The residents of the area, of course, disagree – this is a bad effect from their point of view. The conflict is in progress. It's up to the people carrying on the battle to discover the right weapons.

There is little question that some environmental misfortunes have occurred because a developing civilization said "Damn the consequences – full speed ahead!" but there are some which have taken place only after the most painstaking, meticulous investigations have failed to indicate the possibility of any unfavorable result.

Anyone who visited Clear Lake at a time when the Clear Lake gnat population was at its peak would surely concede that some control measure was absolutely necessary. Of course, if no development had ever taken place around the lake and if no tourists had chosen the lake as the place to spend their vacation, there would never have been a problem. However, the development did take place and the demand for control did arise.

Studies on the biology and possible means of controlling this gnat began in the early 1930's. For nearly twenty years intensive limnological investigations were made and every possible control procedure evaluated. From 1946 to 1949 a variety of chlorinated hydrocarbon insecticides were screened for their toxicity to the larvae of ***Chaoborus astictopus*** and for their possible effects on other organisms in the lake. One of these materials, DDD, was chosen because of its high degree of effectiveness against the gnat larvae and low level of toxicity to fish. There was no indication that an application at the rate selected would have any detrimental effect.

The sequence of events is well documented. What is sometimes forgotten is that the results were spectacular and accomplished in an almost unprecedented manner exactly what the program designers set out to do. The fact that it was necessary to re-treat the lake within a few years and that the third treatment in 1957 was only partially successful is just one more example of mother natures ability to compete in this conflict.

The death of the western grebes and the subsequent discovery of the biological accumulation of DDD in the lake did not mean that controlling the gnats was a mistake; it was rather an indication that the tools employed might produce some side effects which we would prefer to avoid.

It is from such occurrences that we learn. Probably no other example of food chain concentration of pesticide has been so well documented or so widely cited. As a result, a tremendous amount of attention was focused on the use of chlorinated hydrocarbons in situations where they might accumulate. It is possible that the information gained in this instance may have provided some long-term benefits outweighing any temporary damage done at Clear Lake.

Another interesting "conflict" which arose at South Tahoe illustrates a somewhat similar situation. There are many environmental problems in this lake basin as a result of man's invasion of the area. Sewage disposal, garbage disposal, and erosion have threatened to turn the lake into a green pond. There is also a serious mosquito problem. A variety of snow water *Aedes*, *Culex*, and *Culiseta* arise from the mountain meadows and natural marshes in the areas. A mosquito control program was initiated in the valley seven or eight years ago. The original control recommendations were based on a program of selective larviciding and provision for drainage of some of the marsh land. For one reason or another most of the control effort was shifted to the use of thermal aerosols. It now seems there may be a link between this aerosoling and a reduced rate of parasitism and predation on the pine tree scale in the area. Some tree loss has occurred. Whether these losses are truly the result of the aerosoling or are the result of a combination of other factors is still in question. There are a variety of possibilities other than the aerosol all linked to some degree with man's excessive use of the area. One of the basic problems is that the web of reactions in any ecosystem is so interdependent that it is difficult to predict the final effect of any outside influence.

I think we should remember that the earth has not yet reached a biologically stable condition. No species including man is exempt from change or eventual extinction.

Ultimately all of us, whether we are involved in mosquito control, agricultural pest control, plague prevention, fish and wildlife protection or whatever, have a common goal-the preservation of a healthful, productive and enjoyable environment.

ENVIRONMENTAL CONFLICTS IN COASTAL ESTUARIES IN SOUTHERN CALIFORNIA

Harvey I. Magy
Bureau of Vector Control and Solid Waste Management
State Department of Public Health, Los Angeles

Prior to the arrival of the Spaniards, the southern California coastline was broken by numerous estuaries, marshlands, and lagoons formed at the mouths of creeks and streams. During the winter, floods from rains poured into these sites breaking sandbars and allowing the tides to enter. With the reduction of runoff water during the summer, sandbars would usually reform. These were sanctuaries for wildlife and spawning areas for marine fish. Undoubtedly, they were also producing salt marsh mosquitoes.

Within the last hundred years these estuaries, marshlands, and lagoons have been subject to man's disruptive actions. Highways and railroad embankments traversing these lagoons blocked rain water runoff. Runoff was also obstructed following the construction of housing and commercial developments on reclaimed lands. Many sewage treatment plants were constructed in these sites. Treated effluent released into these areas added to water impoundment. With the addition of standing water, albeit sewage effluent, mosquito problems increased – at the same time shifting from salt water mosquito to *Culex* mosquito problems. This was the situation when I became involved in helping local agencies control coastal estuary mosquito problems in 1954.

In preparation for this seminar I made an inventory this year denoting changing mosquito breeding conditions, since 1954, extending along the southern California coastline

Table 1.–Environmental conditions of estuaries, marshes and lagoons in southern California (1970).

	Land Reclamation or Channelized	Receiving Sewer Plant Effluent	Kept Opened Artificially	Natural
Imperial Beach Marshes				X)*
Palm City–Imperial Bank Marshes				X)*
Sweetwater River Marsh & Lagoon				X)*
San Diego Bay Marshes – south	X			
Mission Bay Marshes	X			
Los Penasquito (Sorrento) Lagoon/Marshes		X		
San Diequito Lagoon		X		
San Diego Lagoon		X		
Batiquitos Lagoon				X (recovered)
Aqua Hendionda			X	
Buena Vista Lagoon				X (recovered)
Loma Alta Lagoon		X		
Santa Marguerita Lagoon				X
San Mateo Lagoon		X		
Newport Bay – upper	X			
San Gabriel River	X			
Los Angeles River	X			
Bixbey Slough – Dominquez Creek	X			
Ballona Creek	X			
Malibu Creek				X
Mugu Slough				X
Santa Clara River		X		
Ventura River				X
San Luis Rey River	X(partially)			
TOTAL	8	6	1	9 (4 recovered)

*Improved by sewage effluent diverted to the Metropolitan Sewer System.

from the Mexican border to the Santa Barbara County line, as indicated in the accompanying table.

You will note that mosquito breeding conditions had been substantially reduced in eight of twenty-four marshlands and lagoons, following land reclamation and the construction of concrete channels, although probably to the detriment of wildlife and fisheries' interest. Whereas in 1954 eleven were receiving sewage effluent, most of these with serious *Culex* problems, only six are now receiving effluent from sewage treatment plants.

Apparently nine are in a "natural" state. Of these, five are returning to their pristine condition with the elimination of sewage waters. This may be a mixed blessing, as salt water mosquitoes may well replace *Culex*. (I would prefer this situation.) One lagoon, Aqua Hedionda, has been kept open permanently to the ocean, changing from a creek estuary to an ocean water contact sport lagoon, with minimal salt water mosquito problems.

Have we made progress in solving the environmental conflict of eliminating mosquito sources and conserving the domain of fish and wildlife? This conflict in interest has not been clearly defined in these coastal situations. Progress has been made in reducing *Culex* mosquito breeding problems, through elimination of sewage effluent from these waterways. Many rain runoff sources have been eliminated by draining, filling, and reclaiming land. Making these changes might have been good mosquito control but may have been detrimental to certain wildlife refuges and fisheries. Complete source reduction by drainage, ditching, or filling may be contraindicated depending on local situations. At times, less drastic means for attaining our goals for good mosquito control and satisfying conservation interests are available. When properly used, pesticides may be the best compromise between the pure conservationists and the advocates of vector control by use of insecticides.

I would like to cite an example where insecticide control was the compromise of choice. In 1969 the summer "White House" at San Clemente was overwhelmed by *Culex* mosquitoes, mostly *Culex erythrothorax*. This occurred at the time the California Department of Public Health was engaged in spraying *Culex tarsalis* sources in order to prevent an outbreak of encephalitis. We were alerted and made a helicopter spray crew available. The Orange County Mosquito Abatement District located the source in the adjacent San Mateo Creek. This creek drained the northern part of Camp Pendleton, a training camp for the United State Marines. About a mile inland, a small sewage treatment plant discharged its treated effluent into the water of the creek that was impounded in several large ponds thickly overgrown with tules. For mosquito control, the ideal solution would be to drain, fill, and level these depressions, and open the sandbar at the creek's mouth to drain the creek water. Discussion of these proposals was publicized, and an outcry from conservation groups concerned with retaining wild fowl refuges ensued. Fish & Game authorities suggested that the district use an effective insecticide, applied in a formulation that would be safe to man, fish and wildlife. Following unsuccessful use of larvicide applied by means of ground rigs, our helicopter crew was brought in and we used a high concentrate, low volume BAYTEX® spray at the rate of 0.1 lb. per/acre with good results. A better compromise solution would probably be to thin out the tules through physical or chemical means to allow for access of top-feeding *Gambusia* and also to improve the penetration of low volume, high concentrate insecticides and still retaining enough cover to provide shelter for game birds.

In summary, we must evaluate conventional methods of mosquito source reduction in coastal lagoons and estuaries through filling, draining, land reclamation, concrete lining of ditches, and exclusion of all treated sewage effluent in terms of their impact on the survival of bird refuges and marine fish spawning areas. In select areas the judicious use of insecticides and weedicides may be the method of choice in offering a compromise solution to the interest of conservationists and mosquito control program managers.

THE GENESIS AND GOALS OF THE SOCIETY OF VECTOR ECOLOGISTS

Harvey I. Magy

Bureau of Vector Control and Solid Waste Management
California State Department of Public Health, Los Angeles

In July of 1968, during a luncheon engagement with a small group of vector control workers in southern California, we expressed the sentiment that there was no single professional organization that was available for expressing our individual professional needs. Around the table were members of several mosquito abatement districts, local health departments and the State Department of Public Health. The major difference among us was that we were dealing with different vectors — rodents, flies, mosquitoes, etc. — yet we were dedicated to the unifying principle of bringing vectors under control through preventive measures. We decided at that moment to establish a new professional organization.

When we examined this concept more closely during this and later meetings, we recognized that we were using the tools and evaluations of the science of ecology to control vectors, thus the name we have chosen: Society of Vector Ecologists.

During our formative meetings we attracted people of diverse training —— entomologists, mammalogists, engineers and general biologists —- who shared our dedication. "In essence we are a society that is dedicated to fulfilling the need to bring together a professionally diversified group of people inspired by a common purpose. The intentions of this multi-disciplinary assemblage is to strengthen the mechanisms whereby vector problems are solved by the use of inter-disciplinary knowledge based on the application of sound ecological principles," to quote Mr. Richard Husbands, one of the formulators of our philosophy.

On August 7, 1968 we organized as SOVE*, electing Mr. Roy Eastwood as our first President. I became the second President in 1969. Howard Greenfield is now President-elect. Our Society has deliberately grown slowly in order to enable us to work out more effectively a clarification of our objectives and organizational structure.

We have members in California, Colorado, Washington, D. C., Georgia, and seven from overseas. In all we have about 90 members and a potential of quadrupling our membership in California alone. One-fourth of our membership is from mosquito abatement districts; one-fourth from local health departments; one-fourth from the California Department of Public Health; and the remaining members compose a cross section from various campuses of the University of California, the University Extension Service, state college, other universities, Armed Forces, U.S.D.A., Public Health Service, private industry, and local agricultural departments.

The purpose and objectives of SOVE, taken from our constitution, are as follows:

Purpose: The purpose of this organization is to encourage the study and suppression of disease vectors and nuisance organisms through environmental management and the conservation of water, land, and reusable waste products of man's endeavors. The organization aims to develop the highest possible ethical and professional standards whereby the members may pool their knowledge in a dedicated effort to provide the greatest possible service to all persons affected by health hazards and annoyances caused by vector and nuisance species.

Objectives: The objectives of this organization shall be the following: (a) Encourage the active participation of public and private agencies in all aspects of the study and suppression of vector and nuisance species. (b) Provide educational meetings and otherwise facilitate the exchange of pertinent information among all members. (c) Examine the full spectrum of problems caused by vector and nuisance species and define those areas in which additional research and technological development are needed. (d) Use appropriate means to inform the general public of the health hazards and nuisance caused by vector and nuisance species, and what means are being used by public and private agencies to suppress these problems. (e) Seek to provide public recognition of the practicing field of Vector Ecology as a professional activity. (f) Develop a basis for establishing professional standards as well as criteria for training of Vector Ecologists. (g) Facilitate the unification and professional advancement of individuals active in the field of Vector Ecology.

New membership requirements, which are presently being voted on if passed will accept for Regular Membership an individual with a bachelor's degree and three or more years of experience in the Vector Control-Ecology field or in related fields of education and research. Other memberships include (1) Affiliate Graduate Membership – requiring a Bachelor's degree plus work in the Vector Control field but lacking the required experience; (2) Student Membership, and several (3) Honorary Memberships. Our new constitution provides for a very generous "grandfathering" period for those who have performed at least seven years of creditable or administrative service in this field, but lack formalized baccalaureate education.

We recognize the diversity of educational backgrounds among our members. Since professional competence is primarily acquired through experience, we have emphasized experience as our unifying requirement for membership. Under the active chairmanship of Dr. Fred Legner, of the University of California at Riverside, our Curricula Development Committee is reviewing undergraduate courses that would be desirable for a professional Vector Ecologist.

I have been asked by Program Chairman Ron Wolfe to relate what our Association is doing to meet the present concern about ecology. I am certain he is referring to the public clamor for an environment that should be aesthetically pleasing, free of water, air, and land pollutants and contaminants, and devoid of persistent hazardous man-made chemicals. Firstly, unifying and strengthening each member's concept of environmental management in the suppression of vector species, as expressed in our Purpose and Objectives, is probably the most important contribution that we can make at this time in maintaining a healthful and pleasing environment. Many of our members are in decision-making positions that may affect the environment, or some day will be assuming these responsibilities. As an example, our of-

*The name California Association of Vector Ecology was used temporarily while the Society was being formed, but to prevent geographic limitations, and because the letters C.A.V.E. have been pre-empted by another organization, the members have chosen Society of "Vector Ecologists" as the official title for their organization. Editor.

fice in southern California was instrumental in launching the Santa Clara River Conservation Committee, made up of many state and local agencies. Organized for the purpose of dealing with a very serious midge problem, we are dedicated to using environmental conservation and manipulation methods rather than short-term, expedient measures. Also, as already mentioned, SOVE is concerned with better training of Vector Ecologists in the undergraduate level for their future professional career. In addition to that, we are developing in-service training programs for our working members. Presently, we are negotiating with the federal government for a special training program on usage of pesticides. One of my outgoing requests to SOVE membership as President, that I will make at our Second Annual Meeting, will be that SOVE develop position papers on environmental conservation methodology and the proper role of pesticides for obtaining a disease vector and nuisance free environment.

With our organizational problems behind us, we undoubtedly will take a more active role in enhancing the environment through the diligent use of sound ecological principles.

About a fourth of our members belong to mosquito abatement districts, which are corporate members of the California Mosquito Control Association. We look forward to working cooperatively with your organization, which has many goals in common with SOVE, for the purpose of making this a more healthful and pleasing world to live in.

THE FIVE "W's" AND THE "H" IN PUBLIC INFORMATION

Lee Hurte
Kings Mosquito Abatement District, Hanford

I have the feeling that most of my remarks today will be quite redundant for the simple reason that the basic concept of public information or public relations has not changed in at least a hundred years. We may have altered some of our techniques to cope with the new media of radio, which was born commercially around 1920, and television, which scientists say is still in its larval stage. There is very little I can say about public information that managers, trustees and staff members don't already know . . . But your problems . . . if I can judge by my own district manager's problem, is finding the time to sit down and plan, write and make the proper contacts which make an effective public information program. You have your hands full and are wearing too many hats already.

Long ago, the working press established the idea of placing the most pertinent facts of a news story in its lead paragraph. These facts became known in journalistic circles as the five W's and the H. Who, What, When, Where, Why, and How.

WHO

Public information is a two-pronged force. It creates an interest and awareness in the general public, or with a special public, and stimulates them to action. But another public is your internal staff who must keep informed of the activity, the policies and the operation of your organization. Your staff is also your public relations personnel. That operator out there in the field, or that secretary in the office is the organization. The public knows your organization only through the outside contacts made by your staff. To the public, your staff is the organization. Both of these publics then, internal and external, constitute the "WHO" in public information.

WHAT

What will you do when you reach these publics? You will want to inform them so as to create an awareness of your organization. You want to get them interested in what you are doing; in what you want; in your problems and how your problems relate to their problems. You want to stir them to action to solve your common problems. You want to advance, or to change the image of your organization.

With mosquito control agencies, this could be from a spray operation to an abatement concept . . . . or, you may want your publics to know that you are here to help them solve their problems, rather than to have them help you solve your problems. I believe it was Dale Carnegie who said, "You can reverse people's attitudes by expressing an interest in their problems." What you will do with your public is the "WHAT" of public information.

WHEN

Your public information program should envisage a timetable of events. At Kings, we are working on a change of image that abatement entails more than just spraying. This is a long-range program because it means changing people's minds, their attitudes, their long time, set methods of doing things. Therefore, within this long-range program is a series of short-range plans.

In six months we may want to encourage efforts to seek new solutions to problems. In twelve months, we will want our public to know that insecticides are a temporary solution which time may completely eliminate as an effective abatement method. In 18 months, new directions by better water management can become an acceptable solution . . . and perhaps, in two or three years, the public will have acquired a new image of the district. They will have confidence in our ability to help them solve their problems. "WHEN" is your timetable for effective public information.

WHERE

It is quite obvious that each district has problems which are peculiar to that district. Yet, in our field of operation we have common objectives, and we can develop public information services which can coöperatively and jointly benefit each district. There is no reason why the materials which I will use can't be adapted for the use of every district in the Central Valley, or in the State of California. The problem of mosquito resistance has suddenly narrowed our field of operation to a more cooperative effort.

WHY

The "WHY" of public information is also quite obvious. When I think of ecology, I think of mosquitoes polluting the atmosphere. I think of the health hazard they constitute, and of the growing problem of resistance. It all boils down to the fact that we have a "selling" job to do . . . and that brings us to the "HOW".

HOW

Any public information program must have the materials and the media in order to get its message across. Our five point program at Kings consists of news releases, leaflets, pamphlets, films, and radio announcements.

We send news releases periodically to four newspapers in the county. These include Hanford, Corcoran, Lemoore, and the Naval Air Station paper, "The Golden Eagle". The Hanford and Lemoore papers have high school supplements in which we ran our "WANTED DEAD" Ad. The school editor ran an editorial on the mosquito problem. The Hanford publisher has also favorably editorialized our position on mosquito resistance. In his editorial the editor mentioned something about insects being an excellent source of protein, and we can fortify our bread with insect meat. He ended his editorial with the timely remark, "If we can't beat them we'll eat them".

The Lemoore editor waxed poetic when he headlined our news release with: MOSQUITOES TOO SMART FOR SPRAYS SO LANDOWNERS DEVISE NEW WAYS. Our leaflets and pamphlets are mailed, used by schools, and the Chamber of Commerce and banks give them to their customers. We are currently working on a school resource manual which will have student projects for the science and social studies classes, and tell the role of the district in mosquito abatement.

Our film library is used in lectures, at service clubs and schools. We have three radio stations in the area and they reach from Fresno to Bakersfield, so there is some overlap in our radio coverage. Some of our radio releases have qualified as radio news items.

Our five "W's" and the "H" public information program has been made much easier because, as you probably have noticed, we have used many of the accumulated ideas and writings of you men in the various districts. We have taken gleanings from Health Department and other pamphlets and adapted them to our local needs.

A committee of managers has asked me to submit, as a package, this public information program for use by other districts on a contractual basis. Each district can then receive, from a single source, leaflets, pamphlets, radio announcements, news releases, such as you have seen here today, to help the district carry on its own public information program.

I want to thank you for the privilege of appearing before you, and I believe that with our common goals we should certainly be able to use the tools of public information to the best advantage in combating our common enemy to the health, safety, and comfort of the residents of California.

"OPERATION OUTREACH", A VANGUARD FOR FUTURE ADMINISTRATORS

Thomas D. Reynolds

Orange County Mosquito Abatement District, Santa Ana

The practice of public agencies of providing services corresponding to the needs of a growing population and changing technology is a challenge for the administrators of today and the future.

Providing services compatible to a demanding public requires that management stay abreast of current administrative practices for budget and fiscal policy, as well as for maintaining close ties with personnel and the public. An organization's success depends upon the administrator's intuitive skill in adapting to change by recognizing a need for new or different objectives and exercising flexibility in implementing these objectives. Whether the administrator's ability to do such is inherent or developed through experience and education, it is the art of administrative process.

Management in the public sector, for a long period, tended to exploit rather than train or educate its personnel. The private sector, properly influenced by a free-enterprise economy, recognized the need to expand and upgrade management years before government made any attempt in that direction.

Citizens in our society demand that local, county and state agencies seek qualified people to fill positions in government. It is incumbent upon public agencies to provide opportunities for personnel to advance both in training and in education.

Colleges and universities, public and private, offer a variety of subjects and fields of study for students of business and government. The University of Southern California initiated, in 1968, a program quite unique in the academic world. "Operation Outreach", as it is known, is the transferral from a purely academic environment to on-the-spot locations where application and technique can be directly focused. A series of programs were established at various civic centers in coordination with County Employee Development Offices. Coursework at these "campuses" is designed for the practicing public administrator as a vital example of public and private support to promote the caliber of personnel in public administration today.

San Bernardino, Ventura, Chino and Santa Ana presently participate in conjunction with U.S.C.'s School of Public Administration, Civic Center Campus, enrolling over 800 students on a part-time basis. Courses leading to a Master's Degree in Public Administration, comprise a variety of subjects to include finance, budgeting, organization management, personnel relations, statistics, etc. with an option to pursue specialized areas as Health Services, Public Personnel Resources Management, Social Change and the Administrative Process.

U.S.C. is initiating a similar program in Sacramento this year offering a "rich source of research opportunities for gifted graduate students and doctoral candidates." Other schools may offer broader approaches to education than U.S.C. but the University's objective in bringing education to the front door of federal, state, county and municipal governments is an asset to the participating organizations and, ultimately a benefit to the public.

Private institutions generally require higher tuition than publicly supported schools, however, student expenses may be defrayed in part through federal, state, county and municipal educational funding. The G.I. Bill, Federal aid for law enforcement officers and other personnel, and County practices for tuition reimbursement have aided full-time employees to a great extent. The County of Orange, in 1970, through its educational development program, doubled tuition allowance to $200 a year.

Mosquito abatement districts, as segments of local government, should set aside a budgeted amount for personnel training and additionally provide incentives for the continued education of its qualified people. An administrator must have tools at his disposal to adequately challenge problems of the day and prepare for programs in the future.

A THREAT TO SPECIAL DISTRICTS

Marvin C. Kramer
California Department of Public Health
Bureau of Vector Control and Solid Waste Management, Sacramento

In May, 1970, the Institute for Local Self Government published a book entitled "Special Districts or Special Dynasties? Democracy Diminished". The book may well become a best seller. The Institute wrote in the introduction: "This publication focuses on independent, taxing, non-school special districts––those with substantial, if not complete, independence from other units of local governments."

The Institute for Local Self Government is a non-profit, tax-exempt, educational and research corporation. It describes itself further as: "In frequent affiliation with the League of California Cities, the Institute's research projects are broad-based and flexible to provide a bridge between the academic community and local government practitioners. Research projects are intended to result in 'Designs for Action'."

I would like to give you a few more quotes from the book. "Not only are there hundreds of new special districts in the last decade but that form of local government continues to be unresponsive, substantively and procedurally, to the electorates they were established to serve. Most damaging to local self government is that special districts are clothed with 'low political visibility' . . . Worse, the chief by-product of the situation, 'non-accountability', shields the technician-turned-bureacurat as he myopically pursues his 'single-purpose' business under the unexamined banner of 'efficiency' and 'service' . . . . at the expense of other taxing units, their constituencies and the public at large. . . .

"Standing starkly inimical to representative governance (and, as this study shows, congenitally so), special districts must be separately and carefully scrutinized with a view to weeding them out of the urban jungle by the most forthright action at the earliest moment, or we run the risk of even stronger central government, ... leading to the ultimate denial of local self government . . . .

"With general government now statewide, through counties, and with cities the centers of the bulk of the State's population, there would seem to be few compelling or even practical reasons for the formation of new and continuation of old special districts . . . .

"But no particular, legitimate expediency (out of which they were born and flourish) can justify their continued re cognition as units of local self government when, in addition, they have become, on the record, undemocratic and non-responsive even within their own milieu. They are more likely to be dynasties than democratic local self-governments . . . ."

Are these valid charges? Let's examine the record. Special districts tax only the people in the area in which the benefit exists. Alternative agencies would tax people in areas in which the benefit did not exist.

With regard to responsiveness to the individual citizen, it is easier for the people to go to a close level of government. The people would be further removed, by geography and by governmental structure, from, for example, a regional government.

The report is really more an argument than an analysis. Mosquito control districts are painfully close to their constituents. How much more immediate response can one get than that invoked by a pesky mosquito? "Service requests" are telephoned to the nearest office of the mosquito control agency, processed, and action taken usually within 24 hours. Nor is this the only type of response. Employees of the districts are working routinely with mosquito producers and assimilating information learned each day into the operational mechanism. Members of governing boards are neighbors of the constituents and subject constantly to their influence. The districts are accountable also to the press.

Budgets are clear, there is an audit by a certified public accountant or the county auditor and there is a precise record of all expenditures.

Taxes, if put on city or regional government rolls, would be at least as high for services now performed by special districts. Some cities have tax ceilings and could not assume these functions.

Mosquito control agencies control living pests that are most adaptable and whose characteristics are complex. The technical knowledge and precision operation required of mosquito control agencies are not general knowledge. One criticism leveled at mosquito control agencies in particular by the attorney from the California Taxpayers Association was a derisive remark that drainage districts do drainage so why should there be mosquito control agencies too as a duplication when mosquitoes are controlled by drainage. Obviously, he is unaware of the wide variety of types of sources of mosquitoes and of the program elements necessary for the successful conduct of control.

In my experience I have heard frequent unsolicited comments that mosquito control agencies give greater return per tax dollar of cost than any other agency.

The Institute and its widely read book are causing discussions in high places of the feasibility of special districts. Actually, the special district seems particularly well suited to the requirements for successful mosquito control. It does not have the limitations that are an inherent part of some of the other jurisdictions. It is sensitive to the people's needs, has a specialized objective that requires technical knowledge and a precision approach, has necessary flexibility of operation (some species of mosquitoes go through all of their immature stages and emerge as flying adults in five days), is not hemmed in by political boundaries when the large sources of mosquitoes are outside of those boundaries, taxes only the people who benefit, has the necessary right of entry for inspection and control, and has the power to remove offending sources of mosquitoes.

Mosquito control agencies can stand the searchlight of public scrutiny, but must not be judged on false impressions. Their story must be told, in the ungrammatical vernacular of the day, "like it is". Campaigns to provide public information because of a shift of approach to mosquito control brought about by the natural phenomenon of pesticide tolerance seem almost inevitable, and this would appear to be the vehicle by which some overdue fence mending might also be accomplished.

Recently in California the Local Agency Formation Commission was created by the Legislature for the purpose of review of proposals for formation or any reorganization of special districts. In the original Act, its membership was made up of two members from the Board of Supervisors, two members from incorporated cities, with the fifth member chosen by those four. Obviously, there was no representative of special districts. Assembly Bill 1155, Knox, of the 1970 Legislature, which was passed, signed by the Governor, and is now a part of the Code, makes provision for two additional members if the commission of any county orders representation of any independent special districts and adopts rules and regulations affecting the functions and services of independent special districts. The need for getting your story to LAFCO and to the people is critical and immediate!

STATE OF CALIFORNIA

Robert W. Crown, Assemblyman
Alameda County

The people of California are dependent upon the activities of the state legislators. Sometimes the people suffer as a result of the lack of knowledge by legislators in technical fields. Legislators must have many contacts with the various experts in their respective fields. They must take their work seriously, but not themselves. Our society is experiencing a reaction to pesticides and to chemicals in general. This has reached a state in which many people no longer are balancing the equities. They may look at some of the ills of pesticides and not realize the often far greater ills that have been controlled or eliminated by pesticides. Malaria is practically unknown in our American society today, yet many people are in the great "period of reaction" and no longer think of this.

There is a myriad of bills that have been introduced in the federal and state legislatures pertaining to the control or elimination of various pesticides. What can we anticipate in the future? We are still riding the crest of the environmental revolution. What is the legislative procedure for the enactment of these bills in California?

If a legislator wishes to change the law, for example regarding pesticides, he introduces a bill. To do this, he contacts the Legislative Council in Sacramento, the attorney for the legislature. That person draws in proper form the proposed legislation. He then returns it to the legislator who takes it into the Assembly Chamber, where it is given a number. The Speaker then assigns that bill to a committee, and it is set for a hearing. Interested citizens may ask to appear on the date the bill is to be heard, and may testify for or against it. Upon conclusion of the testimony, the committee will vote on the bill. A simple majority in favor of the bill will pass it from the committee. It then will go to the floor of the Assembly, at which time it is set for debate. Citizens may appear in the gallery to listen, but they may not speak. A simple majority of the Assembly can pass the bill, after which it will go to the Senate. A bill containing an appropriation requires a two thirds vote.

In the Senate the bill is assigned to a Senate Committee, where once again it is set for a hearing, at which time interested citizens may appear to testify for or against it. A simple majority of the committee in favor of the bill will move it to the Senate floor. There once again citizens may appear to listen but may not speak. If a simple majority of the Senate favors the bill and it does not contain an appropriation it will move to the Governor's desk, where it either may be signed into law, or it may be vetoed. If it is vetoed, it returns to the two houses where it then must receive two thirds of the votes in each House for the Governor's veto to be overridden.

A very important part of the process is the lobbying that takes place outside the committee rooms or the legislative chambers. Most of the activity really is accomplished at restaurants, in the office of a legislator, or elsewhere. These discussions between the citizens and the legislator provide the legislator with information which may change, sway or reinforce his position. This is the way his position may be formed before he actually goes into the committee rooms of the houses.

If one cannot appear in Sacramento, he should write letters to his legislators. There are certain rules he should follow. Mimeographed material should not be used, because it does not appear to represent the expression of an individual in his own words. It is best to send a personal letter, clearly written or typed. To be most effective, one might start with a complement to the legislator even if he doesn't deserve it. This catches his eye because most of his mail is uncomplimentary. Most people do not write unless they are angry or disturbed about something. Then immediately go to the heart of the matter, then end the letter – hopefully make it short, because he has a great many letters to read. Thank him and recognize that he will at least follow his conscience even though he may not agree with you.

A question raised by some is "Are you more effective working through a lobbyist or by going to Sacramento individually?" Whenever possible, a lobbyist should be obtained, because that person is on the scene all or most of the time. He gets to know the legislators personally and establishes a certain personal relationship with them. He thus has easier access to many of them.

LEGISLATIVE OUTLOOK FOR 1971

Nicholas C. Petris, State Senator
Alameda County

As a member of the Assembly Ways and Means Committee several years ago, I served on a sub-committee which reviewed the State participation in research in the mosquito control program. I am familiar with the frantic scramble each year for the tax dollar and the difficult decisions the legislators must make on priorities. The State in 1971 is in financial trouble. I would not encourage anyone to be optimistic about getting State money for his favorite program. However, I do believe one should fight hard and vigorously for a program which he believes is necessary to protect the health of the people of California. I do not know of anything that should have a higher priority than public health.

My interest in public health prompted me to become interested in legislation on pollution. My first interest was related to pesticides in which I was hoping to switch jurisdiction from the Department of Agriculture to the Department of Public Health. We all have become narrow-minded, afflicted with tunnel vision in the mad rush to develop the biggest, the best, and most dynamic and productive economy in the history of the world. The great captains of our industry have had a lot to say about manufacturing policies and whether or not there would be any safeguards taken to protect the public from the pollution of the air, the streams and the ocean. People in government have also contributed to the problems.

I express grave disappointment in what happened in 1970 with relation to legislation on the environment. Yet, in fact, we did enact a large number of bills on environmental problems, including the protection of our resources, our land, increasing penalities in water pollution with fines that can be levied against any company or public agency up to $6,000 per day. In the air pollution field similar fines were increased. But we should not be lulled into a sense of satisfaction and security by reports that California is leading the way in control of the environment. It is true that we have made the most progressive studies, and have the toughest legislation of any state in the Union and of any nation in the world. But I hope this does not persuade you that we are doing alright and should forget about the problem. The test which we fail to apply is what we have accomplished.

There has been a lot of publicity about California's smog control laws for vehicles, and there have been claims by industry that they have turned the corner, that air pollution in Los Angeles last year and the year before dropped to lower levels. These statements, which are not true, reflect the basic arrogance of the industry, which, after all, claimed over a period of many years that there really wasn't any problem. After the problem was made clear by our medical people, and after the Legislature stressed the need for solution, the members of the Legislature were not able to muster enough strength to pass simple, basic restrictive legislation over the opposition of the automobile manufacturers, the oil companies, and others.

These companies opposed my bill which would have eliminated totally the internal combustion engine by January 1, 1975. Why did I take such an extreme position? In 1970, when so much progress in cleanup was claimed, there were more smog alerts in Los Angeles than at any time since they have been recorded. I am pushing this matter because of health. Doctors have assured me that the smog problem is the fastest growing and worst problem in the health field in the United States. Emphysema is now so widespread that it accounts for the second largest number of persons who retire early because of disability. This may be caused by cigarette smoking, but many doctors believe that a great part of it is also caused by smog from automobiles. In Los Angeles more than 90% of the smog comes from automobiles. When industry claims they have turned the corner and reduced the smog, they are not telling the truth.

The engineers and chemists working on this problem are the top people in the top industry in the top companies in the United States. Are they incompetent, or is this a reflection of their attitude?

A team of doctors in Los Angeles has reported that they were not able to find a 12 year old child among the children they tested who was born and raised in the Los Angeles area and still living there who did not already have the beginning of lung damage, which they believed was caused by smog. When the industry says that the consuming public is not going to buy a smaller engine, or one that is less powerful because it is powered by some other source of energy, I will fight them, and that is just what I am going to do.

Two logical things we should have in California, it seems to me, is an inspection of automobiles by an independent source other than the industry, and frequent testing and inspections after the automobiles are on the highways. At present there is no systematic method of inspection and enforcement. We prepared legislation to accomplish this last year, but it failed. We did the same thing in the areas of environment on controlling the coast-lines, or saving what is left of our coast-lines. There is a lot of apprehension about the fact that more and more development has taken place up and down the coast, which are great for the people who buy into it and live in these subdivisions, but too many of them exploit the coast 100% for their own use and keep the public out. We had a lot of legislation on this last year, and a couple of bills finally made it. They are so weak that it seems to me they are an insult to the intelligence of the people of California. There is an agency which is supposed to supervise this; it serves on a temporary basis at the whim of the Governor. It has no staff, no budget or money to operate, no penalties in case of violation, and no strong language indicating that it really means business.

At the beginning of the 1970 legislative session there were great hopes for major achievements in protecting our environment. About 1,000 bills were introduced dealing with various aspects of the environmental problem. But because of organized opposition, we came out in one area after another with no legislation at all or very weak legislation. However, federal legislation is being passed to fill in some of the gaps. For example, the Muskie Bill was passed by Congress and signed by the President, and it requires that automobile engines be 90% pollution free by January 1, 1975.

What is all this commotion about – air pollution, water pollution, pesticides, the use of land, this concern about our environment? It is all about life, the kind of society that we want, the kind of civilization that we want. Our major concern should be human resources. Too many of us are getting so involved in the environmental problems which are physical and which do affect our health that we do not find enough time to apply our thinking to the human resources. The waste of human talent in our society because of the inadequacy of opportunities for large segments of our population to find their place in the sun, to develop intellectually through proper educational and employment opportunities is truly deplorable. We must try to understand the reasons for the present turmoil, try to find out why young people are upset. We must try to get those who are most militant to calm down, and we must listen to others. Young people today have some very good suggestions and constructive criticisms. If we listen to each other, especially about the environment, we may be able to close the generation gap. I think together we can make this a better society for all of us – the old, the young, and the unborn future generations. I urge everyone to join us in the legislature to help find a common meeting ground so that we can move ahead together. There is very little time left for us to do it.

HOW DO YOU ANSWER THE CRITICS?

William Hazeltine

Butte County Mosquito Abatement District, Oroville

I have a cause. It is to try to get people to realize that decisions on pesticide use should be made by competent people and based on good data. At present, we are caught in a social sickness which boggles the imagination, if you will just read the clues which are evident and available. My assignment and hope is to try to point out how to answer effectively the controlling minority and thereby awaken the complacent public before the whole system goes to pieces.

As agencies, we are dedicated to protecting the public's health, yet it was a mosquito control program which was attacked in a suit in 1966, as the start of a campaign which seems aimed at the destruction of effective world wide mosquito control as well as agriculture. One group of critics say they are not against all pesticides, just those which they say persist. Another group filed a suit against the California Director of Agriculture, in effect asking for a ban on the organophosphate compounds. Couple with this the Fish & Game Code which says it is illegal to put oil on water, or to use anything in water which is harmful to aquatic life, and you can see why I am upset. We have a tough enough job protecting the public's health, without inappropriate actions of anti-pesticide advocates.

I have heard local mosquito control people say that "we don't use DDT in mosquito control," and infer that it is therefore unworthy of a defense. I believe by now that most people realize the hazards in this kind of statement.

For the record, I should clear up one important point. Depending on whom you listen to, I supposedly am being paid off by the NACA, Shell Chemical Company, and Montrose Chemical Company. I wouldn't doubt that there are more on the list, but I have heard these. I have told everyone that I am not employed by any chemical company, and that my only concern is that pesticide producers be able to stay in business and supply their products. My interest is the products, not the suppliers. My Board of Trustees concurs in the need to keep all pesticides available, and unanimously have said to fight.

We have recently seen six major pesticide suppliers or potential suppliers get clear out of the pesticide research field, and I hope you realize that without research, we cannot have any new pesticides. To suggest that we can start effectively and efficiently to control mosquitoes without pesticides, is naive and signals a deficiency in understanding the problem. Most of the anti-pesticide advocates have never tried to make a living at pest control, and they seem prone to tell us what not to do.

Biological controls are good, and must be used, but chemicals are also necessary for an effective program. Carp were introduced into California, and are now part of our environment. The only way we could get rid of them is to introduce some other species to out compete them. They are much more persistant than any pesticide.

I find it hard to define a critic, but as a group they seem to enjoy using phrases such as: (1) We need an Environmental Protection Agency, particularly as it relates to pesticides. (2) Chemicals must be assumed to be guilty until proven innocent. (3) Any dose of a chemical which causes any adverse effect proves the chemical is bad. (4) We must live in balance with nature. (5) Synthetic chemicals are bad and natural chemicals are good. (6) Some even go so far as to say – we must destroy the system, so we can start living in tune with nature.

Notice I did not include a large segment of our society who are innocently being led to false conclusions by the critics. These people are really quite understanding, even if they are fickle at times. When we tell them the truth, I believe we can expect their support. Notice also, I did not include the person who voices legitimate complaints, and who seeks answers and discussion instead of just T.V. or newspaper coverage for his differing view, nor the legitimate scientist who honestly seeks answers, not the promotion of his own advocate position.

The critics are dedicated. They will stay up nights and probably use publicly financed telephone lines to coordinate their campaigns. They are dedicated to their cause, just as we should be dedicated to our case. I trust we are agreed that we must use our chemical technology wisely for the health and nutrition of people, and to maintain an environment consistent with the needs and consistent with good judgment.

We need to know what these critics are really proposing to do, and what they really want, as individuals and as groups. If you have not already done so, I recommend you read carefully the story Battle Tactics for Conservationists in the January 1971 Reader's Digest. We need to observe carefully how these people make their presentation, what they empasize as important, and what they neglect to mention. We need to review all the available information about the spokesman, both personal and professional. I don't propose the information be used for any personal attack, but it is often valuable in predicting how a person will react.

We need to know a person's source of information. We need to know the details of the papers and reports they are quoting, not just the portion they select for their quotes. You might even be able to use the parts they do not quote. Recall the statement of "five plus million pounds of DDT supposedly present in the Antarctic ice," yet in this report, the author states his control was no good, and only one of five filters could be measured for residue. When someone tries to tell me about Antarctic pollution with DDT, I suggest they re-read the article, and point out the points they must have missed. Unless someone questions the data, it can be cited, even though it is wrong. There are many such examples of indiscretion and conflicting statements, just waiting to be found and recorded for use, when confrontations occur. This appears to be one of the results of preparation of data to support adversary positions, and the consequent neglect of the principles of science. In a scientific study, you cannot just sweep unpopular data under the rug; you must account for all the facts, and you should try to present them correctly and honestly.

As an example of data management, the following example should be interesting.

A paper by Cox in Nature, 1970, reports on DDT residues in an open water fish species in the Gulf of California. Collection locations were reported as longitude and latitude. The author shows a table and a graph, and these do not agree. The pesticide residue data are in an odd form. For example, he shows 14×10^{-9} concentration of residues and 36% DDE, 36% DDT and 28% DDD. This sounds pretty bad until you translate it into usual units, and it turns out to be .005 ppm DDE, .005 ppm DDT and .004 ppm DDD. The author also said the printer had neglected to make a correction in the figure table. Besides the tabular data not really supporting any conclusion of uniform residues in the oceans, I decided to plot these "representative locations of collections". Now I am not a navigator, but I would locate these "representative" positions along the coast of Mexico, and the higher, although really quite low residues, as found in fish offshore from the major river drainages of the rich agricultural area near Hermosillo, where there is lots of DDT used. The location with the highest residues showed an average total of .058 ppm of DDT and its metabolites. These particular fish also showed that 85% of their residue was DDT, not DDE as expected, suggesting very recent accumulation of these residues.

While the author concludes contamination, I tend to view his data as of little reason for concern, once I put it into comprehensible terms and found out why the table did not support the figures. Perhaps the printer's error is allowable, but the large whole numbers for the residue data seem intended to create an impression for the casual reader, and lead him to a false conclusion.

Similar misleading statements report bird egg residues up to 2600 ppm (Lipid basis) which translates to about 175 ppm whole egg, and I see 3000 ppb, which is only 3 ppm, but it sounds terrible.

If you were to suggest that the farmers of Mexico stop using DDT because it might hurt pelicans in the Gulf of California, you could expect an answer such as "who eats pelicans". One of our problems perhaps is that most of us have never really been hungry, or at high local risk from malaria in the past 25 years.

I am suggesting that we must have a thorough analysis and synthesis of the literature and words of the critics, as well as the sincere skeptic or even the "white hats," to see when there is agreement and when there is discord. If there are real problems, we must be prepared to recognize them honestly, and try to find answers and solutions. This is where an honest approach differs the most from an advocate approach to problem solving. The advocate admits nothing or very little about benefit or protection.

We need to demand a return to the scientific method.

Recall these requirements:

We observe, then
We form a hypothesis, then
We conclude, and possibly publish our ideas so others can evaluate our conclusions and test our methods.

A modern twist is to change part of this method to "performing experiments to support our hypothesis," instead of to test it. This way you avoid having to change the hypothesis – and conduct experiments designed to see if you can get no correlation of cause and effect. If your hypothesis is correct, you should not be able to refute it.

Simple positive correlations do not prove anything about cause and effect, but negative correlations disprove.

We should insist on correction of the nonsense being told by some that publication constitutes some kind of proof. Publication only makes your data and conclusions available to other people for scrutiny and test, and nothing more.

There are some real dangers in risk-benefit thinking. This idea infers that compromise and trade-offs are the way to go. You cannot compromise facts, and there is seldom a need to compromise the consequences, once you set up priorities. The critics seem to hate priority thinking – such as "how many human lives is one peregrine falcon worth?"

Perhaps I dislike risk-benefit ratios, because I see confusion on what risks are really important. If you believe the critics, everything is a risk, and we are right back to an advocate system again because of a disregard for priorities. I somehow do not trust the critics to tell honestly the benefits, if I try honestly to tell the risks. I prefer to think about absolute risks, priority of needs and the odds of anything going wrong, as a better measure of what constitutes a proper application of pesticide.

The State Water Board has a policy which proposes that any beneficial use of water is equally important. So water to drink is no more important than water to look at or play in or for fish to swim in or for crop irrigation. These are equal. Dilution of sewage is considered of lesser importance so there is still hope for a better priority system some day. Water to prevent salt incursion of the Sacramento Delta and for irrigation must be compared to the need for water to drink and supply the plumbing fixtures in Southern California. People should get a higher priority than fish. A recent opinion in the USDA – EDF suit suggests that fish and wildlife may have some equality with people.

We need to understand and explain the difference between the legal and the scientific systems of proof. While the courts have their place, they seem to have been subverted when the EDF asked them to pass on scientific matters. The system difference is advocacy in the courts, and the whole truth in science. In the scientific view there is no innocence or guilt; the hypothesis is either consistent with the facts, or the hypothesis is in need of change.

Let's assume we are agreed up to here; we have done our homework, which is an individual responsibility and we have even done some real soul searching to find an honest reason for our motivations, and we still think a fight is in order. Then I suggest we fight. Talk to friends, service clubs, newspaper editors and reporters, TV people and anybody else. We have been talking to ourselves too much.

This brings us directly to the HOW part of an answer.

First, we need an operating organization to accumulate, digest and synthesize all the available data. As a first step, we need an information bank which will tell both sides. The Scientist's Institute for Public Information (SIPI) in St. Louis was proposed to do this, but after reading their magazine "The Environment," I still think we need an objective organization. While I individually intend to fight openly for what my facts and logic say is right, I also believe in finding as many facts as possible and am willing to be convinced by good data. This is why I was happy to see the start of an organization called Terra. Terra is committed to go down the middle of the road and to try to provide data impartially. One way this can be done is to provide computer retrieval literature references on pertinent subjects to everyone, at a reasonable cost. This way, a person cannot say he did not know of some reference, and it will be harder for anyone to overlook conflicting facts. A state organization also has been formed. It is aimed at telling agriculture's position.

I have tried to promote an active state organization because I believe an active educational program is now called for. I have a cause, as I said before, and now as never before there is an urgent need for balance in decision making and balance in the information presented to the public.

Money is necessary for support of any organization or cause, but even more important is time – our time – yours and mine. We must be active in our search for answers and I believe success or failure as an association or agency for public benefit will depend on how much we do. We must read and sort information, and this takes lots of time. It is only after a self-disciplined study that we can intelligently discuss the facts. We must know what the critics know, and a lot more, if we are to gain public acceptance. The critics propose very simple explanations for very complicated situations, and this can lead to very wrong conclusions. People don't really care what you or I personally like or dislike; they are not usually swayed by our prejudices nearly as much as by our convictions supported by hard facts. Their basic question is whom to believe, particularly when more and more people are standing up and pointing out the discrepancies in the critics advocacy. I suggest, "When in doubt, believe in facts."

When you discuss pesticides do not stipulate to something just to get acceptance. This is one reason I don't like the trade-off concept. I've heard people say, "We know DDT causes thin bird eggs, but ——————." If you do not feel sure of something do not just up and give it away, thinking it will make you look more objective. Admit to, and argue with good facts, and good logic, and nothing else. It's far better to say "I don't know" than to say "yes" when you don't know. You can see why I was not good at social debating, and why I did not go into public relations work. Whether they are nice or not so nice, we are obliged to provide facts to the public, and to do it in such a way as to achieve a balanced consideration. If we are asked to present a discussion or when we talk with friends and tell only the benefits, we are really no different than the critics.

We must be prepared for labeling and perhaps even condemnation. The greatest knack for us is to keep cool on unimportant issues. Don't lose it when someone brings out Rachel Carson or Paul Ehrlich. Save your fire for the real issues, such as whether there is as much risk to a fetus from DDT as from a highball the expectant mother consumes befor dinner.

I urge you to think constructively about answering the critics. Instead of saying "I don't think your assumptions are correct," or "I don't like what you say," change it to an approach of "how do these additional facts fit into your hypothesis?" Get the critics on the defensive. Let them try to defend their position, when you call their bluff with facts they have not cared to consider.

Another important aspect is being able to tell why you feel qualified to question his data. Your credibility will be continually tested, unless you get this issue cleared up early. Here are some answers. (a) It seems reasonable to state that the critic's position is controversial, and if his data are good, they should be able to stand a critical evaluation. (b) If his data and conclusions are clearly presented, and correct, then they should mesh with other data. (c) The true test of science is acceptance by the reviewer, not the experimenter, and you are therefore trying to help him by evaluating his data.

If a person is insecure, and you are making a public appearance, be sure to tell him beforehand that you are having a record made so you can re-evaluate his statements – to see if you have missed something important in his data, which will help you in reaching a good conclusion – of course.

In an advocate proceeding, or in the courts, you are trying to convince the audience or jury or judge, you are correct in your position. Coolness, good principles and courtesies as long as you can tolerate the situation, help to convince the observer that you know your field, and really have nothing to hide. As a challenger, you have an added advantage because most people like the underdog.

Be sure to dig on priorities. I love the Gypsy Moth story where DDT was banned to save the environment. A writer has quoted me as saying "the so-called environmentalists want to outlaw DDT to save the environment, but who are they going to save it for? The moths?" The Gypsy Moth is an example of slight, if any real DDT damage being avoided, and as a consquence, there are now millions of acres infested with these forest-killing pests. If forest and habitat are important, priorities were surely overlooked in the decision to ban DDT for that use.

World use of DDT as a residual treatment for *Anopheles* control is similar. Don't ask people to risk the slight hazards of DDT, let them have malaria instead.

There is a lot more advice I could offer on how to answer the critics, but time does not permit. Most of you are good at press relations, and this is very important. "Get the headlines" is a good slogan.

Summary

We need to recognize and understand our critics, how they think, how they talk, and why they think and talk the way they do. We should know what they read and say, and a lot more. We must organize and work efficiently as associations, as neighbor districts and as individuals, so we can get our message out, and do our assigned job too. There is a real need for continuing education, which is a mark of professionalism, whether this education is self taught or in the classroom. Once we have a good store of facts, we need to tell others in hope of having a return of rational judgement. The public is skeptical, but may still let us make most of these value judgments. It is up to us to keep them informed, and to make good decisions, as well as to maintain good press relations. You can bet the critics are just waiting for us to make a mistake, and it is up to us to disappoint them.

CURRENT MOSQUITO CONTROL PROBLEMS IN NEW JERSEY

Robert L. Vannote
Morris County Mosquito Extermination Commission, New Jersey

It is with real pleasure that I can again join with you in the discussion of mosquito control problems and to extend to you the best wishes of your associates in New Jersey.

Although we are separated by thousands of miles, and in most instances our problems differ, we, as mosquito control workers, have much in common.

New Jersey is a relatively small state of some 7,836 square miles, yet is one of the most densely populated. Along the Atlantic and Delaware shores it includes some 300,000 acres of tidal wetlands. The north and northwestern portion of the state is characterized by rolling hills and flat valleys, the highest point being 1,802 feet located in the extreme northwestern corner. Middle and south Jersey is relatively flat and, except for the industrial belt, is largely wooded or agricultural. Extensive recreational centers border the Atlantic coast. The major mosquito sources include the tidal wetlands, extensive flood plains in the flat upland valleys and numerous natural swamps and glacier pockets.

Records indicate that the first mosquito control program began in New Jersey in 1901. In 1912 legislation permitted the organization of county mosquito extermination commissions, coordinated by the State Agricultural Experiment Station. This organization, with few modifications, is still operative.

The approach to mosquito control in New Jersey has always been conservative. In the days of the beginning, little information was available on the subject of mosquito biology or methods of control and the general public, although recognizing the need, was sceptical of success. Therefore, mosquito control began through public education and demonstration, a slow process demanding a sound, conservative approach. Today, mosquito control is a recognized, acceped function of public works.

The general approach to mosquito control in New Jersey has been based on water management or source reduction with larviciding serving a supplemental role. Adulticiding controls are considered emergency in nature or a premium type of operation.

It has long been general policy to employ only water management methods of mosquito control on the tidal wetlands. This has resulted in a minimum of opposition by wildlife interests and has had little effect on the general ecology of the marshes. This policy has been relaxed on those tidal marshes where pollution has destroyed the marsh ecology and changed the character of the mosquito problem. In one county, large scale experimental application of Paris Green granular larvicides was used in 1970 with variable results. Detail reports are not yet available.

New Jersey has experienced little or no resistance problems. This is probably due to our climate and the fact that until the introduction of ABATE®, insecticidal larvicides were used as oil solutions rather than as emulsions.

It would appear at this time that the 1971 Insecticide Recommendations for Mosquito Control in New Jersey would include:

LARVICIDES:

1 – No. 2 Fuel Oil with flash point of 150° F – low 5 – distil ranges – long lasting – quick-kill.
2 – Diluted New Jersey Pyrethrum Larvicide – 0.0066% – special uses.
3 – ABATE in water (w/w) 0.019% prepared from 4E conc. – spring and flood waters – ground and air.
4 – ABATE Granulars at 0.1 lb. per acre actual – air.
5 – FLIT®MLO.

CATCH BASINS:

1 – No. 2 Fuel Oil
2 – 1% BAYTEX® in oil (v/v)

POLLUTED IMPOUNDED WATERS:

1 – ABATE Granulars – 1-2% up to 0.5 lb. actual/acre;
2 – BAYTEX Granulars – 5% up to 0.5 lb. actual/acre.
3 – ABATE Emulsion in water 0.056% (w/w) up to 10 gal/acre.
4 – BAYTEX Emulsion in water 0.168% (w/w) up to 10 gal/acre.

ADULTICIDES:

Thermal –

1 – 1.5% – 3% (v/v) malathion oil solution – 20-40 gph @ 3-5 mph.

Aircraft –

1 – 1.5% – 3% (v/v) malathion oil solution – 1-2 qts. per acre.

During the past year the State of New Jersey has announced its claim to the title of all tidal wetlands. This claim is based on an old colonial act giving the State the income from the sale of such lands for school purposes. In addition, to control the development, dredging, alteration, and utilization of the marshes, a Wetlands Bill was enacted by the legislature. Through the efforts of the State Mosquito Extermination Association, mosquito control was made exempt from the restrictive provisions of this Bill. Similar bills are now before the legislature of many Atlantic coast states.

A Pesticide Act is currently being considered by our legislature that would invest complete regulation, without appeal, in the Commission of Environmental Protection. Again, mosquito control interests are seeking exemption.

In New Jersey, as in California, the attacks against special taxing agencies threatens the tranquility of mosquito control. One of the major forces sponsoring consolidation of special agencies is the National Association of Counties.

In New Jersey this action has taken form in the introduction of legislation known as the "Mosquito Act" which would permit the reorganization of county government by referendum. The act provides for a number of plans for the reorganization of county government and includes the authority to combine many of the autonomous boards and commissions into the body of county government. This act does exempt any autonomous agency whose activities cannot be effectively operated as a function of county government. On this basis mosquito control in New Jersey is seeking exemption.

It is recalled that for many years mosquito control was the "voice in the wilderness" crying out against the pollution of our rivers and waters. Today, because pesticides are a tool of mosquito control, our voice is lost in the baying of the pack of ecology opportunists.

One fact is evident. The mosquito control workers, regardless of their location, must employ a vigorous offensive to protect our time-honored objectives and methods. Unless the public is kept well-aware of the constant ability of the mosquito to re-establish itself in former numbers, with all the hazards to human health and welfare, our methods of operation and the tools of our profession will be so hamstrung that our efforts will become of little avail.

Never before has mosquito control been challenged on so broad a front by such an enlightened, aggressive opposition. It will demand a greatly expanded attack on all association levels headed by our most vigorous and farsighted mosquito control leaders.

Common to all essential public endeavors in today's market place we must be prepared with dollars to invest in such legal and public information services to build and maintain the importance of mosquito control and to protect our methods of operation.

Yes, we, the mosquito control workers of these United States, have a great and honored heritage passed down to us by our former leaders in California and New Jersey. We have every reason to be proud and honored to serve in this great humanitarian endeavor. We must not, at this time, lose the faith.

RECENT VECTOR CONTROL DEVELOPMENTS IN OREGON

A. G. Dickie

Lane County Health Department, Eugene, Oregon

Vector control problems in Oregon fall into four basic categories; (1) rabies; (2) plague, and associated rodent control problems; (3) ticks, and tick-borne diseases; and (4) encephalitis and mosquito control problems. In the Northwest, vector control is carried on either by local public health agencies or by independent vector control districts, and is divided about equally between these two forms of organization. Owing to climatic and population factors none of these organizations is large by California standards. Whatever the form of organization, it does not follow that independent mosquito control districts are necessarily larger or more complex organizations than the vector control section of any particular public health agency, although this is usually the case. As an example the vector control division of the Lane County Health Department is considerably larger in terms of budget, manpower, and equipment than all but one or two of the independent abatement districts in Oregon or Washington. Lane County also has the most extensive aerial application program in normal years north of the California border. This includes the use of both helicopter and fixed wing aircraft.

Whether it is preferable to have vector control organizations operating as integral parts of local health agencies, or as independent vector control districts is a question without a final answer. Vector control organizations in health departments tend to encounter a wider variety of demands and are therefore less highly specialized, even though mosquito abatement may be their major activity.

RABIES

This disease frequently becomes of concern to vector control organizations that are part of a local public health agency, and is usually thought of occurring only in dogs. Recently the reservoir of this disease in wild life has attracted more attention in Oregon. Although there were no reported cases occurring in bats in the state during 1970, evidence previously obtained suggests that the disease is enzootic in these animals and nuisance complaints are frequent.

There was considerable publicity and alarm over the discovery of rabies in skunks during 1970. These animals came originally from the Wolfe Creek area in Josephine County and had been captured, deodorized, and bred for purposes of commerical distribution to pet shops. A positive diagnosis for rabies was obtained from one of these skunks after it had been sold. This case is illustrative of increasing problems arising from the fashion of keeping exotic animals as pets.

PLAGUE

There was one human case of bubonic plague in Oregon in 1970, the first since 1934. The circumstances were similar to those of the Idaho case of 1968. The 1970 Oregon case involved a hunting party of three men, and occurred in northwestern Oregon last November. This party was encamped near the gate of a ranch thirty miles from Imnaha. One of the party shot a cottontail rabbit which was skinned by a second man. A third man (the victim) gutted and quartered the rabbit. They all ate it. The victim became ill after two days with symptoms that included mild bubonic swellings which were less conspicuous than those usually occurring in typical cases of this disease.

At first tularemia was suspected but a blood culture for this was negative. More blood was obtained and the subsequent culture gave a positive result for plague, later confirmed by CDC, Atlanta. By this time the victim had returned to Lebanon, Oregon and died there in a hospital. This 1970 case did not exhibit a typical transmission pattern, i.e., no flea vector was involved. Apparently the infection resulted from contact with contaminated blood with lesions on the hand. In the previous Idaho case the rabbit (a Snowshoe hare), was shot and killed, and apparently the same kind of transmission occurred as in the Oregon case. There was axillary lymph node involvement in both cases.

In regard to surveillance of plague in Oregon during the year, flea pools were all negative. Fleas were taken from *Microtus* and *Peromyscus* species and from *Spermophilus beecheyi.*

TICKS AND TICK–BORNE DISEASES

Wood tick surveys, carried out by the Oregon State Board of Health Vector Control Section, began in 1967. The purpose was to learn disease distribution, species distribution, and seasonal occurrence in Oregon wood tick populations. Increased use of outdoor recreational facilities means an increase in both tick-borne disease problems and in the nuisance factor. Survey methods have been directed toward the three major ixodid species found in Oregon that readily attach to man: *Dermacentor andersoni*, *Dermacentor occidentalis*, and *Ixodes pacificus*. Attempts to collect argasid ticks of the genus *Ornithodorus* which is associated with relapsing fever, have not been too successful to date. Tick surveys have been sent to the Rocky Mountain Laboratory at Hamilton, Montana, for testing.

During the 1967 survey, tick pools were found positive for tularemia, Rocky Mountain spotted fever, and Colorado tick fever. Frozen *Ixodes pacificus* pools from the Tillamook Burn area in Oregon's Coast Range are currently being screened for *Rickettsia rickettsi*, since a benign strain of this Rocky Mountain spotted fever organism was isolated from an *Ixodes pacificus* pool collected in this area in 1967. Positive tick isolates occurred in 15 of Oregon's 36 counties.

In regard to seasonality and distribution, *Dermacentor andersoni* has been found east of the Cascade Range along the Columbia River Gorge to areas in Wasco County, from February to July. *Dermacentor occidentalis* has been found from the California border into Lane County west of the Cascade Range to the Coast. This species is active from January to July. *Ixodes pacificus* ranges in all of Oregon west of the Cascades and extends up to the Columbia Gorge into Wasco County where it coexists with *D. andersoni.* This tick species can be found throughout the year in limited areas with peak populations occurring in late fall and early spring. There have been two notable findings from this program; (1) the isolation of the Rocky Mountain spotted fever organism from *Ixodes pacificus* in Tillamook County in 1967; and (2) the determination of Colorado tick fever in a *Dermacentor occidentalis* pool in Douglas County.

ENCEPHALITIS AND MOSQUITO CONTROL PROBLEMS

Although no human cases of western equine encephalitis were reported in Oregon during 1970, there were 90 reported cases in horses. One human case of St. Louis encephalitis was reported from Baker County in eastern Oregon.

No confirmed horse cases of western equine encephalitis were reported from the State of Washington during 1970, although there were 114 in 1969. This appears to be due to greatly increased surveillance and vaccination efforts. There were two human cases. One of these was a one-month old girl at Sunnyside, Benton County, Washington, and the other a nine-year old boy at Othello, Adams County, Washington. Both cases recovered without apparent residual effects.

Up to now there has been little evidence of resistance to insecticides. However, it is suspected that it may be starting to occur with ULV malathion against *Culex* mosquitoes in Lane County, Oregon. In Clackamas County, Oregon, it has been concluded from preliminary studies that moderate resistance to fenthion is evident in *Culex pipiens.*

Irrigated pasture mosquitoes, particularly *Aedes nigromaculis*, are a problem in both Lane and Jackson counties in Oregon.

Snow pool mosquitoes are becoming of concern in Oregon due to the increasing popularity of recreation areas in the Cascades. The application of insecticides in such areas is expensive and is also restricted by U.S. Forest Service regulations.

It is anticipated that as we get into the forthcoming season there will be considerable resistance by the public to our use of chemicals; however, this is not a problem that Oregon is alone in facing.

PANEL: ENTOMOLOGICAL PROGRAMS OF CALIFORNIA MOSQUITO ABATEMENT AGENCIES

MODERATOR: Keith Kraft – Santa Clara County Health Department

The primary purpose of this panel is to point out the wide variety of entomological problems faced by various mosquito control agencies in California.

Although we all share the common goal of controlling mosquitoes, our approaches may be quite different and generally reflect the specific needs of the communities we serve. In recent years, many mosquito control agencies have expanded their activities to include the control of other vectors of importance to their communities. Whether in development of new approaches to mosquito control or expansion into broader vector control programs, the job of the entomologist is becoming increasingly complex.

The following presentations by members of the Entomology Committee represent some of the special programs developed for their agencies. You are encouraged to participate in the discussions which follow the presentations and to contact the participants if more detailed information is desired.

THE EVOLUTION OF MOSQUITO CONTROL AT SOUTH LAKE TAHOE

Fred C. Roberts
El Dorado County Service Area No. 3, South Lake Tahoe

Mosquito Control Service Area No. 3 encompasses 195 square miles east of the crest of the Sierra Nevada Mountains down to the shores of Lake Tahoe. Through the spring and summer, snow-melt water flows down the mountains to the two main rivers within the service area – The Upper Truckee River and Trout Creek. The water systems widen into expansive meadows and marshes as they reach the lowlands adjacent to Lake Tahoe. The volume of snow-melt water is characteristically increased by intermittant thundershowers. The climate, topography, and plant communities of the Tahoe Basin provide an abundance and variety of larval mosquito habitats. These natural mosquito sources have been supplemented by the inadvertent creation of domestic and commerical sources during the development of the area.

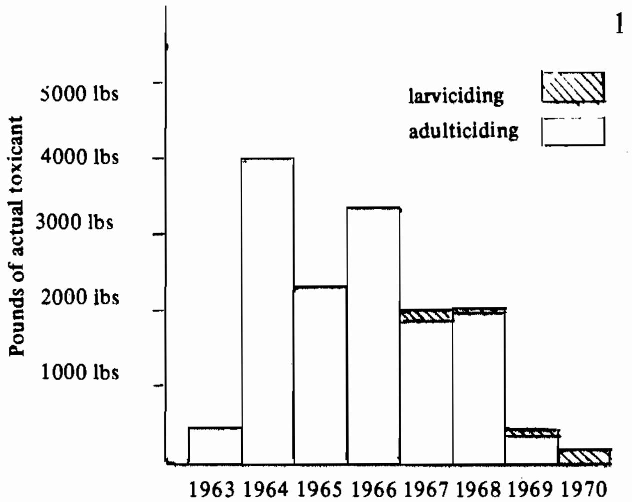
A list of mosquitoes that occur within the service area would contain many mosquitoes familiar to persons involved in mosquito control in California. Mosquitoes of the species *Culex tarsalis, Culiseta inornata, C. incidens, Aedes vexans* and *A. increpitus* are abundant in the South Tahoe area. Mosquitoes more unique to the service area occur in the snow-melt habitats; *Aedes communis, A. cataphylla, A. hexodontus, A. cinereus* and *Culiseta impatiens*. Present, but less abundant, are mosquitoes of the species *Culex peus, C. pipiens, C. territans, Aedes nigromaculis, A. sierrensis, A. schizopinax, A. fitchii, A. melanimon* and *Anopheles freeborni* (Kramer et al. 1968; Womeldorf 1966). The snowmelt *Aedes* mosquitoes are ready biters and along with mosquitoes of the species *Culex tarsalis* and *Culiseta inornata* make up a complex of mosquitoes that are severely pestiferous.

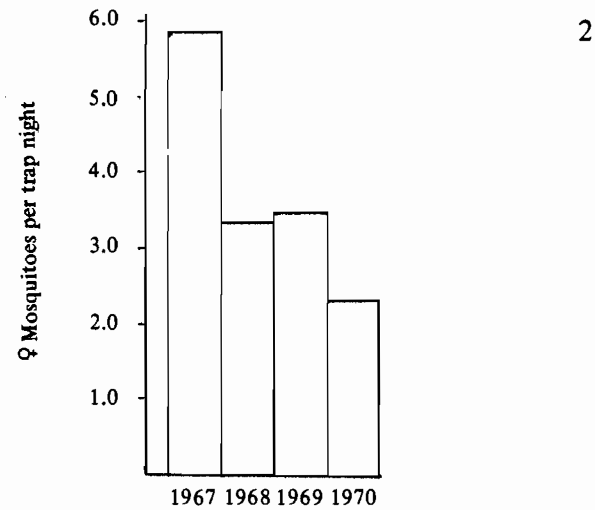
In spite of an abundance of pest mosquitoes, the establishment of El Dorado County Service Area No. 3 did not occur until 1963. It was at this time that the growing number of residents provided sufficient tax base. The opportunity to establish a mosquito abatement district was passed over in favor of a county service area which would be governed by the county board of supervisors.

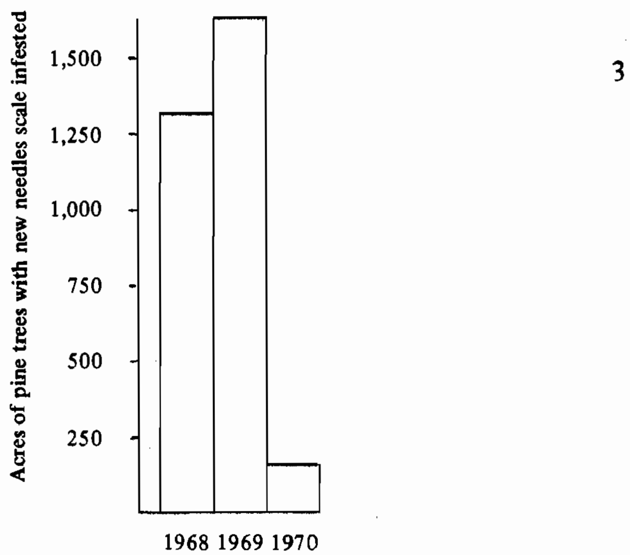
FOGGING

The most expedient and inexpensive method to control the mosquitoes in the early years was by thermal fogging with a malathion and diesel oil mixture. This method was heavily relied upon through 1968 (see Figure 1). Each residential area was treated at least once a week. During the period of 1963 through 1968 an average of 2,438 pounds of malathion (actual toxicant) was applied throughout the South Lake Tahoe residential areas. The fogging was received with mixed reactions by the public. Some residents complained of the fog. Others requested more frequent fogging and praised its beneficial effects.

An administrative, operational and technical review of the service areas was conducted by the State Bureau of Vector Control in 1966 (Womeldorf 1966). Based upon the findings of the study, a recommendation was made to shift emphasis from adulticiding to larviciding. The recommendation was made in order to increase the effectiveness of mosquito control and to prevent a public outcry that could result from an increasing disfavor toward insecticides. A gradual transition from adulticiding to larviciding was pre-







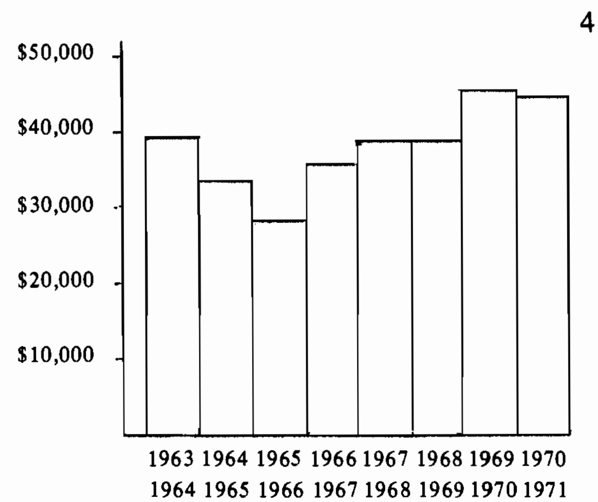


Fig. 1.–Insecticide use.
Fig. 2.–Mosquito abundance.
(light trap data from the month of July)

Fig. 3.–Scale insect abundance.
Fig. 4.–Total budget.

vented when the fogging was found to be disrupting the forest ecosystem. In the summer of 1968 a pine needle scale infestation was found to be heavily infesting lodgepole and Jeffrey pines in 1,280 acres within the residential areas of South Lake Tahoe (Dahlsten et al. 1969; Hunt 1968). It was suggested that fogging was not only eliminating mosquitoes, but also the predator-parasite complex of the scale insects, thereby allowing the scale populations to increase unchecked. Hunt (1968) recommended that the adulticiding be discontinued in favor of strict source abatement.

LARVICIDING

In 1969, the fogging was cut back dramatically and larviciding was emphasized. In 1970 no fogging occurred. The shift to larviciding paid two dividends, a decrease in the density of mosquitoes (Figure 2), and a decrease in the scale problem (Figure 3). The service area budget was increased, however, because of the purchase of larviciding equipment and the hiring of an entomologist (Figure 4). The significant reduction in the use of insecticide failed to offset the increase. The budget session of July, 1970, pitted supervisors in favor of returning to the cheaper adulticiding against supervisors who wished to continue the larviciding. The larviciding program prevailed at least for another year.

INTEGRATED CONTROL

Through the guidance of the State Bureau of Vector Control, and the pressures of an environmental crisis, the service area rapidly developed a larviciding technology. Even better control appears in the offing. If the agency is to progress toward an integrated control program, more emphasis will have to be placed upon source reduction and biological control in the future. The need for this program emphasis is obvious to those engaged in mosquito control activities. It, however, is not obvious to the less technically oriented taxpayers and county supervisors who finally determine the program direction of the service area. It would indeed be fortunate if the development of insecticide resistance in mosquito populations, or another environmental crisis, were necessary to supply the impetus for the needed program changes.

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MAINTENANCE AND USE OF A MOSQUITO COLONY BY A LOCAL AGENCY

Elmer J. Kingsford

Butte County Mosquito Abatement District, Oroville

Butte County has maintained a small mosquito colony for the past three years. We began with a sub-colony of parathion susceptible *Culex pipiens*, obtained from the Fresno Laboratory. After developing some finesse in caring for this colony, we then developed our own colony of *C. pipiens*, collected from a local breeding source. Once our local colony was established we discontinued the *C. pipiens* sub-colony, obtained from the Fresno Laboratory. Chance contamination of the susceptible colony made it extremely difficult to maintain in thrifty condition.

A number of *Aedes sierrensis* eggs were obtained from the Fresno Laboratory in an attempt to establish a colony of this species. We had rather poor success, and the larvae from the few eggs that did hatch did not survive beyond the third instar. However after further correspondence with personnel at the Fresno Lab., re-reading what literature we had, and a few idea sessions of our own, we tried again. This time we collected larvae and pupae from one of our local sources. Oviposition was good but again the egg hatch was poor. The few individuals we did manage to rear to maturity reproduced well, however the problem of getting those eggs to break diapause was still present. This was remedied by raising the pH of the hatching medium. After several weeks, Miss Cleveland who was then my lab-assistant, suggested that we simulate the usual leaf mold medium with tea. This simplified our technique. Under our conditions *Aedes sierrensis* eggs hatch and the larvae develop well in a solution of 2000 ml of tap water laced with 200 to 300 ml of strong tea. We have our own well (water supply). In the larval stages, we feed our colonies a commercially-prepared Laboratory Animal Chow, and rear them in white enamal trays. The adults are fed on raisins and sugar cubes, with white mice as a blood meal source, and kept in one foot cube screen cages. We tried a turkey for blood meal source, but mice seemed as good, and a lot more quiet. Rearing techniques can be obtained from the literature and most labs will share their knowledge and experiences.

Many people who have been to visit our facilities say, "This is interesting, but what do you do with them?" Let's now consider this.

The establishment and maintenance of a mosquito colony supplies information that can increase our knowledge and understanding of the species involved, and perhaps even of mosquitoes in general. This information can then be applied to field problems wherever and whenever applicable. The development of our colonies was initiated by our District's need for this kind of knowledge about a particular and general bio-assay work. We do not yet have a producing colony of *Anopheles freeborni*..

The development of our first colony (obtained from the Fresno Lab) arose out of a need for additional experience at maintaining a colony, and the increasing need for a bioassay tool of known susceptibility. The experience gained has been of considerable use. As a bio-assay tool, the colony has been used to determine efficacy of swath widths and application rates of the District's spray equipment, using the methods outlined by Gillies, Womeldorf and Walsh (1968). What appeared to be field failures and the need to know the response of a given uniformly reared population to a particular chemical brought about the development of our other colonies. We are currently compiling data from them, using the modified WHO system as developed by personnel of the BVC & SWM.

Our colonies have been used by several of the schools in our area as a source of live material for class room demonstrations and teaching aids. The educational value of our colonies is becoming more apparent as the requests for materials and tours increase.

I believe that usefullness, and consequently, the value, of the mosquito colonies to the District are limited only by our own ingenuity and resourcefulness.

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USE OF DURSBAN FOR MOSQUITO CONTROL IN LOG PONDS IN THE SHASTA MOSQUITO ABATEMENT DISTRICT

William C. Hazeleur

Shasta Mosquito Abatement District, Redding

Lumbering is a major industry in northern California. There are fourteen timber processing plants in the Shasta Mosquito Abatement District. Six of these use ponds as a means of storing and sorting logs before entering the saw mill.

Log ponds have long been a difficult problem for the Shasta MAD. Through the years many methods of control have been tried. Airspray applications by fixed wing planes and by helicopters have been tried. Sprayers have been mounted in boats and barges. We have even had the men walk on the logs carrying hand sprayers or dragging hoses from spray tanks on shore. One company even installed a sprinkler system, similar to the ones used on their log decks, over the pond in an attempt to achieve even distribution of the insecticide.

Log ponds in our area primarily produce *Culex peus*, but also considerable numbers of *Culex tarsalis* and *Culex pipiens* originate from these sources. Since most of the ponds are located in close proximity to residential areas and since most of our residents cannot tell the difference between *Culex peus* and *Culex tarsalis*, we feel that it is necessary to maintain close control over all mosquito production in these ponds.

For the past few years the district has been treating log ponds with BAYTEX® (fenthion) at 0.1 lb/acre. Although fenthion gives good larval kill, retreatment is necessary every seven to ten days in the summer months.

During the summer of 1970 we decided to treat a log pond with DURSBAN® to determine if we could get longer lasting control. A cedar mill pond was chosen. The concentration of organic material in this water is extremely high. The pond was measured and was found to have a surface area of 4 1/3 acres, with an average depth of six feet. The pond is a contained body of water with no discharge into any water way.

A sufficient amount of Dursban concentrate to achieve a final concentration in the pond of 10 ppb was poured into a water truck containing 550 gallons of water. This amount of water is what was determined to be necessary to provide even coverage of the surface area of the pond.

The truck was provided by the mill, and is normally used for fire control purposes. The truck has a 1,100 gallon capacity tank and a slow r.p.m. (670) high pressure Pacific pump. The pump is operated at 125 pounds pressure giving a discharge flow of 11 gallons a minute.

This mixture was pumped from the truck through a one inch diameter hose manually manipulated by a man. The pond's surface was covered with floating logs in addition to debris in the form of wood, moss, and bark.

The results are presented in Table 1. In all cases the majority of mosquito larvae were allowed to develop to the third instar before the pond was treated. First instar larvae appeared three to four days prior to each treatment date. Example: The pond was treated June 16, 1970, and again July 17, 1970. First instar larvae appeared July 13, 1970. This is 28 days from treatment to reinfestation or 32 days from treatment to treatment.

Table 1.–Log pond treatment with Dursban at 20 ppb in the Shasta MAD.

Treatment Date	Days Between Treatments
June 16, 1970	
	32 days
July 17, 1970	
	33 days
August 18, 1970	
	30 days
September 16, 1970	

In summary, we got four to five weeks of apparent residual larvicidal action in log ponds using Dursban at 20 ppb. Although much information is lacking, we feel that the results are significant and hope to get more detailed information next year.

THE IMPACT OF MISCELLANEOUS ARTHROPODS ON MOSQUITO ABATEMENT

James L. Mallars
San Joaquin Mosquito Abatement District, Stockton

California mosquito abatement agencies in recent years have expanded their interests to other major groups of insects affecting man's comfort, health and welfare. These include investigations and control of domestic and biting flies, gnats, wasps, hornets, and aquatic midges.

The expansion of metropolitan and suburban areas as well as a desire for increased services has also stimulated agency scrutiny of miscellaneous insect problems. Mosquito abatement agencies in many localities have developed responsibility in this area for a number of reasons:

1. The agency is primarily a service organization which retains a high flexibility of rapid reaction to events and problems.

2. Other local agencies such as the Agricultural Commissioner, Extension Service, or Health Department are too often overwhelmed with intern services.

3. Public relations are improved, enhancing an atmosphere of dependability or reliability.

4. A large segment of the public cannot afford private services, thereby is compelled to perform its own control measures.

5. Local governmental jurisdictions such as city councils, etc., conceive the agency intrinsically predisposed to specialized services.

6. Certain professional groups, e.g. physicians, deem it an obligation to expand services.

Some of these viewpoints are now illustrated below; A resourceful dermatologist in San Joaquin County, for example, determines that many of his patients are suffering from a non-medical problem but most likely a response to an arthropod affliction, which he refers to the Mosquito District.

In many cases the findings reveal light infestations of fleas of which the patients are unaware or unable to detect. One woman was subjected to flea bites for an entire year before detection. More often field contact with flea and diverse insect problems is efficacious in deference to a brochure or telephone contact. Two reasons become evident. The problem may encompass an entire neighborhood, requiring instruction to key people to stimulate area control. The problem may present complications such as cracked soil, etc., requiring selective control recommendations.

Another physician at times requests the District to provide live collections of mosquitoes or fleas to produce antigen for highly allergic patients. Other circumstances involve straw itch mites, tropical rat mites or other parasitic mites which often involve considerable investigation. In a few instances entomophobia is involved. In other instances because of pressures and unfamiliarity with medical arthropods per se, calls are referred by other local agencies. In this illustration a person suffered from acute dermatitis, attributed a high population of gnats and flies in the area. Close examination revealed enormous numbers of free living mites under the house and in dust in adjacent sheds causing the dermatitis.

Growth of subdivisions in the fringe areas of cities have stimulated invasions of field crickets, chinch bugs, predacious and darkling ground beetles. In our experiences with field crickets, one city council requested the District to appear before the council to offer an area-wide solution. The intent was to involve the District in cricket control. The District stated the problem, the control, but indicated the more important entity: this type of insect problem establishes that "you must help yourselves." With guidance the City Council designed a brochure on crickets which was disseminated to the local residents through the City Engineer's office. To effect control in acute cases the City Engineer provided an efficient Sevin® apple pumice bait or instructed the resident of its availability. A personalized service was thus represented on an individual basis to a large localized problem.

Additional requests involve pantry pests, various household insects, earwigs, spiders, ticks, etc. In all of these involvements, procedure is limited to answering, evaluating and suggesting specific control recommendations to the requests. Depending upon the insect and the severity of the problem the homeowner is referred to the pest control industry in many instances.

Finally a forethought is perhaps in order. In many of these involvements do we relate to the homeowner the types of spray applicators and their specific operation? For example, in one encounter an individual was spraying the walls of his house with Sevin® for chinch bugs. Fortunately a low toxic compound was involved. A recommendation by phone resulted in the concentrate pouring out of the bottle sprayer on to the concrete driveway while he walked continuously through it in bare feet. Do we caution the individual to avoid use of indoor faucets to prevent siphoning when using a bottle sprayer? Do we verbally stress the importance of proper disposal or storage of the pesticide container although it appears on the label? Do we emphasize the proper dosage rate since many people commonly react to the "popular" idea––"two ounces is good, six ounces is better?" Do we evaluate the total surroundings for hazards, e.g. pet birds, fish, sensitive plants, and other entities?

In summary, then, mosquito abatement agencies are broadening their activities. Public demand for services, knowledge, and technique is forcing a trend. We are truly evolving into "vector control districts." A vector in this sense implies an arthropod which transmits a disease or parasite or an organism alien to our welfare and immediate habitation.

YELLOW JACKET CONTROL IN CALIFORNIA

Calvin J. Rogers
San Mateo County Mosquito Abatement District, San Mateo

Over the past decade yellow jacket problems have become increasingly prominent as our expanding population seeks the enjoyment offered by outdoor living and recreation. To most a sting is a painful interruption of their activities but to hypersensitive persons a sting presents a very real danger of physical harm and possibly death. Yellow jackets are particularly troublesome to public and private outdoor recreation areas, youth camps, and schools. Throughout the state several groups, including the University of California, State Department of Public Health and at least three mosquito abatement districts and one local health department, are engaged in yellow jacket control and study programs to combat this growing problem.

Two ground-nesting species, *Vespula pensylvanica* (Saussure) and *V. vulgaris* (L.) are of major concern. Both are strongly attracted to human foods at out-of-door meals.

The necessary steps of control evaluation and population sampling have been facilitated by the development of a standardized yellow jacket trap (Rogers and Lauret 1968).

A control method, based upon yellow jacket feeding habits, has been developed wherein toxic bait is provided which foraging adults carry back to the nest as larval food thereby effecting colony destruction. Bait stations of suitable design are dispersed throughout the area to be controlled. Several bait materials have been used including cooked ground horsemeat, fish flavored cat food, canned pet tuna, ground beef liver, and Hawaiian Punch® fruit drink concentrate. The proteinaceous baits are preferred by most workers. The insecticide used must be slow acting to allow sufficient time for the adults to transport the bait to the nest, and it must not repel the yellow jackets. Chlordane wettable powder and mirex have been used successfully. (Grant et al. 1968; Rohe and Madon 1969; Ruddock and Rohe 1968; Keh et al. 1968; Lewallen 1968.)

Chemical attractants may be used in conjunction with (but not mixed into) the toxic baits to enhance the effectiveness of control programs. Among these found to be effective are 2, 4, – hexadienyl butyrate (Davis et al. 1967), hyptyl crotonate (Wagner and Reierson 1969), pentyl butrate (Rohe and Madon 1969), and hyptyl butrate (unpublished data).

Various types of dispensers have been developed which allow free access to the yellow jackets while protecting birds, cats, dogs, other small animals, and children from the toxic bait (Grant et al. 1968; Ruddock and Rohe 1968).

Individual nests may be destroyed by chemical treatment applied through the nest opening using a standard hand sprayer. The use of protective clothing (coveralls, bee veil and gloves) is recommended.

The increasing need for broader coverage in regional programs of integrated control involving extensive park, forest and suburban areas, coupled with the current trend for insecticide restriction, indicates a definite necessity for the development of alternative control approaches. Currently direct nest destruction is the only control approach effective against other yellow jacket species, especially the aerial-nestors, leaving a significant need for study and control technology in this field. Programs of investigation must be continued to provide the information on yellow jacket biology, habits, and behavior required for the development of new control techniques possibly involving biological and naturalistic procedures in addition to chemical control.

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BLACK FLIES IN THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

Frank W. Pelsue
Southeast Mosquito Abatement District, South Gate

One of the entomological programs that the Southeast Mosquito Abatement District has become involved in, in recent years, is the control of Black Flies (Simuliidae). Black Flies have always been present in the Los Angeles Basin in the foothill regions, but only recently have they become a nuisance. With expanding urbanization, residential areas have moved closer and closer to natural streams in the foothills, thus invading the black fly environment. Unfortunately, in some of these streams, biting species are present; and these are very distressing to the residents living close to the breeding sites. Fortunately, most of the water in streams causing the majority of the problems are controlled by the Los Angeles County Flood Control District, so any work done by the Southeast Mosquito Abatement District is done under a contract with the County Flood Control District.

In 1968, we had our first encounter with black flies occurring in the Big Tujunga Wash area of the San Fernando Valley. At this time, the extent of the population was such that chemical control measures were not necessary. We recommended to the Flood Control District that reduction of the water flow would probably take care of the problem. Fortunately, the stream dried up so breeding was eliminated for the remainder of the season; however, in 1969 the story was quite different. With the increased rainfall and snow pack, all the dams were relatively full so no water could be stored. This left the stream in Big Tujunga Wash with a continuous water flow. Accompanying this continuous flow of water was a tremendous build up of black fly larvae.

At this time, a shut-down of the water was impossible; consequently, chemical control was effected. Results of this treatment will be reported later in the paper.

During the 1970 season, no problems developed involving black flies in the District, as population levels remained below the nuisance threshold. However, one problem developed outside the District; and we were called in as consultants. The problem was rather unusual as it developed in a botanical garden in a residential area of the Palos Verde Hills. In the Southcoast Botanical Gardens, a man-made lake and stream were completed last year. During the summer, a tremendous larval population of black flies built up. In the lake and stream, a vanishing species of fish, Mojave Chub *Siphateles mohavensis* Snyder, was introduced last year. The Superintendent of the Botanical Garden wanted to control the black flies without harming the fish, so we recommended a treatment program that was very successful in achieving this end.

In the Southeast Mosquito Abatement District, the following species of black flies have been collected by the Author: *Simulium vittatum* Zetterstedt, *S. argus* Williston, *S. virgatum* Coquillett, *S. tescorum* Stone and Boreham, *S. canadense* Hearle, *S. aureum* Fries and *S. piperi* Dyar and Shannon. All of the above species have been collected in the Big Tujunga Wash area of the District. In 1968, the only species apparently causing any trouble was *S. tescorum.* Adults were collected and observed biting. In 1969, we encountered a large infestation of black flies in the Tujunga Wash and also in the Hansen Dam Spillway. In these areas, only *S. argus* and *S. vittatum* were found. We received several "biting" complaints from a golf course adjacent to the Hansen Dam Spillway, but never actually observed which species were biting. Both areas were treated with ABATE® at the rate of 0.5 ppm. flowed in for one hour.

Another site where we have found black flies is the San Gabriel River in the area of the Whittier Narrows Dam. We have taken only two species in this area, namely *S. vittatum* and *S. virgatum*. In 1970, a moderate infestation was observed; however, no reports of any biting were received.

The infestation of *S. vittatum* at the Southcoast Botanical Garden was effectively controlled using ABATE at the rate of 0.1 ppm. with no harm to the Mojave Chub observed.

Control of black flies by the Southeast Mosquito Abatement District is effected only on an as-needed basis when the population level exceeds the nuisance threshold. Our first choice for control is water management; however, if the water cannot be managed effectively, the only other alternative is chemical control. In most cases, if control is necessary, chemical control is the most effective method to use. The larval stage is the most vulnerable to control, so timing is important. The pupal stage does not seem to be affected by insecticides at concentrations lethal to larvae, so two or more treatments may be necessary if there is a high pupal population as well.

The insecticides reported in the literature as being effective against black flies are as follows: DDT, TDE, dieldrin, parathion, fenthion, Carbaryl, methoxychlor, and ABATE. Of the insecticides listed, ABATE provides suitable control of black fly larvae while apparently not affecting non-target organisms at the dosages described. Of course, Abate is a non-persistent insecticide which helps to protect the environment.

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MIDGE CONTROL IN CALIFORNIA

Charles P. Hansen

San Mateo County Mosquito Abatement District, Burlingame

Many California mosquito control agencies have included midge (Chironomidae) control into their expanding vector control programs. These insects are not known to be vectors of diseases but as adults closely resemble mosquitoes without bloodsucking mouth parts. The primary reason for developing midge control programs is to reduce the chironomid production which may be a cause of discomfort, economic loss, and even mental anguish to our communities.

Midge problems have undoubtedly been troublesome to people for many years but only during the past 10-15 years has intensified control been practiced. It would be easy to blame man for the midge problem since it came about with the great influx of people causing the development of subdivisions and new cities. Frequently surrounding aquatic sources become overloaded with organic materials and create an imbalance in the environmental evolution necessary to prevent nuisance potentials. Neighborhoods with heavy infestations of midges have expressed the need (often loudly) for control of these pests. Some universities, the state and county health departments and mosquito control agencies have undertaken studies to develop successful materials and control methods.

Significant nuisance problems do occur in urban and suburban areas throughout California (Whitsel et al. 1963) especially since these pests are readily attracted to lights of nearby housing developments and industry. Midges will congregate on shrubbery, door screens, under eaves and on the walls of houses. Large numbers of chironomids are very annoying to people because they limit their freedom to enjoy many outdoor activities, from a back yard barbecue to a day on the beach. Besides discomfort, midges have been known to cause economic losses. They have disrupted the manufacture of paint and plastic products (Bay 1964), landed on freshly painted surfaces (requiring additional coats of paint), obscured motorists vision, and stained bedding hanging outdoors (Mezger 1967). For reasons such as these, some agencies have met the demands or needs for midge control expressed by the people whom they serve.

Areas which are the recipient of inflow waters rich in nitrogen and phosphorous frequently have heavy midge production (Magy 1968). The larval habitats consist of muddy substrates, algal mats, and submerged vegetation. Natural water bodies are capable of midge production by themselves, but man-made water developments have enhanced the problem. The more common midge production sources are rainfall depressions (San Mateo MAD), fresh water lakes, ditches, recreational lakes (Magy 1968), sewage oxidation ponds, flood control channels (Orange Co. MAD), reservoirs, water stabilization lagoons (San Joaquin MAD), etc. These sources serve as habitats for more than 150 midge species found in California (Grodhaus 1968). In the San Mateo County MAD, there are eight to ten species known to occur that exceed the annoyance threshold.

Many materials and approaches have been used to control chironomids in California over the past 10-15 years. Some approaches noted are naturalistic control using carp (Mezger 1967) (Kimball 1968), engineering recommendations for design and operation of man-made lakes (Magy 1968), quick breaking phosphate emulsions (Brumbaugh and Mallars 1968), granular treatment using ABATE® and Baytex® at 1% (Barnes 1969), and injection of Dursban® 4 lb. emulsifiable concentrate into flood control channels (Thompson et al. 1970). Currently many California mosquito control agencies successfully use either Abate, Baytex or Dursban in the granular form.

The purpose of this paper was to present an overall picture of California midge problems in diverse geographical areas and a review of some methods to eliminate the problems. Many California mosquito control agencies have seen the need for expansion into other entomological programs and those districts having newly developed recreational areas, intensified urbanization, etc., will be required to place midge control at the top of the list when they expand their scope of vector control.

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EDUCATIONAL ASPECTS OF MOSQUITO CONTROL

Gilbert L. Challet
Orange County Mosquito Abatement District, Santa Ana

Public education is an integral part of the mosquito control program in the Orange County Mosquito Abatement District. This District devotes many man-hours, materials and monies to this task. The public education program, while distinct in many ways from our control operations and abatement programs, also is a primary part of these operations.

Our educational program is based on entomological information about mosquitoes, as well as other insects the general public commonly mistakes for mosquitoes. It is our objective consistently to inform the public on how and where mosquitoes breed and what each person can do to prevent a public nuisance on his property. It is the responsibility of the vector ecologist to prepare this basic information for presentation to the public by every District employee and through every available channel of communication at every available opportunity.

EDUCATION BY EMPLOYEE CONTACT

Direct communications to the resident by the District employees is considered most effective. The individual's annoyance from mosquitoes or other insects can be observed and evaluated by the mosquito control operators. In the case of actual or potential breeding sources on private property, control and abatement measures can be worked out immediately with mutual satisfaction. Effective acceptance by the public, however, depends upon a well trained and informed mosquito control operator. A continuous, informal in-service training is required to keep the operator informed on all phases of the District's abatement and control program as well as on developments in mosquito control methods, pesticides and equipment. Written information and visual aids designed for public understanding are the foundation for our educational program. Orange County has developed four basic informational sources, one or more of which are given to each person contacted by the mosquito control operator: (1) the District pamphlet, "Where To Look & What To Do" for all persons contacted, (2) "Report to Service Requester" for all persons who have requested the District for help in locating and abating an annoyance from mosquitoes, (3) "Report to Householder" for all persons whose premises were inspected on a house-to-house basis to locate unknown sources in a neighborhood where excessive mosquito annoyance had been reported, and (4) "Pest Control Bulletins No. 1 thru 23" which are given to persons who have requested information on a common household pest or who have mistaken another insect for a mosquito.

Pamphlet: The foremost tool in our public education program is our District pamphlet. This pamphlet is given to each person contacted on a service request whether an individual homeowner, a representative of another public agency or anyone coming to the office. They are supplied to each city hall in Orange County. They are included in the mosquito study kit which will be described later.

The pamphlet describes for the urban property owner what he should look for and what he should do to prevent mosquito breeding. It gives a minimum of facts about the life history of the mosquito. Also included is information on aquatic midges (Chironomidae) since the Orange County Mosquito Abatement District is authorized to control these pests. There is a short paragraph on the use of mosquito fish and also a section on Orange County Mosquito Abatement District policy on mosquito control. Administration of the District is on the last page and included are the Trustees' names and which jurisdiction they represent. Displayed prominently on both front and back is the phone number for Orange County Mosquito Abatement District.

Report to Service Requester: This report is left with the person initiating the service request along with a pamphlet. It tells what the inspection has revealed as to the cause of the request.

The first section tells what we have found on the premises and what we have done to prevent a continuing public nuisance. Included is a reference to the pamphlet that indicates what the service requester may do to prevent mosquito breeding.

Secondly, if we cannot find the source on their premises, we then say in what type of source in the neighborhood we found mosquito breeding or that we have not found breeding and will continue to inspect the neighborhood.

The next section indicates what mosquito-like insect was found around the home and what the District can do about this insect. If they are chironomid midges we are authorized to control these insects but not others.

There is a place for comments and the signature of the operator, date and time.

Report to Householder: This report is left on a premises that has been inspected for mosquito breeding. It can be inserted into the pamphlet and both left with the householder.

This report tells whether or not mosquito breeding has been found and where it was found. If mosquito breeding was found, we state what, if any action has been taken by the District.

The next section asks that the householder correct the breeding situation and refers him to the pamphlet for instructions. Along with this there is room for any written instructions or comments.

This is followed by space for signature of operator, date and time.

Pest Control Bulletins: To answer questions by service requesters and telephone inquiries on other insects and how to control them, Orange County Mosquito Abatement District and several other agencies within Orange County deloped a Pest Control Bulletin series. These bulletins consist of a one sheet description, habits and control methods of 23 of the most common pests encountered by the homeowner. These have been useful to the District in saving time of the operator that is asked the question in the field and the Vector Ecologist's time on the telephone explaining these insects' habits to homeowners. It has provided our operators with identification materials in the field at the time they are needed. The bulletins provide all agencies with consistent recommendations approved by the University of California and the USDA. Also, they save switching of phone calls from agency to agency for an answer, which is very disconcerting to the public. At the first call we can take the person's name and get the bulletin in the mail so that it will arrive the next day and provide reference for control methods.

EDUCATION THROUGH THE SCHOOLS

The Vector Ecologist is responsible for developing, coordinating and carrying out the District's educational program through the schools, both public and private. Since Orange County has 491 primary and secondary schools, personal appearances are no longer possible. Speaking engagements are accepted, however, from the eight colleges and from special classes.

Mosquito Study Kit Program: Some twelve years ago, when requests from schools for talks on mosquitoes became too numerous, the District developed a number of mosquito study kits for loan directly to classroom teachers for a period of one week. The classroom use of mosquito larvae served two purposes. The development of the aquatic stages to pupa and adult demonstrated typical metamorphosis and that mosquito fish *(Gambusia affinis)* are very effective predators of mosquito larvae. The use of the study kit also served the purpose of helping the students learn how and where mosquitoes breed. The District's educational objective was met if the student learned that mosquitoes will breed in containers holding water for a week or so and that dumping the water and removing the containers prevent mosquito breeding. Also that the use of mosquito fish in ornamental ponds and horse troughs would prevent mosquitoes. Enough pamphlets are included with the study kit to supply one to each student to take home for his parents perusal.

The kit contains three pint jars for live specimens of mosquito larvae, mosquito pupae and mosquito fish. Also included are two vials, one for mosquito egg rafts and one for dead adult mosquitoes. Two small beakers for rearing and one small hand magnifier make up the remainder of the kit. All of these contents are in an easy-carry case.

Another part of the kit is the printed matter which includes the following:

1. Instructions for use of the kit.
2. Schematic drawings of the egg raft, larva, pupa and adult.
3. Reprint of an article on OCMAD.
4. University of California Circular No. 439, "Mosquito Control on the Farm".
5. Bureau of Vector Control Bulletin, VC-1 on mosquito control.
6. Synopsis of film, "The Mosquito".

We include a twelve minute film titled, "The Mosquito" distributed by Encyclopedia Britannica Films.

Speaking: Since speaking engagements have been limited, we have accepted only four in 1970. These have been: (1) a talk on mosquito control to five classes at Troy High School in Fullerton on April 22, 1970, "Earth Day", (2) a talk on mosquito control and pesticides to the Frontiers in Biology Class at Golden West College in Huntington Beach, (3) at Santiago School in Santa Ana, a presentation on mosquito control to a gifted class of 5th and 6th graders from the whole school district, and (4) a yearly visit to Orange Coast College for a presentation on mosquito control, job opportunities in mosquito abatement, and pesticides to the Introduction to Agriculture Class.

To supplement our presentations, the District has developed a 35mm slide series of 40 pictures showing typical operations and sources. This series can be supplemented and changed according to the needs of the expected audience.

COMMUNITY PROGRAMS

We have participated in various fairs throughout the County. The District has developed a display for this purpose and it has worked out more than satifactorily.

The District Manager accepts all requests to speak at service club meetings. These speaking engagements are usually geared toward the community in which it is held. Another aspect of education comes in at this point because Orange County Mosquito Abatement District has a policy to document many aspects of its operation through photographs. These photographs are used in presentation to these service groups because we can show them sources in there own community that they can readily identify.

The Vector Ecologist works with the 4-H program on Entomology, sponsored by the University of California Agricultural Extension Service. We have training sessions for 4-H participants in this program. These training sessions provide entomological facts on mosquito control. The Vector Ecologist also assists the 4-H program by providing judging of entomological exhibits at the County Fair.

There are many programs in the community such as 4-H in which facts about mosquitoes and mosquito control can be used as an educational process. We feel that our most effective education is with the young people.

FLIT AND OUR CHANGING TIMES – A PILOT'S VIEW

Floyd King
Turlock Mosquito Abatement District, Turlock

To a mosquito control pilot change is time –– in many cases precious time. The inconvenience of having to use several insecticides takes precious time if the chemicals are not compatible. The draining and flushing of the airplanes' dispersal systems creates problems in disposing of the flushed material if one cannot take time to "fly it out".

As a mosquito control pilot on the Aircraft Committee, I am to inform you of the pilot's views of change and the use of one of our latest aerial weapons –– FLIT® MLO.

Problems arise with the use of each different chemical. Some are easily solved, others take a high degree of ingenuity. As the past shows, a dispersal method has been worked out for every chemical used; although in some cases, results have not always been as great as desired. Many things contribute to the degree of effect a chemical obtains, low maximum toxicity allowed, stability in its carrier, evaporation, wind effect and, last but not least, pilotage.

Last season brought to us FLIT. Thus began an interesting bit of experimentation. Gone were the problems of maximum toxicity and stability, but magnified in their place were wind effect and a greater concentration by the pilot.

It all began "naturally" during the busiest part of our season. At one area in our District, all other chemicals failed us. The larvae had become so tough and immune, they were drinking our spray and asking for olives. About that time, Humble Oil Company representatives were looking for testing grounds and we had them. Since this is a pilot's view report, I won't get into every technical detail but will cover a general description of the tests.

On an afternoon in late September, I met with G. V. Chambers and Bill Gordon from Esso Research and Engineering Company and ran a calibration, using our existing nozzles. Calibrating for one gallon per acre, we used a 40-foot swath. This testing was made using a Piper Pawnee 235–C.

The next morning, flying over a 40-acre field, spraying half at one gallon per acre and half at two gallons per acre by halving the swath, we became acquainted with the problems we were to have.

Calm air, coupled with the lightness of FLIT, coated my windshield so visibility was near zero. A delayed turnaround on the end of the field helped clear the windshield by airblast and evaporation. Within a short time, I learned that the clearing only happened if the windshield had been freshly cleaned. After picking up bugs and dust, it would no longer clear off by itself. Hand wiping, via a side window port, helped; however, the abrasions on my arm, caused by the wind pushing it back against the sharp plastic, pointed out the fact that that wasn't too practical or desirable a way to clean it.

A good light, steady breeze and working crosswind helped keep the FLIT off the windshield. However, we didn't always have ideal conditions and visibility for me, because of the oil film. Gil Chambers and Bill Gordon were flagging the field and taking photos of the spray as the plane passed directly over them.

At the start, we completely flushed and dried the aircraft spray system before loading with FLIT, so that we could calibrate more closely, by avoiding any chance of clabbering of the oil and water. The first few drums of FLIT were without any type of emulsifier. Once we started using it with emulsifier added, all that was required to ready the plane was to drain the hopper and wind driven pump. Installing a quick drain in the pump simplified the process. After loading and take-off, the booms could then be cleared while ferrying. Reverting back to another chemical was only a matter of loading up, even with 20 gallons of FLIT in the hopper there were no clabbering problems and, as before, the booms could be cleared while ferrying.

Tests were made to determine a suitable attitude for application, drift and recovery. Most runs were made with a 40-foot swath and 10 feet of altitude. The recovery rate ran about 80 percent on open containers and plates. We were limited by time, so were not able to check too well on the penetration of heavy foliage. A fair pattern and recovery showed up on a few test runs at powerline heights. Further testing will be needed to check the feasibility of working at that height. Wind became a problem over 8 mph when steady, but gustiness at speeds even less than that caused greater problems. A steady breeze could be used to an advantage, but gusts could shoot the pattern to peices.

Because of its peculiar working action, droplet size is of great importance. Too small and light a droplet, and it will stay airborne and drift too far past the target. If too large and heavy, it will penetrate the water too deeply and fail to spread on the surface as is necessary for its type of action. Using 12 teejet nozzles with D8 orifices and No. 45 hollow-cone swirl plates and 23 pounds pressure, a good droplet size was obtained, which gave us one gallon per acre. Placement of nozzles seemed to be a semi-minor item. One nozzle at the side of the fuselage, one 24 inches out from that and four nozzles 32 inches apart to the tip of the boom, produced a well filled and even pattern.

Our test fields were from 40 to 200 acres in size. They were rough, unimproved, flood irrigated pastures, with one leveled pasture included. Species of mosquito larvae were *Culex tarsalis* and *Aedes nigromaculis*. The easiest stages to kill were fourth instar and pupae, with third's a little harder, second and first instar progressively so. This requires a closer watch on the larvae to be able to pinpoint the correct time to spray.

For the pilot, the major setup for using FLIT would be to work out some kind of system for washing the windshield in flight. It does wash off very easily. With the talent and ingenuity we have in this Association, a solution of sorts should be fairly easy to come by.

Late stage of larvae, high temperatures and wind are all happenings while the plane is being changed from one chemical to another; each one being an enemy to successful spraying. Unfortunately, we cannot pick one easy chemical to work with and expect it to do all that we want.

We will have to live with our changes, improving each system to work well with every chemical in our arsenal. The problems are always present, but at least not always insurmountable. We can put our aircraft in the right spot, at the right time, in the right way, but sending the chemical from the plane to the ground to get the required kill depends entirely on the right dispersal system. So as changes of time go on, we, the pilots, will continue to use a great deal of our time changing, 'til that elusive day comes when one great insecticide or whatever will do all we require.

PROGRESS REPORT ON AIRCRAFT AND GROUND CHEMICAL APPLICATION STUDIES FOR MOSQUITO CONTROL

Norman B. Akesson, Reid Borgwardt and Wesley E. Yates

Agricultural Engineering Department, University of California, Davis

We have continued our work on chemical applications for vector control operating both ground aerosol machines and aircraft for a series of test runs during 1970.

We participated in an extensive program with the Colusa Mosquito Abatement District, the Bureau of Vector Control and Solid Waste Management, and other State and University groups. Our principle contribution to the work was in connection with (1) swath spray distribution patterns, (2) micro-weather considerations and aerial distribution downwind. The swath pattern studies were conducted by Don J. Womeldorf and Patricia A. Gillies and used biological analysis techniques.

Three series of large-scale applications were made in June, July and August, primarily for larval control in rice fields. Dursban® was used at rates of 0.011 to 0.025 pound (active ingredient) per acre in solutions varying from straight technical (0.025 lb/acre) at 1.6 fluid ounces per acre to various dilutions with polypropylene glycol at the same total rate of 1.6 fluid ounces per acre. Approximately 30,000 acres were sprayed each month.

The larval control was excellent on the first treatment, but decreased considerably in the second and third runs. The recoveries by bioassay, and from one run using plastic sheets and gas chromatography, showed that the amounts of Dursban caught in the last two runs also decreased considerably.

Samples of fallout and air-borne Dursban were collected up to ten miles downwind from the treated areas, but air levels were low and when using a non-evaporative formulation and a medium atomization spray of approximately 200 micron VMD (volume median diameter) the downwind contamination was not excessive. Flight times were ordinarily in the evening under temperature inversion conditions and relatively low winds. Tests showed that by flying the Pawnee aircraft at 50 to 100 feet elevation and using D2-25 (SPRAYING SYSTEMS®) nozzles directed downward and operated at 70 pounds per square inch pressure, swaths of 600 to 700 feet could safely be taken.

Flight costs alone, according to Kenneth Whitesell, Manager of the Colusa Mosquito Abatement District, averaged around two and one-half cents per acre. The cost of Dursban was around 10 cents per acre at 0.0125 pound per acre.

Further aircraft technical low volume runs were made at Bakersfield with a Call Air aircraft using 800067 and 80005 type fan nozzles directed downward at 40 pounds per square inch. The downwind transport from the 80005 nozzles indicated a fallout level of around 100 micrograms/ft^2 at 165 feet, dropping to about 10 micrograms at 1000 feet. The airborne levels started at 660 feet showed 20 micrograms per filter and stayed high at 11 micrograms per total filter sample at one-half mile. Comparison with two types of ground rig aerosol generators showed the aircraft low volume downwind drift, even flying at 10 feet height, gave higher downwind deposits than the ground rigs. Little difference was to be seen between the Fort Belvoir type aerosol generator and the twin-fluid California Blower rig. For example, the downwind deposit from the aerosol generator gave 50 to 70 micrograms/ft^2 at 165 feet, dropped to 3½ to 4 micrograms /ft^2 at one-fourth mile and to 1½ to 2 micrograms/ft^2 at one-half mile. The air samples were 40 to 15 micrograms per total filter for the Belvoir and California Blower rig respectively at 165 feet, but these dropped to nearly the same levels of about 11 micrograms/filter at one-fourth mile and to 5 micrograms/filter at ½ mile. No evaluation of mosquito control was made on the Bakersfield runs, but a check of the general insect (predator) population showed significant effects on these to ½ mile.

Ground rig aerosol runs were also made at Corcoran using bacillus and virus sprays in non-evaporative cottonseed oil carriers. The first series was run using virus applied downwind with the Belvoir cold aerosol generator while the second series was run using our modified Cal Blower with three twin-fluid nozzles and with the bacillus THURICIDE®. Both dye and biological activity tests were made downwind to ½ mile. In the case of the dye the Belvoir aerosol machine gave downwind levels of deposit 10 to 40 times that of the Cal Blower. The weather was significantly different for these runs with a strong inversion for the Belvoir run and a near neutral or lapse (turbulent) weather for the Cal Blower run. The active bacillus data on the Cal Blower run show a peak of deposit at about 300 feet falling back to ½ this level at 600 feet, but continuing downwind at about the same level, one-half mile.

Thus, it would appear that either of the cold aerosol generators will effectively cover a significant swath of 700 to 1000 feet by simply applying the material on the upwind side of the field and allowing it to drift and deposit across the crop. This can have great significance to the mosquito control districts who might use the aerosol machine to advantage for both larvae and adult control in certain specific areas where wind drift and temperature inversion weather can be used to keep the material close to the ground.

It appears from these tests, as well as from controlled drop size tests in a closed room, that the Belvoir nozzle can produce drops as small as 7 micrograms VMD, while the Cal Blower seems to be limited to about 25 micrograms VMD, at the same flow rate. The drop size from the Cal Blower machine is greatly affected by the flow rate and in order to produce a very fine aerosol, the flow rate must be small per nozzle at around 15-20 milliliters per minute. In order to get a sufficient volume for a wide swath there must then be several nozzles used with this machine. However, the Belvoir nozzle is not as flow rate sensitive and showed 7 micrograms VMD at 15 ml/min. and 11 micrograms at 133 ml/min. Several other types of atomizing nozzles will be examined this season to see if a high efficiency cold aerosol device can be found which will not require the high energy demands of the present atomizer systems. It is also anticipated that further studies will be made on swath and total distribution recovery from aerial sprays particularly in relation to low volume, low evaporative materials.

INSECTICIDE SUSCEPTIBILITY OF MOSQUITOES IN CALIFORNIA: STATUS OF RESISTANCE AND INTERPRETATION THROUGH 1970

Don J. Womeldorf, Patricia A. Gillies, and Kathleen E. White

Bureau of Vector Control and Solid Waste Management, Dept. of Public Health, California

Organophosphorus insecticide resistance, becoming progressively worse since its first detection in *Culex tarsalis* Coquillett (Gjullin and Isaak 1957) and in *Aedes nigromaculis* (Ludlow) (Lewallen and Brawley 1958), now extends to all available organophosphorus compounds in certain areas. Other species are also involved. This paper summarizes the resistance problem as it is presently understood, comments upon interpretation of laboratory data, and briefly reviews the outlook for present and potential alternative materials.

Mosquito larvae were tested in the California resistance surveillance program as described by Gillies and Womeldorf (1968). Laboratory data were compared with field observations to aid in interpretation. Only those data developed in the computerized probit analysis program incorporated into the resistance surveillance program are included in this report.

CURRENT STATUS

Instances of high organophosphorus tolerance were listed by Womeldorf et al. (1966, 1968) for larvae of five mosquito species. Table 1 summarizes, by year of first laboratory confirmation, additions to the lists. The criteria applied earlier are again used: the population mean lethal concentration (LC_{50}) exceeded 0.005 parts per million (ppm) parathion, methyl parathion, or fenthion; or 0.1 ppm malathion. The highest level for the year of detection is included.

Table 2 summarizes detected high organophosphorus tolerance to date. The absence of an indication of resistance may mean simply that it has not yet been determined, not that it does not exist.

Aedes nigromaculis continues to be the most heavily pressured mosquito in the Central Valley. High fenthion resistance is related to severe cross tolerance, extending to other organophosphorus materials (Gillies et al. 1967, Schaefer and Wilder 1970a). By the close of the 1970 season, resistance against all available organophosphorus larvicides was evident in three areas: the central San Joaquin Valley (principally Kings and Tulare counties); the northern San Joaquin Valley (Stanislaus County); and the central Sacramento Valley (mainly Butte, Sutter, and Yuba counties). Examples of the magnitude of extreme resistance are given in Table 3. In most of the rest of the Central Valley, resistance has been increasing in extent and in magnitude.

In addition to the larval control problems, adults have

Table 1.–First laboratory demonstrated high organophosphorus tolerance in larvae of five Californian mosquito species – year and LC_{50} level with 95 % confidence limits, by mosquito abatement district and insecticide.

SPECIES	M A D	MALATHION			PARATHION			METHYL PARATHION			FENTHION		
		Year	LC_{50}	95% limits	Year	LC_{50}	95% limits	Year	LC_{50}	95% limits	Year	LC_{50}	95% limits
Aedes nigromaculis	Delta										1968	.0054	.0047–.0061
	Consolidated							1970	.0087	.0070–.011			
	Fresno Westside										1970	.0090	.0075–.011
	Turlock										1970	.026	.020 –.032
	East Side										1970	.0077	.0053–.011
	Solano County				1969	.027	.020 –.037	1969	.0050	.0033–.0074			
	Sacramento-Yolo				1968	.0067	.0048–.0092						
	Sutter-Yuba										1969	.035	.027 –.045
	Colusa										1969	.0090	.0066–.012
	Butte County										1970*	.012	.0096–.016
	Tehama County							1969	.020	.014 –.027			
Aedes melanimon	Tulare				1961	.016	.012 –.021						
	Kings				1965	.0062	.0055–.0069						
	Delta				1964	.0058	.0048–.0069						
	Consolidated				1966	.0067	.0062–.0071						
	Fresno Westside				1964	.0060	.0056–.0066						
	Merced				1966	.0081	.0076–.0087						
	Sacramento-Yolo				1968	.0056H	.0025–.012						
	Sutter-Yuba				1964	.026	.020 –.037						
	Colusa				1966	.0070	.0038–.013						
	Butte				1965	.0059	.0055–.0064						
	Corning				1967	.0055	.0046–.0065						
Culex peus	Northwest										1969	.0062	.0055–.0070
	Tulare	1970	.11	.098–.12							1970	.034	.030 –.039
	Madera										1964	.01H	.0049–.017
	San Joaquin							1970†	.0051	.0044–.0059			
Culex pipiens	Delano	1969	.13	.10 –.15							1969	.0054	.0049–.0059
	Madera	1969	.15	.13 –.17									
	Sacramento-Yolo										1968	.0062	.0051–.0075
Culex tarsalis	Coachella Valley				1970	.016	.013 –.020						
	Southeast	1969	.23	.11 –.13									
	Kern				1964	.0074	.0066–.0083	1964	.0066	.0058–.0073			
	Westside										1970	.0062	.0045–.0085
	Delano										1969	.0060	.0044–.0077
	Tulare							1969	.0085	.0043–.012	1969	.017	.021 –.023
	Kings				1969	.026	.020 –.033	1969	.032	.026 –.039			
	Fresno				1969	.0053	.0045–.0063	1969	.0085	.0063–.010			
	Fresno Westside	1969	.20	.11 –.36	1969	.022	.018 –.028	1969	.018	.016 –.021	1969	.023	.021 –.027
	Madera				1970	.011	.0092–.014	1969	.0059	.0048–.0072	1969	.0081	.0057–.024
	San Joaquin							1969†	.0056H	.0035–.016			

H – statistically significant heterogeneity
* – Elmer Kingsford data
† – James Mallars data

Table 2.–Laboratory demonstrated high organophosphorus tolerance in larvae of five Californian mosquito species, through 1970, by mosquito abatement district and insecticide.

	Aedes nigromaculis				*Aedes melanimon*				*Culex peus*				*Culex pipiens* Subspp.				*Culex tarsalis*			
MAD	MAL	PAR	MPA	FEN	MAL	PAR	MPA	FEN	MAL	PAR	MPA	FEN	MAL	PAR	MPA	FEN	MAL	PAR	MPA	FEN
Southeast										X	X	X	X			X	X			X
Orange County									X	X	X	X	X			X				X
Los Angeles County West																X				
Northwest												X				X				
Carpinteria																				X
Coachella Valley																		X		
Goleta Valley												X								
Kern	X	X	X	X									X	X				X	X	X
West Side																	X			X
Delano		X											X							X
Kings	X	X	X	X		X				X		X				X	X	X	X	X
Tulare	X	X	X	X		X			X			X	X			X	X		X	X
Delta	X	X	X	X		X										X				
Consolidated	X	X	X			X							X			X	X			
Fresno	X												X	X		X	X	X	X	X
Fresno Westside		X	X	X		X											X	X	X	X
Madera									X			X	X				X	X	X	X
Merced	X					X											X			
Turlock		X	X	X								X				X	X			X
East Side	X	X	X	X					X		X	X	X			X				
San Joaquin		X		X							X	X				X			X	
No. San Joaquin County	X																			
No. Salinas Valley										X			X	X	X	X				
Solano County		X	X						X			X					X			
Sacramento-Yolo		X				X										X	X			
Sutter-Yuba		X	X	X		X					X						X			
Colusa		X		X		X														
Butte County		X	X	X		X						X	X			X	X			
Corning						X						X								
Los Molinos	X																			
Tehama County		X	X									X								
Pine Grove	X																			

MAL – Malathion
PAR – Parathion
MPA – Methyl Parathion
FEN – Fenthion

Table 3.–Highest laboratory determined organophosphorus tolerance levels in larval *Aedes nigromaculis* from the areas of greatest resistance by selected insecticide – year, LC_{50} with 95% confidence limits, and LC_{90}.

INSECTICIDE	CONTROL AREA											
	Kings (southern San Joaquin Valley)				Turlock (northern San Joaquin Valley)				Sutter-Yuba (central Sacramento Valley)			
	Year	LC_{50}	95% Limits	LC_{90}	Year	LC_{50}	95% Limits	LC_{90}	Year	LC_{50}	95% Limits	LC_{90}
EPN	1970	.019	.015 - .029	.080	1968†	.0013	.0012 - .0014	.0019	1969	.0029	.0025 - .0034	.0058
Parathion	1970	.37	.27 - .51	1.19	1970	.11	.073 - .16	.67	1970*	.48	.40 - .57	1.2
Methyl parathion	1970	.64	.43 - 1.24	3.40	1970	.035H	.019 - .074	.025	1969	.20	.15 - .27	2.0
Fenthion	1970	.025	.022 - .029	.060	1970	.026	.020 - .032	.13	1969	.035	.027 - .045	.20
Abate	1969	.016	.012 - .10	.030					1970*	.0099H	.0033 - .031	.027
Dursban	1969	.0055	.0046 - .0069	.015	1970†	.013	.010 - .016	.054	1969	.031	.091 - .12	.18

H – statistically significant heterogeneity
* – Jerald Harvey data
† – Judy Souza data

been shown to be resistant against organophosphoruses (Wilder and Schaefer 1969), and erratic results have been experienced by several mosquito control agencies using propoxur (BAYGON®). We have not tested adults, but the results of several tests performed upon larvae of various degrees of organophosphorus resistance are listed in Table 4.

Aedes melanimon Dyar, discussed by Gillies et al. (1971), continues to be nearly unaffected by organophosphorus resistance from the operational point of view, but appears rather to normally exhibit relatively high tolerance. Several collections in the summaries by Womeldorf et al. (1966, 1968) were incorrectly included. A review of the original data shows that pupation and mixtures of species invalidated the results. The listings in Tables 1 and 2 are correct and replace those of the 1966 and 1968 papers.

Culex tarsalis exhibits the most dramatic recent increase in resistance of all Californian species. In mid-1969, severely organophosphorus-resistant populations were detected in Kings County. By the end of the year, the problem had been found to extend to agencies from Kern to Fresno counties (Georghiou et al. 1969, Schaefer and Wilder 1970b, Mulla et al. 1970). Gillies and Womeldorf (1970) reported that usual or approximately double operational dosages of malathion, parathion, methyl parathion, fenthion, EPN, ABATE®, and Dursban® all failed to yield satisfactory kills of the Kings County *C. tarsalis* population. At the close of the 1970 season, the problem populations had been determined to extend more or less continuously through the San Joaquin Valley into Stanislaus County, with some high laboratory-determined levels being found in areas of the Sacramento Valley as well.

The status of *C. peus* Speiser and *C. pipiens* subspp. is little changed from that of the 1968 summary. Malathion resistance is widespread, and fenthion resistance appears definite in limited areas. Some evidence of resistance against other organophosphorus compounds has been found, mainly in Southern California.

Anopheles freeborni Aitken were collected and tested from sites in the Sacramento Valley (Womeldorf et al. 1970): no organophosphorus resistance was discovered. The relatively high tolerance levels were considered to be normal for the species. Limited information indicates that the same levels of tolerance exist in other parts of the State.

Since the 1968 summary, no appreciable organophosphorus resistance has been delimited in other species of operational importance. The information remains incomplete.

INTERPRETATION

Gillies et al. (1968) illustrated typical regression lines for *A. nigromaculis* populations from Kings and Tulare counties resistant against parathion and fenthion. Parathion line slopes became less steep as resistance progressed, as shown by Brown et al. (1963), until a point was reached at which the line slope steepened, signifying a return to a homogeneous population, but one homogeneous for resistance. Fen-

Table 4.–Laboratory determined propoxur tolerance in larval *Aedes nigromaculis* of several degrees of organophosphorus resistance. Slight = no control problem; moderate = failure with one or two materials; severe = failures with all available larvicides.

M A D	LOCATION	DATE	DEGREE OP–R	LC_{50}	95% INTERVAL	LC_{90}
Tehama Co.	Ohm	7- 3-70	slight	0.12	0.089–0.14	0.23
Los Molinos	Harry	7-29-70	slight	0.14	0.12 –0.16	0.22
Los Molinos	Harry	9-23-70	slight	0.11	0.09 –0.12	0.16
Tehama Co.	Goff	7-28-70	moderate	0.23	0.2 –0.26	0.36
Sutter-Yuba	Sutfin	7-10-70	severe	0.26	0.12 –0.21	0.55
Sutter-Yuba	Weeden	7-10-70	severe	0.21	0.068–0.39	0.63
Sutter-Yuba	Morrison	8-29-70	severe	0.25	0.20 –0.30	0.46
Sutter-Yuba	Morrison	8-30-70	severe	0.25	0.18 –0.30	0.57
Turlock	Hatch	8-28-70	severe	0.19H	0.032–0.29	0.57
Turlock	Hatch	8-29-70	severe	0.13H	0.016–0.23	0.66

H = statistically significant heterogeneity

thion line slopes, on the other hand, remained steep and unchanged as the population tolerance increased.

It now appears that the above response for populations from the south and central San Joaquin Valley is not typical of populations from the rest of the Central Valley. In the north, parathion responses have followed the above-described pattern, but fenthion lines slopes are much less steep in the resistant populations than in susceptible populations (Table 3). The same is generally true of other organophosphorus compounds.

One significance of this difference is related to adult control. Comparing laboratory-determined levels of larval fenthion tolerance to field observations of fenthion failures against adult *A. nigromaculis* in the Sutter-Yuba Mosquito Abatement District led to the conclusion that at a dosage rate of 0.1 lb/acre fenthion applied by aircraft, adulticidal failures can be anticipated if the larval populations show appreciable 24-hour survival at a laboratory concentration of 0.01 ppm. With the less steep line slopes in the northern area, a great many problem populations show 90% or less larval mortality at 0.01 ppm, even with relatively low LC_{50} levels, and it may be inferred that adulticidal control is apt to be poor. Also, development of larval resistance is likely to be very quickly followed by extreme adult resistance. Field observations in the Turlock Mosquito Abatement District have borne out these suppositions.

The same relationship may occur in the case of propoxur. Schaefer and Wilder (1970a) listed propoxur LC_{50} and LC_{90} levels in *A. nigromaculis* larvae of 0.15 and 0.22 ppm (susceptible strain) and 0.20 and 0.33 ppm (resistant strain, Tulare County). Propoxur larval levels from the northern population, shown in Table 4, differ from the southern organophosphorus resistant material more at the LC_{90} than at the LC_{50}, indicating that considerably more population variation may exist there than in Tulare County, and even that there may be a greater potential for increased resistance in the north. We did not perform tests upon adults from the northern population, and so are not able to compare the adult response with the data presented by Schaefer and Wilder, who found only a 1.6-fold difference between susceptible and resistant strains.

The failure threshold concept expressed by Brown et al. (1963) and Gillies (1964) and further discussed by Womeldorf et al. (1966) and Gillies et al. (1968) has proved to be well-founded for *A. nigromaculis* in the light of several years' experience with it. Schaefer and Wilder (1970c) noted that a 3 to 4-fold increase in larval tolerance could lead to field problems. It is interesting that their laboratory-determined levels for materials which failed in the field all exceeded our "borderline" threshold of 0.005 ppm or the "definite" threshold of 0.01 ppm for materials applied at 0.1 lb/acre.

The threshold approach is limited, of course. For example, EPN levels in the problem areas of the Turlock and Sutter-Yuba mosquito abatement districts are well below the thresholds (Table 3), yet field observations have shown failures when the material is applied at 0.1 lb/acre. Apparently, other unknown factors operate in the laboratory or in the field to make the failure threshold for EPN lower than for the parathions or fenthion. The failure threshold limits may also not be applicable to the carbamate RE-11775, since Schaefer and Wilder (1970b) showed excellent field results against larval *A. nigromaculis* populations with LC_{50} levels ranging to 0.017 ppm.

Culex tarsalis failure thresholds for most of the organophosphorus compounds seem to match those for *A. nigromaculis*. In addition, there may be an indicator for incipient resistance against the major chemicals directed against Californian populations. A review of data from 1963 to the present shows that 0.01 ppm fenthion, parathion, or methyl parathion produce 100% 24-hour laboratory mortality of susceptible populations, and that all resistant populations have a greater or lesser degree of survival at that concentration. It is therefore proposed that in the case of these three materials, survival at 0.01 ppm be taken to warn of incipient resistance. Such populations should be very closely watched to ascertain operational success or failure of the pesticidal application.

OUTLOOK

Chemical control of extremely organophosphorus-resistant larval populations of *A. nigromaculis* and *C. tarsalis* is in clear jeopardy. There is little hope that the answer to resistance will be provided by a new organophosphorus compound. Of the so-called conventional insecticides, the carbamates offer the greatest promise. It is discouraging to note, however, in the data of Schaefer and Wilder (1970b) regarding the carbamate RE-11775, that the organophosphorus resistant strains of *A. nigromaculis* in most instances show not only elevated LC_{50} levels, but also that the line slopes tend to be less steep than in susceptible populations. This combination does not bode well for the future of the compound when it is applied operationally for any length of time. Their data obtained on laboratory colonies of *C. tarsalis* are more encouraging: although LC_{50} levels are slightly elevated in the organophosphorus resistant strains, the line slopes appear to be not substantially different from susceptibles.

Other classes of compounds are subjects of University of California research. Recent reports on a variety of materials indicate that there are prospects of replacing conventional compounds, but nothing has appeared which is both effective and immediately available.

Older matreials are being re-examined. Husbands and Lewallen (1971) reported on the potential of phenothiazine, but it is not yet operationally available in an optimum formulation. Paris green has been shown to kill organophosphorus resistant larval *A. nigromaculis* and *C. tarsalis*, but environmental considerations and the fact that there are no established residue tolerance levels preclude its present use in pastures (Womeldorf and Force 1971). The petroleum oils, including the fuel oils and those formulated and registered specifically for mosquito control, have received considerable attention. They may provide acceptable control, but it is unlikely that control levels achieved with organophosphorus compounds against susceptible populations will be within economic reach.

Adult control is also uncertain. Propoxur failures give rise to real concern, since it has been an effective adulticide (Ramke et al. 1969). Field tests with carbaryl, conducted in cooperation with the Sutter-Yuba Mosquito Abatement District, showed that no appreciable reduction in the numbers of organophosphorus resistant *A. nigromaculis* was achieved when the material was applied by aircraft at the dosage rate of 0.5 lb/acre. The natural and synthetic botanicals, under study at the University of California, need to be closely examined for their field efficacy against highly resistant adult mosquitoes.

It is increasingly evident that mosquito control in California will have to cease to rely upon pesticides and to relegate them to their proper position in a control program which coordniates physical, biological, and chemical control technology.

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EVOLVING VECTOR CONTROL TECHNOLOGY — TRENDS TOWARD SPECIFIC SUPPRESSIVE MEASURES

Mir S. Mulla
University of California, Riverside

The term "specific" where used as an adjective has many connotations. In the present context, it implies the availability or development of suppressive measures which are formulated or restricted to the control of vector arthropods —or arthropods detrimental to the health of man and animals. The term still in the minds of many users has different meanings and is subjected to various interpretations dictated by the values held by the society and the information available at a given time and place.

In the strict sense, only few vector control methodologies practiced so far are considered to be specific. Among these one can point to some specific measures such as genetic manipulations (which are not operational as yet), release of sterile insects for the control or eradiction of natural populations, and the use of specific pathogens and parasites. None of these measures, however, has become operational in general due to the lack of adequate background information. The bulk of the measures which have reached practical status in vector control programs is either somewhat specific or broad spectrum in the broad sense. Such measures include: source reduction, habitat management, introduction of predators, use of chemical preimagocides, larvicides and adulticides, and other suppressive measures. These measures interfere or alter the components of the ecosystem other than the target organisms either temporarily or on a permanent basis. Selection of a given control methodology is based on many factors, discussion of which is beyond the scope of this paper.

Since the early days of the development of vector control technology, basic and applied biologists and vector ecologists have made concerted efforts to develop, promote and employ "relatively specific" vector control strategies. The need for the development of such measures is more obvious now than ever before. In the field of vector control technology, we are beginning to investigate genetic mechanisms, pathogens, hormones, pheromones, attractants and other specific chemicals inducing behavioral changes in the target insects. A number of juvenile hormone analogs have been evaluated in the laboratory and further studies will shed light on the potential efficacy of these compounds against mosquitoes. The possibility of insects developing resistance to these chemicals is deemed remote (Williams 1970), but I would caution against such a notion until we have had sufficient data to support this view.

Although the development of hormonal type of compounds held promise for the control of many insect species, these compounds do not offer much promise at least in the foreseeable future for the control of soil breeding insects utilizing large tracts of land for their breeding and undergoing multivoltine development. A good example of such a group is the genus *Hippelates*, some members of which are involved in vectoring pathogenic organisms to man and animals, and some are highly pestiferous in some parts of the United States, Central and South America and the Caribbean region. From the outset, research on *Hippelates* eye gnats has emphasized the development of specific control measures. This tendency has prevailed over the past two decades. Although broad spectrum soil insecticides such as aldrin, dieldrin, DDT and others were evaluated for eye gnat control (Dow and Willis 1959, Mulla 1960 a, 1960 b, 1961 a, 1961 b, 1964, 1965, Mulla et al. 1960, Tinkham 1952, 1953), these materials were not employed in area-wide control programs. Some of the persistent insecticides such as aldrin, dieldrin and DDT, however, were employed for eye gnat control on a limited basis in the Coachella Valley (Tinkham 1952, 1953), but soon it was found that eye gnats in that Valley had acquired resistance to the cyclodiene group of compounds (Mulla 1962 a). DDT was employed for 2-3 years for eye gnat control, but only a small fraction of the total breeding grounds could be treated. Even though Trithion was found to give some control of organochlorine - resistant eye gnats (Mulla 1961 b, 1964, 1965), very small acreage was treated with this material in the Coachella Valley. Since the eye gnats breed in both cultivated and noncultivated irrigated soils (Mulla 1962 b), it was inconceivable that such limited coverage of the breeding sources with soil insecticides will produce desirable reduction in the eye gnat population.

Alteration of the farming practices from an intensively cultivated practice to noncultivation yielded complete control of eye gnat breeding in perennial crops where cover crops and weeds providing food for eye gnat larvae were eliminated (Mulla 1963). Such a practice was advocated earlier (Tinkham 1953) but without much grower acceptance. Recently, many farmers have gone to noncultivation on their own accord, but many more are still clinging to the practice of intensive cultivation in the form of disking, rototilling and others. In order to provide a solution in these disked areas, it was found that application of herbicidal oils to the soil either before or soon after cultivation in perennial crops yields excellent control of *Hippelates* eye gnats (Mulla et al. 1966).

All these strategies developed for eye gnat control are hardly considered to be "specific". Some of these procedures probably had more hazardous environmental implications than others. In view of our current knowledge, the insecticides aldrin and DDT probably had the greatest environmental side effects than the other methods. The noncultivation and application of herbicidal oils to control the cover crops and weeds probably had lesser effects on the farming habitat where the eye gnats propagate.

In the 1960's extensive studies on natural enemies of eye gnats were also initiated. Although a number of native and exotic parasites and predators were studied, colonized and released (Legner and Bay 1964, Legner et al. 1966), these natural enemies did not suppress eye gnat populations to a desired level.

Practical strategies for the control of eye gnats in the mid–1960's consisted of noncultivation in perennial crops and application of herbicidal oils to the cover crops or weeds prior to or soon after disking. Both these measures did not find widespread acceptance, and additionally these measures could not and cannot be practiced in field and vegetable crop fields, golf courses and other breeding grounds of *Hippelates* eye gnats. Moreover, these measures aimed toward the suppression of eye gnats in their immature stages had to be employed regardless of the productivity of a given piece of ground. Productivity of various breeding grounds producing eye gnats will change and at times a given source may produce very few or no eye gnats, but in a larvicidal scheme all breeding sources have to be treated. On account of this and other reasons discussed above, research on the development of specific control measures was initiated three years ago. These studies were conducted in cooperation with the Coachella Valley Mosquito Abatement District.

In these studies emphasis was placed on the development of measures utilizing genetic manipulations and chemical attractants. The latter approach turned out to be the most promising one under present circumstances. In the course of studies on chemical attractants and attractive baits, a dry attractive bait was developed. This bait was evaluated against field populations of eye gnats both in olfactometer and as area-wide control program.

In olfactometer studies, it was found that the bait can be extended with up to 50% of sugar by weight without detracting from the efficacy of the bait. A quick knockdown insecticide such as dichlorvos or naled or a stomach poison such as ronnel or trichlorofon in the range of 0.5–1.0% gives excellent kill of the eye gnats.

Five large-scale experiments were conducted on the efficacy of attractive baits. In one large experiment where 3500 acres of farmland and 10 golf courses were subjected to semi-weekly treatments with the bait, eye gnat populations were markedly depressed by 3–5 applications. In other tests conducted on a semi-isolated ranch, 2–3 treatments with the bait yielded excellent control of eye gnats.

The attractive baits developed for the control of eye gnats are also attractive to Muscoid and Calliphorid flies. Among the Muscoids, *Musca domestica*, *Musca autumnalis*, *Muscina*, *Fannia and Atherigonia* are attracted. At this time it is not known as to how many other arthropods are attracted to this bait. From all indications we have now, the bait developed for eye gnat control is a "specific" method. It may not be "highly specific," but it certainly looks more promising than any other control methodology available at this time. Although problems and limitations associated with the widespread use of such a bait are not known at this time, it seems that the use of specific attractive baits offers great promise for the control of eye gnats, some Muscoid and Calliphorid flies.

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EFFECTS ON METAMORPHIC DEVELOPMENT OF *CULEX* SPECIES WHEN TREATED WITH A QUATERNARY COMBINATION

Dean Leedham

Consan Pacific, Inc., Whittier

With the current public awareness of "Environment", "Ecology" and "Balance of Nature", and with the accompanying emotional movement to ban apparently all chemicals, regardless of demonstrated safety, and downright need, choosing to ignore the scientific community, seeking and getting their desired results through lawsuits or political means, extreme expediency is required to search out and develop new compounds to satisfy the new criteria, and to reevaluate older compounds, passed over and forgotten.

We do know that because of ever increasing resistance to certain classes of pesticides, and some of these of a highly toxic nature, the adverse effect others have on the biota, and certainly the overall awareness of very real environmental problems, a good deal of work is being done to find materials that will serve as good mosquito larvicides and still meet the requirements of being environmentally compatible.

Some areas of study include new petroleum derivatives, certain aliphatic amines, compounds classed as surfactants, that is those used normally in detergents and as emulsifiers, and polysubstituted organic nitrogen compounds.

Most agencies are now familiar with and even use one of the petroleum derivatives. Mulla and Georghiou have reported on various studies made on the aliphatic amines, the surfactant group and the polysubstituted organic nitrogen compounds.

Mulla (1967), in studies of the biological activities of a group of organonitrogen compounds, showed LC_{50} and LC_{90} values (24 hours) of 1.4 ppm and 3.1 ppm respectively for young larvae of *Culex pipiens quinquefasciatus*, with one of the compounds which is a mixture of alkyl dimethyl benzyl ammonium chlorides and alkyl dimethyl ethylbenzyl ammonium chlorides.

Mr. G. L. Challet, of Orange County MAD, used a similar compound this past summer (1970) and determined that a 1 ppm concentration would provide 15 days control. This test was conducted in a nonmaintained swimming pool. The species involved were *Culex peus* and *C. p. quinquefasciatus.*

Taft and Strandtman (1945) used a mixture of alkyl dimethyl benzyl ammonium chlorides in laboratory studies to determine the effect on larvae of both *Aedes aegypti* and *C. p. quinquefasciatus.* Using a 10% concentration in tap water, they determined that dilutions of 1:100,000 (1ppm) prevented hatching of eggs, killed all stages of larvae and also killed pupae. Dilutions of 1:250,000 (.4 ppm) killed first and second instar larvae of *C. p. quinquefasciatus*.

The 1:100,000 dilutions killed only first, second and third instar larvae of *A. aegypti*. They observed also that at 1:250,000 dilutions about 80% of the first instar larvae were killed, but that the remainder did not mature but remained in the stage they were in.

During the summer of 1964, Knott's Berry Farm of Buena Park, California, began using the product "Consan" for algae control in their artificial ponds. Consan is a mixture of alkyl dimethyl benzyl ammonium chlorides and alkyl dimethyl ethylbenzyl ammonium chlorides.

Several months after beginning use of "Consan" for algae control, the ground's maintenance supervisor reported a lessening of mosquitoes in the park. This continued to the point where mosquitoes were no longer a problem.

In 1965, Rose Hills Memorial Park in Whittier, California, also began the use of Consan in their ornamental pools. They also reported that after a period of use, their mosquito problem had lessened.

Similar results were reported by others, some observing the absence of larvae in pools as well.

This prompted Mr. Don Saurenman, President of Consan Pacific, to further investigate these results.

In 1966, an entomologist, Mr. R. D. Magor, was employed to conduct a series of tests to determine the effectiveness and action of Consan on mosquito larvae. Mr. Magor established a colony of *C. p. quinquefasciatus* in the laboratory and maintained this colony for the duration of the tests.

A series of four tests was conducted. These tests considered concentration, effect of media (stagnant vs. fresh water), and length of time to obtain 100% mortality of larvae. He used small glass bowls to conduct the tests in, preparing the various concentrations to be tested in 100 ml of media. Tests against all four stages of larvae were made with rather high concentrations, 15, 30 and 50 ppm. Late third and fourth instar larvae were used in this test and some of the larvae pupated during the test. All larvae and pupae were dead by the ninth day at these rates.

In all tests, six replicates were made. The balance of the tests utilized concentrations of 0.5, 1.25, 2.5, and 5 ppm, Consan, active basis. Seventy percent of the larvae in all tests were killed by the end of the second day. A few individuals survived through to the fifteenth day in stagnant water and at the 1.25 ppm rate. There was no imaginal development in any of the tests, and there was not any significant difference between fresh and stagnant water. The highest percentage of mortality in all tests occurred at ecdyses.

The mode of action of quaternaries on mosquito larvae has been rather broadly described as "surfactant action". This seems a bit of a simplification, but on further analysis is at least partly correct.

Quaternaries do have surface tension reducing properties. Consan at .0001%, 1 ppm, has a surface tension of 49 dynes/cm. At .001% the surface tension is 46 dynes/cm. Distilled water has a surface tension of 72 dynes/cm.

Among other properties of quaternaries to be considered are their keratolytic and emollient actions. These are somewhat important properties in considering mode of action. Keratolytic refers to action on the scleroproteins, and emollient means both soothing and softening.

The action on proteins was recently demonstrated by Cheo (1970), who found the protein covering of tobacco mosaic virus particles was immediately coagulated when treated with a 400 ppm solution. In these tests he used Consan as a source of quaternary.

The high mortality rate of mosquito larvae at ecdyses, when treated with quaternaries, becomes meaningful when compared to results reported by Taft (1945). He concludes in tests conducted on several invertebrates such as Paramecia, Euglena, Planaria, an annelid worm, *Euchytrae albidus* and Crepidulae (a cilliate) that the type of protective covering of an animal determines the effect quats will have. The most affected would be those animals with a flexible, permeable covering. Further work is being done on the mode of action of Consan.

The tests reported in this paper indicate the action of quaternaries and in particular Consan, to be biostatic in nature.

In most screening tests for mosquito larvicides, only those showing good biocidal activity are considered, and for very valid reasons. However, it is conceivable that fast population decimation is not always necessary and therefore the slower acting materials would be of value. Some suggested areas for use of materials of this type would be abandoned or non-maintained swimming pools, flower containers in memorial parks, dairy drains, artificial ponds, bilges of boats and many others.

The effectiveness of certain quaternaries in mosquito larval control has been demonstrated, with an indication of the mode of action. In light of these results, it is suggested that products of this type be not only further looked at, but put into use for the specialty "spot" treatment applications they fit into so well.

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PHENOTHIAZINE AS A MOSQUITO LARVICIDE

Richard C. Husbands and Lawrence L. Lewallen
California State Department of Public Health, Fresno

Phenothiazine (thiodiphenylamine), which was synthesized by Bernthsen in 1883, was investigated in 1934 by Campbell et al. and was found to be an effective insecticide in laboratory tests on culicine larvae. In a relatively short period of time following his discovery, this material was tested on a wide variety of insects both in the laboratory and field by researchers in several countries. Among these were the following: Bushland (1947); Chandler (1944); Deonier et al. (1945); Dobrosmuislov (1945); Eide et al. (1945); Fink et al. (1938); Gersdorff and Claborne (1938); Ginsburg (1944); Ivanov (1949); Jordan et al. (1941); King (1938); Mail (1936); Nesterw-Odskaja and Lubinski (1946); Shemelinin (1947); Smith et al. (1935, 1937, 1938); Siganur and Bagira (1945); Vainberg et al. (1946); Velbringer (1947); Viktorov et al. (1947); Weidner (1950); Yates (1946); and Zuker (1944). Among the many other insects tested, results were also obtained on the Clear Lake gnat (Deonier and Lindquist 1942) and on *Aedes*, *Culex*, and *Anopheles* mosquitoes. When the mosquito species were indicated, these tests included ***Aedes aegypti*, *A. vexans*, *A. sticticus*, *Anopheles punctulatus*, *A. maculipennis*, *Culex quinquefasciatus*, *C. annulirostris*, *C. territans*, *C. pipiens***, and *Armigeres milnenises*.

This compound failed to develop into a widley used insecticide because of several factors. First, it had to compete with the wonder insecticide, DDT, which was being developed at this same time; secondly, it appeared to be useful on some insects but failed completely on others; thirdly, it was erratic in its action and for some unknown reason did not give the same results from test to test; fourthly, it was never formulated to take advantage of its peculiar properties or applied to obtain optimum action from the formulation; and fifthly, its breakdown products were not determined from field measurements so that the effects of these residues could be evaluated in terms of their action on other insects (predators), fish, and other biota. Although laboratory tests had been conducted by several researchers to determine the influence of solubilizers (such as acetone and alcohol) upon the effectiveness of phenothiazine, the results were far from satisfactory since these tests did not take into consideration the dynamic effect of sunlight on this material which could result in the activation and deactivation of phenothiazine and its breakdown products. Sunlight will enhance the in vitro toxic action of certain compounds (Clark 1922) (Efimov 1923), and this should be considered in any laboratory evaluation of phenothiazine.

Additional confusion has been developed from the great variety of formulations that were applied in field tests for mosquito control. Aerial applications have been reported in which phenothiazine was mixed with road dust, talc, soap, petroleum products (kerosene, diesel oil, crankcase drainings), and unknown surface active agents. These were usually successful, but the results were erratic since time of application (morning vs. evening) and formulation were not given due consideration along with habitat variation.

Phenothiazine, which is practically insoluable in water, is oxidized to two components, phenothiazone and (which is further oxidized to) thionol. This occurs both in air and water in the presence of sunlight. Fink et al. (1938) found that the oxidation product, phenothiazone, was only 1/100 as toxic to *Culex* larvae as the parent compound. Gersdorff and Claborne (1938) also showed in the laboratory that phenothiazone is not toxic to mosquito larvae but that goldfish were ten times more susceptible to phenothiazone than to phenothiazine. Phenothiazone was also found to possess highly potent fungicidal properties (Goldsworthy and Green, 1939).

In 1964 while investigating the photodynamic action of certain photosensitizing compounds on mosquito larvae, the senior author discovered that the chemical structure of phenothiazine was similar to a class of compounds that were under study and which had been determined to result in the cellular photolysis and death in treated larvae. Further tests indicated that under certain conditions sunlight influenced the toxic action of phenothiazine in mosquito larvae. Additional tests were designed to investigate this observation and to determine if the action of sunlight enhanced or limited the insecticidal effectiveness of this chemical and if this action was influenced by the material that was used to solubilize the phenothiazine.

MATERIALS AND METHODS

Laboratory Tests:

Micronized phenothiazine (average 4 microns) was used to prepare a 20% solubilized (Tween 80) solution. Two separate stock solutions were prepared from this 20% solubilized material. One solution was prepared in distilled water and the other was prepared in acetone. Each of these was used to prepare the final dilutions which were replicated and tested at the same time. Each test consisted of 20 fourth-instar *Culex pipiens quinquefasciatus* larvae in 99 ml of distilled water in glass containers. Stock solutions were kept in the dark and were prepared 24 hours before each test. Each test was prepared by adding 1 ml of the properly diluted solutions to the water containing the larvae to produce the desired concentrations of phenothiazine.

Larvae were treated and held in each solution during the entire period of each test (24 hours). Sunlight-exposed larvae were treated as follows: the larvae were treated with the phenothiazine solution and were held in total darkness for

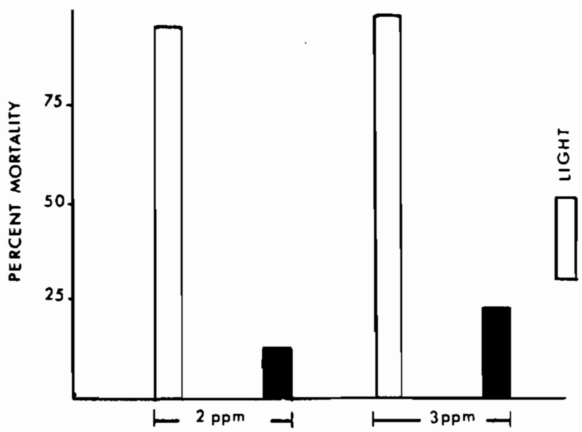

Figure 1.–Percent mortality of *Culex pipiens quinquefasciatus* 4th instar larvae treated with solubilized (Tween 80) phenothiazine when exposed either to sunlight or darkness.

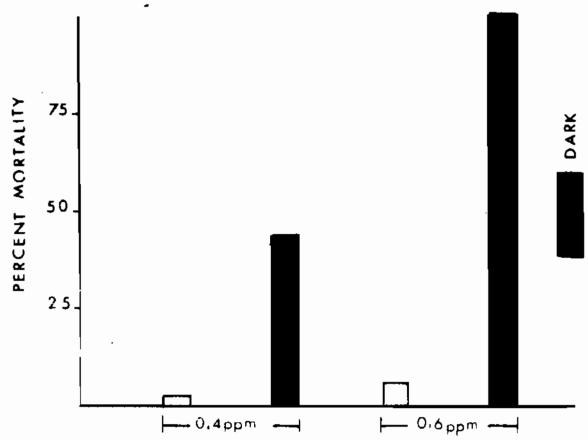

Figure 2.–Percent mortality of *Culex pipiens quinquefasciatus* 4th instar larvae treated with acetone solubilized phenothiazine when exposed either to sunlight or darkness.

two hours which then was followed by three hours of exposure to mid-day sunlight. The treated larvae were then returned to total darkness. Mortalities were determined at the end of 24 hours. In order to provide a comparison and to determine the toxic action in the absence of sunlight, replicated tests were also run in total darkness at each of the dilutions used for the tests that were run in sunlight. Untreated controls were also run in distilled water, both in sunlight and in total darkness.

Preliminary results were obtained from larvae treated at 2 and 3 ppm which revealed that the acetone diluted Tween 80 material was much more toxic than the same material without acetone. Since the purpose of this experiment was to investigate the in vivo activation and in vitro deactivation of phenothiazine in sunlight and not the effect of solvents upon the toxic action of phenothiazine, it was necessary to reduce the concentration of the acetone diluted material to 0.4 and 0.6 ppm in order to demonstrate the light and dark action of phenothiazine with this solvent.

RESULTS OF LABORATORY TESTS

Figure 1 illustrates the results that were obtained with dilutions made from the (Tween 80) solubilized 20% phenothiazine. Larvae exposed to sunlight which had been treated with 2 and 3 ppm Tween 80 solubilized phenothiazine show average mortalities of 95% and 97%. The larvae that were maintained in these dilutions in total darkness for 24 hours show average mortalities of 17% and 24%. (The surviving larvae recovered completely and were able to produce viable adults.)

Figure 2 gives the results of tests on larvae with the acetone stock solutions of phenothiazine diluted to 0.4 and 0.6 ppm. Treated larvae exposed to sunlight gave average mortalities of 4% and 8% respectively. Similarly treated larvae which were maintained in darkness show mortalities of 40% and 100%. The controls of untreated larvae showed no mortality both in sunlight and in total darkness.

DISCUSSION

Some experimental results were obtained which indicated that phenothiazine will produce a photodynamic effect in mosquito larvae when the larvae are exposed to sunlight. This action was only demonstrated in the 2 and 3 ppm solutions which were prepared from the 20% solubilized phenothiazine.

The greatest amount of phenothiazine that can be dissolved in the Tween 80 is approximately 20%. The addition of this 20% material to water will cause some of the phenothiazine to be thrown out of solution. At the dilutions used, approximately 30% of the material will be precipitated as extremely fine particles. Apparently this material is picked up by the larvae in sufficient quantity to provide a basis for the photochemical action before it can be deactivated (converted to its oxidation products) in solution by the action of sunlight. At these dilutions, the dark-exposed larvae apparently did not obtain sufficient phenothiazine to produce high mortalities.

The absence of a photodynamic action in the acetone diluted material can possibly be explained by the additive solubilizing action of the acetone when it is added to the residual solubilizing effects of the Tween 80. This produces a product in the final dilutions (0.4 and 0.6 ppm) with a substantial part of the phenothiazine remaining in solution. Apparently, while it is in this state it is rapidly oxidized to phenothiazone or thionol by the action of sunlight without causing the photodynamic action. However, in total darkness the soluble phenothiazine is much more toxic provided it has sufficient time to affect the larvae adversely.

The different actions obtained from these two methods of solubilizing phenothiazine illustrate the importance of

Table 1.–Field tests with phenothiazine 18.5% solution on *Aedes nigromaculis* larvae, Kings County, California.

DATE	TIME OF APPLICATION	RATE	STAGE	24 HOUR MORTALITY
9/29/70	11:40 a.m.	0.6 lb/acre	2nd instar	75.0%
9/29/70	6:45 p.m.	0.6 lb/acre	2nd a instar	100.0%
10/ 8/70	12:15 p.m.	1.2 lb/acre	3rd &4th instar	93.0%
10/ 8/70	6:25 p.m.	1.2 lb/acre	3rd & 4th instar	99.0%

Table 2.–Field tests with phenothiazine 18.5% solution on *Culex tarsalis* larvae, Merced and Kings Counties, California.

DATE	TIME OF APPLICATION	RATE	STAGE	LOCATION	24 HOUR MORTALITY
10/13/70	3:00 p.m.	1.2 lb/acre	3rd & 4th instar	Kings County	100.0%
10/14/70	1:00 p.m.	1.2 lb/acre	3rd & 4th instar	Kings County	100.0%
10/29/70	10:30 a.m.	1.2 lb/acre	2nd, 3rd & 4th instar	Merced County	100.0%

developing a suitable formulation for the conditions under which the material will be used in the field. The action of sunlight is a significant factor in each of the cases demonstrated and it would appear that the success of field applications is greatly dependent upon the formulation selected for treatment and the timing of application.

1970 FIELD TESTS

Field tests conducted during 1970 demonstrated that phenothiazine is an effective control agent on larvae of *Aedes nigromaculis* and *Culex tarsalis* at a dosage of 1.2 lbs/acre.

Most of these tests were carried out on irrigated pastures in Kings County where insecticide resistance levels are extremely high in both species. Plots were laid out measuring 1/32 acre in size in fairly open water or with extensive vegetative cover. Water depth varied from one or two inches to six inches or more. Pre-treatment and post-treatment larval density was determined by taking 20 random dips within each plot. Aliquots of an 18.5% solution of phenothiazine formulated in Tween 80 were diluted with ½ gallon of water to form the finished spray which was applied with a one-gallon sprayer pumped to 30 psi and fitted with an 8004 Teejet fan nozzle on the wand. Post-treatment counts were made at 24 hours, although it was noted that within 3 to 4 hours most of the killing effect had already been manifested.

Difficulty in plating out of the phenothiazine in the spray can was experienced and some tests were done with the 18.5% solution cut with an equal part of acetone or propylene glycol. Although this tended to alleviate the plating, it did not overcome it. In routine applications this would be a nuisance factor. Hot water with vigorous shaking followed with an acetone rinse or acetone alone was required to clean up the spray can.

Applicators should be careful to avoid spillage of phenothiazine on the skin since some people are sensitive to this compound and experience a skin reaction.

This compound can also cause staining of fabrics or other objects; therefore, great care should be exercised in controlling where the material is placed.

To determine the effects of sunlight, both daytime and late evening applications were made. At the 1.2 lb/acre rate on third and fourth instar *A. nigromaculis* larval, no great difference in daytime versus evening applications was apparent, but at 0.6 lb/acre on second instar larvae the evening applications were superior to daytime applications. Results of these tests are shown in Table 1.

Limited tests run on *Culex tarsalis* indicated that phenothiazine is also an effective control agent on this species. Results obtained at the 1.2 lb/acre rate seemed to indicate that a lower dosage might be just as effective, but time limitations did not permit verification of this. The tests on *Culex tarsalis* are shown in Table 2.

DISCUSSION OF FIELD TESTS

Some of the early work with phenothiazine indicated erratic results when this material was tested as an insecticide in the field. This may have been due in part to a lack of awareness of the importance of particle size (a range of 2 to 8 microns is most effective) and the effect of sunlight on the compound.

Formulation is also an important aspect that can affect results. Drench grade formulations for use on livestock cannot be used in the manner described here.

Although there are disadvantages to the Tween 80 formulation, it could be used in control programs, but it is hoped a better formulation can be devised for reasons noted previously.

This work has indicated that phenothiazine can be used effectively against highly resistant populations of mosquito larvae and perhaps the acute need for such a material will result in the solution of difficulties now associated with its use as a mosquito larvicide.

Samples of phenothiazine for this work were kindly furnished by West Chemical Products, Inc., 42–16 West Street, Long Island City, New York 11101.

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MOSQUITO CONTROL AND LAKE TAHOE'S NATURAL COMMUNITIES — ARE THEY COMPATIBLE?

Fred C. Roberts
El Dorado County Service Area No. 3, South Lake Tahoe

The purpose of this paper is to present some of the problems associated with insect control in forest recreation areas. No attempt will be made to describe those very complex problems that have to be solved in order to establish mosquito control. Instead the presentation will be dealing with the special problems that arise, or are accentuated, when mosquito control impinges upon natural communities.

HISTORY

Mosquito control began in the El Dorado County portion of the Tahoe Basin in 1963 when County Service Area No. 3 was formed. The purpose of the service area, as established in the 1963 resolution of the County Board of Supervisors, is to provide the citizens with control of insects adversely affecting man and plant-life. Since the service area was created primarily because of mosquito problems, the first few years were spent concentrating upon mosquito control. Recently the control program has broadened into efforts to establish integrated mosquito control and also to fulfill our responsibilities in the control of insects affecting plant-life. These problems are tremendously challenging in themselves, but we also intend to have full knowledge and take responsibility for the impact our agency has on the natural communities.

The desire to preserve the natural beauty of the Tahoe Basin has been expressed by many. Perhaps the best indicators of their seriousness is evidenced by some rather recent changes within the Tahoe Basin:

1. The proliferation of organizations with the goal to preserve Lake Tahoe (League to Save Lake Tahoe, Lake Tahoe Area Council, Voice of Conservation at Lake Tahoe, Lake Tahoe Environmental Institute).
2. The active participation of national conservation groups (The National Wildlife Federation, The Sierra Club).
3. The construction of one of the worlds two most modern and effective sewage reclamation plants.
4. The export of all reclaimed water and solid waste.
5. The formation of a basin-wide Tahoe Regional Planning Agency.

The responsibility to coordinate all planning within the Tahoe Basin has recently been shouldered by the Tahoe Regional Planning Agency. It is made up of representatives of the Federal Government, from Nevada and California, the four counties and two municipalities within the basin. The regional-coordinating agency has met local resistance in some cases, but has developed an aggressive program to preserve the basin. They have begun by accumulating basic environmental data from the best available technicians. This basic information, with the aid of a computer, will go into a planning method that approaches the systems-analysis method. The ultimate goal is to insure that man's changes are not beyond the buffering ability of the natural communities.

ADVERSE IMPACT

Mosquito control may have adverse impact upon natural environments in at least five ways:

1. The introduction of unknown compounds
2. The introduction of nutritive compounds
3. The introduction of exotic species
4. The removal of species occupying essential niches
5. The alteration of the landscape

The introduction of unknown compounds is a matter of course with nearly all mosquito control agencies. The residues of the organic insecticides and their fate in the treated ecosystems is often not known. If we are to understand what consequences our insecticides will have on the natural system, we must know what the residues are, and where they are going in the system.

It is possible that our agency may use insecticides of nutritive value to produce organisms. If the organophosphate insecticides broke down in such a way as to result in free phosphates, the introduction of the phosphates to Lake Tahoe through run-off water could be stimulatory to algal growth. If this were the case, our agency would simply be another ramification of development of the basin that has increased the eutophication rate of Lake Tahoe.

In the course of biological control, a mosquito control agency may introduce an exotic species that represents a type of contamination in a natural environment. The damage may be merely the loss of a few competing native species or it may bring the total collapse of an entire community (Ehrenfeld 1970). Although the range of exotic organisms a mosquito control agency may transplant is limited to those of mosquito control value, great care should be taken to insure that the consequences of such a transplant are thoroughly understood. The literature is replete with examples of intentional transplants that have brought about unforeseen ecological consequences (Ehrenfeld 1970).

Mosquito control methods, both chemical and biological, may remove species that occupy essential niches in an ecosystem. Perhaps the best example of this problem can be provided by our agency. In the early development years, it was expedient to completely depend upon thermal fogging to establish control. As early as 1963, this type of broad spectrum approach was criticized when occurring in a natural environment (Odum 1963). The parasite-predator complex of the pine-needle scale seemed to have been severely depressed by the systematic mosquito control fogging (Dahlsten et al. 1969). The result was a dramatic increase of the scale insects until they threatened Jeffrey and Lodgepole pines in 1,280 acres of the service area (Hunt 1969). Our agency depended completely on larviciding over the past two mosquito seasons and observations indicate that the scale population is reduced on the new growth of both pine species. The correction of the scale problem with the Jeffrey pine, because of a complication in the scale life cycle, has not been as dramatic as with the Lodgepole pine. Some Jeffrey pine stands are severely weakened and the change to larviciding may have occurred too late to save them.

Alteration of landscape is another way a mosquito control agency can impact natural environments. Source reduction is essentially changing habitat. Not only might the habitat changes of source reduction be aesthetically repulsive to the basin citizens, but biological ramifications, such as soil loss and nutrient release, might also occur that would endanger the natural communities.

INSECTICIDE CONTROVERSY

Our mosquito control agencies are deeply involved in the present pesticide controversy. Before factions of either side should assume that this presentation is taking sides, a simple illustration should indicate that the problems covered in this presentation transcend the controversy. Peakall (1970) suggests that the use of certain insecticides represents a grave danger to bird populations. Dr. J. Gordon Edwards (1970), however, states that pest control may actually increase bird populations. Either one of these eventualities should be circumvented. A dramatic increase or a dramatic decrease in bird populations at Lake Tahoe could threaten the natural communities.

SOLUTION

When a mosquito control agency recognizes the potential harm it can cause natural communities, a significant change occurs in its self-image. No longer can the agency have the luxury of simply considering itself the citizens' protector against pest and vector mosquitoes. The agency recognizes itself as another potentially destructive force of development – another freeway, another parking lot, another condominum. Such an agency must recognize that no matter how carefully measured its impacts may be, when added to the forces of other development, they may be destructive. It is therefore logical that the agency should fully cooperate with a "regulatory agency" that would take responsibility for the regulation of all the forces of development to insure that the degree of impact remains below the level that the natural communities can buffer.

Is mosquito control compatible with the natural environment of the Tahoe Basin? This question cannot be answered at present. In the meantime our agency will use all of the scientific resources we have available to reduce the impact of our insect control on natural communities and still provide insect "control". We will continue to recognize the need for a regulatory agency that will unify all of the ecologically interdependent actions of agencies, corporations or individuals. Therein lies the answer to the question we have posed.

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SOLUTION TO A DRAINAGE PROBLEM IN A SIMULATED PASTURE WITH IMPLICATIONS FOR ITS APPLICATION IN ACTUAL PASTURES

Leyburn F. Lewis and Darrel M. Christenson
United States Department of Agriculture, Fresno

In 1969, the U.S. Department of Agriculture and Fresno State College entered into a cooperative agreement for research of mutual interest. The College contributed land and assistance for the establishment of a small pasture for mosquito studies. This paper reports on one aspect of this cooperative endeavor in the pasture. Personnel of our Western Insects Affecting Man and Animals Investigations in Fresno, with the help of Fresno State College, constructed thirty-one experimental depressions (or plots) each about one foot deep by six feet wide by nine feet long in the small pasture. The banks of each depression sloped at a 45° angle so when water was six inches deep in the plot the surface area of the water covered 0.001 of an acre. Since the primary purpose of these plots was to hold water at a rather constant level, each one was lined with a continuous sheet of 6 mil polyethylene plastic film and covered with soil at a minimum thickness of 10 inches. Water for irrigation was provided by an automatic sprinkling system.

The plots were completed so late in the fall of 1969 that they were seeded initially with annual rye grass only. Seeds of a typical pasture mix for the Fresno area were sowed in the late spring of 1970 and a good initial stand and good early growth were obtained.

We had anticipated that adequate drainage would not occur within the plastic-line depressions during the winter months, and accordingly planned to keep them drained with a sump pump. We were unaware until the seasonal rains actually came that the whole pasture area was partially underlain by a hardpan. Nevertheless, the combination of plastic and hardpan caused but minor drainage problems through the winter and early spring.

However the onset of the region's usual hot summer temperature and low humidity necessitated a sharp increase in the volume of irrigation water in order to keep the pasture in a good state of production—or, in fact, even to keep the grass and legumes alive at all. The stepped-up irrigation schedule caused water to accumulate in some of the depressions to an extent that resulted in mosquito production unless the plots were bailed out every few days. And the problem remained unmitigated through several modifications in the design of the sprinkling system and numerous alterations in the watering schedules. We then tried a 6-inch diameter hole through the 10 inches of soil in the bottom of the most troublesome plot and removed a 6-inch-diameter disk of the underlying plastic. This gave relief for only a short time as the soil between the plastic and the underlying hardpan rapidly became saturated and water again accumulated in the plot. A 4-inch posthole auger was then used to extend the hole to a depth of about three feet. This three-foot deep hole resulted in adequate drainage in that particular plot. A similar hole was bored in other troublesome depressions and in each instance the drainage problem was eliminated.

We then seriously addressed ourselves to the proposition that similar vertical drainage might be used in some situations in other pastures with a natural drainage problem. Two difficulties were readily apparent: (1) Open holes in pastures can not be tolerated because of hazards to livestock; (2) The removal of surplus water only should be accomplished, not the siphoning off of water needed for plant growth. Both problems apparently were solved satisfactorily by filling the holes with coarse aggregate toped off with a few inches of rich loam. In several trials in the experimental plots, starting with six to eight inches of water, depressions that still held water after a week with a six-inch-diameter hole in the plastic, drained within 24 hours when a four-inch-diameter hole of adequate depth was excavated and refilled with coarse aggregate topped off with a few inches of loam. The aggregate served adequately to keep the holes open, the loam provided a top layer that not only filtered the water slowly but at the same time supported plant growth.

Loam is believed necessary for the top layer of the holes so that plant roots can help hold the top soil from sifting downward through the aggregate and provide avenues through the soil for surplus water. The column of coarse aggregate should not itself become cemented together to an extent that it becomes impervious to water, nor should it interfere in any way with future farming activities. The column can be plowed over or through, disced over or through, leveled over, or subsoiled without inconvenience, damage, or other interference. Seed drills or planters should operate without interference or harm over or through the column.

Further discussion should be made of the statement above that a hole of adequate depth is required for good drainage. California's Central Valley soils, as with all alluvial soils, were, of course, laid down in layers some of which are more permeable than others. We obtained better drainage when our holes were bored through the hardpan into an underlying sandy layer than when they terminated within the hardpan. We are here defining a hardpan as being any water-impervious layer, whether it is an iron- or lime-cemented stratum, or a plowsole or plowpan. All result in poor drainage and mosquito production. The deepest we found it necessary to bore was about 6½ feet, but most holes were less than four feet.

As a preliminary to initiating further research on the technique we consulted Fresno-based personnel of the ARS

Soil and Water Conservation Research Division (Ground Water Recharge Research Project) and the California Water Quality Control Board. Both groups expressed interest in such a project.

The chief reason we believe the above technique warrants further investigation is that there are pastures in the San Joaquin Valley in which all attempts at chemical mosquito control have been abandoned because of insecticide resistance. Because of that resistance the need is great for any additional method of drainage in pastures, especially in small acreages near urban areas where the owners keep a horse or two but have no equipment for subsoiling, releveling, or constructing recycling systems and where but little chance exists for alternative cropping systems. Techniques are needed also for eliminating troublesome areas in larger pastures that otherwise are adequately leveled and drained. Some of the things we need to ascertain experimentally are: (1) The optimum depth and diameter of holes for effective drainage. (2) How large an area on the average will one hole drain? (3) How much loam should be placed on top of a column of aggregate?

We believe the boring of holes poses no great problem. Construction should in no way interfere with normal land usage, either during the boring process or later. Appropriate tractor or vehicular mounted posthole diggers can excavate many holes per day. Coarse aggregate is relatively cheap and relatively easy to place in holes. Rich loam will be available in every pasture. Additionally, vertical drainage, as with any type of drainage, should result in greater tonnage of forage per acre in the drained area.

DISTRICT'S EXPERIENCE USING PRIVATE CONTRACTORS FOR VEHICLE AND EQUIPMENT MAINTENANCE

E. L. Geveshausen and Gardner C. McFarland

Southeast Mosquito Abatement District, South Gate

One of the important expenses of operation of mosquito abatement districts is that of vehicle and equipment maintenance. This expense is characteristic of any operation involving motor vehicles, mechanical equipment such as sprayers, engines, compressors, office, shop and yard facilities such as gasoline pumps and air conditioners.

Several factors involving vehicle and spray equipment are most important in mosquito and other vector control operations.

1. The vehicles and equipment have to be functional, so that the time of the control operator is most efficiently utilized. This is particularly important since the major cost of most operations is labor cost.
2. Vehicles and equipment must be in top operating condition, particularly during the operational season, to provide efficient ulitization of labor.
3. Spare equipment must be kept to a minimum to minimize inventory costs, standby deterioration, and to keep storage space as small as possible.

A regular program of vehicle and equipment replacement is necessary, tailored to the usage. In addition, consideration must be given to obsolesence. When new, more efficient equipment is presented at the market place, careful evaluation will determine whether immediate replacement should be made regardless of the regular replacement program. An example is that of the introduction of right-hand drive, automatic transmission Jeeps and Scouts. Our District determined that such equipment could allow one-man operations. Trade-in losses of standard drive vehicles were minor in comparison to savings in labor costs. Operational vehicles are replaced after 25,000 miles service and not later than five years of operation. Staff vehicles are replaced between service of two to four years and with maximum mileage of 50,000 miles. This program with staff vehicles is predicated on a favorable new-car purchase availability through the General Services of the State of California and favorable prices received from bid offers for the used staff cars.

Mention was made of the requirement that vehicles must be in top-operating condition. Nothing is more frustrating than to have vehicles non-operational at the time of heaviest usage. Vehicles will break down, however, under the best of maintenance. The decision then is whether to have a vehicle and equipment maintenance division, In-House, so to speak, or to make arrangements for the maintenance by an outside garage.

We have determined that the best program for our District is to have the major part of motor vehicle maintenance performed by privately operated garages. Selection of such facilities is determined by the following criteria:

1. Proximity to vehicle storage areas
2. Motor vehicle service capability
3. Reliability
4. Parts charges
5. Labor charges
6. Agreement for immediate service of vehicles when vehicle need is urgent
7. Capacity for service of at least three vehicles concurrently

The decision to use private garages for motor vehicle maintenance rather than employ vehicle and equipment mechanics was based on relative costs and shop capability. When considering the cost of one mechanic employed at a yearly gross salary of $10,380 in our area, $1,647 per year must be added for fringe benefits for a total of $12,027 yearly cost to the District. By comparison, the labor cost for major motor vehicle service by private garages is listed as follows:

July 1, 1968 – June 30, 1969	$1,670.45
July 1, 1969 – June 30, 1970	$1,973.20

Vehicles in the District fleet at two separate yards include 41 vehicles as follows: South Gate – 2 staff cars, 1 staff station wagon, 1 utility pickup truck, and 20 Jeeps and Scouts. North Hollywood – 1 staff pickup truck, 16 Jeeps and Scouts.

No parts are included in the evaluation since such items are the same wherever the service is performed. Parts provided by the two vehicle repair garages came to a total of $2,243.35 in the 1969-1970 fiscal year.

Even though no motor vehicle mechanic or mechanics as such are employed, the operational personnel do perform certain maintenance and garage functions:

1. All operational employees are responsible for maintenance of vehicles assigned to them which includes:
   a. Vehicle wash and cleanup
   b. Steam cleaning
   c. Tire change and repair
   d. Lubrication including filter changes
   e. Gasoline and oil service
2. In addition, Senior Inspector-Operators, when time permits and during winter months and inclement weather, perform several motor vehicle maintenance functions:
   a. Preparation and painting of operational vehicles including minor body and fender work
   b. Brake maintenance and replacement
   c. Minor tuneups
   d. Repair and replacement of accessories such as seat belts and mirrors
   e. Tire balancing
3. Senior Inspector-Operators also install, adjust, and repair all spray equipment, both hand and motor vehicle mounted.

All operational personnel are assigned other maintenance duties including:

1. Building maintenance – cleanup, painting
2. Outside yard cleanup
3. Minor service of facilities such as replacement of furnace and air conditioner filters
4. Minor steam cleaner repair and service
5. Necessary gardening
6. Minor electrical service such as replacement of switches and plugs
7. Minor plumbing repairs such as replacement of washers
8. Carpentry work as needed such as installation of shelves, racks, and sheathing

The number of man hours expended by all operators for motor vehicle maintenance amounted to 1612 man hours in the fiscal year, 1969-1970. Of this time, 1322 man hours were involved in steam cleaning of vehicles, tire repair, lubrication, and oil changes. Two hundred and ninety man hours were expended in brake work, minor tuneups, spark plug changes and painting, and other mechanical work.

In conclusion, we are of the opinion that outside automotive maintenance in private shops is more economical, more flexible, and more useful, particularly in the period of maximum use of equipment.

LABORATORY AND FIELD STUDIES OF A NEW CHIRONOMID SPECIES IN THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

Frank W. Pelsue and Gardner C. McFarland
Southeast Mosquito Abatement District, South Gate

Control of Chironomid midges has been a major activity of the Southeast Mosquito Abatement District (SEMAD) for a number of years. Since 1952, urbanization of the areas adjacent to water spreading basins, flood control dams, and flood control channels have resulted in an increase of midge species causing discomfort to residents and economic loss to industry.

When the Southeast Mosquito Abatement District was first formed, the only major midge producing areas were the Los Angeles, San Gabriel, and Rio Hondo Rivers and the Rio Hondo Spreading Basins. As industry and housing encroached in these areas, it became clear that midge control as well as mosquito control was necessary. Gardner McFarland, Manager of the Southeast Mosquito Abatement District, recognized that economical control of pest midges would have to be instituted. However, the available literature regarding midge control was rather limited. The District, along with the California State Health Department's

Bureau of Vector Control and Solid Waste Management, and Los Angeles County Flood Control District approached the University of California at Riverside, for the purpose of initiating a research project on the control of Chironomid midges. In 1959 an agreement between the Los Angeles County Flood Control District and the University of California at Riverside was reached and the research project was started. The data obtained from this project have provided the basis for midge control throughout the State.

We have found over the years that concrete flood control channels, rivers, earthen water spreading basins, recent man-made lakes, and sewage stabilization lagoons provide an ideal habitat for midge production. The primary reason for this was the prevention of the establishment of a balanced biota, due to intermittent waters, and highly polluted waters.

In past years, the primary control measures used against pest midges have been the planting of German carp, *Cyprinus carpio*, in approved areas, elimination of the source by draining and drying for short periods of time, and chemical control where the above mentioned procedures cannot be applied. In the areas where the Flood Control District has control of the water, midge breeding can be eliminated by drying, but under certain circumstances this is not possible so chemical means are used. Any control work done by the Southeast MAD is covered by a contract with the Flood Control District, and this contract has been renewed every year since 1962.

There are many golf course lakes and other permanent water impounds throughout the District that produce Chironomids. In these sites, we plant German carp and cat fish where feasible. Cat fish species utilized include bull heads, Channel and White cats.

Midge control is slightly more complex than mosquito control in that there is a wide variation in the susceptibility to insecticides of the various midge species that a given source may contain. One source may contain several pest species, but usually one species predominates and of course the type of situation dictates which control method is utilized. Our approach to midge control is slightly different than that of mosquito control in that the adult population level is considered before control measures are effected, whereas mosquitoes are controlled regardless of the adult occurrence.

Many insecticides have been found to be effective in controlling midge larvae by several workers (Fellton 1941; McFarland et al. 1962; Hilsenhoff 1959; Anderson et al. 1964; Anderson et al. 1965; Mezger 1967; Mulla et al. 1969). In early reports, the chlorinated hydrocarbons were the compounds of choice; however, their use was gradually phased out due to development of resistance (Lieux and Mulrennan 1956); toxicity of fish and other non-target organisms and their accumulation in the environment.

In recent years, the organophosphate insecticides have been the materials of choice. Those presently used by the Southeast Mosquito Abatement District are fenthion, ABATE®, DURSBAN®, and parathion, in certain situations. Malathion was used for midge control, but development of resistance in midges, as well as in mosquitoes and its toxicity to fish had virtually eliminated its use in the SEMAD. The insecticides used for midge control are usually in the granular form, particularly hard-core granules as they release rather slowly and tend to release on the surface of the mud the area of midge larvae concentration.

Until last year, we were able to control most of our midge species with the Public Health Protection (PHP) chemicals already mentioned. However, in 1970 we encountered a midge species we were unable to control at previously acceptable dosage rates. After bringing this species to the attention of various authorities in the field (Dr. Bay, UCR; Mr. G. Grodhaus, BVC & SWM; Dr. Mulla and Saul Frommer, UCR) we find this is probably a new species of midge in the *Chironomus* sp. (*attenuatus* complex number 51). We first encountered this species in the Coyote Creek which runs along the southeastern border of Los Angeles County. From this point we have found that it has spread throughout the District.

Presented in this paper is a preliminary report on laboratory and field studies conducted by the Southeast Mosquito Abatement District during the summer of 1970. In the remainder of the paper *Chironomus* sp. (*attenuatus* complex No. 51) found in the SEMAD will simply be referred to as species 51R as compared with a susceptible strain maintained in Dr. Mulla's laboratory at UCR, which is designated as 51S.

MATERIALS AND METHODS

Laboratory – Larval specimens of midge species 51R were collected in the Coyote Creek and Cerritos Drainage Flood Control System for study in the laboratory. The specimens were collected at irregular intervals throughout the summer for resistance testing. The screening tests were conducted using the method developed by Mulla and Khasawinah (1969). Briefly, this method consists of placing approximately 5 gm. of white sand in a 4 oz. dixie cup and adding 100 ml of tap water then carefully placing 20 larvae per cup. The larvae are allowed to equilibrate for at least one hour to allow them to construct their tubes. Any 30 mesh sand would be suitable for this procedure. However, we found that Monterey White sand is preferable due to its extremely white appearance. This white background provides excellent contrast with the bright red midge larvae, facilitating mortality determinations. Both the Monterey White and a local crystal white sand were used in the tests. The midge larvae did not seem to display any preference for either one. The insecticide in acetone was then added to each cup at various concentrations, with the mortality recorded in 24 hours.

Each test was run in duplicate and replicated three times for each insecticide tested. Results of the tests were averaged and plotted on probit log paper using dosage response lines to determine the LC_{50} and LC_{90} levels. These levels are expressed in parts per million (ppm). Each replicate was run with a check, with the mortality results in each replicate corrected using Abbot's Formula.

The criteria used for determining mortality was as follows: (1) larvae found in tubes were counted as alive, (2) larvae outside tube, but still displaying "normal" behavior after stimulation were counted as alive, (3) larvae and pupae outside tubes displaying erratic behavior or still were counted as dead, and (4) larvae and pupae eaten by healthy larvae were counted as dead.

The following insecticides were used in the study: fenthion, 0, 0-dimethyl-0- [4-(methylthio)-m-tolyl] phosphorothioate; ABATE 0,0,0,0,-tetramethyl 0,0-thiodi-p-phenylene phosphorothioate; DURSBAN 0,0-diethyl -0-3, 5, 6,-trichloro-2 pyridyl phosphorothioate, malathion, 0, 0-dimethyl-s-1, 2 di (ethoxycarbam yl) ethylphosphorodithioate, Chevron chemical RE-11775, m-sec-butylphenyl N-methyl N-(phenylthio) carbamate; SEVIN®, n-methyl-l-naphthyl-carbamate. Stock solutions of insecticide in acetone were made up from insecticides in stock at the SEMAD.

FIELD STUDIES

Our field studies were carried on in the Coyote Creek, Cerritos Channel, Maplewood Channel, and Palo Verde Channel. All of these flood control channels are located in the Greater Long Beach area. The Coyote Creek is a concrete channel with a low-flow channel down the center. During the summer, the low-flow channel is able to handle all of the run-off water from home irrigation, dairy, and industrial waste and any other sources. The low-flow channel usually builds up with bottom sediments approximately six to ten inches deep. The channel is trapizoidal in shape approximately 15 feet across at its widest point and two feet deep. The water usually runs on the average of 12 second feet (12 cubic feet of water going past a given point each second). Comparatively speaking 12 second feet in the particular low-water channel is moderately fast which compounds the problem of insecticide treatment.

Insecticides used in the Coyote Creek were DURSBAN, both E. C. and 1% Durham granules; fenthion 1% Durham granules; ABATE 1% Durham granules; methoxychlor 2% Durham granules; and Los Angeles Chemical Company emulsifiable concentrate, all at different time, of course. Granules were applied by using a PCB spreader from a Scout driving along the creek. Emulsifiable concentrate was applied using the injection method, flowing the insecticide into the water for one hour. Population samples were taken at four sites pre and post treatment, the post treatment sample being taken 48 hours after treatment. Each sample consisted of a two-scoop composite using a 6" x 3" bottom sampler. Samples were taken to the laboratory and counted using the U.C.R. Aquatic Counting Tray developed by Anderson and Bay (1962).

In the Cerritos Channel drainage system, we used 2% methoxychlor granules, 1% DURSBAN granules, 1% ABATE granules, and 5% malathion granules at different times. The dosage rates for all the materials were at 0.2 to 0.3 pounds per acre. These were applied using a PCB Spreader from an International Scout spray vehicle. The same sampling techniques mentioned above were used in these treatments as well.

Dr. Charles Schaefer, U.C. Fresno, supplied us with a sample of Chevron RE-11775 for field trials. We chose two flood control channels for these tests. Both channels are located in the Greater Long Beach area and are designated Maplewood and Palo Verde. Maplewood Channel runs parallel to the San Gabriel River for approximately one mile then empties into the S. G. River. A test plot was marked off equaling approximately one acre. The channel is approximately one mile long and 40 feet wide. The bottom is very flat so the water moves very slowly, approximately one second foot. The bottom sediment consisted of fine silt and algae. Five population samples were taken at given intervals and two check samples were taken outside the test plot area. Population samples were taken the day before treatment and post-treatment samples were taken at 24 hours and 48 hours. The Maplewood test plot was treated with Chevron Chemical RE-11775 E.C.; treatment was accomplished using an International Scout vehicle with a 100 gallon tank and a spray boom. The treatment dosage was at the rate of 0.05 lb. actual per acre. A second treatment was done using the same material in the Palo Verde channel following the same procedures as mentioned above. Dosage rate in this test was 0.1 lb. actual per acre.

Another treatment site was the Cerritos Channel in Long Beach. Population samples were taken following the same procedures mentioned earlier. This channel is concrete and flat bottomed. Only about 20% of the channel was covered by water during the summer and the water flow was about three to four second feet. We treated the channel several times during the season with ABATE 1%, DURSBAN 1% methoxychlor 2% and Malathion 5%. All four insecticides were in the granular form and were applied at the rate of 0.2 lb. actual per acre. Treatment was accomplished using proximately 22 acres. The water depth varied from 2 to 5 inches in the treatment area. The water temperature averaged approximately 22°C.

RESULTS AND DISCUSSION

Laboratory Test:

Results of the laboratory tests are shown in Table 1. There seems to be a high degree of resistance to fenthion, ABATE, and DURSBAN when these results are compared with the susceptible strain of species 51S maintained in Dr.

Table 1.–Effectiveness of several insecticides against *Chironomus* sp. (*attenuatus* complex 51 SEMAD) showing LC_{50} and LC_{90} values expressed in parts per million.

Insecticide	July, 1970		October, 1970		*Chironomus* sp. (51)[a]	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
FENTHION	0.35	1.6	0.46	2.6	0.008	0.031
ABATE	0.21	0.55	0.66	1.7	0.0007	0.0013
DURSBAN			0.33	0.75	0.00042	0.0009
MALATHION			0.025	0.047	0.0021	0.0054
RE – 11775			0.0195	0.0670		
SEVIN	0.185	0.550				

[a]A susceptible laboratory strain maintained at UCR in Dr. Mulla's laboratory.

Table 2.–This Table gives a breakdown of treatment results in the various test sites during the 1970 season.

Field Location	Date	Insecticide Used[a]	Dosage Rate	Pretreatment Larval Samples[b]	Post treatment Larval Samples	% Reduction in 48 Hours
Coyote Creek	6/9	Dursban	0.05 ppm	360		
Coyote Creek	6/9	Dursban	0.05 ppm	420	360	11
Coyote Creek	7/3	Abate	0.2 lb/a	5000	6520	0
Coyote Creek	7/7	Fenthion	0.2 lb/a	9040	1820	79
Coyote Creek	7/14	Fenthion	0.2 lb/a	6360	4300	32
Coyote Creek	9/29	Malathion	0.3 lb/a	2300	260	88
Cerritos Channel	7/22	Methoxychlor	0.25 lb/a	1560	1280	11
Cerritos Channel	7/28	Dursban	0.3 lb/a	1280	200	84
Cerritos Channel	8/18	Abate[d]	1 lb/a	4200	3640	10
Cerritos Channel	9/16	Malathion	0.2 lb/a	1700	220	85
Maplewood Channel	9/23	RE–11775[c]	0.05 lb/a	3672	1224	53
Palo Verde Channel	9/28	RE–11775	0.1 lb/a	3000	4368	0

[a]Sand granular formulations
[b]Average of composite samples expressed in number of larvae per square foot
[c]Emulsifiable concentrate
[d]Special slow release 5% granules

Mulla's laboratory at U.C.R. (Mulla and Khasawinah 1969). Although malathion tolerance is lower than that of ABATE, fenthion, and DURSBAN compared with species 51S even this is rather high. The results in this Table are based on 24 hour mortality counts. It might be interesting to note that in fenthion and DURSBAN, we did not achieve 100% kill in any of the replicates at the highest dosage of 1.0 ppm. after 72 hours of exposure. In fact, after 24 hours at the highest dosage level, all of the larvae were out of their tubes with some of the larvae still moving; but after 72 hours, some of the larvae re-entered their tubes indicating that they had not received a lethal dose of insecticide.

The dosage mortality regression lines for fenthion, ABATE, and DURSBAN shown in Figure 1 tend to indicate a rather heterogeneous population for resistance; of course, one would expect this in a field population. Selection pressure from fenthion has been rather consistant for the last 7-8 years due to routine spraying for mosquitoes. However, ABATE and DURSBAN pressure has been present for only the last 2-3 years and only in special situations prior to

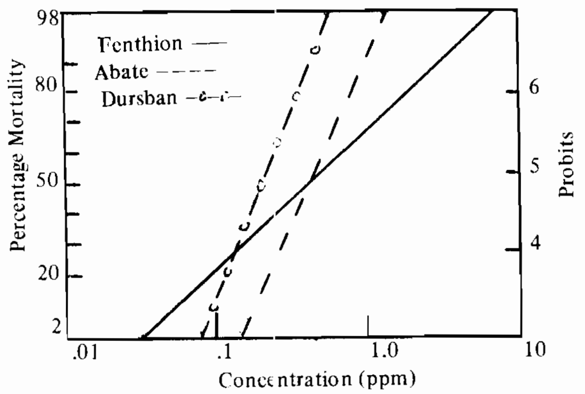

Figure 1.–Dosage mortality regression lines for fenthion, ABATE, and DURSBAN.

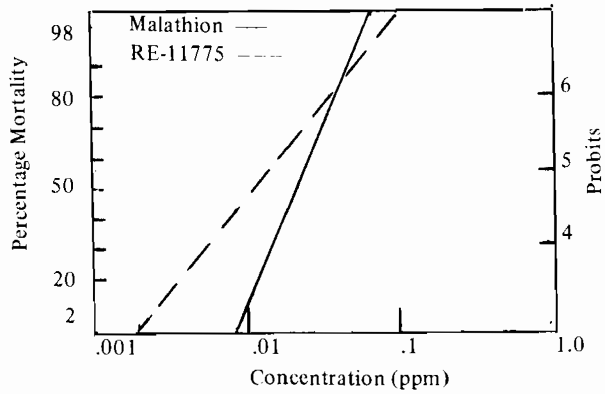

Figure 2.–Dosage mortality regression lines for malathion and RE-11775.

1970. This might mean that perhaps fenthion tolerance has imparted a cross-tolerance to ABATE and DURSBAN, similar to what occurs in some strains of mosquito species.

Regression lines shown in Figure 2 indicate a homogeneous population for malathion resistance while species 51R appears to be heterogeneous for Chevron RE-11775 with similar LC_{50} and LC_{90} values to malathion. There appears to be some very interesting biochemistry going on in this midge species relative to insecticide metabolism.

At the present time, laboratory results using malathion indicate a level of susceptibility within reasonable dosage parameters. Comparison with a susceptible laboratory strain of the same species, maintained in Dr. Mulla's laboratory at U.C.R., show approximately a 10-fold resistance level for species 51R. This would tend to indicate that malathion susceptibility will fail with subsequent selection in the 1971 season, leaving us without a suitable means of chemical control.

Tests using SEVIN showed susceptibility levels on a par with ABATE indicating either cross-resistance imparted by O.P. compounds or a natural tolerance to SEVIN. The former is probably true as laboratory experiments with another "new" carbamate, Chevron RE-11775, showed a level of susceptibility approximately 10-fold below that of SEVIN, but on a par with malathion susceptibility.

FIELD STUDIES

In the fall of 1969, we first noticed a population buildup of species 51R in the Coyote Creek. We had received quite a number of complaints from residents in the area, consequently control measures were effected. Dursban granules were applied to the infested areas at a rate of 0.1 lb. per acre. Present along with species 51R was *Tanypus grodhause*. As *T. grodhausi* is rather tolerant, at acceptible dosage rates, to fenthion and ABATE (Mulla et al. 1969) we chose DURSBAN for the treatment. Treatment results using DURSBAN at this time were very good. It should be kept in mind, that during the 1969 season fenthion was routinely sprayed in the Coyote Creek for mosquito control.

We first noticed a buildup of species 51R in June of 1970. Prior to this time, we had treated Coyote Creek for two other species of midge using DURSBAN emulsifiable concentrate. These species were eliminated and replaced by species 51R. If species 51R was present prior to June, the population must have been at a very low level, as no specimens were found in larvae samples during this period. Approximately three weeks after the first treatment, a heavy population was found in the Coyote Creek. We treated this time using 1% ABATE granules at a rate of 0.1 lb. per acre. Post treatment samples showed no reduction in the larval population.

Four days later, we treated with 1% fenthion granules at a rate of 0.2 lb. per acre. This time we reduced the larval population from 10,000 larvae per sq. ft. to 3000 per sq. ft. representing a sizeable reduction; however, this was still well above the nuisance threshold. Next we tried methoxychlor emusifiable and granules with little or no results. The larval population continued building and so did the complaints; so we tried fenthion again receiving approximately a 50% reduction still not below the nuisance threshold.

In the meantime, we were finding species 51R in other areas and receiving complaints as well. At this time, we contacted the Los Angeles County Flood Control District and requested that Coyote Creek be cleaned. After much deliberation, they consented to clean the low-flow channel. They also cleaned several other channels that were infested, but population reduction was only temporary. Within a few weeks, population levels were again above the nuisance threshold level although below the maximum populations before cleaning.

In the meantime, Orange County MAD was having similar problems with the same species of midge and the same insecticides. However, they tried everything in their insecticide shed and found that malathion would control species 51R, the SEMAD treated their channels infested with species 51R achieving good results, at a dosage rate of 0.2% lb. per acre. Table 2 shows field results using the various compounds.

Treatments in the Coyote Creek and the Cerritos Channel using malathion granules, at 0.2% lb. actual per acre resulted in larvae population reductions on the average of 85-90% towards the end of the midge breeding season.

In our field trials using Chevron RE-11775 E.C. at rates of 0.05 lb/acre and 0.1 lb/acre, we received poor results obtaining less than a 50% larval reduction for both treatments. The apparent reason for this was the rapid breakdown of RE-11775 in highly organic waters (telephone conversation, Dr. C. Schaefer). Perhaps if we increased the dosage rate for this compound to 0.1 lb/acre, we might achieve control at levels similar to what occurred in the laboratory at rates of 0.05-0.1 ppm.

Recently the Southeast MAD provided the University of California at Riverside two, five thousand dollar grants to study midge species 51R and other midges in the Coyote Creek and adjacent areas. Two research projects under the direction of Dr. Bay and Dr. Mulla are presently exploring ways of controlling this midge from biological and chemical approaches.

SUMMARY

During the 1970 season, the Southeast Mosquito Abatement District experienced insecticide failures in controlling a new species of Chironomid midge, *Chironomus* sp. *attenuatus* complex 51). In many of our concrete flood control channels, all of the public health protection chemicals presently used to control Chironomid midges failed at our normal dosage rates of 0.1 to 0.2 pounds of actual per acre.

Laboratory and field tests clearly indicated that specie^c 51R was resistant to fenthion, ABATE, DURSBAN, SEVIN, methoxychlor, and malathion when compared with susceptibility data on the same species maintained in Dr. Mulla's laboratory at U.C.R. However, even though Malathion resistance was present, the level of resistance was below that of fenthion, ABATE, and DURSBAN, consequently, control was achieved using this material late in the season.

Laboratory tests using a new carbamate, Chevron RE-11775, showed promise; however, field tests indicated that this material was too unstable in highly organic waters, at dosage rates of 0.05-0.1 pounds per acre to be useful in our type of situation.

As the season progressed, it became clear that intensive study of this problem was necessary. So, two grants of five thousand dollars were given to the University of California at Riverside by the Southeast Mosquito Abatement District to conduct research on the biological and chemical control of this midge, under the direction of Dr. Bay and Dr. Mulla.

Results of the research carried on by the U.C.R. workers in the control of Chironomid midges should not only uncover valuable information regarding this species, but will aid in the control of all midge species.

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CALIFORNIA SPECIAL DISTRICTS ASSOCIATION

Ralph W. Chapman

California Special Districts Association (CSDA), Spring Valley

The California Special Districts Association (CSDA) covers all special districts in California. Special districts today are in greater danger than they have ever been of being phased out of local government in the state of California. The trend, which has been going on for a number of years, not only in this state but throughout the United States, has been to try to abolish all special districts, to set up regional – or "big brother" – government, to bring the districts under cities, counties and states. In President Nixon's recent "State of the Union" speech, there is an indication that an effort may be made to reverse the trend.

California special districts became organized about 1½ years ago. Assemblyman Knox introduced AB2054 at the beginning of the 1969 session. When our present secretary, Glenn Reiter, saw a copy of this bill, he stated that it would take away district powers and would effectively destroy them. Senator Schrade from San Diego met with us and reviewed this bill. He stated that what we were getting was our own fault. All special districts in California were rather smug and complacent, and had paid little attention to what was going on in Sacramento. They had not heeded the warning that Sacramento was in the process of doing away with special districts. Assemblyman Knox, who is known as the father of "Lafco" and the "District Reorganization Act," stated that the more special districts that could be eliminated, the better off the people in California would be. He was chairman of the Assembly Local Government Committee.

Senator Schrade advised us that AB2054 had passed the Assembly, with a good margin, so it was too late to do anything there. This was in the closing days of the 1968 session, and he said he could not offer any hope. He said the bill was to be presented on the Senate floor, and that historically this kind of bill was not likely to be killed on the floor. We asked him to try – at least we would go down fighting. We did make a strong effort, contacting many of the Senators. Senator Schrade worked with us, and on the evening of the last day he said: "It is coming on the floor tomorrow, there is nothing more you can do, so you might as well go home. Don't plan on the bill being killed – I don't think we can do it." The next afternoon Senator Schrade phoned to advise us that the bill had indeed been killed on the Senate floor.

AB2054 would have been the first step in elimination of special districts. It took away all authority and all power from all special districts in California. Many special districts have failed to realize this. After this close call, we got together with Senator Schrade and asked "What can we do?" He said: "Special districts, as old as the state of California, have never done anything to protect themselves, have never organized, except in their own groups of special interest. The feeling in Sacramento is that they are so loose, each going its own way and not caring about the other, that they cannot be encouraged to organize. This is one of the reasons the legislature may try to phase them out, because they are a disorganized group of local government. The only thing that will save them is for them to organize and work together."

This was the beginning of CSDA. Today we have approximately 250 special districts in our organization. That is not many, compared with the 2300 in existence. There are 43 different types. Sacramento recognizes strength, numbers, organization. This is why we feel it is so important for every special district to belong to this Association. We have had a difficult struggle. For example, the Irrigation Districts Association thought we might provide competition for them, which we would not. That Association had become complacent. Today it is active, with a lobbyist, a full time attorney, increased mailings, etc. To do these things, it has doubled the fee of every water district. Otay's annual fee had been about $600 per year, now it is up to $1200. San Diego County's Water Authority is up to $3500.

CSDA sponsored AB1155, which puts two district representatives on the Local Agency Formation Commission (LAFCO) within the various counties in California. This bill was Assemblyman Knox's bill – it originally was the bill of Senator Coombs of Riverside. At the beginning of last year's session we felt that so many districts were having trouble with their respective LAFCO's that we should recommend increasing LAFCO to seven members, two from cities, two from counties, two from special districts, and one at large. Senator Schrade requested Senator Coombs to carry this bill for us, and he agreed. In the meantime, we had been working with Assemblyman Knox, and he had reconsidered his position toward special districts. He admitted he had been in favor of phasing them out. After six months close association which CSDA has had with his office, he has changed his mind and in fact told us that if anyone developed a bill to change LAFCO, since it was his bill that created LAFCO some years ago, he would like to be the one to put in the bill. We went to Senator Coombs and asked him if he would mind turning his bill over to Assemblyman Knox. He agreed, just wanting to be sure the bill got in and, hopefully, passed.

We put together the Senate bill with AB1155. Assemblyman Knox spoke before the Senate Local Government Committee, explaining why he favored the bill. He said this was the first time in history that anyone had ever come to Sacramento to stand up and speak out for special districts, to let the legislators know that they are organized, working together in cooperation, and that they have developed a good case for themselves.

AB1155 passed, and today in San Diego County we are using it as a pilot for the procedures. The San Diego LAFCO has passed a resolution inviting special districts to sit on the Commission. It appears that within the next several months in San Diego County we shall see two representatives of special districts sitting on LAFCO, which will be the first in California.

We believe the associations of various types of districts are good, but should be strengthened. They should let CSDA carry the bills they want through the legislature, because it is only through this combined effort that we can get the strength necessary to get what we need. Special districts need many things now in California. CSDA has its own insurance program at excellent rates, with Blue Shield. CSDA obtained the best talent it could find to work with us. Our legal counsel is James Creger of Best, Best and Creger of Riverside. They are known as the finest governmental attorneys in the state. Our legislative director in Sacramento is Robert Beckus. He has been there for 17 years, is well liked and respected throughout the capitol.

We know there are some bad special districts. There was one in northern California which had no adequate records, and those they did have were stuffed in a shoe box and put in a closet. We made an effort to provide a two-week training program for their bookkeeper. If mosquito abatement districts joined CSDA, our legislative program would be to pick up any problem they had, or any legislation they needed, and try to carry it through Sacramento. The cost at present is $50.00 per year plus $.20 per $1,000 of the district's operating budget, not including capital, bonds, or reserves.

The policies of CSDA are decided by a majority vote of the Board of Directors, of which there are 15 members. The Board is voted in by the membership at the annual meeting each October. The members come from all parts of California, and we try to keep them as evenly distributed as possible. A cross section of all types of districts is represented on the Board.

Matters develop so fast in Sacramento that usually an almost immediate decision must be made. There is no time to prepare questionnaires for the entire membership and to await their answers. The biggest problem we have is to move fast enough. Robert Beckus, our legislative director, monitors all bills. The Board of Directors has established policy guide lines from which we work, but the Board can not routinely pass or reject each bill. Beckus copies bills of interest to us and sends them to Secretary Glen Reiter, who duplicates them and mails them to the members. We have been able to get copies out to 2200 agencies in as little as 14 hours. Districts are expected to phone or write to us if there is something they are worried about. In 1970 we analyzed 5300 pieces of legislation. Of these, we commented on several hundred. We would appreciate an opportunity to look at any bill a special district plans to introduce.

PANEL: LOCAL AGENCY FORMATION COMMISSIONS – THEIR INFLUENCE ON MOSQUITO ABATEMENT DISTRICTS

MODERATOR: Richard F. Peters

Contra Costa County Mosquito Abatement District, Concord

The Local Agency Formation Commission (LAFCO) Act was passed in 1965. The Knox Bill which gave rise to the LAFCO structure contained a very substantial bias against special districts. But we believe that the very strength of home rule in California has derived from the fact that many agencies, representing many people, are contributing to the practice of local government, from the policy level to the actual execution of specific functions.

The special district has been a very disturbing thing to many people for a long period of time. In 1931 there was an effort made to arrest, or to make extremely difficult the formation of new districts – this was called "The District Investigations Act." In deterred the development of mosquito control for many years. It was only after the application of this Act to mosquito abatement district formation had been set aside that the legislature decided it should no longer apply.

The LAFCO aspect of harnessing and arresting new political subdivisions was brought into being in 1965. It amounted to an intermediate level sounding body which could look at and make determinations about the desirability of various forms of local government. When we consider that there are 58 counties in California, roughly five times that many major cities, and 100 times that many special districts of all kinds, it is quite clear why there has been concern about the districts.

Probably the first impact of LAFCO on mosquito abatement districts took place in Contra Costa County. Somehow the feeling existed in Contra Costa County that the executive officer of LAFCO needed to make inroads by taking on various unnecessary special districts. In this county there are two mosquito abatement districts, plus an area with no organized control. For certain persons it seemed like an excellent opportunity to make a change by bringing the entire matter to issue.

LAFCO IN CONTRA COSTA COUNTY

John Brawley

Contra Costa County Mosquito Abatement District, Concord

The problem in Contra Costa County started years before LAFCO was created. The Contra Costa Mosquito Abatement District in the early days encompassed the central portion of the county, and was isolated from the coastal portion containing Richmond, El Cerrito and several other cities by a ridge of hills which provided a geographic barrier and helped produce different climatic conditions. It was of no great concern to people in the central areas as to whether or not there was a mosquito control program on the west slope of the hill. Certain people in the western portion of the county wanted a mosquito control program, but others were violently opposed to it. This situation simmered for a number of years until LAFCO came into being.

In 1964 a committee was appointed by the Board of Supervisors to study the needs in the county and to make recommendations. The committee presented the recommendation that the Diablo Valley MAD in the east part of the county, the Contra Costa County MAD in the central part of the county, and the uncontrolled area in the west part of the county be included in a single county-wide service area which would not only do mosquito control but also perform other functions, all under the direct control of the Board of Supervisors.

The matter was quiet for several years. At one time the Contra Costa County MAD was approached about the desirability of a service area being formed in the western part of the County and contracting with the MAD. The Board of Trustees of the District was agreeable to annexation or to almost any reasonable solution short of giving up its own program. In 1969 the situation finally came to a head, with some of the local people mounting an offensive, using LAFCO procedures. The matter was brought before the Board of Supervisors, who initiated the action requesting LAFCO to study this subject and hopefully to recommend that the entire west portion be annexed to the Contra Costa MAD. At the public hearing, only city council members and managers of two cities, Richmond and El Cerrito, appeared in opposition. There were some 60 letters from private citizens urging that the area be annexed to the MAD. There were two cities very much in favor of the annexation. At the same time, the executive officer of LAFCO suggested to the Commission that, if the annexation were successful, the Board of Supervisors should consider taking over the mosquito abatement function in the entire county. He carried this matter to the Board of Supervisors and got a commitment from them that they would be willing to take over the operations if the cities wished it.

Our Board of Trustees did not want the string tied to the annexation that if the annexation occurred the County would take over the program. We even debated whether we would accept the annexation – we do have that option under the District Reorganization Act. This matter had been stewing for too many years and was not going away, so we decided to face it. The Board did agree to consider the annexation, to hold the hearings that were necessary, but they made it quite clear that they did not want the County Supervisors to take over. A hearing was set up, and opposition consisted only of a vocal minority of the city councils of Richmond and El Cerrito. The annexation was completed, but, immediately following, one of these cities reminded the Board of Supervisors to keep its promise to take over the function of the District. The Supervisors passed a resolution and sent out copies to each of the cities in the District, offering to do mosquito control if the cities wished it. Our Board of Trustees is appointed almost entirely by city councils – we had 13 appointees from cities and one representing the county. Particularly among the eight original cities, the trustees contacted their respective city council members to support the district. The city of Lafayette was the first to come through with a letter to the Board of Supervisors stating "No thank you, we like the district, we want to keep it." Other cities did likewise, so the Supervisors threw the matter into the mayors' conference for a quick decision. I was offered ten minutes to talk to this Conference to explain that the District was in a better position to handle the control than was the county. At the conclusion of the debate, the mayor of Brentwood in the Diablo Valley MAD in east county, said: "We all know that these studies take time, cost money – I move that this matter be tabled and that we move on to other more important business." The mayor of San Pablo agreed: "We have been trying for many years to get a program going in the west part of the county, we now are within sight of our goal, we have been annexed and hopefully during the coming season we can get some relief–let us not delay the matter further." A roll call vote was 10 to 4 in favor of tabling the matter, hopefully forgetting it, and letting the districts carry on. The four mayors voting for carrying out the study to give the program to the County Supervisors were from the west area which had never been served by an organized mosquito control agency. Every mayor of every city served by a mosquito abatement program unanimously supported us.

We got considerable newspaper publicity, and this should have been the end of the matter, but it was not. A few weeks later we were surprised when we got another resolution from the Board of Supervisors, this time directed to our Board of Trustees, saying that if the parties concerned were interested, they would be willing to take over the program. This resolution also went to the Diablo Valley MAD. It irritated the Contra Costa County MAD Board, which could not understand why the Supervisors could not take no for an answer. The District Board took a very polite approach, requesting that a committee of our Board meet with the Supervisors or a committee of that Board, and stating that we would be happy to listen to any reasons why the Supervisors thought they could do the job better or more economically.

The Supervisors immediately replied, saying they were referring the matter to their local government coordinating committee. Perhaps we could have dropped the matter, but the District Board said "NO! We want the meeting. We want to know why the Supervisors persist on this." Our Board President wrote to the chairman of the local government coordinating committee, asking again that a date be set. Finally, late in September the meeting was held. At this meeting the Supervisor's committee seemed apologetic. It was obvious that this was a political matter, that pressure had been applied to the Supervisors. The committee indicated that the meeting was not really necessary, that there was nothing special to present to the District, that the committee itself recognized that the District was doing a good job. The LAFCO executive officer pointed out that this was the way things were going, that the Supervisors were always looking for ways to cut down on expenses, and that we may hear about this from time to time, as the Supervisors try to meet their problems. The Supervisors themselves gave every indication that they would like to forget the matter. Inasmuch as it took over six months to arrange for the original meeting, our Board felt that the county would not initiate another meeting in the near future.

Under the District Reorganization Act, there is no provision at this time for the Board of Supervisors or LAFCO to dissolve an operating district so long as that district is functioning and carrying out its powers, without going to a vote of the people to uphold them. If the district were not functioning, the Supervisors could dissolve the district with the consent of LAFCO.

LAFCO IN FRESNO COUNTY

Theodore G. Raley
Consolidated Mosquito Abatement District, Fresno

I am gratified by the results of the conclusion by LAFCO in Fresno County, but I feel the matter is just tabled and will come up again. For the moment the situation seems rather quiet on the special districts study front. There are four mosquito abatement districts in Fresno County, covering an area of about 3700 square miles. They came into being in a logical, orderly way, as the people in the involved areas were ready to take on the burdon of paying for mosquito control. The first district started in 1941, covering just the metropolitan area of Fresno, about 55 square miles. As World War II was concluded, and new insecticides were available, other people wanted relief from mosquitoes, forming what is now part of the Consolidated MAD in the communities surrounding Fresno in 1946. There were four incorporated towns and an area of about 250 square miles. Even as this district was being formed, there were petitions being circulated by adjacent communities requesting permission to be annexed.

There had been some question during the formation of the Consolidated MAD of joining with the existing Fresno MAD, but there were two reasons why such did not seem practical. First, the assessed valuation of the Fresno area was much higher, so that that area did not want to pay higher taxes to support the Consolidated MAD area. Secondly, there was a feeling in the smaller communities that the big city would run the show. By 1948, not only had the original Consolidated MAD been organized, but annexation of additional area had enlarged the district to approximately 1,000 square miles to include essentially all the area surrounding the metropolitan part of Fresno County.

We noticed many years ago that the oil country in the vicinity of Coalinga had some very valuable assessed land and practically no mosquito problem, so it seemed like a good idea to annex the Coalinga-Huron area to the Consolidated MAD. We discussed this with various service clubs in that area, but those people preferred to have their own district. Because of their high assessed valuation and minor problems, they adopted a tax rate of about one cent. Soon after that, the people in the west side of Fresno County, in the Firebaugh – Mendota area, thought that progress had reached the place where they could get reasonable mosquito control, even with all their water. As I recall, they went to the Fresno MAD first and requested that district to annex them. But the Fresno MAD preferred not to, because the problem was great and the assessed valuation was low. They then came to the Consolidated MAD. Our tax rate at that time had come down to 12 cents, a rate we could live with. But we felt the problem was too great and the income potential too small for our district to take on that burden so we declined to annex them. The people on the west side, however, were determined, so they started their own district, the Fresno Westside MAD, at a tax rate of about 28 cents. Thus there was a logical and orderly formation of four districts in Fresno County, districts the local people in each area were willing to pay for.

In each instance, except between the Fresno and Consolidated MAD's, there are geographical borders which make the division into separate districts seem quite practical. The Fresno and Consolidated MAD's have the problem of a joint border in the growing part of the metropolitan area of Fresno, which has caused some confusion and was in fact the seed for the proposed study by LAFCO. As yet we cannot see any logical or practical way for this boundary to be moved.

This background provides the information behind the first in-depth, county wide study of special districts, starting with mosquito abatement districts and also cemetary districts, with funds provided by the Board of Supervisors. This study was initiated about 1968, but LAFCO itself was not in a position to conduct the study. A contract was made with the Fresno Community Council, in an amount of $10,000.00. With this contract, the Community Council employed the Head of the Business Department of Fresno State College to conduct the study. This professor, not very familiar with mosquito control or county government, paid some of his students to make the actual investigations.

Our strategy, as we saw the report, was to kill it before LAFCO, and we were successful in doing that. The report had no substance, no depth. It had three recommended alternatives for mosquito control. One was that the four districts remain in their present legal status but be put under one administration. One administrator serving four MAD Boards would be a very difficult task. The second was that consideration be given to putting the mosquito control program on a valley – wide basis, under one administrator. I doubt if the people of Fresno County are interested in taking on the problems of Tulare, or Kings or Madera Counties. The third was that there be one MAD in Fresno County under one administration.

The body of the report was nothing more than the statistics the students had taken from various readily available publications. There was no tie-in of the recommendations. We had no difficulty killing this at LAFCO as the report was presented. LAFCO did accept the report, because it had contracted for it, but it unanimously rejected the recommendations. We hope there will be no new movement to start another study of special districts in Fresno County for some time. The most encouraging thing to the mosquito control people in Fresno County was that even in the report of the Community Council there were sections that were very complimentary to us. There was not a single person appearing at LAFCO who favored the recommendations of the report by the Community Council.

LAFCO AND MOSQUITO CONTROL IN TULARE COUNTY

W. D. Murray

Delta Mosquito Abatement District, Visalia

The Local Agency Formation Commission in Tulare County has requested a study, now in progress, of the mosquito control program in this county. Actually, the initial request for the study was made by the city of Porterville, whose city council refused to accept inclusion in a proposed Foothill Mosquito Abatement District. The southeastern part of the Valley floor of Tulare County has never had organized mosquito control. On two occasions, one in 1952 and the other in 1969, the State Health Department, coordinating with the Federal Government on the one hand and with the Tulare County Health Department on the other, has conducted emergency mosquito control because of actual or threatened encephalitis in this populated area. After several abortive efforts to obtain organized mosquito control, a strong effort in 1970 resulted in signatures of nearly 30% of the registered voters to form a new district. Two incorporated cities are included in the area, Lindsay in the north, adjacent to the Delta MAD, and Porterville in the approximate center. The city council of Lindsay requested inclusion in the proposed district, but the City Council of Porterville, in spite of appeals by the city of Lindsay, by a strong organization committee for the proposed district and in the face of signatures by nearly 20% of the registered voters in the corporate limits of Porterville, rejected all requests. At the formal hearing before LAFCO on the proposed district, a councilman for Porterville, serving as a member of LAFCO said that what he and the city of Porterville were asking was "a study to see if in fact the mosquito abatement districts that are operating in Tulare County today are doing it in the best possible method." He added that Porterville as a city was in effect an all purpose district, incorporated for the purpose of providing services to themselves, and could take care of its own mosquito problems.

LAFCO prepared a resolution calling for a study reorganization committee, in accordance with Government Code Sections 56220 through 56236, in which the following subject districts were included as participants and each requested to appoint a member to serve: all eight cities in Tulare County – The two MAD's located exclusively in Tulare County (Tulare and Delta MAD's). Further, LAFCO specified the following items for study and for preparation of a written report.

1. The population and population density in Tulare

County.

2. The location, extent and dimensions of mosquito abatement problems in Tulare County.
3. Methods of mosquito abatement.
4. Cost comparison of methods of mosquito abatement.
5. Cost analysis of mosquito abatement under alternative plans of reorganization.
6. Cost analysis of present mosquito abatement programs.
7. Comparison of costs of present mosquito abatement programs under alternative plans of reorganization.
8. Tax base necessary to support mosquito abatement program under alternative plans of reorganization.
9. Adequacy and efficiency of present mosquito abatement programs.
10. Definiteness and certainty of boundaries of districts resulting from a consolidation or annexation.

The reorganization committee was instructed to prepare answers to these items within a period of approximately two months.

The Committee met near the middle of January and established officers and developed procedural plans. It was noted that there were many possible alternatives to achieve organized mosquito control in Tulare County:

1. The proposed Foothill MAD could be formed, with no structural effect on the adjacent existing districts.
2. The proposed Foothill MAD area could be annexed legally to any one of three existing districts.
3. Different sections of the proposed district could be annexed to the adjacent MAD's.
4. The proposed Foothill MAD could be consolidated with a consolidated Delta and Tulare MAD.

The Committee noted that, if the foregoing studies were to be made, it would be just as logical to consider also the possibility of a county-wide single MAD, both to determine resultant tax rate and the logistics of mosquito control under such a plan. This would involve taking away from Delano and Kings MAD's the areas of their districts extending into Tulare County. Since Porterville had raised the total issue, it also would probably be a part of the study to consider the merits of having the mosquito control program operate as an arm of county government, or perhaps even as a part of the county Health Department.

Fortunately, the present two major mosquito abatement districts are active participants on this Reorganization Committee and are in a position to offer sound advice and to influence any voting. For example, a major issue is one of an incorporated city performing its own mosquito control, and letting another city plus the surrounding rural area do what they may please.

The Delta MAD has prepared three maps showing the breeding records of the three major species in this district, the pasture mosquito, the house mosquito, and the encephalitis mosquito. In the case of the pasture and the encephalitis mosquitoes, breeding inside the limits of any city is quite rare or nonexistant, yet these two species can be a severe problem when adults move into the cities from the surrounding rural areas. In California, aerosol fogging has never been appreciably successful, and there is no effective control possible by a city. In the case of the house mosquito, there are many sources inside the city. Those resulting from street gutters and catch basins can be controlled by a city, but the numerous potential back yard sources such as unused swimming pools, wading pools, cooler drains, other standing water in buckets etc., can be controlled only by an organized MAD program. A city does not even have a legal right to enter onto private property for mosquito control. But in Tulare County a major part of adult house mosquitoes inside a city can arise from the immediate suburbs, from similar sources as noted inside a city, but also from open cess pools and irrigation activities. Sometimes large polluted water sources such as dairy drains and sewage treatment plants, neither of which would occur inside a city's limits, are extremely important. Cities can help on their own sewage plants, but normally are not sufficiently trained or organized to provide assured, effective control. Experience by the Delta MAD has been that house mosquitoes move in tremendous numbers for four and five miles from these major rural sources.

The Tulare and Delta MAD's hope to provide sufficient information that a strong recommendation for the formation of the proposed Foothill MAD can be forthcoming. The absence of control in the Lindsay area has always plagued the Delta MAD because of heavy mosquito migrations from the uncontrolled territory. However, it would be unwise to attempt to block a look at some of the alternatives. Mosquito districts in many parts of the state were formed to cover a small area and have grown until they have coalesced with adjacent districts. These borders, sometimes following ancient school district boundaries, are not always logical under today's governmental structures or for mosquito control logistics. A review by an independent citizens group to reshape boundaries, or even in some cases to merge parts or all of districts, might be in the best interests of total local government. Under no condition, however, should mosquito abatement districts as a whole acquiesce to the tenets of some anti-special district do-gooders, who have tried to lump mosquito districts with other types of districts, especially utility-type districts, which have been in frequent conflict with cities. There is a strong case for mosquito abatement districts in local governmental structures, and it is hoped that these districts will be able to assist in assuring their continued existence and effective programs.

What may happen, specifically, in Tulare County? If the facts are presented carefully to receptive ears, the city council of Porterville may still request inclusion in the proposed Foothill MAD and the formation can proceed without complications. However, if the Committee should urge any reorganization of the proposed area with existing MAD's, there would be an election by all the involved people. If a majority voted favorably, the city of Porterville could be brought into the selected alternative whether the city council of Porterville was in agreement or not.

LOOKING AT ONE THING . . . . AND SEEING ANOTHER

Louis F. Czufin

Chevron Chemical Company, San Francisco

This is the opportunity every public relations man dreams about — the chance to put on his white hat and his star and try to convince a bunch of professional gun-slingers that they ought to go straight.

I'd like to reemphasize "professional" in this sentence. There are hundreds of meetings of various groups, associations, and industries taking place right now, but I doubt very much if there is any single group of individuals meeting anywhere that is more dedicated or more professional or doing more important work, that is more shrouded in mystery, misinformation, and clouds of miasma, than you folks are right here!

I think that if there were a competition of "what's the least known association of meaningful people with a meaningful purpose", you folks would take top honors.

From a professional public relations viewpoint, this is completely understandable. You are a highly motivated group of scientists that is just too damn busy doing important work to bother about getting involved in "public relations" which does seem to have somewhat of a phony taint about it.

But something like public opinion is giving you problems in each of your specific areas in Washington, in Sacramento, and in the meetings of concerned citizens, conservationists, biologists and ecologists.

But I'm not here to cover this same old, tired subject, my talk is in two parts only. Now that I've berated you for not communicating with the general and certain specific publics, I'll get right to the second part of my presentation and that is some suggested action that might be taken by your Association and by yourself, in the field, as it were.

You are considering the establishment of professional public relations assistance. This will take a budget, assessments and commitments. Until they are accomplished, there is no reason why you should use this rationale to avoid the subject of public relations and say, in effect, "I don't know anything about this subject, somebody else should do it, I don't want to get involved." Well, you are involved and you do have public relations whether you want it or not. You can't get away from it. Everyone has public relations. It's only a question of whether you have good public relations or bad public relations.

Good public relations is not just a matter of releases, publicity, pamphlets, speeches, beautiful booklets, or propaganda or fancy talk. Some people think that's what it is. They are wrong!

How do people get their notions about associations and companies? Basically, they get their ideas from what they hear, what they see, what they read, and (this is important) from their personal contacts with the people in the association. They tend to remember for a long time their personal experiences and that means their experiences with people working in the associations or the district in any way.

Since you folks are somewhat in the "business of selling" your programs, then this simple basic public relations principle is involved: "People like to do business with people they like."

The wise man who lived about 2,000 years ago had a good formula for public relations. He said, "Be nice."

You might want to examine your own particular operation in this respect. Let's call this "public relations on the job". Let's start with the telephone. You are aware, of course, that more people know us through the telephone than from meeting us in person. So how are your telephone manners of your staff? Are you rough or sharp or discourteous when you answer the telephone? Do you give people the notion that their questions are just a nuisance to you?

Do you know the importance of the "hellos" and the "goodbyes" and the "thank yous"? These are the little things but they're mighty big to other people, and to us too. So, like it or not, we're all in public relations. If people like you and your staff, chances are pretty good that they'll like what you're doing.

And now for a few words about "Looking at One Thing . . . . And Seeing Another", or "Creativity". Most of us think of this activity as exclusively relating to an artist or writer or a photographer or a sculptor. The fact is, we're all creative and this is what we go through when we're faced with a problem and suddenly the answer to the problem or the frustration appears as an idea. If ever there was an association or an effort that needed a creative approach, a new idea, it is the profession of mosquito abatement.

I see in this room the fiercely scientific, self-motivated personnel of the great California Mosquito Control Association and I ask "Are you still on the defensive?" Here in this room is the one sure fire tool to gain understanding and press attention, public health; and are we still talking defensively?

OK! I'm sure you've heard this before—it's a frustration, it's an uncertainty, yes, even a failure, and the only sure fire relief from a frustration is an idea.

Let's talk about how and where ideas are born, and this is the key that we should all study. We are really seldom hit with an idea. We need more thought merchants.

But what is an idea anyway? The first thing you've got to do is to recognize an idea. Most people treat it like an unwelcome stranger, "who needs it?" And it's just human nature to want to tinker with it and reshape it so it looks like something more conventional and familiar. It's a lot less intimidating if you can pad it and insulate the shockingly strange parts of it and grind down the rough edges and sandpaper the idea to death. "An idea that isn't dangerous is hardly worth calling an idea", said Oscar Wilde. He was right. It's the shocking part, the frightening aspect, the unknown element that makes an idea an idea in the first place. Ideas are never comfortable. And if an idea does feel comfortable, take another look. It's probably not an idea at all.

Since you are all largely autonomous and highly localized, we want to encourage you in your own creative approach to public relations with ideas—those that are never comfortable.

We need persuasive communication in a rapidly changing society. The world, everything, is changing at lightning speed. We see a capricious, volatile mass of humanity that demands constant change, not only in how we communicate but in the message itself. We never step into the same river twice. We notice that there are more demands for the "why" than the "what" in what people want.

Take a brief look at showmanship. It really is a very simple matter. It's a matter of ingredients more than anything else.

We haven't really begun to tap our own creative sources. For example, we're just beginning to learn about human behavior. This is something that we should all study in this general area of public relations.

Let's examine the question of originality. There is, of course, no such thing as a simon pure original idea. It's usually a look at an old idea with fresh eyes, "Looking at One Thing . . . And Seeing Another".

Wilson Mizner said, "If you steal from one another, it's plagiarism . . . . if you steal from many, it's research." So what we're looking for are new combinations of old ideas. We go through a process of adoption, adaption, twisting and turning, and there's nothing new under the sun. Shakespeare's Hamlet was a Danish legend that he picked up and to which he added the sum total of his experiences. Voltaire said, "Originality is judicious imagination."

So when you say it, when you write it, when you propose it to your community or to your region or district you put it as if it had never been said before.

Walpole did it when he said, "I would have been a handsome man, but they changed me in the cradle." He got it from Don Quixote who got it from Cervantes who got it from the Greeks and the Greeks got it from the Egyptians thousands of years ago.

One other factor, it's a young mind's profession, not a young man's profession. Imagination is an exercise, it's the degree of resilience. And in your profession, this is important. Who wants to hear the same old approach year after year? You can be 30 and your mind is turned off. Forty, 50, 60, 70 and you're receptive to a changing world. So build with imagination. You can always tear it down with analysis. When you get too analytical aren't you failing to use your imagination?

As an example of the most sophisticated press contact possible, Dr. Hazeltine of Butte, and Dr. Edwards of UC, recently took on Dr. Riseborough of UC in a DDT/pelican debate on Channel 9 in San Francisco. The feathers really flew and our cause was buttressed by this thankless effort on part of Edwards and Hazeltine.

Let's get down to a local level. You're getting ready to larvicide a small area. You studied population rate and all of the complex variables and you've computed exactly when, and where, and how, and why, you're going to do the job. Isn't this the time to call in the local radio, TV and newspaper people and tell them in an interesting creative way, perhaps using simple graphics, just what you're about to do—where, when, how and why. An interesting headline or theme, a "grabber", is in order. Now is the time to turn on your creative juice.

Let's discuss "Special Publics" a moment. These are the opinion leaders, the influentials. In California, we're fortunate, differing from Louisiana and other swamp areas, we don't have to worry about the Crawfish Club, or the Shrimp Society, or the APA, the Alligator Protective Association, but we do have to worry about the Isaac Walton League, The Sierra Club, the Audubons, and other conservation groups.

You're ready to spray; isn't this the time to call these people and tell them the story, where, when, how, who, why and with what spray. Invite them to come over and monitor your program, take bird counts, photographs, observe and be informed.

There are, of course, other possibilities and we'll talk about them some day when we have more time. For the moment let's not get too involved. Let's keep it simple. We can do a good job if we work within five areas of activity:

1. develop a public information committee,
2. a speakers bureau,
3. keep up your press contacts, and
4. watch those special interests.

All it takes is a young mind that can handle a real idea. And number 5? That's the easiest of all. Every time you get the chance, BE NICE!

FUNCTIONAL CONSOLIDATION OF GOVERNMENT AND ITS EFFECT UPON MOSQUITO ABATEMENT DISTRICTS

James W. Bristow
Southeast Mosquito Abatement District, South Gate

The Los Angeles Times on June 15, 1969, asked "How much longer will metropolitan Los Angeles tolerate its outmoded and obsolete pattern of city and county government? Solving America's many compelling urban problems is dependent upon more than spending billions of dollars or the enacting of federal and state legislation. Much of the fault lies in the urban areas themselves. The obsolete structures of local government continue to be a barrier to effective action and to be resolutely resistant to change."

The newspapers and others seem to have the idea that if we would suddenly do away with all of the special districts and the city and county governments, and equally suddenly have an umbrella regional government over everything, and take away from the lower echelons of government all the powers to tax, and concentrate all power in an elected regional board, this would solve all the problems of the people. The ecologists also seem to be advancing this as the answer to overall planning. What is the big thing that is bothering them?

The major thing is planning. Planning covers a multitude of sins. There are 78 cities in Los Angeles County. There are seven counties and over 140 cities which could be members of the Southern California Association of Governments (SCAG), which is our present regional group, however, only 80 or so cities now belong to it. When some people talk of planning, they say that a small city, such as Commerce, or even a large one such as Los Angeles, plans for the things which will happen within its borders only, and does not take into account the things which happen beyond its borders. Therefore, they say there must be regional government which will take care of all these things, which will plan for the entire area. They even say, "Population density should be pre-planned." They want to take an area which now has 8,000,000 persons and re-plan it so that industry, population densities, etc. can be changed.

I do not believe this can be done. I do not believe people now or at any other time will stand still and be maneuvered in any such manner. The people themselves have built California on the basis of the fact that they did what they wanted to do. Most present Californians came here from some other state. They settled where they wanted to, went to the school districts of their choice.

Almost every college in this state has a Department of Government, which teaches men and women to work for government. What are the colleges teaching? I have been invited for the past 11 years to conferences that have been put on at USC, UCLA, Pepperdine College, and others. I have read some of the results of some of these conferences. Nobody who was addressing the groups had any practical experience in going out and getting elected to office or actually managing a municipality or county. What is the theory on which they work? I have heard of none of them who did not believe sincerely in regional governments. Some of the bureaucrats from Washington have come up with the idea that the entire United States should be divided into five regions, and all state and county governments should be discarded. The five regions should be divided into workable regions under them, and this setup would represent the government.

President Nixon in a recent address advocated the power to the people. How should we do this? By forming a regional government with eight or ten million people and electing five men to govern it? Will that return the power to the people? Will each person as an individual be able to talk to one of the five men who would be elected to a region with eight million population?

What effect would these changes have on special districts — on mosquito abatement districts? Special districts are as old as the State of California, starting in 1850. At that time it took an act of the legislature to create a special district. In 1911 the Mattoon Act was passed which made it easier for special districts to be formed. There are 43 kinds of special districts in California, performing almost every function of government which could be needed by a group of people. Prior to the incorporation of Commerce as a city, we were part of a lighting district which furnished street lights, we were part of a district which furnished street repairs, part of a park district, part of a district which picked up garbage and trash. We withdrew from all of them when we became a city and assumed all these obligations as a city. This is right and proper and as it should be.

But — we did not withdraw from the system that provides county-wide health services, because for one thing state law would not permit it, and we did not withdraw from the mosquito abatement district. We knew we could not control mosquitoes by a program confined to within our city borders. State laws do not provide us with the legal rights to do all the necessary things to accomplish good mosquito control, even if we wanted to.

Southern California would not have a population of 3,000,000 — it probably would be lucky to have one fourth of that — if it were not for the Metropolitan Water District. This District in its planning and work has done the greatest job of water transfer, and provision of water for an arid area of any organization in the world today. Water bills in other areas of the country, even in non-arid areas, may be two or three times greater than bills for comparable water use in the City of Commerce. This is due to the foresight of men who foresaw the growth of Southern California. The irrigation in the San Joaquin and Sacramento Valleys, and in the Coachella Valley, are all feats of engineering and planning which are unmatched in the history of the world. Yet we have the experts in ecology and government who say "these districts that did all these things did not plan them properly for the population densities. If we had planned them we would not have done them this way. We would have provided for areas of given population densities, for cities, for agriculture." We do not have any all-prevading power in this country, that can tell people how they are going to grow and develop, and I hope we never do. Yet this is what people are talking about when they talk about planning, about regional governments that will tell you what to do. What would be the future of MAD's in such a plan? They would be taken over immediately by the regional health services.

At a previous conference of the Association we were shown movies of Houston, Texas, in which large planes loaned by the Army flew over the entire city, spraying malathion. People said "What a wonderful thing it is to meet the threat of an epidemic!" Texas had a law which said that a mosquito abatement district could not be formed except along the coastal plains where salt marshes exist. In other words, the city of Houston could not form a MAD. All the pictures of Houston with the Army planes flying over spraying everything below –– homes, factories, parks, with insecticide showed lack of planning. I say that here in California we have done and will continue to do a better job of planning through special districts. We have shown a better ability to accept the responsibilities which are ours, by the use of special districts, than any other state in the Union. Referring to the report just presented by W. D. Murray on the MAD's in Tulare County, one area had no local program, and when an encephalitis threat occurred the State came in and, with help of the Tulare MAD, sprayed the encephalitis mosquito breeding areas and kept the threat of epidemic out, by working in an area which was not willing to pay for its own program.

I have read a great deal about regional governments and how they would be developed. I have read predictions that within the next few years the State of California would be covered by regional governments. The League of California Cities has adopted a resolution that cities and counties should be required to join their respective regional governments. At present the Southern California Association of Governments is voluntary. Its Board of Directors is made up of elected officials from the counties and cities involved.

I am not opposed to regional government. However, I am opposed to the ivory tower concept of regional government which forces something on the people which will do them little or no good. Some of its advocates think regional government will and should alter history. I am utterly opposed to this concept of it. We must have regional planning, but when we use the term planning we do not mean to determine what population densities should be permitted at the various municipalities and the various elements of our present government. When I say cooperation, I mean voluntary! W. E. Hazeltine, in his talk at this conference, said "If you have the facts, you do not need to join the adversary system." He dislikes the idea of proof according to law, but wants proof according to facts. When we come up with facts, I do not think we will have a hard time telling the public on what we are doing. We in Mosquito control have shown a foresight which is unprecedented in any other part of the world.

CERTIFICATION OF MOSQUITO CONTROL PERSONNEL

John H. Brawley

Contra Costa Mosquito Abatement District, Concord

In 1966 the CMCA Ways and Means Committee was instructed to make a study and recommendations on certification of mosquito control personnel. A report was presented to the Board of Directors, and the Committee was instructed to develop specific plans for a certification program.

Over the past four years considerable information has been developed on how certification might be accomplished, but not a great deal of information on advantages and disadvantages or whether there is a need for certification.

The subject has become quite controversial, and even those persons favoring a certification program are divided as to whether such a program should include all mosquito control workers, administrative personnel only, or should be limited to operational employees.

Historical

In the years prior to World War II, mosquito control was largely a matter of drainage with the application of petroleum oils for larviciding where drainage was not feasible.

When DDT was released for civilian use after the war, jeeps, airplanes, and smoke generators were used to spread pesticides over large areas for the control of mosquitoes. The results were spectacular. People with no engineering or entomological training were able to carry on control programs which compared favorably with those conducted by experienced mosquito control workers.

In the post-war years, California's irrigated agriculture, industry, and urban development have grown at an unprecedented rate. The size, numbers and complexity of mosquito control problems increased accordingly. Additional complications were added when mosquitoes became resistant to DDT and other chlorinated hydrocarbon pesticides, and it became necessary to use more toxic chemicals.

Through the process of trial and error, organized mosquito control programs have developed some competent professional workers. Unfortunately no standards have been established to guide the training programs for professional mosquito abatement personnel of the future. Control activities in the future will become even more complex due to greater involvement in the control of other vectors, more widespread insecticide resistance, and greater public and governmental pressures against polluting or upsetting the environment.

Growing Environmental Problems

There is a growing public concern about polluting or altering the environment. "Ecology" has become a common household word, and there are organized efforts to ban certain if not all pesticides. Pesticides are under fire because of possible long-range effects on the environment as well as the immeidate toxicity hazards to man, domestic animals, wildlife, and beneficial insects. As mosquito programs lean more heavily on biological and source reduction methods, they will encounter a less publicized part of the ecology movement, the preservation of natural aquatic habitats for wildlife, amphibians, crustaceans, and insects. Plans to drain a swamp or marsh, or even to alter the margins of mosquito breeding ponds, may meet with organized opposition. In those situations where drainage can be accomplished, the standards for water quality control must be met.

Increasing Pesticide Regulations

Nearly five years ago increasing restrictions on the use of pesticides made it necessary for local control agencies to work out a contractual agreement with the Bureau of Vector Control & Solid Waste Management so that some standards might be established which would be acceptable to the California Department of Agriculture. The Department of Agriculture is the regulatory agency for pesticides in California.

Legislative efforts to ban DDT have resulted in further tightening of pesticide regulations. Since January of last year it has been necessary to report all insecticide use. The mosquito abatement agencies submit a monthly report to the BVC & SWM and this information is forwarded to the State Department of Agriculture.

Effective January 1 of this year all pesticide dealers were required to obtain a license, and all pesticide salesmen must register with the county Agricultural Commissioner.

For nearly fifty years the State law has required all persons doing pest control for hire to be licensed either as an agricultural pest control applicator or as a structural pest control operator. No exemption is provided for governmental workers. However, the courts ruled in 1932 (in the case of Contra Costa County vs. Cowell Portland Cement Company) that employees of the County engaged in pest control work were not doing the work for hire, but as a governmental function and as an exercise of the police powers of the State.

In 1967 the State of Utah amended their economic poison application act to require that:

1. Each person actually performing the physical act of applying economic poisons by aircraft or ground equipment for hire or compensation in excess of $50 per year is required to have a license. Each operator must be individually qualified and licensed. A company or governmental agency may not take out a license and then allow their employees to apply pesticides under that one license.
2. Persons applying economic poisons who are employed by a governmental agency must obtain an applicator's license annually, but such agency or its employees shall not be required to pay the license fee in performing the official duties of the agency.

At the California Weed Conference in Sacramento earlier this month (January, 1971) Dr. Julius E. Johnson, Vice-President and Director of Research and Development for Dow Chemical Company, suggested that pesticides be classified into two categories, one for professional use only, and one for non-professional use. Those for professional use could be applied only by licensed professionals! This statement appears to have gotten very good news coverage, and seems to represent a growing sentiment that the use of pesticides must be rigidly controlled.

Need for Certification

Greater skills and knowledge will be required to meet the challenge of the future and the general public must be assured that persons entrusted with the responsibility for protecting them from vector-borne diseases and annoyance are not only competent to perform that function, but can do the job without creating new and possibly greater hazards.

The growing public concern over the use of pesticides requires immediate serious consideration of a program of training, examination, and certification of personnel involved in the application of these chemicals.

A long-range program designed to upgrade the knowledge and skills of all mosquito and vector control personnel should be started at the earliest possible date with the ultimate objective of establishing minimum qualifications for the various levels of responsibility in vector control programs.

The requirement in the State of Utah that mosquito personnel engaged in applying insecticide be licensed as pest control operators along with an attempt this past year by the California sanitarians association to get the State Legislature to pass a bill requiring mosquito and vector control personnel to be licensed sanitarians, is a strong indication that if we do not take action to establish some minimum standards of proficiency someone else will establish them for us!

Objectives of Certification

The prime intent of certification is to protect the public:

1. from immediate and long-range detrimental effects of pesticides used for vector control, and
2. from substandard performance and unprofessional practices in vector control programs.

Certification should also operate to provide career opportunities which will encourage young men and women to prepare themselves for employment and advancement in vector control work. In the furtherance of this objective, college courses could be designed to help prepare interested persons for this profession. But this will require that some standards be established.

The desired skills and experience for various levels of responsibility should be determined by experienced vector control workers rather than by persons having little or no technical knowledge and experience in this particular field.

Arguments Against Certification

There would be some loss of local autonomy, since the local agencies could employ only persons who met the minmum qualifications. This could be tempered somewhat by providing supervised in-service training classes of employment.

Some difficulties might be encountered by those agencies having large numbers of temporary or seasonal employees.

Some agencies might also find it necessary to increase salaries in order to obtain or keep qualified personnel.

Recommendations

After four years of study and investigation on this matter I feel that a program for certificate of registration for all vector control workers should be established at the earliest possible date.

The most practical method appears to be registration by the Bureau of Vector Control & Solid Waste Management of the State Health Department, patterned along lines similar to those for registration of sanitarians. It should include an advisory committee selected by the CMCA to determine the desirable minimum requirements for certification.

Such a program could be established by relatively minor legislative amendments to Title 17, Chapter 5, Subchapter 3, of the California Administrative Code, and perhaps minor revision of Division 3, Chapter 5, Article 4, Section 2270 of the Health and Safety Code, as well as revision of appropriate sections of the Pest Abatement District Act.

During the coming year the CMCA should give serious consideration to implementing a basic program of certification and should solicit the support of all local control agencies in this endeavor.

LITTLE USED TECHNOLOGY VALUABLE IN A PROGRAM OF COMPREHENSIVE MOSQUITO CONTROL

MODERATOR: Thomas D. Mulhern

Bureau of Vector Control and Solid Waste Management

California State Department of Public Health, Fresno

Science and modern technology today can send a man to the moon and bring him back when he wants to come back, or he can meet a companion in outer space. Against the background of a modern world full of equally great scientific marvels, it is unacceptable that we should be unable to kill a mosquito.

Much closer to home, here in California, we live among extraordinary triumphs of water conveyance engineering which affect the daily lives of each of us, and yet we take these near-miracles for granted. We have seen the construction of thousands of miles of canal-rivers which transport the water from north to south in this great state; we see the waters of the Sacramento River system traded for waters from the San Joaquin; we see the desert made to bloom where man has provided water in areas overlooked by nature; and now the engineers are causing water from the Sacramento River system to run uphill over the Tehachapi Mountains to serve the needs of the arid areas to the south. We can, if we will, apply some of this engineering know-how in removing the excess water from pastures and other irrigated areas before the mosquitoes can complete their life cycles.

We must look beyond the confines of the individual fields for the overall solution. Just as the Water Resources Department of the state must consider all supplies and all present and prospective needs in planning the ultimate systems, and the irrigation district must consider its entire delineated area as a unit, taking into account the effects of the adjacent similar units, so also mosquito control agencies must ultimately elevate their sights to take into account the comprehensive handling of all troublesome sources of mosquitoes which exist within their jurisdictions, taking a leading role in encouraging the development of area-wide drainage systems where there are none.

Examination of the soil maps of the most troublesome pasture areas shows that they are generally located on soil types that cannot be expected to take water readily, which is well known by the farmer who tries to irrigate them and by the mosquito workers who must try to control the mosquitoes produced on such lands. Study of the corresponding contour maps shows that most of these troublesome pasture areas have a natural hydraulic gradient or slope of five ft/mile or more – quite sufficient for the drainage of water in prepared channels, although too flat for good distribution of in-field water by strip check pasture irrigation. From observed samples, it is evident that only relatively simple engineering is necessary to design systems of area-wide or basin-wide drainage for these troublesome pastures. Getting the excess water out of the irrigated fields and into a drainage system when irrigation is complete may be more difficult, particularly in the poorly leveled fields that are characterized by low areas scattered over the field – but it is equitable that the landholder accept primary responsibility for the handling and removal of excess water from his fields before mosquitoes can develop.

The papers and discussions at this meeting have emphasized the immediate and urgent need to broaden the base of mosquito control to the status of "comprehensive mosquito contol", applying all of the available technology of naturalistic control, prevention or source reduction, and chemical control, each in appropriate situations. We are all in agreement with the concept but since naturalistic control through the use of fish has been the subject of several other papers, and chemical control has been discussed by many, the principal emphasis of this panel has been restricted somewhat to prevention and source reduction, allowing however for considerable overlap into the other aspects of mosquito control.

We are fortunate in having here a battery of capable speakers to briefly summarize highly successful results which have been obtained through prosecution of action programs involving prevention and source reduction. Their contributions gain in importance because they are not merely theoretical but instead are in essence reports of successful operational programs which have contributed substantially to the success of the respective districts. We believe that the wider use of the technology presented can contribute importantly to comprehensive mosquito control.

A LONG-TERM SOURCE REDUCTION PROGRAM, NOW IN THE MAINTENANCE PHASE

E. Chester Robinson

Alameda County Mosquito Abatement District, Oakland

The Alameda County Mosquito Abatement District was formed in 1930, not because of malaria or encephalitis, but primarily due to annoyance caused by mosquitoes from the salt marshes along 85 miles of the bay front areas of Alameda County, plus those around Richmond in Contra Costa County. These mosquitoes, primarily *Aedes dorsalis* and *Aedes squamiger*, frequently moved into Berkeley and Oakland and on south through what is now Fremont. Those who travel the Nimitz Freeway toward San Jose will note that there are few old houses anywhere in this southern area although there are many new ones now. This area was then so full of mosquitoes that even jack rabbits left for the hills in the spring when the mosquitoes emerged. Later, during the depression period when labor was available the district did a lot of drainage work.

Originally Alameda County MAD was in a sense also a Drainage District. In the early years very little attention was paid to what we now call the backyard problem or the problem catch basins, tree holes, etc. The work was directed primarily toward the control of mosquitoes by salt marsh ditching, putting in levees and tide gates, and filling. This was a very successful program and enhanced not only the value of the property but also the areas around so that people were able to live there.

Transition has been a slow but interesting process. Most of that land has now been filled. We have sold our dragline, and we are not far from selling our tractor. Instead of large heavy trucks with oil tanks, we are now using small jeeps with 50-gallon tanks. Our primary effort is now in the residential areas where we have thousands of catch basins, fish ponds, swimming pools, etc. The salt marsh problem has been almost eliminated, the areas having been filled and now occupied by industry and warehouses. Land values in these areas are up to $15,000 or $20,000 per acre. This development has increased the assessed valuation of the district so that in the last 15 years the tax rate has gone from $.015 per $100 valuation down to $.008. Larviciding costs have been reduced from some $12,000 per year 15 years ago to about $6,000 in 1970 in spite of greatly increased unit costs of these materials.

We cannot go it alone, but with cooperation from flood control, water conservation, etc., we are able to give the people of Alameda County an outstanding mosquito control program. With the insecticide-resistance problem, all of us must place a greater portion of our effort on source reduction. We must get the cooperation of the landowners, even though they are being called upon to pay even heavier taxes on their property.

ACCEPTANCE OF RESPONSIBILITY FOR AREA–WIDE DRAINAGE IN AN AGRICULTURAL AREA

Howard R. Greenfield

Northern Salinas Valley Mosquito Abatement District, Salinas

The Northern Salinas Valley Mosquito Abatement District has been involved in a drainage program since 1952. This responsibility was undertaken when the Monterey County Board of Supervisors and the City of Salinas expressed the desire that the District do so. These governing bodies presented the idea that the primary drainage responsibility should be the rehabilitation and maintenance of a system of drainage ditches that had been the responsibility of a long defunct drainage district known as Reclamation District 1665. In 1916, the District had constructed approximately 23 miles of main channel and 12 miles of lateral drains. In the ensuing years, the Reclamation District paid its bonds and the interest on the bonds, and having done this, ceased to function physically although continuing in existence as a legal entity.

In the preliminary discussions between the three agencies (county, city and mosquito abatement district), the county and city representatives vigorously expressed their interpretation of the Health and Safety Code governing mosquito abatement districts: i.e., that becoming involved in a drainage program was not only legal, but was also a valid mosquito control technique.

After due consideration, the Board of Trustees accepted the responsibility, and in due course approved the purchase of a 5/8 yard dragline, a position of "heavy equipment operator", and said, "Let us begin". Approximately 2½ years later the initial cleaning and regrading work on the main channel had been completed. Then the District embarked upon another drainage project which eliminated approximately 2,200 acres of salt marsh mosquito breeding area and at the same time reclaimed approximately 1,200 to 1,400 acres of slough land for agricultural usage.

It was at this point in time that important complications developed. Agricultural interests began to apply pressure to influence the Board to clean private drainage systems. Also, in the main channel, which had been cleaned 2½ years before, regrowth of weeds (tules, cattails, and hemlock) had become so dense that mechanical cleaning had to be reprogrammed unless an alternative could be found. The District Board of Trustees then reviewed its drainage accomplishments and made two very important decisions which I believe are worthy of reporting:

The first decision was to establish a policy relative to the entire drainage program. That policy statement first acknowledged that the drainage program had proved to be a valid mosquito control technique. Therefore, in the future any drainage (water management), program initiated by the District must meet the following conditions:

1. It must improve a recognized source of mosquitoes.

2. Costs of the drainage project should not materially exceed the costs of temporary chemical control over a five year period.

Upon fulfilling those two conditions, any drainage project contemplated by the District would be included in the operating budget in the same way that chemical or other control techniques are budgeted. In addition, the Board of Trustees recommended that other means of controlling unwanted plant growth be explored which might be less expensive than mechanically removing the weed growth. Eventually the District became involved in a fully integrated and planned program of weed control on those drainage systems which were under District Jurisdiction. This phase of operations is no longer limited to drainage systems but has been expanded to include any mosquito source where the elimination of plant growth will eliminate or reduce mosquito production. Examples are industrial waste ponds, sewage holding ponds, and lakes.

When a drainage project was proposed, we analyzed the economic relationship compared with other techniques that were available to us. It is a simple matter to spray an acre of mosquito source, and accurately determine the unit costs, as for example: $.26 per acre per application. It is more difficult to assess the costs and benefits of a drainage project which takes water off an area where it is causing a problem and channels it perhaps several miles away to another area where there is no problem. Obviously the cost of a drainage project is many times greater than the cost of one larvicide treatment, so the costs must be allocated over the entire period of benefits. We have done drainage projects which cost as much as $10,000 to eliminate one source. However, the costs are offset by savings in temporary treatment over a period of 5 or 10 years.

In the 17 years of its existence this program has had some startling successes. Initially the District routinely sprayed with larvicide the 23 miles of drainage channels. After we had cleaned, regraded and reshaped the structures, the cost of larviciding practically vanished. Once in 2 to 4 years we might have to apply a larvicide on part of the system. The rest of the time the ditches function effectively.

During the past 17 years, we have removed over 1½ million cubic yards of tules, muck and dirt from drainage systems and have eliminated many mosquito problems. We have not actually eradicated them, but have reduced them until they are no longer a costly control problem.

The Soil Conservation Service and the Flood Control and Water Conservation Districts of Monterey County all participate with us in solving the drainage problems of agricultural areas. We cannot do the job alone. Also, the salt marsh mosquito problems have been largely brought under control by ditching and a considerable amount of diking.

Without the drainage program, mosquito control in our District would be less effective and substantially more costly.

IMPLEMENTATION OF A PROPERTY OWNER RESPONSIBILITY POLICY

Jack H. Kimball

Orange County Mosquito Abatement District, Santa Ana

A property owner responsibility policy was adopted by the Board of Trustees of the Orange County Mosquito Abatement District in 1954. (Kimball 1956) The purpose of this policy was to abate public nuisances as defined by the so-called Mosquito Abatement Act of the California Health and Safety Code. Section 2271 reads as follows:

"Any breeding place for mosquitoes which exists by reason of any use made of the land on which it is found or of any artificial change in its natural condition, is a public nuisance".

Need For Policy

In 1954, after the first seven years of mosquito control experience, our District concluded that the spraying of mosquito larvicides on private property was not the most desirable method of mosquito abatement. The owners were more than glad to reimburse the District for the actual cost of the work but were not interested in water management, weed control, drainage or in the maintenance and operation of their agricultural irrigation systems or their industrial waste disposal facilities. The property owner responsibility policy was needed to provide a positive incentive to suppress, eliminate and prevent unnecessary mosquito breeding sources.

Property Owner Responsibility Means Source Reduction

Our interpretation of the term "source reduction" is not limited to the physical act of eliminating a body of water, large or small, by the conventional methods of filling or draining. Source reduction methods in Orange County include any effort or act that will aid in the reduction or elimnation of adult mosquito production from any body or container of water that is conducive to the breeding of mosquitoes.

The following quotation from the paper, "The Three R's of Vector Control", presented at our 1968 Annual Conference by Richard F. Peters, Chief, Bureau of Vector Control and Solid Waste Management, California State Department of Public Health, is an excellent descriptive summary of the term "source reduction".

"Source reduction is basic to the philosophy of mosquito control, requiring a kind of religion-like application. Its prerequisites include precise and comprehensive awareness of water sources, distribution, and utilization, as well as land management and residual water recirculation and ultimate disposal. It depends upon keen administration and technical guidance supported by fine timing and sound cost accounting. It necessitates meaningful record keeping, both biological and operational. Expressed as program action it presupposes performing the proper function in the proper place at the appropriate time."

Source reduction by the person or agency responsible for the prevention of mosquito production may include one or more of the following methods: (1) Suppression of existing breeding sources by the one and only known biological method using mosquito fish; by naturalistic methods such as weed control; and by chemical control methods using suitable larvicides. (2) Elimination or reduction of existing breeding sources by making a physical change in the environment such as filling, draining, leveling or by making an operational change in the method of management and eventual disposal of irrigation water as well as of community and industrial waste water. (3) Prevention of breeding sources by applying well established ecological facts about mosquitoes to the design of all new water use facilities and all new waste water disposal facilities and to the planning of their operating and maintenance procedures.

The above three basic methods of source reduction were analyzed in excellent detail by Richard C. Husbands, Technical Consultant, Bureau of Vector Control & Solid Waste Management, California State Department of Public Health, in his paper, "Cost Analysis Comparisons in Mosquito Source Reduction", presented at our 1970 Conference.

Scope of Policy

When the Board of Trustees adopted its policy on Property Owner Responsibility, it did so with the knowledge that it applied to all property as defined by Section 2271 of the State Health and Safety Code (Brown 1968). This meant that all local public agencies as well as private property owners were responsible for abating mosquitoes created by their operations. In 1969 the State Legislature decided that state agencies should be responsible. Federal agencies and military reservations are not subject to the State Code but they have been responsive and cooperative when approached on a sound and positive basis.

Direct Communication With Property Owner

The primary objective of the Orange County MAD is to eliminate and prevent unnecessary mosquito producing conditions by working on a cooperative basis with public agencies and private parties.

An unnecessary mosquito breeding condition is defined by the District as any condition which permits mosquito breeding that can be eliminated by good engineering design and construction, or which can be maintained so as to minimize mosquito production.

A communication has been developed that is designed to initiate cooperation between the mosquito abatement district and those responsible for planning and operating the facility (Kimball 1965). This communication makes the potential problem a matter of record and includes the following: (1) The existing or planned development has created or will create a public nuisance by the production of mosquitoes if the facility is not properly designed and constructed, or is not properly operated and maintained on a continuous basis. (2) The legal owner is responsible to abate the nuisance and to prevent its recurrence in accordance with the provision of the California Health and Safety Code (Sections 2275 & 2276). (3) The District will provide technical information on mosquitoes and mosquito control methods which may be helpful to the owner in designing, constructing and operating the facility without creating unnecessary mosquito breeding conditions. (4) The District, as part of its District-wide mosquito abatement program, will provide the following services as needed by the legal owner: (a) furnish and deliver whatever quantity of mosquito fish are necessary for adequate control within suitable ponds and holding reservoirs; (b) maintain surveillance of all potential mosquito breeding sources and inform the responsible party of any breeding that requires control to prevent a public nuisance; (c) furnish information and training on routine mosquito control methods to the person in charge of the facilities; (d) furnish emergency mosquito control services, using the District's special spraying equipment and mosquito larvicides, to prevent a public nuisance whenever mosquito breeding conditions are created by operational failures.

Indirect Communication Through Other Public Agencies

The District can easily locate existing mosquito breeding facilities and communicate directly with the responsible party. Locating property owners who are planning developments that in the future can create a mosquito breeding nuisance is much more difficult. If unnecessary mosquito breeding sources are to be prevented, it is vitally important that the District communicate with the owner or his planning engineer prior to construction. He must be informed of his legal responsibility and of the availability of technical information on how to prevent an unnecessary mosquito breeding source through good engineering design, construction and maintenance. Since new developments must comply with many regulations to qualify for a building permit, indirect communication with the property owners can be accomplished through those agencies responsible for setting and enforcing regulations on land use, construction design standards, and on industrial waste and domestic sewage treatment and disposal facilities.

In Orange County, mosquito source reduction by indirect as well as direct communication has been a fact for many years because of the close working relationship and cooperation extended to our District by these agencies. New developments have "built out" unnecessary mosquito breeding sources and have provided operating and maintenance procedures which permit economical and effective mosquito suppression in these sources which cannot be eliminated. The types of new developments include street draining and storm sewer systems; cemeteries; dairy farms; treatment and disposal facilities for domestic sewage and industrial wastes; flood control channels and impoundments;

and water spreading facilities for the replenishment of the underground water supply. Cooperating public agencies include the public works departments of the 25 cities and of the County of Orange; the County Planning Department; the State and County Dairy Inspection Divisions; the County Water Pollution Department; the Santa Ana River Basin Region and the San Diego Region of the California Regional Water Quality Control Board; the Orange County Flood Control District and the Orange County Water District.

Source Reduction Requires Surveillance and Records and Personal Contact

Although a strong preventative source reduction program is essential, equal effort must be applied to suppression, reduction and elimination of existing mosquito breeding sources. Location, mapping and surveillance of each breeding source combined with accurate record keeping is necessary to document each problem. The mosquito control operator is the key individual in this phase of the source reduction program. He gathers the information, analyzes the problem and works directly with the property owner or his representative at the site of the breeding source. He works cooperatively in an effort to teach and guide the responsible party on how to abate the public nuisance by modifying conditions that are conducive to mosquito production. Many sources have been neutralized by the use of mosquito fish, by improved water management, by weed control and/or by physical modifications such as filling, grading, draining, minimum water depths and slope embankments. For sources that cannot be completely neutralized or abated on a permanent basis, the use of chemical larvicides may be required to prevent a public nuisance, and the mosquito control operator is available to the property owner for instructions and demonstrations on use of suitable spray equipment.

The mosquito control operator, in order to develop a consistent and effective source reduction program for implementation by the property owner, must be a special type of person. He must be dedicated and he must be an expert on all phases of mosquito control, including the safe use of chemical pesticides. In addition, he must be familiar with agricultural principles so that he will recognize where recommended practices will result in substantially lessened mosquito production (Mulhern 1970). He must also be thoroughly trained in fish and wildlife management so that his use of pesticides will be in accord with the "Policy on Pesticides" as adopted on September 17, 1970, by the United States Department of Health, Education and Welfare.

The mosquito control operator is the one who must recognize the need for source reduction and who must either initiate action directly with the property owner or transfer his findings through his foreman to the administration for technical guidance and management decisions.

Written Notification Clarifies Need For Abatement

Although the abatement of a public nuisance by known source reduction techniques can be economically justified, the property owner must usually make a considerable initial investment in time, effort and money for physical modifications and for planned maintenance and operating facilities. The property owner, whether an individual or a public agency, should not be asked to make such an investment without first being informed by the District in writing of the cause and extent of the public nuisance and the District's recommendations for correcting the problem. Such reports and recommendations by District management must be based on the records accumulated by the mosquito control operator and must establish beyond a doubt that a public nuisance exists because the property owner has created an unnecessary mosquito breeding source by the use of his land or by an artifical change in its natural condition.

Accurate reports based on technical analysis, presenting proven techniques for the reduction of a specific mosquito breeding source problem, actually serve as an informal notice of abatement when presented to the property owner in writing. Reports of this type are welcomed by the property owner and source reduction recommendations are usually implemented in good faith. Recourse by the District to the formal legal abatement procedures authorized by the California Health and Safety Code is seldom needed or desired.

When public agencies, whether they be federal, state, county or local, are asked to abate an existing public nuisance or to prevent unnecessary mosquito breeding sources in developments to be constructed in the future, written reports documenting the problem and recommending mosquito control requirements are essential. Since the adoption of a property owner responsibility policy by the Board of Trustees in 1954, this District has implemented seven major source reduction programs by public agencies. One of the first and probably most important was by the Orange County Flood Control District in 1956 just prior to the design and construction of our current flood control system, as authorized by a $40,000,000 bond election. That same year, the Orange County Water District adopted mosquito source reduction in connection with its program to replenish the underground water basin by spreading surplus Colorado River water along five miles of the Santa Ana River and into a number of infiltration basins. Other public agencies which have recognized their responsibility for mosquito abatement include the California State Highway Division in regard to freeway drainage facilities; the University of California, Irvine, in regard to its operation of the San Joaquin Marsh Wildlife Sanctuary; the Corps of Engineers, U. S. Army, in regard to drainage facilities serving ammunition bunkers and open space leased for private farming operations; and the U. S. Marine Corps, Camp Pendleton, for the control of the San Mateo Creek and its ocean outlet adjacent to the "Western White House" at San Clemente.

Conclusion

The implementation of a property owner responsibility policy is necessary on a biological basis and justifiable on a financial basis. The prevention or elimination of each unnecessary breeding source within urban communities and within industrial and agricultural operations reduces the mosquito control workload requirements. This reduction in workload will save many tax dollars each year and the savings will be reflected by a decreasing rate of expenditure for chemical control operations as the urban or the agricultural or the industrial developments increase within the District. The accumulated savings to the District, as well as to the property owner, resulting from the source reduction program, probably will never be measured or recognized by the general public. A source reduction program based on the responsibility of the property owner to abate a public nuisance is absolutely essential in any fast growing area like Orange County if mosquito-free living is to be attained and enjoyed at a minimum expenditure of public funds.

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RECLAMATION OF OVERFLOW LANDS TO AGRICULTURE BY A MOSQUITO ABATEMENT DISTRICT AS A MEANS OF PERMANENTLY ELIMINATING AN INTOLERABLE MOSQUITO PEST

Robert H. Peters

Northern San Joaquin County Mosquito Abatement District, Lodi

The last time I talked at a CMCA Conference was three years ago, when I discussed the subject "Where and how do we stop nursing the public?" I believe mosquito control agencies are guilty of following the path of convenience, of least resistance. I ask the question: "Why do we continue to control mosquitoes when we should be abating the sources?" About ten years ago I said: "In the Central Valley of California it appears that we have no choice but to recognize that a mosquito source reduction approach is inevitable." Fifteen years ago I even added a little corn to the situation in a paper in which I said "To rephrase the national commerical, you can be sure if your program is based on source reduction." In 1951 I remarked: "With the apparent resistance of certain mosquitoes to some insecticides, we feel that more than economy is the effect when we eliminate the source of our mosquitoes."

With this in mind, I would like to discuss the present subject – reclamation of our river bottom sources. What is reclamation as it applies to mosquito control programs? I believe it can be summed up as the finest form of mosquito source reduction. It is a large, bulky, difficult way of going about something, but there is no finer return. We have just completed 25 years of this program. We have a river, known as the Mokelumne, which goes through the most populated area of our mosquito district. This river is approximately 30 miles in length, and involves river bottom areas most of which were in a natural jungle state as of 1945 when our district was formed. Our district, as did most, came into existence because the public no longer would tolerate the numbers of mosquito pests. We formed this district in San Joaquin County ten years before the Stockton district was formed, and I believe it was primarily because our problem was that much worse.

Our problem was based on at least three *Aedes* species of mosquitoes, principally *A. vexans*. We also had the *Culex* species which are associated with organic wastes – at that time winery wastes and sewage were drained into the river bottom jungles. We were faced with a problem which had no sensible solution other than starting on it and changing the area from a land "uselessness" to "usefulness". We thank our lucky stars that we were able to start on this program years ago, because I am sure that today the force of the environmentalists would have created difficulties for our jungle clearing.

During these years we utilized our own equipment, which I believe is a key to an effective source reduction program. We operated two D-7 Caterpillar tractors, scrapers, ditchers, and even two draglines during this period. We ended up by modifying our river bottom area to a point that it is difficult now to find an *Aedes vexans* mosquito in this vast area, which comprises over 2000 acres of land. The bulk of the land, because of the reclamation aspect and the need to farm it, had to be levied. In some areas, where levies were not possible, we set up a two-elevation relationship. In this way we deepened the water jungle areas which had tules, etc. This part of the program was done primarily at district expense, but the rest of the program was self-supporting, on what we call a cooperative endeavor. We did not resort to anything other than demonstrations to enable us to see what we were doing. We contacted people from time to time and said "Go down to see what the 'Jones' bottomland looks like." In due time the momentum carried, and just this last year we completed the last piece of what I would call virgin jungle that exists in the populated area. This program was coordinated with all aspects of source reduction throughout the District.

I qualify what I am about to say by stating I do not consider it to be scientific, and also I know you cannot compare one district against another, or one square mile against another. I compared the Valley districts from Sacramento through the San Joaquin Valley, and I think that, although it does not mean a thing and there cannot be anything concluded from it, it is rather significant that our district must be used as a standard of insecticide usage. Using our district as a unit of one, I compared how many times more insecticide per square mile some 15 other districts in the Valley were using. The closest was between two and three times, and the average was between five and six times. I believe that, under the circumstances and as rough as this is, there is some significance, and that it does justify mosquito source reduction. Our Board of Trustees must be given a great deal of credit in setting the policies for this program.

A speaker at one of our sessions said "There is no such thing as a problem unless you want to be negative. Think positively and you have nothing but an exciting challenge." This to me is mosquito source reduction. To me it has made the difference between an interesting and a dull program. I believe very much in comprehensive mosquito control, but I also say that eventually every exciting challenge or problem requires a solution, and we need more people who are technically qualified in order to provide these solutions if we are to get ahead of the problems we now face. We have, after all, spoiled our public to a point that it is now difficult to get them out of our hair, to get them away from the customary service which we have been providing, but we do not have too much of a choice in the future.

I quote and dedicate to my old college professor who 30 years ago said: "If you can get rid of the water that produces mosquitoes, you won't have mosquitoes." That man was Professor William B. Herms.

COOPERATIVE WATER MANAGEMENT IN TIDAL AREAS OF SOLANO COUNTY MOSQUITO ABATEMENT DISTRICT

H. C. Pangburn

Solano County Mosquito Abatement District, Suisun City

Prior to the formation of the Mosquito Abatement District in 1930, the duck clubs, which covered about 50,000 acres, flooded and drained their lands at will. The most popular method of club management was to drain off water shortly after the close of duck season and allow the property to dry completely so that all necessary pond work could be done before July 1. The reason for wanting the ponds in shape for flooding at this early date was due to the yearly encroachment of salt water into the Delta during summer months. The time of arrival of salt water varied from year to year depending on the amount of run-off from the Sacramento and San Joaquin rivers. With the very first hint of salt in the water of the sloughs, tidegates on the shooting areas were opened and flooding commenced. The purpose was to trap all the fresh water possible for the benefit of waterfowl and the betterment of the sport of duck shooting. It is impossible to imagine the numbers of mosquitoes produced by this method.

The second most popular method of water management, and one we practice today, was that of keeping water on the shooting areas during the entire year. The difference between modern methods and those practiced prior to the MAD is that of water levels.

The former method of water control was that of simply opening tidegates and flooding to whatever level the existing tides allowed. This was fine for producing duck food and duck broods but it also produced nearly as many mosquitoes as the summer flooding mentioned above. The reason is that tidal heights vary greatly. During a period of lower tides, water levels would drop several inches and then would rise again with the advent of the higher tidal series. This fluctuation of water level makes the ideal breeding situation for *Aedes dorsalis*, our most common salt marsh mosquito.

With the formation of the Mosquito Abatement District, it was realized immediately that if any mosquito control was to be accomplished it would be necessary to change the habits of the duck club operators. This was not easy. It took a great deal of persuasion and the serving of dozens of abatement notices before much progress was made. It didn't take very long, however, to show results of our efforts and duck club owners became increasingly more cooperative as they realized we were really serious about controlling mosquitoes.

It was not too difficult to persuade duck club owners, who normally dried their properties during summer, to delay flooding until shortly before duck season, salt water or not.

Since the building of all the various dams, from Shasta on down, and with the summer and fall releases of impounded water, salt water encroachment has not been a factor in duck club flooding. For the past several years the District Board of Trustees has allowed duck clubs to flood their lands three weeks prior to the opening day of duck season. This, of course, varies from year to year but has been satisfactory to both the Mosquito Abatement District and duck club owners.

Our problems intensified when we approached the owners of ponds which had been flooded for years and suggested that they would have to dry their places during summer months or install such tidegates and weirs as necessary to maintain a constant level of water. Some pond owners complied by draining their properties rather than make the expenditures for additional gates and weirs. The majority of club owners with wet ponds, however, decided to continue this practice and we were launched upon a mission of trial and error to make these ponds attractive to waterfowl but breed no mosquitoes.

The solution to the problem was really quite simple once we discovered that it was impossible to maintain a water level at the height the clubs seemed to prefer. We found that to maintain a true water level at least one of the two daily tides must allow some water to flow onto the area. It was necessary then to arrive at a satisfactory water level, for the particular property, and then set the weir and intake gate at proper positions to attain this level.

Since there is considerable variation in elevation of different properties, quite a little experimentation was needed before satisfactory water levels were reached.

The weir used in this work is a plain open ended and open topped box fitted with a slot on each side to receive the weir boards which will determine the height of water on the up-stream side of the outlet gate and the amount of flow over the boards is regulated by the amount of water allowed onto the property through the intake gate. Both the intake and outlet gates are completely automatic in operation so that once a water level is established it will remain constant throughout the summer, and this constant water level will completely eliminate *Aedes dorsalis* from the area.

STANDARDS FOR RECIRCULATION SUMP AND PUMP SYSTEMS

Richard H. DeWitt

Kern Mosquito Abatement District, Bakersfield

Many words have been written regarding the importance of field drainage to agriculture and good mosquito control. There are many ways of accomplishing drainage of irrigated lands, with the method usually being determined by several important factors:

1. natural and available drainage channels,
2. no available natural drainage,
3. good or poor quality water,
4. water cost, and,
5. the extensive use of fertilizers on high cost crops.

Presently in the southern end of the San Joaquin Valley we have the same need for good drainage as the rest of the state. We are, however, faced with perhaps a little different situation than some other areas, in that (1) we have no natural drainage, (2) per acre feet water costs run from a low of $4.00 on the valley floor to as high as $15.00 around the low foothill area, and (3) we have the extensive use of fertilizers to grow high cost crops.

Since the Kern District source reduction program began some 22 years ago, I would like to go back to that time. In 1949 a survey was made that indicated that not only did we need field drainage but also that attempts by many farmers to drain their fields was creating severe and difficult to control areas, miles in length and with some of the so called spots covering as much as two to three hundred acres on nearby undeveloped lands. It is true that 20 years ago water was cheaper and more plentiful. This coupled with adjacent undeveloped lands created the large drainage dump areas which accounted for a large part of the airplane control work being done at that time. As you might expect when the farmer was approached regarding the mosquito problem he was creating, he was in most cases quite cooperative as long as it didn't cost him anything.

For a year or so we tried a cooperative plan with the farmer aimed at draining the field with adequate drainage or tail water ditches into well defined sumps, or in some areas, a series of ponds. We hoped that sufficient percolation would take place between irrigations. Where some water remained between irrigations, *Gambusia* were planted to take care of any *Culex* problem which might develop. At this time the District owned and operated a bulldozer, a ditching plow and a tow grader. The charge to the farmer was based on actual cost of operation of the equipment. Any culvert pipe or materials needed was furnished by the farmer.

We were somewhat inexperienced in those days and it was about a year or two after our cooperative program started that we began to see that our simple and inexpensive method of field drainage was beginning to break down. The sumps either were not large enough, or had silted in or sealed off, and in many areas the irrigators had become over confident in the drainage facility and in turn more careless in handling the water. In any case we soon arrived back at the original problem.

During this period it had been observed on a few of the large farms that field drainage of excess irrigation water was being collected and returned by use of a low lift pump for reuse. We refer to these systems now as tail water return systems or irrigation return flow systems.

It had become quite apparent by now that if we were to solve our field drainage or surplus irrigation water problem the return flow system would be the ideal method. One important barrier seemed to stand in the way, this of course, being the cost to the farmer. Asking the farmer to install such a system chiefly to control mosquitoes was ridiculous, or so it seemed at this time. It was apparent that there would have to be money saving advantages to the farmer if such an expenditure were to be made.

This led to about a six month investigation into cost figures which included: excavation, pipe costs both surface and underground, motor and pump costs, power company run in costs. Comparative cost figures of the low lift 5 to 15 hp pumps to the deep well 100 to 150 hp pumps and what the savings in fertilizer could amount to as well as crop acreage reclaimed from previous drowned out areas. With this information in hand we proceeded to influence the farmer in the benefits of the return flow system and we began to succeed.

The laying of pipeline seemed to be the largest cost item so wherever possible reverse grade ditches were installed to deliver the excess water back to a sump located at the head of the field where it could be pumped directly into the irrigation system thus eliminating the need for a return pipeline. Most of these reverse grade ditches, however, were eventually replaced with pipeline due to maintenance and weed problems. In recent years many farmers have made use of Federal A.S.C.S. funds to help pay the cost of return flow systems. Many farmers today really are unaware that this money is available to them until informed by District source reduction personnel.

For the first five or six years many hours were spent in contacts and persuasion to obtain the cooperation of the farmer in the installation of the return flow system. Although a good number of farmers cooperated within a short time a few others waited as long as six to ten years before quietly making the installation. Interestingly enough in some of these cases it was the farmer's young son, an agriculture student just home from college, who was actually responsible for the installation.

As a matter of interest, I would like to show some recent cost figures for an average or small return flow system. We will say, for example, this will be taking the drainage from an 80 to 160 acre field. The underground return pipeline would cost approximately $1,650, a 5 or 10 hp pump including switch box installed $800, the sump would be approximately 60' x 30' x 6' at a cost of $50 and a pump well with screened inlet $275 for a total cost of approximately $2,775. Federal A.S.C.S. funds can pay up to $1,000 on an installation of this kind.

We feel that although the District was in a large way responsible for many of the early return flow systems in the County we are pleased to report that the installations are now practically automatic with the large newly developed lands. In the last 20 years agriculture has become a highly specialized business with the margins of profit decreasing while cost of operation is increasing. I think that the voluntary use of return flow systems in the southern end of the San Joaquin Valley today is directly related to tighter and more efficient farming practices necessary today.

In closing, I would like to emphasize that the return flow system has in no way eliminated all of our mosquito problems. We do feel, however, that it has reduced problem sources by a good 50%. For the return flow system to be an efficient tool, the field it is serving has to drain properly, a poorly leveled field is not going to be corrected by its use.

WHOSE CONCERN IS THE DAIRY DRAIN PROBLEM?

George R. Whitten

Delta Mosquito Abatement District, Visalia

In the early part of 1958 the Delta Mosquito Abatement District began a program of constructing dairy drain systems. Figure 1 shows a typical drain before we had begun the program. Figure 2 shows one of our first construction jobs, very neat and incorporating the best ideas we could devise at that time. Unfortunately, some of the early jobs were not fully satisfactory because of several problems we had not anticipated.

Our intension was to use three reservoirs allowing one to dry while filling the other two. This was supposed to allow the dairyman to use his tractor and scraper to clean the solids out. The fallacy of this thinking was soon apparent. Only the surface of the manure dried. Where as much as two feet or more of solids accumulated, at least a year was necessary for this to dry sufficiently for a wheel tractor to scrape out the manure. One other factor made this type of system impractical: the manure seals off even sandy soils, thus restricting percolation from the reservoirs.

Between 1958 and 1971, the Delta MAD has constructed about 60 dairy drains and sewage effluent reservoirs. Of the many factors which were considered when planning these dairy drain and sewage effluent reservoirs, one of the most important is the dairyman's plans for the future. A large number of the older dairies and smaller dairies are only marking time and are not going to rebuild or upgrade their system unless pressure from outside sources forces them to. Even then they have no plans to expand their operations.

Many of these older dairies, if given a little time, will go out of business of their own accord. When working on these dairies, we try to hold the cost down and minimize the mosquito problem as best we can and hope for an early demize.

The dairy of the future must get larger; by this I predict that five years from now a 1000 cow dairy will be considered small. To identify the dimensions of this dairy drain problem let's use a 100 cow dairy as an example.

A figure of 100 gal/day/cow is a conservative figure for the liquid manure discharge from the average dairy in Tulare County. On a 1000 cow dairy this means that 100,000 gallons are discharged every day, 365 days a year. This amounts to 112 acre-feet of effluent per year. If you consider the fact that it takes 2½ acre-feet of water to produce an acre of cotton, sugar beets or alfalfa, this 1000 cow dairy would develop enough liquid manure to irrigate 45 acres of any of these crops.

This is an over simplification which I use only as an illustration because this liquid manure is also being discharged in the winter period when no crops need irrigation. Also, without some dilution with water the crops would be damaged with too much fertilizer.

The point I am making with this illustration is that this liquid manure must go somewhere. If there is enough land in conjunction with the dairy it can be a real asset and cannot only pay its own way, but can produce a profit for the dairyman.

If through faulty planning provisions have not been made for long-term utilization of this liquid manure the resulting problem will not only plague the dairyman but also the mosquito abatement district and as a result the community.

The most efficient system for handling this liquid manure that we have found consists of a storage reservoir which will hold three weeks discharge from the dairy, which in the case of a 1000 cow dairy would be 2,100,000 gallons. The effluent can be either gravity drained or pumped into one

Figure 1.–Shows typical dairy drain in 1958.

Figure 2.–Shows dairy drain constructed by Delta MAD.

end of the reservoir. The reservoir must be at least 100 feet from the milk house and 50 feet from the milk barn.

The barn and corral washings contain quanities of dirt and sand which are washed out with the manure and end up in the reservoir along with particles of hay and other solids. These accumulate at the inlet end of the reservoir and gradually the organic materials decompose and move to the other end of the reservoir to be picked up by the pump and dispersed in the irrigation system.

The pump should be located at the opposite end from the inlet and the pump discharge into the irrigation system must be at a point where irrigation water can dilute and move the organic solids out to the crop areas.

The insoluable portions of the solids accumulate at the inlet end and after a period of 5 to 10 years can be baled out with a dragline. This renews the system for another 5 to 10 years. The lifetime of this system should be almost unlimited.

SOURCE REDUCTION BY NEGOTIATION AND THE USE OF CONCRETE–LINED DRAINAGE AND FLOOD CONTROL CHANNELS

Gardner C. McFarland

Southeast Mosquito Abatement District, South Gate

Other members of the panel clearly demonstrate that the best, most efficient mosquito control includes a variety of technological approaches besides that of specific chemical control of the target organisms. This is true, since the environments that provide the sustenance for many different genera and species of mosquitoes are extremely complex from the standpoints of the natural and improved or degraded activities of man and animals.

One of the techniques used by the Southeast Mosquito Abatement District is to evaluate carefully the responsibilities of all those agencies that have an impact on the production or potential production of public health and pest mosquitoes as well as chironomids and other aquatic arthropods.

A great number of governmental agencies are involved and include:

Federal Agencies:

- The Corps of Engineers
- Soil Conservation Agencies

State Agencies:

- Highway Department
- Parks and Recreation
- Water Resources

County Agencies:

- Engineer
- Flood Control
- Health
- Parks and Recreation
- Road Department

Local Agencies:

- City Departments including Street, Parks, and Public Works
- Districts including Mosquito, Water, Cemetery, and Sanitation

The above list of agencies affect our District. There are other agencies and districts that will affect the activities of other mosquito abatement districts, such as irrigation districts.

Source reduction aspects of negotiation with agencies include:

1. Establishment of design criteria for paved and unpaved flood control channels. This would include the requirements of adequate apron slopes as well as suitable inverts or low-water channels. Also included are proper ingress facilities into and along paved and unpaved channels.
2. Proper design of channel drop structures to prevent formation of scour ponds.
3. Development and responsibility for adequate vegetation control programs which would include aquatic and semi-aquatic vegetation.
4. Systematized schedules of rotation of water percolation and/or flow to interrupt breeding cycles of mosquitoes and chironomids in water conservation programs.
5. Integration of chemical weed control programs with mosquito control programs which would include the use of certain larvicides on recommendation of the district.
6. Establishment of special rules and instruction by management of agencies with ornamental ponds and lakes. This would include adherence to recommendation of the district with regards to aquatic weed control that might affect the biological role of fish and arthropod predators of mosquitoes and midges.
7. Acceptance by agencies such as flood control districts of an advisory role by mosquito control agencies.
8. Good communications between agencies and the District to insure adequate prevention of mosquito development as a result of construction and maintenance

of various water-carrying structures.

9. Cooperation with local agencies in a scheduling of the cleaning of street gutters and flood control channels to reduce breeding materials for mosquitoes and midges.
10. Education of public works departments and road departments as to the role of backup of water as the result of tree roots.
11. Negotiation with flood control districts and other agencies with a similar responsibility of removal of debris and fine cleaning of paved channels to reduce mosquito and midge breeding.
12. Cooperation with responsible agencies for the removal of debris such as newspaper bundles from catch basins.
13. Advisory role with the governing bodies of local agencies on the impact of unregulated parking of cars in streets which prevent proper cleaning of gutters and streets.

It is clear, that mosquito abatement districts and other agencies doing mosquito control must serve as coordinators of the many prevention activities since the life cycle of many species of mosquitoes and chrionomids is short, yet varied.

The best job of protection of the public health and comfort can then be accomplished most efficiently and at the lowest cost.

FUTURE INFLUENCES OF GOVERNMENT ON VECTOR CONTROL PROGRAMS

Howard R. Greenfield

Northern Salinas Valley Mosquito Abatement District, Salinas

Ever since the beginning of time, man has evidenced concern about tomorrow. What happened yesterday is recorded history. Today is barely tolerated because tomorrow is the suspenseful future. As we approach the Twenty-first Century, our anxiety and concern over the entrance into the great new century is visibly heightened.

James W. Bristow, in his Presidential Address to the California Mosquito Control Association in 1968, expressed this concern about the future of vector control in the Twenty-first Century and requested that an ad hoc committee be formed to study the problem of vector control 10, 20 and 30 years from now. With the able guidance and technical expertise of Richard F. Peters, Chief, Bureau of Vector Control and Solid Waste Management, and Dr. Guy F. McLeod, University of California Department of Agriculture, the committee submitted its findings to the membership of the CMCA at the Thirty-seventh Annual Conference.

Today, as a member of the Committee of the Future, I would like to present an area of concern not touched upon at the Thirty-seventh Annual Conference, "Future Influences of Government on Vector Control Programs".

Lest there be misunderstanding, let me state a conclusion regarding vector control programs in California and, for that matter, in the United States. These programs which we identify with today and their administrative and operational aspects in the near future will be of historical significance only. To those of us who entered the field of vector control 20-25 years ago, the words "local autonomy" and "local control" were synonymous with mosquito control. Mosquito control administrators with minimal guidance and even less governmental restrictions were in complete command of their programs. Now there is every indication that so-called "local control" over programs has no sound and little substance in the future scheme of things to come. Likewise, the concept of local autonomy is largely a dead issue.

I think we are agreed that public concern over environmental quality almost has reached explosive (if not hysterical) conditions. At the same time there is an observable relationship which suggests that man (the public interest) is constantly widening the gap between himself and the environment he is so desirous of protecting. This is quite evident, because the general public keeps pressing for control of noxious arthropods, plant pests, etc., which interfere with public health or with enjoyment of leisure time. Public demand for a "clean" environment will of necessity force state and federal governments to become more involved in the planning and ultimately the regulatory aspects of programs involving ecological or environmental modifications. And, one of the first areas of concern by government will be with programs already in existence. Are they being properly staffed and administered? This question brings the issue of manpower directly before us. Let us briefly examine our manpower requirements in the light of what is happening around us.

There is a trend toward totally trained technicians, subprofessional and professional team members. It is noticeable in the federal government, especially in those departments and bureaus scientifically oriented. They tend to appoint, at the policy determining levels, people who have demonstrated professional competency and problem solving abilities, rather than people who belong to a specific political party. Our educational system (universities and colleges) indicates that over 52 percent of the graduate and undergraduate students are educated in specializations designed to prepare them for professional occupations.

It is my opinion that there can be no alternative. Vector control must and will follow closely the need for technically and professionally educated staff members if––and this is most important––vector control agencies wish to remain an identifiable and viable entity in the scheme of the future.

Government from the national level down to the smallest city and county is presently involved in the developing concepts of reorganization. At the federal level, the ninety-first Congress has passed a number of bills. The avowed intent of most of the bills brought to the floor of Congress is very clear––to assure for all Americans a safe, healthful, productive, esthetically and culturally pleasing environment, at the same time preserving a balance between population growth and resources use. Reorganization is the key to the preservation of the environment so far as the social scientists and the political scientists are concerned.

In the past few years, super-bureaus and super-departments have been created in the federal and state governments. The activities of the reorganizational activist suddenly are being felt even at the local levels. Witness Fresno County! Questions are being raised regarding the desirability of consolidating the functions of three distinctly different mosquito abatement programs into one agency. In Santa Cruz County, proposals have been submitted to consolidate all service oriented departments into one. Support for such proposals was basically that over the years, the efficiency levels would be increased and costs supposedly would be reduced. County fairs are now being examined by specialists in reorganizational techniques for the purpose of consolidation as a means of spreading the tax dollar.

The megacentropolis complex has in turn brought about the formation of the Committee for Economic Development, composed of some 200 businessmen and educators who, from their fact finding efforts, have become the most vocal of consolidation advocates. Another very important group is not only a strong advocate of consolidation of special districts, but of city and county governments as well. They believe, with some evidence, that only by combining large metropolitan areas with county governments can the complex problem of too much, too often, and too many be solved.

I would like to conclude this by stating that I believe our vector control programs can survive if they are properly documented, properly supported with qualified personnel adequately responsive to the wishes and needs of the public and if lines of communication between our legislative and administrative members of government are part and parcel of our programs. If not, then they perish as an identifiable instrument of local government.

1970 SACRAMENTO VALLEY REGIONAL REPORT

J. D. Willis

Shasta Mosquito Abatement District, Redding

The overall level of mosquito control in the Sacramento Valley during the past year was good, although two districts had severe *Aedes nigromaculis* resistance during the critical part of the control season.

Resistance tests made by the State Department of Public Health, with the help of the districts in the valley, showed that most of the districts had some resistance problems. In the Sutter-Yuba and Butte County Mosquito Abatement Districts extensive testing showed that they were faced with adult resistance as well as larval resistance in their pasture mosquitoes. An adulticide–only policy was carried on for some time until negative resistance tests were shown in the lab.

Many of the managers and trustees of the Sacramento Valley Region, who are aware of the resistance problem, feel that there must be increased research activities, not only by the universities, State Department of Public Health, and private companies, but by individual mosquito abatement districts directed at solving problems of immediate concern to their own programs.

During 1970 a total of $21,781 was spent by individual mosquito abatement districts in the Sacramento Valley region on research programs on mosquitoes. Approximately $23,000 was spent on investigations into occurrence and control of chaoborid and chironomid midges. These amounts are in addition to cash grants of $5,000 to the University of California at Davis for specific mosquito research projects.

The following are some specific examples and amounts spent on some of the research projects:

1. FISH – $2,782
   Importing foreign species. Rice field populations. Number for efficacy. Evaluation of impact on larvae. Assistance for Jim Hoy.

2. RESISTANCE – $3,400
   Treehole residual larvicide. Flit field tests. New com-

pounds on adult pasture mosquitoes. Larval collections for chemical tests. Tests of candidate compounds, larvae and adults. Colonize *Aedes sierrensis.* Attempts to colonize *Aedes nigromaculis.*

3. ENCEPHALITIS – $4,350
Assistance to Reeves' program – sentinel flocks, light traps, station counts. Wide swath ULV, extra light traps, vertebrate collection assistance. Construction of sentinel chicken houses.

4. *ANOPHELES* – $8,183
Assist Colusa ULV, assist Colusa cold fogger, Washino trapping and sampling, wide swath – large acreage, cold fog with USN. Age determination of adults. Try to colonize *Anopheles freeborni.*

5. GENERAL AND ECOLOGICAL – $3,066
Legislative hearings, conferences with legislators, non-target organism level assessment, equipment loaned to other workers – U.C., etc. to develop new equipment and multiple uses. Building and testing new equipment. Serious literature reviews.

6. MIDGES – $23,000 – CLEAR LAKE AND SHASTA MOSQUITO ABATEMENT DISTRICTS
Field surveys, economic levels, field test new compounds, biological control research.

7. GRANTS, *ANOPHELES* – $5,000
Washino

THE ROLE OF SPECIAL SERVICE DISTRICTS IN MEETING CURRENT TRENDS IN REGIONAL AND LOCAL GOVERNMENT

C. Donald Grant

San Mateo County Mosquito Abatement District, Burlingame

All district managers of mosquito abatement agencies in our Bay Region are well aware of basic changes in concepts affecting area wide, or regional problems affecting environmental quality and functional planning coordination. The varied governmental units created over the last decade on a supra-county level, such as ABAG, BART, Air and Water Pollution Control Boards, etc., as well as the intra-county Local Agency Formation Commissions, have testified to the State Legislature's recognition of broader control and coordination needs. Both direct experience with increased public service demands and the expressed policy of most local agency formation commissions regarding consolidations and functional coordination have led to considerable reflection by local managers as to these trends and their effects on district programs.

Although competent resolution of causes and district responses will not necessarily provide for the ability of districts to determine their own destiny in the coming decade, there is good indication that the responsive actions of districts in several aspects could significantly affect the justification of legislature, or regional and county governments in regulating, usurping, consolidating, or dissolving local districts and their services.

REGIONAL AGENCY TREND:

Currently in legislative committee study is the Assembly Bill 2310 introduced by John Knox of Contra Costa County, which was opposed and referred to study in the 1970 sessions. This bill provides for the creation of a regional governmental agency, necessarily including all bay area counties, imbued with planning and regulatory powers over a wide variety of functions involving supra-county interests. In televised discussion panels with Assemblyman Knox on this subject (Channel 2, Oakland, 11/22/70) some significant concepts as to such an entity's regional powers were brought forth.

Such proposed regional agency, under this bill, with legislative adoption, would have become operative with a majority approval in a general election in the collective nine counties on June 2, 1971. It ostensibly calls for the creation of a Conservation and Development Agency of the Bay Area with compulsory membership of the nine counties and serving to supplant ABAG and other regional pollution control agencies. It would be equivalent to an actual governing unit with full taxing powers, including a regional income tax, business privilege tax, property taxes, etc., but would be significantly supported by federal funds (as is ABAG). Through the latter, a large measure of federal influence is also conferred, both in use of grant monies for studies and planning, as well as in extra direct regulatory powers.

Cited fields of influence for such agency would include, but not be limited to, water, air and environmental pollution, water supply, sanitation facilities (sewage disposal), police and fire jurisdictions, recreational development, and transportation. It was indicated that the agency should be able to provide compulsory participation in such programs as rapid transit systems, although bond funding would entail voter elections.

What modifications may be provided in this bill during interim study are difficult to foresee; however, it is assured that a basically similar bill for creation of a regional agency will be put forth and probably passed in legislature, calling for a general election on its adoption. In that there exists an obvious justification for some aspects involving pollution control and regional planning for area wide problems, it is felt that passage will be more dependent upon taxing powers and degree of regulatory powers provided than upon the question of need for such an agency in lieu of separate control boards and greater local autonomy.

COUNTY AND LOCAL GOVERNMENT TRENDS:

Several districts have already felt the effects of change within local government, especially through local agency formation commissions and county administrations. Such effects may be influenced upon administration of the district, inter-agency relationships, functional additions or deletions, or even dissolution of local districts as autonomous agencies. Thus far, the coastal area has not suffered the potential of district consolidation, such as currently is facing Fresno County, largely because of single districts within our counties.

The rising tax overload and increased costs of established government functions has been compounded with new cost demands arising from the bloom of public concern and public demand which have evolved so dramatically during this last decade. Environmental conservation, human relations, and a complexity of urban affairs have increased both administrative and service loads for local governments at a time when inflationary increases in wages and costs are already overtaxing the revenue sources.

As a result, local governments are undertaking comprehensive surveys of all functions and service agencies, seeking greater cost efficiency, often through administrative consolidations, in an effort to provide for increased essential functions and service levels at the lowest costs, while eliminating low priority functions and administrative overlap wherever possible.

Currently in San Mateo County, the Board of Supervisors, through the County Manager and Local Agency Formation Commission, is undertaking a comprehensive review of all special districts, with administrative analysis of their functions and efficiency.

Some of the points of inquiry concern:

Who decides what nuisances are to be controlled?
What is district policy in undertaking additional control needs?
What are the powers and functions of the district?
Is a special district better able to provide such needed functions and why?
Do you have qualified personnel, equipment and facilities for other types of control needs or functions?
What are your inter-agency relationships?
May we have a copy of your master plan for the future?

AND, costs, budgets, tax rates, wage scales, etc.

A specially selected lay committee has been created for reviewing and recommending future comprehensive overhaul of all government organization within the county. One of the initial recommendations has been the consolidation of all police departments within the county. Perhaps most significant in queries by administrative analysts are those concerned with the governing body, the efficiency of trustees in this capacity, and the responsiveness of board policy to cooperate in meeting the collective needs of the county community.

The extent of such questions may appear questionable to autonomous agencies, yet the right of survey is provided as a power of the Local Agency Formation Commission, and the future of our districts may depend very much upon stated policies and performance.

DISTRICT RESPONSES:

During the past decade most of the coastal districts have already broadened their scope of service, from closely allied midge control to a diversity of incidental service needs. Local health departments have long been faced with providing for many such services, such as with the Santa Clara County Health Department, but in most counties these departments do not provide such an operational body able to assume the functions of an abatement district. As need increases in many counties, with pressures from the forementioned potentials, either mosquito abatement districts will have to undertake expanding responsibilities or other governmental entities will necessarily make provisions for such operations within their administrative jurisdiction. This will first duplicate and then supplant local autonomous agencies on the basis of tax overlap and cost efficiency, as has already occurred in previous years.

Types of services and approaches are apparently different within every district, often for good reason, and entail advisory participation, surveillance aspects, contractual programs, legal methods, cooperative inter-agency aid, actual control programs, or, as in the case of Northern Salinas Valley, serving as a receiving, coordinating and referral center for all types of public service requests.

It is readily accepted that neither we, nor anyone else, have the necessary or desired answers in providing for many services on a problem free or highly efficient basis. Since no agencies prefer to enter operational fields with so many unknowns, there is a natural hesitancy in assuming such extra liabilities.

The accelerated rate of problem development, public concern, property tax rates, and evolution of local and regional government are certainly demanding of consideration by local districts as to their future roles in community service. During this past year, these evolving trends have become increasingly manifest in urban areas and caused much conjecture for coastal area district managers on this erosion of our ivory towered autonomy.

POPULATIONS OF MOSQUITO FISH IN RICE FIELDS

James B. Hoy and James J. O'Grady
Entomology Research Division, ARS–USDA, Fresno

The population densities of fish at the time mosquito control is being achieved is information that is necessary for maximum efficiency in control efforts and for a deep understanding of the biological control system.

Removal trapping (Southwood 1966) was used to determine the absolute population of a 0.4 acre portion of one rice paddy 10 weeks after stocking at 100 fish per acre. Eight other paddies in the same field, and 10 paddies each in 20 other fields were sampled with minnow traps to obtain relative estimates of the various fish populations.

Six days of trapping with 60 4-mesh traps yielded an estimate of the population of mature female fish of 5900 $\pm$ 391 per acre in the primary study area. Two additional days of trapping with 70 16-mesh traps yielded an estimate of 4678 $\pm$ 2888 fish per acre. The "q" values for the two trapping periods were 0.7991 and 0.8121 respectively, where the probability of capture is 1 – q.

Sampling of eight other paddies in the same field as the primary study area showed moderate variation of the fish population from paddy to paddy. Sampling of twenty other fields (six stocked at 200 fish per acre, eight stocked at 100 fish per acre and six unstocked) showed little difference in fish populations when the two stocking rates were compared, but great variation within those two categories. The six fields which were unstocked were found to have fish in only one instance, and that population was very low. The stocking dates of the various fields were from 9 to 13 weeks prior to sampling of the fields.

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EXPERIMENTAL CONTROL OF RESISTANT *CULEX TARSALIS* LARVAE WITH BAYGON 70% WETTABLE POWDER IN OIL

Robert D. Sjorgren and Richard H. DeWitt
Kern Mosquito Abatement District, Bakersfield

Resistance to organophosphate insecticides has been a limiting factor in control operations against *Culex tarsalis* within the Kern Mosquito Abatement District for the past two years. The average LC_{90} of this species determined in routine insecticide susceptibility testing during the 1970 season is as follows (information is given in order of the most common to least common usage during the last three years): methyl parathion 0.28 ppm; BAYTEX® 0.20 ppm; DURSBAN® 0.06 ppm; ethyl parathion 0.06 ppm; and ABATE® 0.11 ppm.

The highest OP resistance levels known are recorded from the Beverly and adjacent Pintail Duck Clubs, south of Bakersfield. BAYTEX has been the primary material used on these clubs the last two seasons. The greatest degree of tolerance is shown for this material with an LC_{90} of 0.55 ppm. Other organophosphate levels are ABATE 0.29 ppm, methyl parathion 0.21 ppm, DURSBAN 0.20 ppm and ethyl parathion 0.09 ppm.

Last spring, Dr. Donald G. Denning, Field Research Representative with Chemagro Corporation, contacted the District to determine if it was possible to discharge four ounces of Baygon 70% WP in one quart of oil carrier through an aircraft spray system. At the time his interests were in reference to grasshopper control. Incidental laboratory testing by Mr. Richard DeWitt, Kern Superintendent, of Baygon-oil mixes indicated a rapid knockdown of mosquito larvae.

Due to the high resistance levels to the five above mentioned insecticides, and the questionable registration status of substitute control materials, additional information on the potential use of Baygon 70% wettable powder in oil was desired. Recognizing that the recommended use of this insecticide is as a mosquito adulticide applied at not more than 0.07 lb/acre, and that high levels of cross resistance to this material might rapidly develop upon extensive field applications, thus eliminating the last effective currently registered chemical insecticide, it was deemed desirable to explore the potential use of Baygon for larval control of *C. tarsalis* in the event emergency use of this material to curtail encephalitis virus transmission was necessary.

Table 1.–Results of experimental applications of Baygon–Richfield larvicide oil on organophosphate resistant *Culex tarsalis* larval populations in Kern County during the summer of 1970.

Date	Location	Acres	LB/A	% Mortality
5/19	Smith Pasture	40	0.175	100[a]
9/10	Universal Duck Club	24	0.175	32[b]
9/30	Tracy Duck Club	100	0.175	100
10/3	Cloverleaf Duck Club	100	0.131	97[c]
10/13	Cloverleaf Duck Club	100	0.087	49
10/13	Meadowbrook Duck Club	60	0.087	34

[a]*Aedes melanimon*

[b]Insufficient surfactant present in Richfield larvicide oil

[c]*Gambusia affinis* kill noted in shallow 400 feet^2 area along one border

An initial field evaluation was made, using four ounces of 70% Baygon wettable powder in three pints of Richfield larvicide oil per acre. The application was performed by air on 40 acres of pasture against larval and adult *Aedes melanimon.* Complete control was obtained at 24 hours post-treatment on both stages. Subsequent applications, the results of which are shown in Table 1, were made at four, three and two ounces wettable powder per acre (0.175, 0.131 and .087 lb/a, respectively) against OP resistance *C. tarsalis.* The susceptibility levels of the treatment populations to Baygon unfortunately were not determined.

Although good control of organophosphate resistant *C. tarsalis* larvae was obtained using Baygon-Richfield larvicide oil combinations under field conditions, the operational use of this formulation is precluded by both the 1.9 fold greater insecticide concentration required, and the restriction on the use of oil as carrier of this material.

INSECTICIDE SUSCEPTIBILITY OF *AEDES MELANIMON* AND *AEDES VEXANS* LARVAE IN CALIFORNIA

P. A. Gillies, D. J. Womeldorf and E. K. White
Bureau of Vector Control and Solid Waste Management
California State Department of Public Health, Berkeley

The three species of *Aedes* commonly associated with intermittently flooded, fresh-water resources in the Central Valley of California are *Aedes nigromaculis* (Ludlow), *A. melanimon* Dyar, and *A. vexans* Meigen. While *A. melanimon* and *A. vexans* are generally more restricted in distribution than *A. nigromaculis,* larvae of the three species are frequently collected from the same areas and it is not uncommon to obtain a mixture of *A. nigromaculis* and *A. melanimon* larvae from the same source.

Insecticide resistance in *A. nigromaculis* has been extensively documented, beginning in 1949 with resistance to DDT (Smith 1949). Resistance to the organophosphorus compounds was first verified in 1958 (Lewallen and Brawley 1959) and, by 1969, populations in certain areas of the state had demonstrated multi-resistance, extending to all currently available organophosphorus compounds (Ramke et al. 1969). Since chemical application procedures are generally uniform within a given agency, it can be assumed that *A. melanimon* and *A. vexans* have been exposed to chemicals in the same general manner that produced resistance in *A. nigromaculis.*

Larval populations of *A. vexans* from 12 mosquito control agencies in the state have been tested. Since all collections have been from areas within control agency boundaries, it has been necessary to select test data from isolated sources, not known to have received insecticide treatment, as representative of uncontrolled populations. The LC_{50} determinations of these untreated larvae are within the susceptibility range of larvae from areas receiving regular treatment.

The distributions of the LC_{50} test values determined for malathion, parathion, methyl parathion and fenthion are shown in Figure 1. The LC_{50} values have been grouped at approximately equal logarithmic intervals. Since no resis-

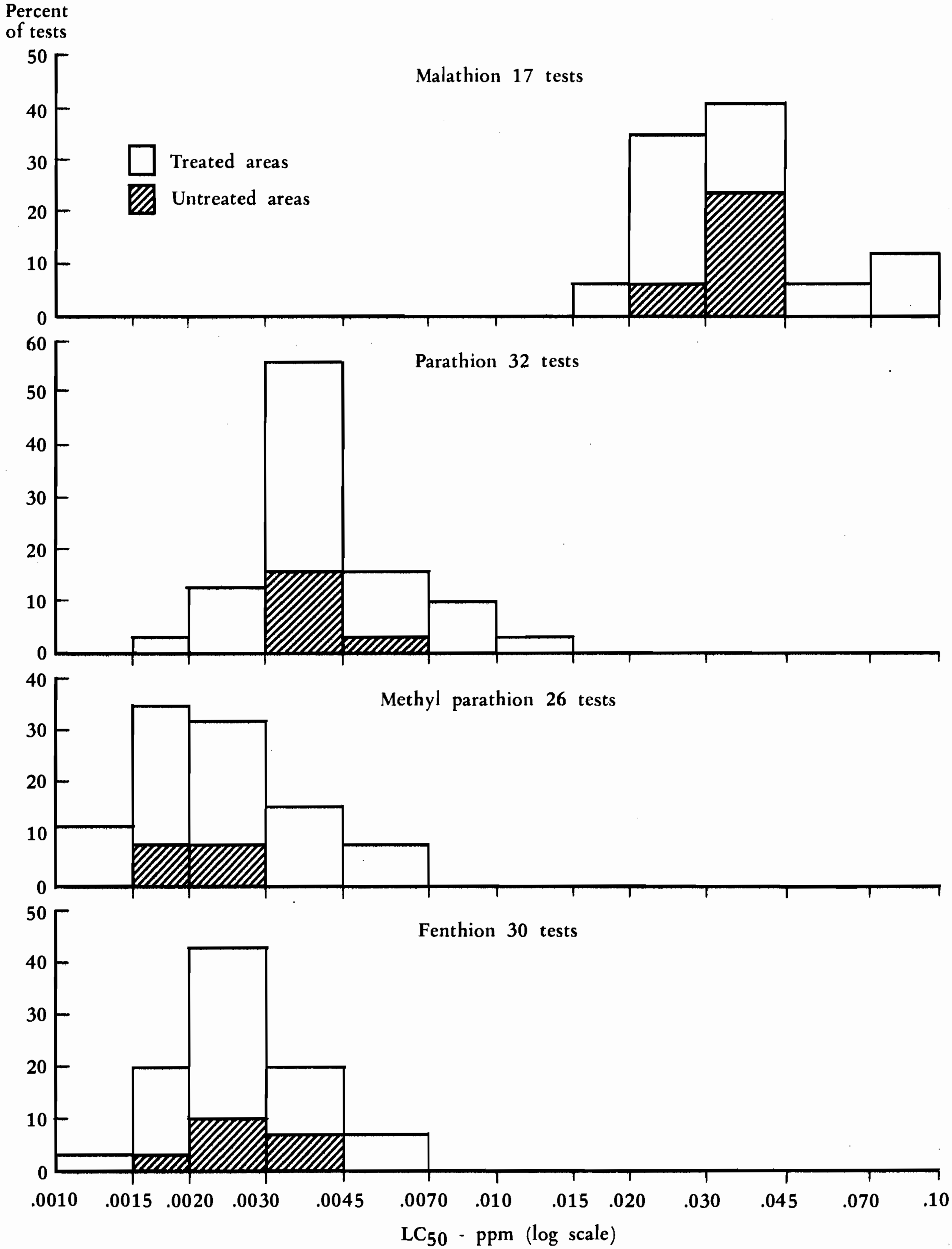

Figure 1.—Distribution of LC_{50} values in tests of insecticide susceptibility of *Aedes vexans* larval populations in California.

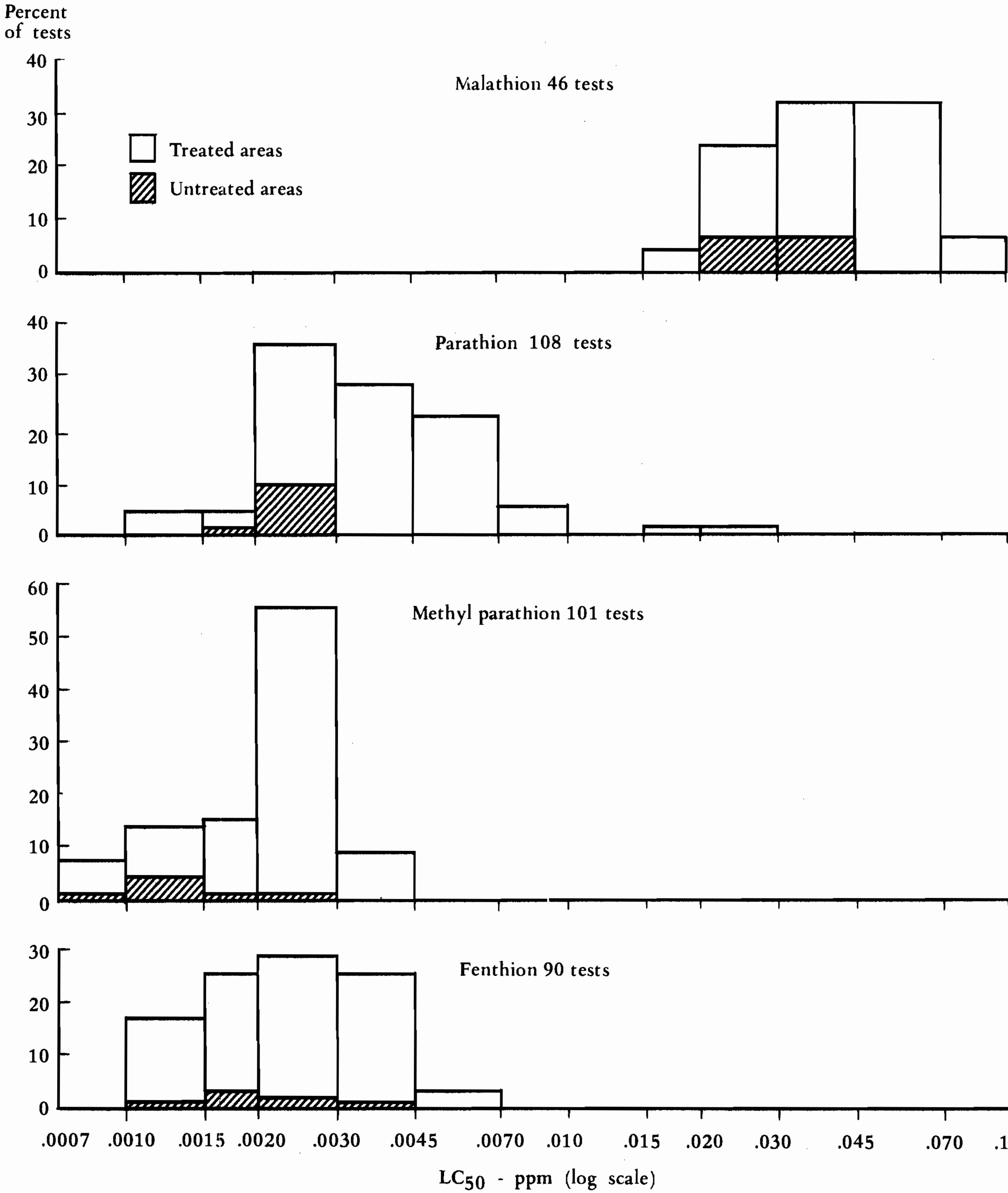

Figure 2.—Distribution of LC_{50} values in tests of insecticide susceptibility of *Aedes melanimon* larval populations in California.

Table 1.–Range of LC_{50} values in tests of insecticide susceptibility of *Aedes vexans* larval populations in California.

Insecticide	Range of LC_{50} (ppm)	No. of tests
Abate	.00081 – .0022	7
Dursban	.00049 – .0012	8
EPN	.0015 – .0041	4
DDT	.018 – .045	4

Table 2.–Range of LC_{50} values in tests of insecticide susceptibility of *Aedes melanimon* larval populations in California.

Insecticide	Range of LC_{50} (ppm)	No. of tests
Abate	.0013 – .0093	9
Dursban	.00036 – .0036	12
EPN	.0011 – .0054	5
DDT	.021 – .93	11

tance in this species has been indicated, Table 1 lists the range of susceptibility at the LC_{50} for ABATE®, DURSBAN®, EPN and DDT.

Although occasional high LC_{50} values are encountered, they are distributed randomly without respect to agency or any particular area within an agency. Additionally, the higher LC_{50} values are not accompanied by flatter line slopes, which is frequently an indicator of incipient resistance (Hoskins 1960, Gillies et al. 1968). These higher levels probably indicate general vigor of the test larvae and represent the high end of the susceptibility range of these species, rather than developed or physiological resistance. From this evidence, it appears that *A. vexans* larvae are susceptible to all materials tested. There have been no reports of field failures from the control agencies.

Results of tests on *A. melanimon* larvae from 23 control agencies were compared to those for larvae from four widely separated uncontrolled areas in the Central Valley (Figure 2). Operationally significant resistance in this species appears to be limited to parathion. Apparently only two control agencies, the Sutter-Yuba and Tulare mosquito abatement districts, are presently affected. The levels of resistance are not high, particularly when compared to those for *A. nigromaculis*, where LC_{50} values greater than 0.1 are common in the areas of resistance. Nevertheless, it has been demonstrated that when larvicides are applied at the rate of 0.1 lb/acre and the LC_{50} of the test population exceeds 0.0050 ppm some degree of loss of control in the field may be anticipated. When the LC_{50} exceeds 0.01 ppm, field failures are readily recognized (Womeldorf et al. 1966). Also, flatter line slopes, indicating the presence of more tolerant individuals within the test population, are found within several additional agencies.

Results of tests against other materials are shown in Table 2. Resistance to DDT is evident, but is of historical interest only. This material has not been used for widespread control since the early 1950's. Interestingly, this resistance is apparently widespread and the present levels are as high, or higher, than those determined during the DDT problem era of the late 1940's and early 1950's (Gjullin and Peters 1952).

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A CANDIDATE CHLORINATED HYDROCARBON CHEMICAL FOR RESISTANT *AEDES NIGROMACULIS* CONTROL

Elmer Kingsford and William Hazeltine

Butte County Mosquito Abatement District, Oroville

The dilemma of how to control chemically resistant pasture mosquitoes (*Aedes nigromaculis*) has become common the past few years. Where districts used to concentrate on control of this species, now, it has been de-emphasized, because of chemical resistance. There has probably been more money and time expended the past three years on this mosquito than for any other species in California.

You are probably familiar with the resistance history of this pest, and the shift toward water management and drainage as control methods. While we fully subscribe to the need for improved water and land management practices, we also subscribe to the need to continue to look for chemicals to use in the fight against mosquitoes.

An article in NATURE (Holen 1969) described a new molecule, similar but different from DDT. The most intriguing part of the article was the use of theoretical thinking to design the molecule. If you want to read an excellent account of how this was done, you should get a copy of this paper, and study it. Among other things, the slight change in configuration of a DDT-like molecule produced a compound which was effective on highly resistant houseflies.

It was this which started the wheels turning, and the reason we decided to look at the compound in relation to some of our resistant mosquitoes. The compound we worked with was Monsanto 0412, and its structure is 1, 1 – bis – (p-chlorophenyl) – 2, 2 – dichlorocyclopropane.

The major difference between this compound and DDT is at the center of the molecule where there is a 3-carbon ring with two chlorine atoms instead of a 2-carbon chain with three chlorine atoms. The mammalian toxicity does not seem to offer any problems.

Laboratory runs with field collected larvae, Table 1, show that this compound in a 24-hour test is about 10 times more active than DDT on *Aedes nigromaculis*, and the dose-response line is steeper. The LC_{50} is about equal to BAYTEX® and the slope is again steeper.

On *Aedes vexans* larvae, it is about equal to DDT, and less active than parathion or BAYTEX. We have no reason to think we have any resistance in *A. vexans*.

On *Culex pipiens* from a laboratory colony, Monsanto 0412 appeared to be about twice as active as DDT.

On field collected *Anopheles freeborni*, Monsanto 0412 seems to be twice as active as DDT and about one-fifth as active as parathion.

We are reporting preliminary information, but the pattern seems consistent enough to allow some tentative conclusions about this experimental compound:

Table 1.–Examples of comparison of LC_{50} and LC_{90} on Mon-0412, DDT, Fenthion and Parathion (24-hour larvae exposure).

SPECIES	INSECTICIDE							
	MON-0412		D.D.T.		FENTHION		PARATHION	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Aedes nigromaculis	.012 (.0045:.015)	.025 (.011:.052)	.058 (.051:.44)	.45 (.40:.82)	.009 (.009:.012)	.080 (.054:.08)	.028 (.008:.07)	.081 (.11:.41)
Aedes vexans	.022	.06	.047	.076	.0015	.0026	.0036	.0054
Anopheles freeborni	.074	.45	.26	.96	.021	.046	.012 (.008:.011)	.027 (.021:.032)
Culex pipiens	.056 (.054:.057)	.11 (.10:.12)	.12	.92	.0027	.0052	.0045	.012

1. Where resistance to DDT exists, Monsanto 0412 seems to be superior to DDT. We speculate that the suggestion in the paper referred to above is correct, and that the mechanism which confers DDT resistance does not effect Monsanto 0412, or only effects it slightly. Holen suggests the compound is sufficiently different in structure from DDT so that DDT dehydrochlorinase does not degrade it, yet it is effective in killing insects.
2. Where no resistance is evident, both DDT and Monsanto 0412 seem similar in activity.

As you might well guess, the prospects of getting this compound developed and registered for use are pretty small in the present climate of environmental activism. We feel this is a symptom of a social and scientific sickness which is in obvious need of correction. Perhaps this compound is too expensive to compete, or it may have other drawbacks which can only be determined in a climate of fair objective evaluation. In the present atmosphere, the needed research will probably not be done, because the compound is already judged guilty by association with the chlorinated hydrocarbon insecticides, of which DDT is the most popular example.

We suggest that when you are tempted to offer the explanation to an irate taxpayer that *Aedes nigromaculis* are resistant to everything, that you be honest with yourself and the taxpayer. There are materials which have prospects of working on resistant *Aedes*, but they have been prejudged and restricted because they might have some of the undesirable characteristics which DDT is supposed to have, or are otherwise being lost in the registration mill. The present situation is really the antithesis of social conscience; it seems more like social madness.

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DAILY FLIGHT RHYTHMS OF THE PASTURE MOSQUITO, *AEDES NIGROMACULIS*, IN THE SAN JOAQUIN VALLEY OF CALIFORNIA

Takeshi Miura

Mosquito Control Research Laboratory, University of California, Fresno

Circadian rhythms play an important role in the control of mosquito behavior (Clements 1963); most often environmental factors such as temperature, relatively humidity, and light intensity have proved to be important phase setters (Wellington 1945, Platt et al. 1958, Miura and Reed 1970).

The pasture mosquito, *Aedes nigromaculis* (Ludlow), is intensely pressured by larvicidings. Larvae have become highly resistant to many insecticides (Womeldorf et al. 1968, Wilder and Schaefer 1970). Therefore, the control of adults of this species became an important operation of many mosquito control agencies in California.

According to Brown and Mulhern 1954, and Gjullin and Peters 1955, adulticidings in the San Joaquin Valley produced a rather poor result due to winds, convection currents, and high evaporation. Lewallen (1964), however, reported that if adulticiding was used in conjunction with larviciding, it would provide a considerable measure of mountain mosquito control.

Adulticidings, according to Rogers (1967), play an important role in the Florida mosquito control program; Wright and Knight (1966) also report that adulticiding is commonly used in Iowa, and it is most effective when the chemicals are used during the time at which mosquitoes are in flight.

The object of the present study is to define the characteristics of daily flight activity of *A. nigromaculis* and to determine the environmental conditions under which adults are most active.

METHODS AND MATERIALS:

Experiments were conducted at the Costa pasture near Hanford, California. Daily flight activities were determined from hourly collections made by non-attractant traps, car-top and malaise traps. Initially trapping was continued through 24 hours, but it soon became evident that there were very few mosquitoes in the air during daylight hours (Miura and Reed 1969); therefore, subsequent flight studies were conducted from one hour before sunset to one hour after sunrise.

The specimens from each hourly collection were killed with chloroform and placed in a dixie cup. At the end of an overnight study, all collections in the dixie cups were taken to the laboratory. The specimens were identified according to sex and species. In addition, female mosquitoes were recorded as blood-fed or unfed and gravid or non-gravid. During each study period observations on biting and swarming activities were also recorded.

Temperature and relative humidity were recorded automatically with a hygrothermograph placed in the shade near the study field. The light intensity was measured by a Gossen Lunasix photometer with a sensitivity range between 0.014 and 14,000 foot candles. Wind velocity was measured with a Taylor Biram's type anemometer.

In order to express the effect of temperature on flight activity quantitatively, the term "median inhibitory temperature" is used. The term describes the temperature at which 50% of a population tested are inactive. Median inhibitory temperature tests were conducted with laboratory reared, 3-day old adults. Mosquitoes to be tested were isolated in a small glass container, approximately 2.5 inches in diameter and four inches deep, having a nylon screen top. The containers were exposed to ascending temperatures of 50°, 55°, 59°, 61°, and 68°F for 30 minutes each, at which time their movements (flights, hoppings) were carefully observed by eye and recorded. There were 10 times for each temperature. Median inhibitory tests were also conducted using descending temperatures.

RESULTS AND DISCUSSION:

The daily flight activity of *A. nigromaculis* was clearly crepuscular with a flight peak during each twilight period. Very few mosquitoes were collected during hours of darkness (Figure 1). A typical relationship of flight activity to daily environmental changes is shown in Figure 2. During day hours, adult mosquitoes rested in the vegetation near their breeding sites. At sunset local weather conditions changed rapidly, and females were sighted sporadically in the air; biting activity began at this time. The first swarm of males was noticed over a fence pole at 7:23 p.m. (light intensity about 14 ft-c). Flight activity began to increase immediately after sunset when the average light intensity was 15.75 ft-c (range 14 to 21). These results agree with the data reported by Kliewer et al. (1967). The relative humidity ranged from 45% to 58%.

At dawn, biting and swarming activities resumed. Substantial catches also occurred just before sunrise; however, the number of mosquitoes collected never reached the even-

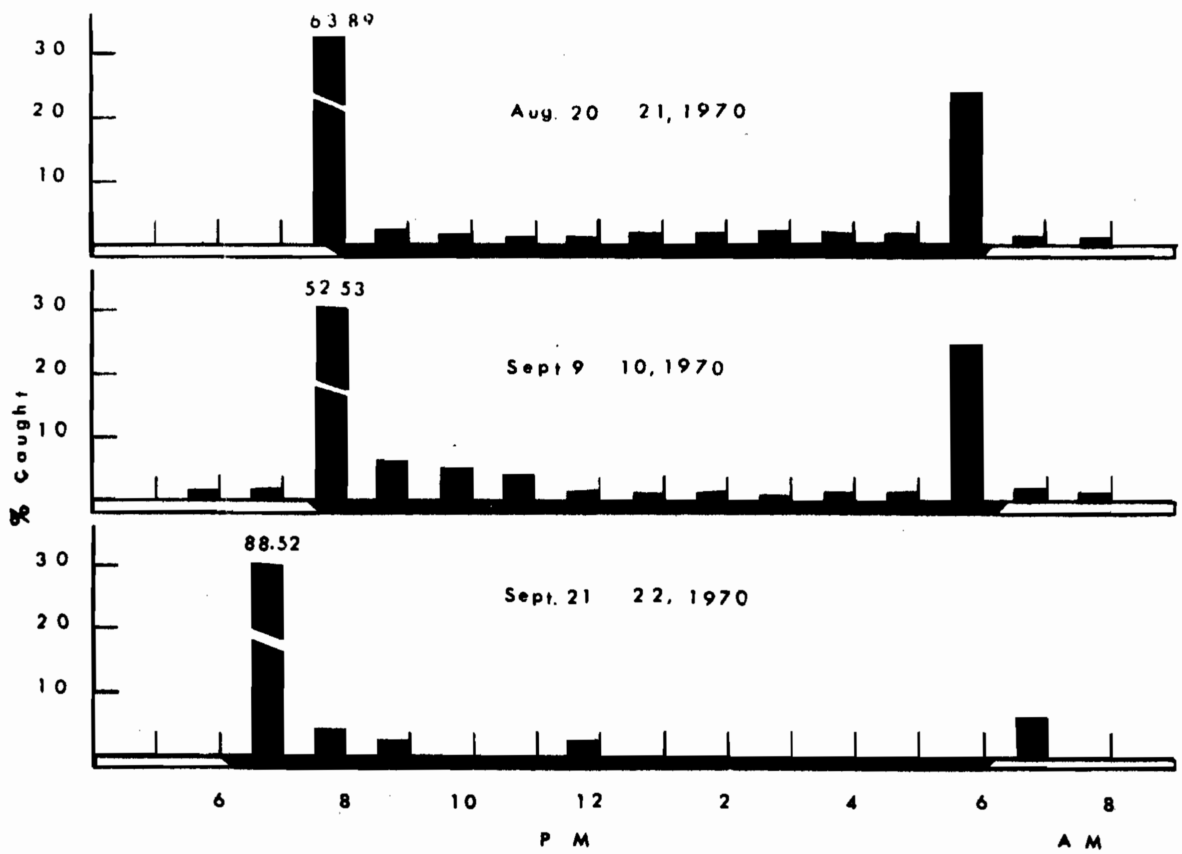

Figure 1.–Overnight hourly car-top trap collections of *Aedes nigromaculis* in the San Joaquin Valley of California.

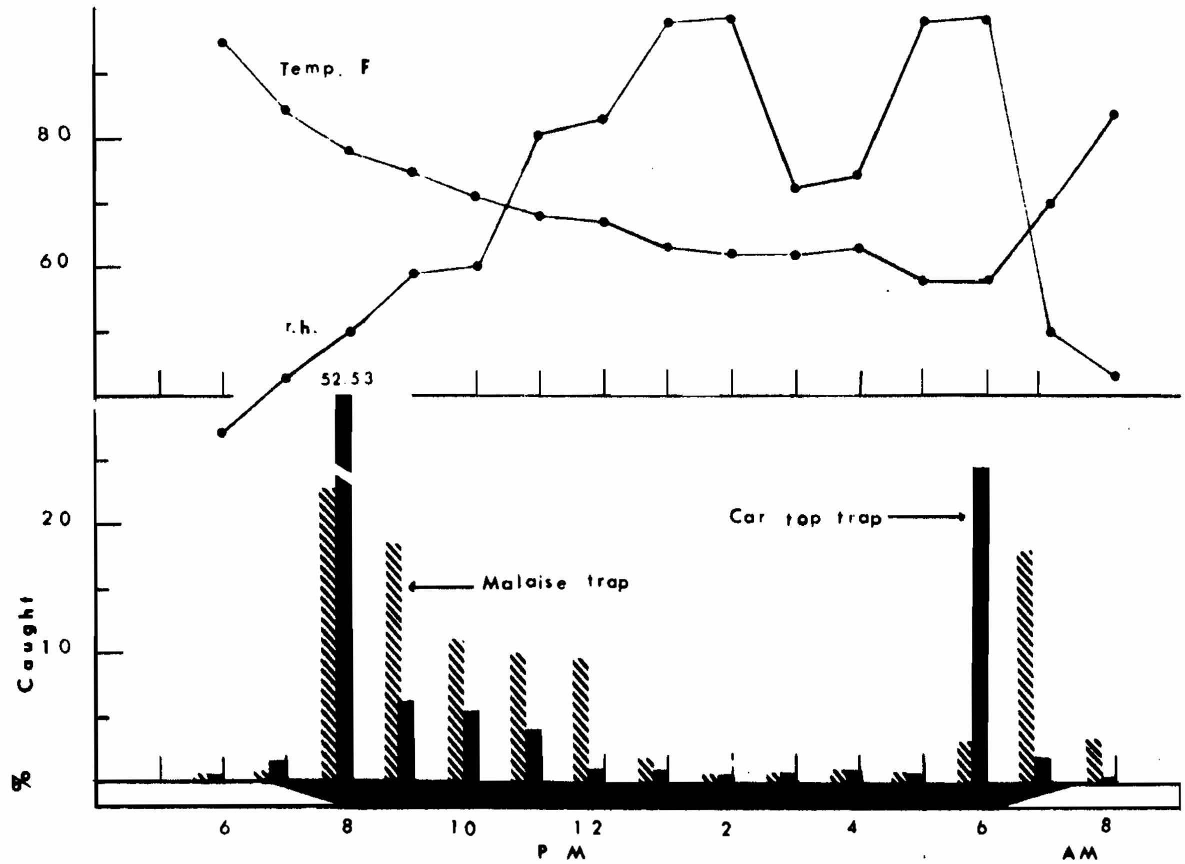

Figure 2.–Relationship of daily flight patterns of *Aedes nigromaculis* as shown by the overnight hourly collections to daily weather change in the San Joaquin Valley of California, September 9-10, 1970.

average temperature was 62.8° F, range 52° to 80°; relative humidity ranged from 45 to 96. Few mosquitoes were collected between the evening and morning peaks.

Initiation and termination of flight activity appear to be influenced by the interaction of light intensity, temperature and relative humidity, although flight may be suppressed by unfavorable temperatures, humidities or winds (Lumsden 1952, Miura and Reed 1970).

During the morning flights the temperature was always much lower than during the evening flights. When morning temperatures were as low as 60° F, flights were greatly inhibited even though the light intensity was favorable (Figure 3).

Figure 4 shows laboratory examinations of the effect of temperature on flight activity. The median inhibitory temperature of males exposed to the ascending temperatures was 62.9° F, and that of descending temperatures was also 62.9° F. For females it was 63.1° and 62.7° F respectively. The common median inhibitory temperature of males and females, calculated from these data, was 63° F.

The lowest temperature at which a given physiological process cannot be carried through a given stage in the life history is defined as "ecological temperature zero" by Allee et al. 1959. The ecological temperature zero of *A. nigromaculis* was calculated as 52.4° F (Figure 5); theoretically the pasture mosquito adults suspend flight activity at 52.4° F.

SUMMARY

The daily flight activity of *A. nigromaculis* was crepuscular with bimodal peaks at the evening and morning twilight periods; there were some nocturnal flights between the periods.

The field observations showed that the initiation of flight behavior of the pasture mosquito depends upon an interaction of temperature, relative humidity, and light intensity. A temperature of at least 60° F and relative humidity of 40% are necessary to stimulate activity. A light intensity of 15 to 1 ft-c seems optimal. If temperatures during these favorable periods were lower than 60° F, flight activity was greatly reduced even though light intensity and relative humidity were suitable.

Based upon the results of this study, it is indicated that the best time to apply adulticides to control the pasture mosquito is in the evening at the twilight period when the temperature is above 60° F and the relative humidity is 40% or higher.

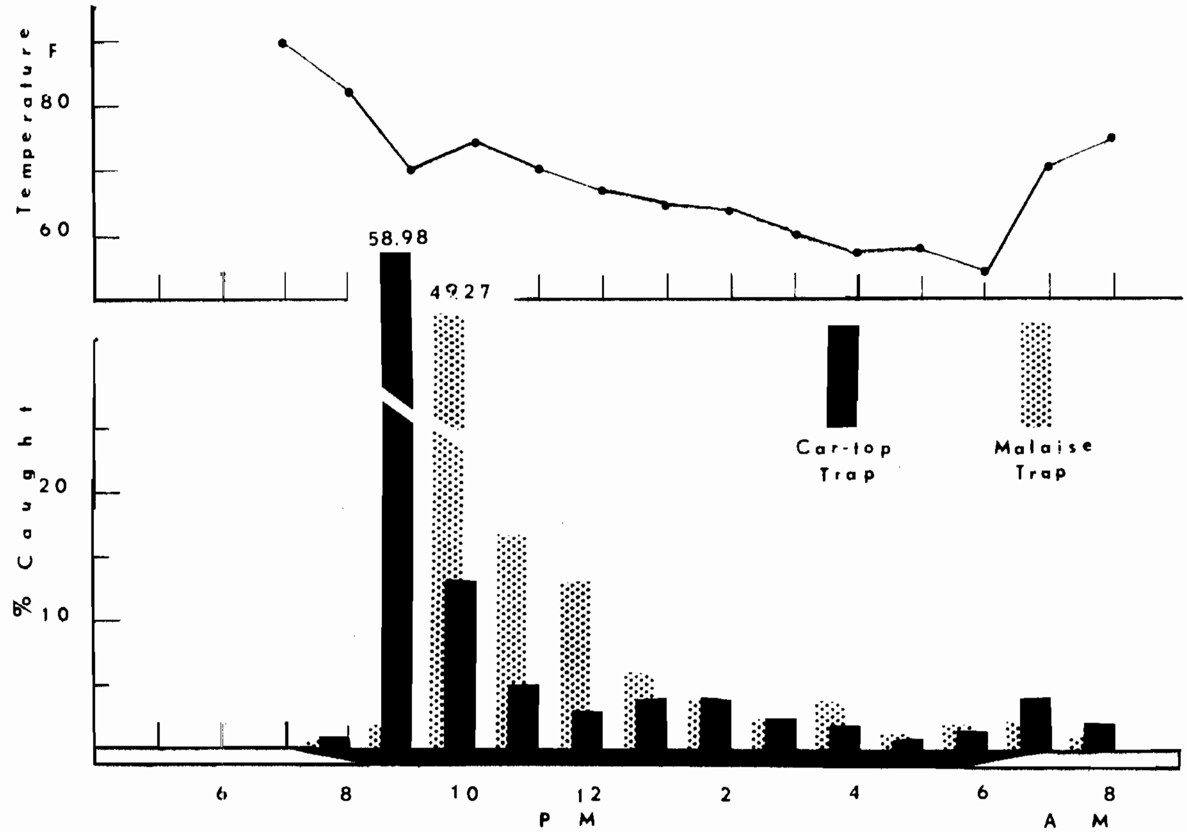

Figure 3.–Effect of temperature on flight behavior of *Aedes nigromaculis*, September 9-10. 1970.

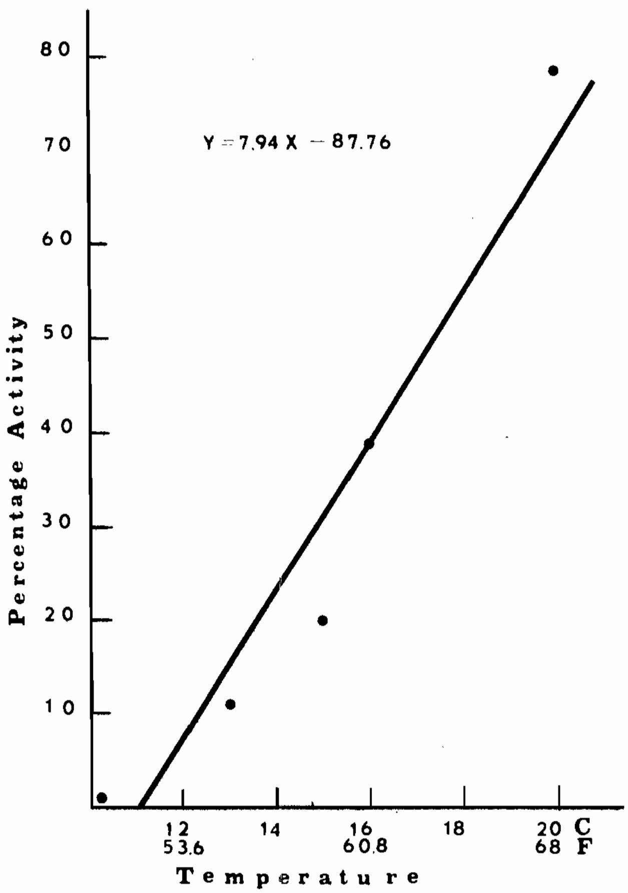

Figure 4.–Rates of flight activity of *Aedes nigromaculis* adults showing the relationship between temperature and rate of flight.

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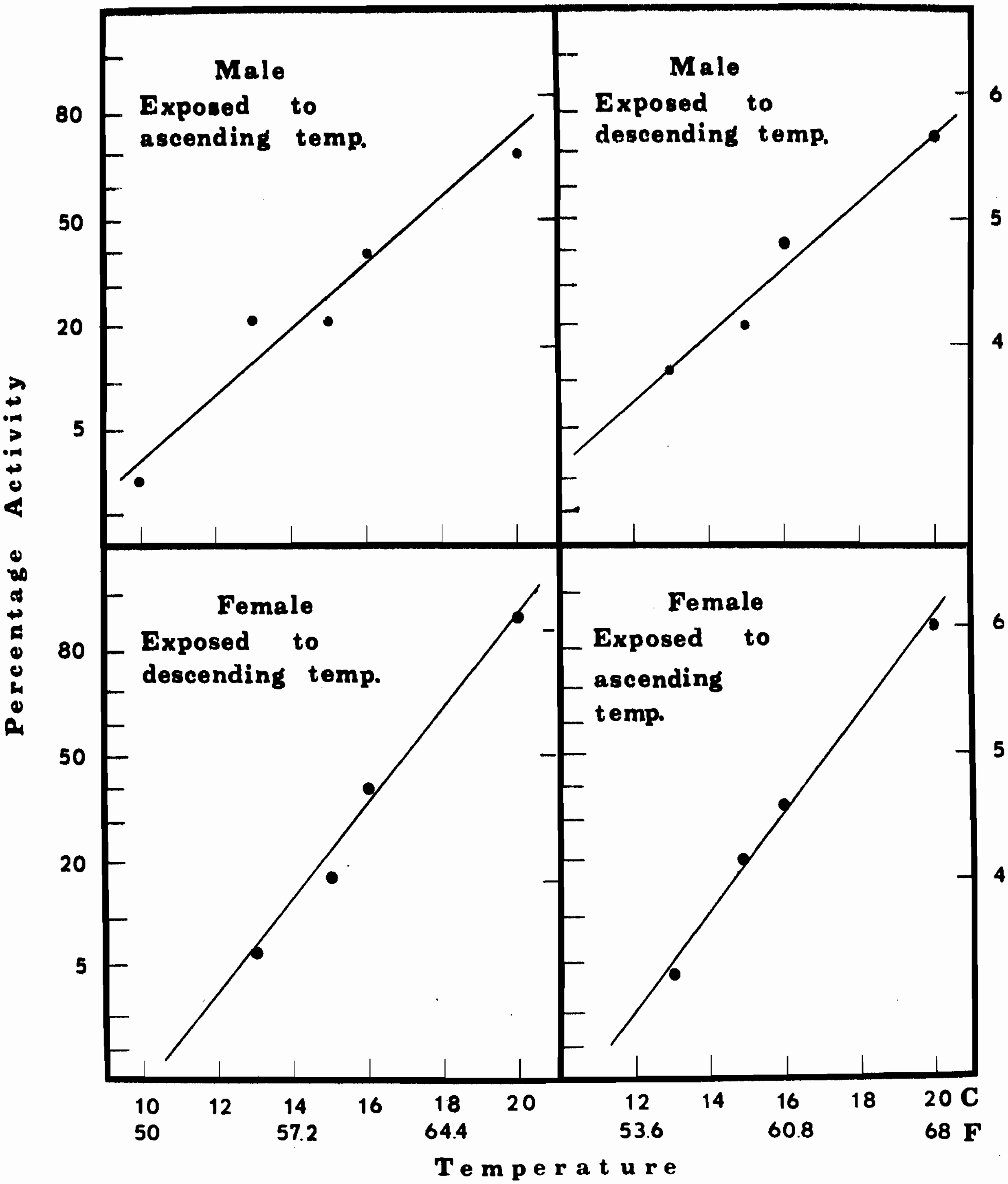

Figure 5.—Overall rate of flight activity of *Aedes nigromaculis* showing the ecological temperature zero point.

UCLA MOSQUITO STUDIES IN TONGA – 1969

James C. Hitchcock, Jr.
University of California, Los Angeles

ABSTRACT

Comprehensive entomological studies on vectors of subperiodic Bancroftian filariasis were continued in the Kingdom of Tonga during May through August 1969. In addition to the extension of the epidemiological studies over 1968, to include blood and clinical examination of the resident population of the Niuatoputapu Group, the age of each female mosquito dissected was determined by the Polovadova method. This age-related information resulted in a clearer picture of the role of the vector in the transmission of filariasis. The age composition of the biting-landing mosquito population of each village showed that the parous age groups were exceptionally stable but the nulliparous age group showed considerable variability. Consequently the percent of infected mosquitoes based on the parous age groups (i.e. the female mosquitoes which had had at least one opportunity to become infected) allowed a more suitable method of inter-village comparison. It was also possible to establish the blood meal at which the vector ingested microfilariae. These and other age-related data were demonstrated with tables and figures.

SUSCEPTIBILITY OF *AEDES* MOSQUITO LARVAE TO CERTAIN CRYSTALLIFEROUS *BACILLUS* PATHOGENS

Eldon L. Reeves and Clemente Garcia
Division of Biological Control, University of California, Riverside

In our continuing search for ecologically acceptable ways to deal with mosquitoes, it is becoming ever more evident that it is desirable to harness some of the natural forces available in our aquatic ecosystems. These natural forces then can be orchestrated with the sensible use of selective biodegradable insecticides and source reduction in order to give a balanced multi-approach pest management system. Pathogens are one of the more important natural forces that suppress mosquito populations. This vast biological force is susceptible to management and manipulation. However, in order to realize the full potential of these natural population regulators it will be necessary to understand the various mosquito host-microbial parasite interrelationships. The limiting factors in this relationship are indeed complex, but we feel that they can be deciphered and utilized in the management of these natural forces.

The primary objective of our research project is the isolation and evaluation of virulent insect pathogens that can be utilized in a biological or integrated control program against mosquitoes. Current research to evaluate and characterize several bacterial pathogens of the crystalliferous *Bacillus* type, including the bicrystalliferous isolate BA-068 (Reeves 1970; Reeves and Garcia 1971), which possess virulence for larvae of various species of *Aedes* mosquitoes, will be reviewed. These pathogens characteristically possess one spore and one or more proteinaceous crystalline parasporal bodies per maturing cell or sporangium.

BA-068, isolated from moribund *Culex tarsalis* larvae, consistently produces a spore and two crystals per sporangium. One crystal is diamond-shaped and the second is cuboidal (Figure 1). The activity in this *Bacillus* is primarily contained in the protein crystals with no activity displayed by pure alkali-washed spores when used alone. Highest virulence is attained when the natural spore-crystal combination is used. This phenomenon is probably due to a coupled toxemia-bacteremia, resulting from a sequence of events that yields maximum larval mortality. Isolate BA-068 has been identified, from a sub-culture of our isolate, by the

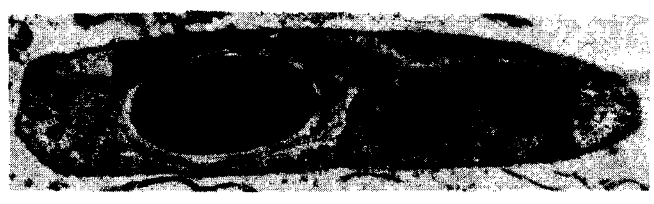

Figure 1.–Electron micrograph of an ultrathin section of *Bacillus thuringiensis* var. *thuringiensis* isolate BA-068 showing a sporangium with a developing spore and two crystalline proteinaceous parasporal bodies. 30,000 X.

Institute Pasteur-Paris as *Bacillus thuringiensis* var: *thuringiensis*, Serotype H-1, even though it does not produce B-exotoxin and it is virulent for mosquitoes. Electron microscopy, biochemical tests and bioassays have confirmed the unique qualities of this isolate. The host range spectrum has been extended to six species of mosquitoes and five species of lepidopterous larvae. A cooperative arrangement with the International Minerals and Chemical Corp. to produce this *Bacillus* for field evaluation against *Aedes* mosquito larvae in 1971 is underway. These field trials will be primarily against the pasture mosquito, *A. nigromaculis*, in permanent irrigated pastures in the San Joaquin Valley. Other tests will be against *Aedes* tree-hole mosquitoes in park and forest areas of the state.

We have isolated several different crystalliferous bacterial isolates from moribund and morbid mosquito larvae, some of which look promising. Also, we have bioassayed 14 crystalliferous cultures from the Institute Pasteur-Paris which revealed five isolates active for mosquito larvae. Each of these active isolates is being included in our evaluation program.

Representative dosage-mortality data for isolate BA-068 against three species of *Aedes* larvae are presented in Table 1. Preliminary small scale field tests with this isolate against the pasture mosquito *A. nigromaculis* (Reeves and Garcia 1971) look promising.

The differential susceptibility of *Aedes* and *Culex* larvae, of the same instar, to treatment with identical concentrations of a sporecrystal suspension of isolate BA-068 offers some insight into the basic factors that regulate susceptibility of mosquito larvae to a crystalliferous bacterial pathogen. For example, we have found that to obtain an LD_{50} in third instar *C. tarsalis* or *C. peus* larvae requires at least 3×10^7 spores/ml of larval culture water as compared to 1.3×10^4 in third instar *A. triseriatus*, with less than 5% mortality in all controls. We would have to attribute this differential susceptibility to a physiological difference between the two genera. Based on previous findings by insect pathologists, utilizing crystalliferous *Bacillus* primarily in lepidopterous larvae, there is good indication that the critical factors controlling susceptibility will be primarily those associated with the natural environmental condition of the mid-gut of the mosquito (Angus 1954; Heimpel and Angus 1959; Lecadet 1966, 1967; Krywienczyk and Angus 1969; Fast and Angus 1970; Pendleton 1970; Somerville et al. 1970).

A brief review of these findings will suffice as background for our work. The proteinaceous crystals are nontoxic to insects in their native crystalline form, but they can be hydrolyzed and activated by certain factors found in the gut system of susceptible insects. Therefore, the crystal in its native form should be referred to as a protoxin. The presence of one or more of the following gut factors appears to be necessary in the gut system in order to hydrolyze and activate the protoxin: alkaline pH, certain proteolytic enzymes, and reducing agents. There may be some plasticity as to the concentration of each of these three factors in different species of susceptible insect hosts. The alkaline pH appears to be the basic requirement, but the presence of reducing agents, i.e., cysteine, thioglycolate, etc., permits hydrolysis of the protein at lower pH values. The reducing agents would act on the disulfide bonds thus permitting the protein molecules to open up and become more susceptible to attack by the proteolytic enzymes. The presence of specific enzymes, which cleave the peptide bonds at specific sites along the peptide chain, would lead to the hydrolysis of the protein, this yielding polypeptides of various molecular weights. Consequently, if the host possesses the correct gut factors to convert the proteinaceious protoxin into its toxic moieties it will probably be susceptible to the paralytic action associated with these toxic molecules.

Table 1.—Dosage-mortality data for first and third instar *Aedes* mosquito larvae exposed to spore-crystal suspensions of *Bacillus thuringiensis* var. *thuringiensis* isolate BA-068 in the laboratory.[1,2]

Species	First instar		Third instar	
	LD_{50}	LD_{90}	LD_{50}	LD_{90}
A. aegypti[3]	1.3×10^5	1.2×10^6	1.4×10^5	3.4×10^6
A. triseriatus[3]	4.3×10^3	1.2×10^5	1.3×10^4	3.2×10^5
A. nigromaculis[4]	1.0×10^5	7.5×10^5	–	–

[1]Based on 3 replications of 50 larvae each at 3 concentrations at 25° C; time 3 days.

[2]Lethal dose (LD_{50} and LD_{90}) based on total spore count/ml of larval culture water.

[3]Laboratory reared.

[4]Field collected near Wasco, California.

The mode of action of these toxic moieties has not been completely determined, but two hypotheses prevail. One would attribute the initial paralysis to the disruption of the membranes associated with the epithelial lining of the mid-gut and the direct leakage of the alkaline gut contents into the hemocoel. The second would attribute the paralysis to the leakage of specific ions, probably K^+, Na^+, Cl^-, across membranes, thus affecting the nervous system and hemolymph of the insect.

Therefore, the decreased susceptibility of *Culex* larvae, in relation to *Aedes* larvae, probably is due to a gut environment that leads to reduced hydrolysis of the proteinaceous crystals or to a cleavage of the peptide chain at chemical bonds that yield moieties that are inherently less toxic than molecules that were enzymatically cleaved at different sites.

In working with isolate BA-068 we have shown that the primary source of activity for the mosquito larvae is contained in the two proteinaceous crystals. One hundred percent mortality can be attained using only pure crystal suspension, but when spores are present in the suspension 100% mortality can be attained with a lower concentration of crystals. Also, the presence of spores would be necessary in order for this to be a self-perpetuating entity in nature. As an indication of the rapidity with which this pathogen works, an LT_{50} = 16 hours at 25^c can be expected.

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FIELD EVALUATION OF ALIPHATIC AMINES – PETROLEUM OIL FORMULATIONS AGAINST PREIMAGINAL MOSQUITOES

Mir S. Mulla and Husam A. Darwazeh

Department of Entomology, University of California, Riverside

Development of resistance in mosquitoes to organophosphate and organocarbamate insecticides in California is a serious problem now. Recent papers on the level, pattern and distribution of resistant mosquito populations have been published (Georghiou 1970, Mulla et al. 1970a and Schaefer and Wilder 1970). The problem as outlined in these published works is widespread and further expanding.

The need for the development of compounds, and formulations having a different mode of action is quite obvious now. One group of such compounds, commonly known as the aliphatic amines, was shown earlier to have a fair level of activity against eggs, larvae and pupae of mosquitoes (Mulla 1967, Mulla and Chaudhury 1968, Mulla et al. 1970-b). These compounds were found to be almost equally effective against resistant and susceptible strains of mosquitoes (Georghio et al. 1969, Mulla et al. 1970b).

In order to further evaulate and develop these compounds for mosquito control in California, various formulations were prepared and tested in experimental mosquito breeding ponds.

MATERIALS AND METHODS

Among the most active aliphatic amines, Aliquot 221 (dimethyl dicocco ammonium chloride), Armeen L-15 (beta primary amine, the alkyl chain 15 carbons), Duomeen L-15 (beta diamine, the alkyl chain 15 carbons) and Duomeen T (beta diamine, alkyl chain from tallow) were subjected to extensive testing and evaluation. The amines were dissolved at various concentrations in Toxisol FLC (starting material for ARCO Larvicide), Toxisol TB and Sunland Auto Diesel. Toxisol FLC and TB are aromatic fractions, having 60-70% of aromatic compounds. In addition to the cationic surfactants (aliphatic amines) in the oils, a nonionic surfactant (either pluronic L-101 or pluronic L-121) was added to some of the formulations at 1% concentration.

The formulations were applied as atomized spray by means of a one-pint all purpose sprayer-atomizer (Smart and Final Iris Co., Riverside, California). The fine mist spray was applied to experimental breeding ponds either at Midgeville at the University of California, Riverside or at Oasis in the Coachella Valley, California. The ponds were 12' x 18' at Midgeville and 18' x 18' at Oasis. Depth of water in both series was 12" and water replenished through valves triggered by a float valve.

Each treatment was run in duplicate ponds. The level of reduction was assessed as percentage of populations assessed at pre-treatment count. Only third and fourth stage larvae and pupae were used in these calculations. First and second instar larvae were counted but not included in the calculations, since these could yield misleading results. First instar larvae could have been hatched just prior to taking samples, thus not having had sufficient exposure time to the treatments.

Mosquitoes breeding in the experimental breeding ponds in large numbers were: *Culex tarsalis*, *C. peus* and *Culiseta inornata.* The ponds at Midgeville were primarily infested with *C. peus* and to a lesser degree with *C. tarsalis*. In the Oasis ponds, *C. tarsalis* was the dominent species, with a few *Culiseta inornata* also prevailing at times.

RESULTS AND DISCUSSION

Armeen L-15 (a beta primary amine) was evaluated at various rates as a solution in Toxisol FLC. At 0.25 lb/acre rate this material when applied in 0.5 and 1.0 gal/acre volumes, yield low to moderate level of reduction (Table 1). Increasing the dosage of Armeen L-15 to 0.5, 1.0 and 2.0 lb/acre, applied in a 0.5 gal/acre, slightly increased the level of reduction. From the data it is apparent that Armeen L-15 in Toxisol FLC is not an effective mosquito control agent.

Further evaluation of Armeen L-15 along with Duomeen L-15 in Toxisol FLC, confirmed the low level of activity of Armeen L-15 formulations. Duomeen L-15 at much lower concentrations, produced excellent control of larvae and pupae (Table 2). The level of pupal control with Duomeen L-15/Toxisol FLC formulations was excellent.

To further evaluate Duomeen L-15, two experiments were conducted with various concentrations of this material with or without a cosurfactant. Duomeen L-15 and the cosurfactant were dissolved in Toxisol FLC and applied at various volumes to ponds in Oasis. In the first experiment, Duomeen L-15 solutions at three concentrations were applied at two rates each. The 1% solution gave excellent control at the 1 gal/acre rate. The 5% and 10% solutions at 0.5 and 1 gal/acre rates gave good to excellent reduction in the larvae and pupae of mosquitoes (Table 3). It seems that 1% or 5% Duomeen L-15 solution produces the desired results.

In the second test, 5% Duomeen L-15 solution in Toxisol FLC was evaluated with or without 1% of a nonionic cosurfactant pluronic L-101. The formulation was applied at 0.25, 0.5 and 1 gal/acre rates. Good to excellent control was obtained with 0.5 and 1 gal/acre rates of the formulation (Table 4). The cosurfactant in this case did not improve the efficacy of DL-15 in Toxisol FLC.

Two additional tests with Duomeen L-15 in petroleum oils were conducted in ponds at Midgeville. In the first test, both 5 and 10% DL-15 in Toxisol FLC plus 1% pluronic L-101 as cosurfactant were applied at 0.5 and 1 gal/acre. Both formulations yield excellent initial control of mosquitoes (Table 5).

In the second test, Duomeen L-15 was dissolved in Sunland Auto Diesel and the formulation was evaluated with or without 1% pluronic L-101 as a cosurfactant. The DL-15 formulation with or without the cosurfactant yielded good control (Table 6). The formulation without PL-101 was slightly better. It was later found that PL-101 is insoluble in this diesel, thus contributing to lower effectiveness of this formulation.

Table 1.–Effectiveness of Armeen L-15 in Toxisol FLC (without a cosurfactant) against mosquito larvae and pupae in experimental breeding ponds. (Oasis, 1-26-70)

Rate		Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days)														
Toxisol FLC	ARL–15	Pre-treatment			1				7				10			
gal/ac	lb/ac	1-2	3-4	P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
0.50	0.25	83	78	27	19	15	12	74	57	52	6	45	86	53	8	42
1.00	0.25	38	62	1	62	23	3	59	38	43	0	32	46	15	1	75
0.50	0.50	138	91	12	56	44	19	39	286	63	6	33	209	39	7	55
0.50	1.00	26	57	8	6	13	0	80	44	11	1	81	66	11	1	81
0.50	2.00	73	93	7	16	18	6	76	54	15	4	81	118	17	3	80
Check	––	67	38	8	65	28	12	13	72	79	38	0	106	80	24	0

Table 2.–Effectiveness of two aliphatic amines in Toxisol FLC (without a cosurfactant) against the immature stages of mosquitoes in experimental breeding ponds. (Oasis, California, 2-70)

Material	Rate	Avg. No. larvae and pupae/5 dips pre- and post-treatment (days)														
		Pre-treatment			1				7				10-14			
and conc (%)	gal/ac	1-2	3-4	P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
Armeen L-15 (3)	0.5	84	78	27	19	15	12	74	57	52	6	45	86	53	8	42
Armeen L-15 (3)	1.0	38	62	1	32	23	3	59	38	23	0	63	46	15	1	75
Armeen L-15 (6)	0.5	138	91	12	56	44	19	49	136	63	7	32	209	38	7	66
Armeen L-15 (12)	0.5	26	57	8	6	13	0	80	44	11	1	82	66	11	1	82
Armeen L-15 (24)	0.5	73	93	7	16	18	6	76	54	15	4	81	118	17	3	80
Check	––	67	38	9	65	28	13	72	72	79	37	0	106	80	24	0
Duomeen L-15 (1)	0.5	71	34	6	65	30	4	15	122	43	3	0	36	116	13	0
Duomeen L-15 (1)	1.0	57	321	1	12	2	0	91	14	1	0	94	20	62	0	0
Duomeen L-15 (5)	0.5	37	20	3	10	4	1	78	10	1	0	96	9	24	0	0
Duomeen L-15 (5)	1.0	150	24	3	12	8	1	67	36	3	0	89	9	36	2	0
Duomeen L-15 (10	0.5	70	24	4	6	3	0	83	12	1	0	96	7	17	1	36
Duomeen L-15 (10)	1.0	79	63	21	2	4	0	52	15	1	0	99	23	10	0	88
Check	––	236	56	19	136	59	12	5	104	63	3	12	111	157	27	0

Table 3.–Effectiveness of Duomeen L-15 in Toxisol FLC (without a cosurfactant) against mosquito larvae and pupae in experimental breeding ponds. (Oasis, 2-4-70)

Duomeen L-15	Rate	Avg. No. of larvae and pupae/5 dips sample										
					Post-treatment (days)							
		Pre-treatment			2 (2-6-70)				7 (2-11-70)			
Conc (%)	gal/ac	1-2	3-4	P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
1	0.5	71	34	6	65	30	4	15	122	43	3	0
1	1.0	57	21	1								
1	1.0	57	21	1	12	2	0	91	14	1	0	95
5	0.5	37	20	3	10	4	1	78	10	1	0	95
5	1.0	150	24	3	12	8	1	67	36	3	0	89
10	0.5	70	24	4	6	3	0	90	12	1	0	96
10	1.0	79	63	21	2	4	0	95	15	1	0	99
Check	––	236	56	19	59	12	12	5	104	63	3	12

Duomeen T (made from Tallow, related to Duomeen L-15) was evaluated as 5% solution in Toxisol FLC with or without the cosurfactant pluronic L-101. When these formulations were applied at 0.5 and 1 gal/acre, they yielded good to excellent control of mosquitoes (Table 7). The 1 gal/acre rate gave the best results. Addition of 1% PL-101 had some positive effect at the 0.5 gal/acre rate.

Duomeen T as 5% and 10% solution in Toxisol FLC at 1 gal/acre yielded good to excellent control (Table 8). In Toxisol TB the compound was less effective than in Toxisol FLC.

When 1% pluronic L-121 was added to 5% and 10% solutions of Duomeen T in Toxisol FLC, the two formulations yielded good results at the rate of 1 gal/acre (Table 9). At 0.25 and 0.5 gal/acre the results were mediocre. The addition of the cosurfactant PL-121 again did not increase the efficacy of the Duomeen T formulations.

The quaternary ammonium salt Aliquot 221 was evalu-

Table 4.–Effectiveness of Duomeen L-15 in Toxisol FLC with 1% Pluronic L-101 cosurfactant against mosquito larvae and pupae in experimental breeding ponds. (Oasis, California, 4-17-70).

			Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days)										
Material and formulation (%)	Cosurf.	Dosage gal/ac	1-2	3-4	P	1-2	3-4	P	(%R)[a]	1-2	3-4	P	(%R)[a]
DL–15 (5)	––	0.25	67	15	5	24	12	2	30	49	10	2	40
DL–15 (5)	––	0.50	42	22	6	5	5	1	79	26	4	0	86
DL–15 (5)	––	1.00	145	37	6	2	1	0	98	21	1	0	98
DL–15 (5)	+	0.25	69	43	5	29	13	1	61	38	10	1	77
DL–15 (5)	+	0.50	113	31	4	15	5	0	86	56	18	0	49
DL–15 (5)	+	1.00	105	23	7	3	1	1	93	53	6	0	80
Check Tox FLC	+	1.00	158	29	6	12	9	6	57	122	20	1	40
Check	––	––	90	34	9	100	30	4	20	206	22	3	42

[a] One percent reduction based on 3-4 stage larvae and pupae against pre-treatment levels.

Table 5.–Effectiveness of Duomeen L-15 in Toxisol FLC with 1% Pluronic L-101 cosurfactant against mosquito larvae and pupae in experimental breeding ponds. (Midgeville)

		Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days)										
DL-15 Conc (%)	Rate	Pre-treatment			1				7			
Formulation (%)	gal/ac	1-2	3-4	P	1-2	3-4	P	(%R)[a]	1-2	3-4	P	(%R)
Duomeen 5	0.5	140	58	1	8	9	0	84	78	46	4	21
Duomeen 5	1.0	159	63	1	15	4	0	94	99	42	0	33
Duomeen 10	0.5	279	64	8	5	3	1	95	155	55	1	14
Duomeen 10	1.0	120	22	6	1	2	0	91	18	16	1	27
Check	––	33	13	1	85	38	2	0	100	31	2	27

[a] See Table 4.

Table 6.–Effectiveness of 5% Duomeen L-15 in Sunland Automotive Diesel (applied 1 gal/acre) and with or without Pluronic L-101 cosurfactant against mosquito larvae in breeding ponds. (Midgeville, 5-15-70).

	Av. No. of larvae/dip[a]		
Chemical and formulation	Pre-treatment	Post-treatment	% 24-hour reduction
DL–15 (W/O)	8	1	87
DL–15 (W)	12	2	83
Sunland Auto Diesel (W)	12	8	33
Sunland Auto Diesel (W/O)	8	5	37
Check	3	3	0

[a] 24 hour after treatment. Pupae present post-treatment.

Table 7.—Effectiveness of 5% Duomeen-T in Toxisol FLC with or without 1% Pluronic L-101 cosurfactant against mosquito larvae in experimental breeding ponds. (Midgeville, 1-6-70).

Material and formulation	Rate gal/ac	Av. No. of larvae/dip Pre-treatment	Post-treatment	% 24 hour red	Remarks
Duomeen–T (W/O)	0.5	22	11	50	Droplets or
Duomeen–T (W/O)	1.0	15	1	93	lenses formed
Duomeen–T (W)	0.5	6	1	83	Film formed,
Duomeen–T (W)	1.0	13	1	92	emulsification slight
Toxisol FLC (W)	1.0	7	5	29	Good film
Check	––	4	5	90	
Check	––	4	5	0	–––

Table 8.—Effectiveness of Duomeen T in two petroleum oils against mosquito larvae and pupae in experimental breeding ponds. (Oasis, 10-27-70).

Duomeen T	Solvent	Rate	Avg. No. of larvae and pupae/5 dips sample: Pre-treatment			Post-treatment (days) and (5) reduction: 2				7				14			
Conc (%)	Solvent	gal/ac	1-2	3-4	P P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
5	Tox. FLC	1.0	211	38	15	22	13	4	68	18	0	1	98	6	19	0	64
10	Tox. FLC	1.0	143	68	3	4	5	3	89	15	0	0	100	7	8	0	89
Check	Tox. FLC	1.0	120	32	2	111	44	3	0	35	15	0	56	13	20	2	35
5	Tox. TB	1.0	103	39	2	49	24	2	37	61	29	4	20	9	27	6	20
10	Tox. TB	1.0	181	65	0	13	7	2	86	30	2	0	97	29	37	1	42
Check	Tox. TB	1.0	135	29	11	85	35	3	5	104	38	17	0	11	35	10	0

ated against mosquito larvae and pupae in experimental mosquito breeding ponds at Oasis, California. At 1% in Toxisol FLC, and without any cosurfactant, the solution at 0.5 and 1.0 gal/acre yielded mediocre reduction in 3-4 stage larvae and pupae. Increasing the concentration of Aliquot 221 to 5% and 10% increased the level or reduction achieved (Table 10). Almost 100% reduction of 3-4 stage larvae and pupae was obtained at both 0.5 and 1.0 gal/acre rates. Toxisol FLC, the solvent alone at 1 gal/acre, yielded little or no control of the immature mosquitoes.

To determine if addition of a cosurfactant will increase the efficacy of Aliquot 221, the nonionic cosurfactant pluronic L-101 was added to the solutions at 1% and evaluated in Midgeville ponds. Adding this material did not increase the overall activity of the formulations of this quaternary salt in Toxisol FLC (Table 11). As a matter of fact, the level of control in all except one treatment was none or very low at best. The erratic results with Aliquot 221 (good results in Table 10 and poor in Table 11) will necessitate further studies on this material. Duomeen L-15 and T consistently performed better and further studies on the formulating of these will be rewarding. The addition of cosurfactants (biodegradeable nonionics) although not improving performance, does increase the spreading capabili-

Table 9.—Effectiveness of Duomeen T in Toxisol FLC and 1% Pluronic L-121 cosurfactant against mosquito larvae and pupae in experimental breeding ponds. (Oasis, 11-17-70).

Duomeen T	Rate	Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days)														
		Pre-treatment			2 (11-19)				7				14			
Conc (%)	gal/ac	1-2	3-4	P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
5	0.25	27	32	19	6	15	10	51	76	16	12	45	61	16	5	59
5	0.50	207	84	2	85	25	0	70	168	11	5	81	87	42	1	50
5	1.00	151	64	6	19	8	1	87	75	8	0	89	63	26	1	61
10	0.25	89	2	2	49	14	3	55	79	30	5	8	50	35	2	3
10	0.50	96	63	9	31	16	1	76	90	32	0	56	56	49	1	31
10	1.00	13	39	16	0	1	0	98	26	0	0	100	37	25	0	55
Check	—	101	40	6	117	66	14	0	61	41	30	0	57	42	22	0

Table 10.—Effectiveness of Aliquot 221 in Toxisol FLC against mosquito larvae and pupae in experimental breeding ponds. (Oasis, California, 2-18-70).

Chemical and formulation formulation formulation	Dosage GAL/ G gal/ac	Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days)										
		Pre-treatment			2				7			
		1-2	3-4	P	1-2	3-4	P	(%R)	1-2	3-4	P	(%R)
Aliq. 221 (1)	0.5	58	140	8	21	30	4	77	20	8	9	88
Aliq. 221 (1)	1.0	7	18	0	4	8	0	56	8	11	1	34
Aliq. 221 (5)	0.5	39	128	12	12	40	7	66	5	10	4	90
Aliq. 221 (5)	1.0	62	41	19	10	6	4	84	15	7	2	85
Aliq. 221 (10)	0.5	16	50	1	2	2	0	96	12	2	0	96
Aliq. 221 (10)	1.0	10	34	3	3	1	0	98	2	0	0	100
Toxisol FLC	1.0	43	16	0	15	36	1	0	26	12	0	25
Check	--	2	3	0	16	2	1	0	5	15	1	0

ty where pollution and scum are present in the breeding sources.

In order to further improve formulations of aliphatic amines, additional studies are contemplated. But from studies presented in this paper, it is apparent that the aliphatic amines formulated and added as surfactants to petroleum oils can be employed against susceptible and resistant mosquito populations.

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Table 11.–Effectiveness of Aliquot-221 in Toxisol FLC with and without 1% Pluronic L-101 cosurfactant against mosquito larvae and pupae in experimental breeding ponds. (Midgeville, 3-19-70).

Material and formulation (%)	Dosage gal/ac	Avg. No. larvae and pupae/5 dips--pre- and post-treatment (days) Pre-treatment 1-2	3-4	P	1-2 1-2	3-4	P	(%R)	7 1-2	3-4	P	(%R)
Aliq. 221 (5) w/o	0.5	246	97	2	44	11	1	89	64	21	1	78
Aliq. 221 (5) w/o	1.0	107	55	2	32	28	1	49	198	46	10	16
Aliq. 221 (10) w/o	0.5	115	30	1	65	21	1	30	109	22	1	27
Aliq. 221 (10) w/o	1.0	208	42	1	29	15	0	64	200	105	2	0
Aliq. 221 (5) w	0.5	77	25	2	21	6	0	78	144	52	3	0
Aliq. 221 (5) w	1.0	97	29	1	19	8	3	63	165	46	3	0
Aliq. 221 (10) w	0.5	78	46	4	18	23	1	52	104	65	3	0
Aliq. 221 (10) w	1.0	137	68	1	44	12	1	81	120	62	3	6
Toxisol FLC w/o	1.0	103	48	3	46	71	7	0	268	75	7	0
Toxisol FLC w	1.0	116	37	0	78	36	1	0	41	48	3	0
Check	--	79	29	4	133	42	2	0	120	42	1	0

INFLUENCE OF ALIPHATIC AMINES – PETROLEUM OIL FORMULATIONS ON AQUATIC NONTARGET INSECTS

Mir S. Mulla and Husam A. Darwazeh

Department of Entomology, University of California, Riverside

During the course of evaluation of aliphatic amines-petroleum oils formulations against mosquitoes (Mulla and Darwazeh 1971), the numbers of nektonic insects collected during sampling were recorded. The formulations were applied to experimental natural breeding ponds located at Midgeville, at the University of California, Riverside, and at Oasis in the Coachella Valley of southern California.

The formulations were applied by means of an all-purpose household pint sprayer-atomizer (Smart and Final Iris Company, Riverside, California). The organisms collected mainly belonged to the following groups: larvae of diving beetles (Dytiscidae and Hydrophilidae), mayfly naiads (mainly Bactidae), dragonfly naiads (mainly *Anax* spp.) and a few damselfly naiads and others. The mayfly naiads are generally the weakest organisms eliminated by the application of most organophosphorus mosquito larvicides (Mulla et al. 1969). For materials and methods, reference is made to Mulla and Darwazeh (1971).

RESULTS AND DISCUSSION:

When Armeen L-15 and Duomeen L-15 were evaluated as solutions in Toxisol FLC against mosquito larvae, the former material did not obviously affect populations of diving beetle larvae, dragonfly and mayfly naiads. In most cases these aquatic insects either increased in numbers or essentially remained the same after treatment (Table 1).

Similar results were obtained with Armeen L-15 in a second test. It was also noted that Duomeen L-15 even at the highest concentration (10%) did not markedly affect these nontarget aquatic insects (Table 2).

Duomeen L-15, as 5 and 10% solution in Toxisol FLC with 1% pluronic L-101 as cosurfactant did not adversely affect populations of diving beetle larvae and *Dixa* midges during one week period post-treatment (Table 3).

Another experiment using DL-15 in 1, 5 and 10% concentrations in Toxisol FLC, applied as 0.5 and 1 gal/acre to Oasis ponds, did not noticeably change the population trends of diving beetle larvae, dragonfly and mayfly naiads (Table 4). Similar results were obtained in another experiment in Oasis ponds where Duomeen L-15 at 5% concentration in Tox FLC was applied at 0.25, 0.5 and 1 gal/acre (Table 5).

In two experiments where Duomeen T was applied to mosquito breeding ponds at Oasis, the applications had no obvious effects on aquatic insects. In the first experiment,

Table 1.–Influence of Armeen L-15 in Toxisol FLC against nontarget organisms in experimental breeding ponds. (Oasis, 1-26-70).

Rate		Avg. No. of organisms/5 dips sample pre- and post-treatment (days)											
Toxisol FLC	ARL-15	Diving beetles				Dragonfly naiads				Mayfly naiads			
Gal/Ac	lbs/Ac	Pre	1	7	14	Pre	1	7	14	Pre	1	7	14
0.50	0.25	1	2	2	2	5	1	0	5	14	44	24	50
1.00	0.25	2	2	1	1	4	9	6	14	3	12	11	9
0.50	0.50	1	1	2	0	2	3	4	7	4	11	9	12
0.50	1.00	0	1	1	1	0	1	1	2	8	32	11	13
0.50	2.00	1	2	2	2	2	3	2	3	11	15	16	31
Check	---	1	1	1	2	4	3	2	2	3	22	6	6

Table 2.–Influence of aliphatic amines in Toxisol FLC against some aquatic organisms in experimental water ponds. (Oasis, California 1970).

Chemical and	Rate	No. of aquatic organisms/5 dips sample pre- and post-treatment (days)											
		Diving beetle larvae				1 Dragonfly naiads				Mayfly naiads			
formulation (%)	gal/Ac	Pre	1	7	10	Pre	1	7	10	Pre	1	7	10
Armeen L-15 (3)	0.5	1	1	2	2	5	1	0	5	14	44	23	50
Armeen L-15 (3)	1.0	2	2	1	1	4	9	6	14	3	12	11	9
Armeen L-15 (6)	0.5	1	1	2	1	2	3	4	7	4	11	9	12
Armeen L-15 (12)	0.5	0	1	1	0	0	1	1	2	8	32	11	13
Armeen L-15 (24)	0.5	1	2	2	2	2	3	2	3	11	15	16	32
Check ——	–	1	1	1	2	4	3	2	2	3	22	6	6
Duomeen L-15 (1)	0.5	1	1	2	1	5	8	6	0	6	2	2	6
Duomeen L-15 (1)	1.0	0	0	0	1	11	10	18	3	15	31	16	7
Duomeen L-15 (5)	0.5	0	2	2	1	1	5	1	1	33	29	6	6
Duomeen L-15 (5)	1.0	3	1	1	0	4	8	4	1	27	26	14	14
Duomeen L-15 (10)	0.5	2	2	1	2	5	9	4	1	50	64	26	23
Duomeen L-15 (10)	1.0	2	2	3	2	5	13	10	1	2	1	2	2
Check —	–	1	3	0	1	4	10	14	9	15	17	8	10

Table 3.–Influence of Duomeen L-15 in Toxisol FLC with 1% Pluronic L-101 surfactant on nontarget organisms in experimental breeding ponds. (Midgeville, 3-26-70).

Duomeen L-15 conc (%)	Rate gal/ac	Avg. No. nontarget organisms/5 dips pre- and post-treatment (days): Diving Beetle Larvae Pre	2	7	Dixa Midge Larvae Pre	2	7
5							
5	0.5	15	6	5	48	9	23
	1.0	5	5	5	18	11	28
10	0.5	11	3	7	60	21	26
	1.0	16	5	7	47	17	7
Check	––	39	21	20	41	66	80

Table 4.–Influence of Duomeen L-15 in Toxisol FLC on nontarget organisms in experimental breeding ponds. (Oasis, 2-4-70).

Duomeen L-15 conc (%)	Rate gal/ac	Avg. No. of organisms/5 dips sample pre- and post-treatment (days): Diving Beetle Larvae Pre	1	7	10	Dragonfly Naiads Pre	1	7	10	Mayfly Naiads Pre	1	7	10
1	0.5	1	1	2	1	5	8	6	0	6	2	2	6
	1.0	0	0	0	1	11	10	18	3	15	31	16	7
5	0.5	0	2	2	1	1	5	1	1	33	29	6	6
	1.0	3	1	1	0	4	8	4	1	27	26	14	14
10	0.5	2	2	1	2	5	9	4	1	50	64	26	23
	1.0	2	2	3	2	5	13	10	1	2	1	2	2
Check	––	1	3	0	1	4	10	14	9	15	17	8	10

this material at 5 and 10% concentrations in Toxisol FLC and Tox. TB at the rate of 1 gal/acre did not affect populations of diving beetle larvae, mayfly, dragonfly, and damselfly naiads (Table 6). The petroleum oils alone also did not affect these populations.

In the second experiment, Duomeen T at 5 and 10% in Toxisol FLC along with 1% pluronic L-121 as cosurfactant was employed. The rate of application was 0.25, 0.5 and 1 gal/acre. None of these volumes of application adversely affected the aquatic organisms during the period of experimentation (Table 7).

During the course of studies on the efficacy of Aliquot 221 formulations against mosquito larvae and pupae in Oasis ponds (Mulla and Darwazeh 1971), fair numbers of mayfly and dragonfly naiads prevailed in the ponds. None of the treatments with Aliquot 221/Toxisol FLC formulations caused reduction of these insects (Table 8). The population density of diving beetles (larvae and adult Dytiscidae and Hydrophilidae) was quite low, and no conclusions can be made regarding effects on these insects.

In the second test, when pluronic L-101 was added at 1% to the formulations and applied to ponds at Midgeville, the diving beetle population was reasonably high. These insects as well as *Dixa* midge larvae were not adversely affected during the one week period of experimentation (Table 9).

The aliphatic amines have shown fair level of activity

Table 5.–Influence of Duomeen L-15 in Toxisol FLC with or without 1% cosurfactant pluronic L-101 on nontarget organisms in experimental breeding ponds. (Oasis, 4-17-70).

Material and conc (%)	Rate gal/ac	Avg. No. nontarget organisms/5 dips pre- and post-treatment (days) — Diving Beetle Larvae Pre	2	7	Dragonfly Naiads Pre	2	7	Mayfly Naiads Pre	2	7
DL-15 (5) W/O	0.25	7	1	3	3	1	1	16	20	16
DL-15 (5) W/O	0.50	5	4	2	0	0	1	21	18	13
DL-15 (5) W/O	1.0	6	3	4	1	2	0	8	12	14
DL-15 (5) W	0.25	4	1	4	0	0	2	18	19	21
DL-15 (5) W	0.50	4	3	2	1	1	1	8	15	18
DL-15 (5) W	1.0	4	3	3	1	0	1	3	20	23
Toxisol FLC W	1.0	5	3	2	0	0	1	5	6	20
Check	---	5	2	5	0	2	2	15	10	13

Table 6.–Influence of Duomeen T in various petroleum oils on nontarget organisms in ponds. (Oasis, 10-27-70).

Material and formulation (%)[a]	Oil[a]	Avg. No. nontarget organisms/5 dips pre- and post-treatment (days) — Diving Beetles Pre	2	7	14	Mayfly Naiads Pre	2	7	14	Dragonfly Naiads Preq	2	7	14	Damselfly Naiads Pre	2	7	14
Duomeen T (5)	FLC	4	6	1	2	32	83	66	50	5	23	9	8	2	6	10	2
Duomeen T (10)		3	0	4	1	75	112	160	23	6	4	10	5	3	3	4	3
Check		2	2	2	3	31	91	34	16	6	8	11	6	0	1	5	3
Duomeen T (5)	TB	3	3	0	5	45	65	52	69	11	7	18	5	3	4	4	7
Duomeen T (10)		1	3	1	5	32	52	46	120	12	14	21	9	2	4	4	6
Check		6	·6	4	7	49	44	77	216	6	3	12	7	2	3	5	7

[a] All formulations in oils applied at the rate of 1 gal/acre.

against mosquito larvae and pupae (Mulla 1967, Mulla et al. 1970). Due to their different mode of action, these compounds can be successfully used against OP-resistant mosquitoes. From the data presented here, it is apparent that these compounds, unlike organophosphates and carbamates (Mulla et al. 1969), have little or no immediate disruptive effects on predacious and herbivorous aquatic insects.

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Table 7.–Influence of Duomeen T in Toxisol FLC with 1% Pluronic L-121 cosurfactant against nontarget organisms in experimental breeding ponds. (Oasis, 11-17-70).

Duomeen T conc (%)	Rate gal/ac	Diving Beetles				Mayflies				Dragonflies			
		Pre	2	7	14	Pre	2	7	14	Pre	2	7	14
5	0.25	2	1	3	2	36	73	121	98	2	2	6	7
	0.50	0	0	0	2	80	64	106	89	0	1	7	16
	1.00	0	1	2	2	44	77	80	82	0	0	4	14
10	0.25	3	3	1	3	65	42	92	57	1	1	11	21
	0.50	1	1	1	1	39	52	79	90	0	0	2	17
	1.00	8	2	5	4	70	241	180	43	2	2	5	8
Check	––	0	1	0	2	91	125	119	82	0	3	4	13

Avg. No. nontarget organisms/5 dips pre- and post-treatment (days)

Table 8.–Influence of Aliquot 221 in Toxisol FLC on nontarget organisms in experimental breeding ponds. (Oasis, 2-18-70).

Chemical and formulation (%)	Rate gal/ac	Diving Beetles			Mayfly Naiads			Dragonfly Naiads		
		Pre	2	7	Pre	2	7	Pre	2	7
Aliq. 221 (1)	0.5	0	1	2	5	17	9	6	15	19
Aliq. 221 (1)	1.0	0	1	2	6	8	8	0	2	7
Aliq. 221 (5)	0.5	2	2	2	8	11	10	2	4	8
Aliq. 221 (5)	1.0	2	1	2	11	11	6	4	6	10
Aliq. 221 (10)	0.5	2	1	1	22	16	11	1	10	9
Aliq. 221 (10)	1.0	0	0	1	12	45	8	1	5	1
Toxisol FLC	1.0	1	1	3	4	8	5	1	11	5
Check	––	2	0	0	0	1	0	0	1	3

Avg. No. nontarget organisms/5 dips pre- and post-treatment (days)

Table 9.–Influence of Aliquot 221 in Toxisol FLC with or without (190) Pluronic L-101 cosurfactant against nontarget organisms in experimental breeding ponds. (Midgeville, 3-19-70).

		Avg. No. of organisms/5 dips sample pre- and post-treatment (days)					
		Diving Beetles			Dixa Midge Larvae		
Material and formulation (%)	Dosage gal/ac	Pre	2	7	Pre	2	7
Aliq. 221 (5%) W&							
Aliq. 221 (5%) W/O	0.5	12	15	6	57	17	12
Aliq. 221 (5%) W/O	1.0	9	5	8	49	25	46
Aliq. 221 (10%) W/O	0.5	37	28	42	77	45	60
Aliq. 221 (10%) W/O	1.0	7	7	7	56	10	30
Aliq. 221 (5%) W	0.5	19	22	8	48	15	36
Aliq. 221 (5%) W	1.0	7	5	13	41	16	34
Aliq. 221 (10%) W	0.5	5	5	16	23	18	55
Aliq. 221 (10%) W	1.0	4	8	4	36	40	52
Toxisol FLC W/O	1.0	19	26	17	127	48	52
Toxisol FLC W/O	1.0	8	8	2	31	27	135
Check	––	4	7	18	51	75	55

PETROLEUM OIL FORMULATIONS AGAINST MOSQUITOES AND THEIR EFFECTS ON SOME NONTARGET INSECTS

Mir S. Mulla, Jorge R. Arias, and Husam A. Darwazeh

Department of Entomology, University of California, Riverside

The case for the use of highly effective organophosphorous and organocarbamate mosquito larvicides has been greatly weakened due to the quick appearance of resistance in mosquitoes to these materials. Development of resistance in mosquitoes in California has reached a serious proportion (Georghiou 1970, Schaefer and Wilder 1970). In order to achieve desired level of mosquito control in the future, other chemical measures which will be less prone to the development of resistance have to be explored and developed.

Petroleum oils have been used for the control of preimaginal stages of mosquitoes for many decades. Thus far, no documented case of acquired resistance in mosquitoes has been reported. By placing selection pressure on laboratory colony of *Culex p. quinquefasciatus*, Micks et al. (1968) were not able to induce resistance in larvae selected by petroleum hydrocarbon larvicides. Although petroleum oils have been primarily used for the control of mosquito larvae and pupae (Hagstrum and Mulla 1968, Micks et al. 1967, 1968, 1969), these substances also act as ovicides (Micks et al. 1967, Mulla and Chaudhury 1968). Additionally, they delay the normal development and alter the behavior of the active aquatic stages of mosquitoes (Micks 1970, Micks et al. 1967). The extent of this delayed action is considerable for some of the fractions and formulations against some species of mosquitoes.

Micks (1970) and Micks et al. (1967, 1968, 1969) studied the biological activity of a new petroleum hydrocarbon (FLIT® MLO) and numerous other fractions against various preimaginal stages of mosquitoes in the laboratory. Hagstrum and Mulla (1968) also studied the activity of a number of fractions against mosquitoes in the laboratory and shed light on the relationship of physicochemical properties to activity. The most promising materials found in these studies were FLIT MLO and Toxisol FLC (starting material of Atlantic Richfield Larvicidal Oil). These two oils as well as other fractions were reevaluated in the laboratory with the objectives to incorporate further improvements over existing formulations. The two commerical products (FLIT MLO and Toxisol FLC) were evaluated in freshwater ponds against mosquitoes, and the effects of such treatments on selected nontarget aquatic insects were studied.

MATERIALS AND METHODS

A new procedure for the evaluation of petroleum hydrocarbons was developed. This procedure varies from the one used previously in our studies (Mulla et al. 1972), as well as from that employed by Micks et al. (1967). The procedures developed by the latter authors using 400 ml. beakers (containing 250 ml. of water) do not simulate field conditions. The space within the beaker above the water surface may lead to abnormal concentration of hydrocarbon vapors, thus producing atypical results.

In the procedure developed here, shallow containers are used so that water surface from the tip of the container is no more than 1.5 cm. To save washing and cleanup time and to avoid contamination, 22 x 22 x 5 cm. (water surface 465 cm^2) aluminum cake pans were lined with Vitafilm® (a plastic film manufactured by The Goodyear Tire and Rubber Company, Akron, Ohio). In each pan, 1500 ml of tap water were placed to which 20, fourth-stage larvae of *Culex p. quinquefasciatus* were added. Within an hour or two after addition of larvae, microliter quantities of petroleum hydrocarbon formulations were dripped over the surface of the water from a microsyringe, the tip of which was held 8-10 cm above the water. The pans were set in a room with ambient temperature in the range of 25-28°C. Each treatment was replicated twice and each formulation was evaluated on 3-4 different occasions.

Larval mortality was assessed at 24 hours. After treatment, the mortality data averaged and a dosage response line established. The LD_{50} and LD_{90} values were calculated.

To evaluate the efficacy of various formulations of petroleum hydrocarbons, the formulations were applied to experimental freshwater breeding ponds at Midgeville (located on the campus of University of California, Riverside) and Oasis in the Coachella Valley of southern California. The ponds at Midgeville were 4 x 6 m and those in Oasis were 6 x 6 m, water depth in both maintained at 30-35 cm.

The formulations were sprayed or atomized by means of a small all purpose one-pint household sprayer (Smart and Final Iris Company, Riverside, California). The material was sprayed over the entire surface of the pond from the banks or planks; but due to the spreading capability of the formulation, no attempt was made to get complete coverage by the spray.

The species of mosquitoes encountered in the breeding ponds were *Culex peus* and *C. tarsalis* in Midgeville ponds, and *C. tarsalis* and *Culiseta inornata* in Oasis ponds. The larvae and pupae were sampled prior to and at intervals after treatment. Five dips were taken selectively along the edges of the pond; the organisms dipped were concetrated, transferred in water to a plastic vial to which 15-30 ml of 95% ethyl alcohol were added. Mosquitoes were segregated and counted into groups of first and second stage, third and fourth stage larvae and pupae. The extent of reduction (as %) was calculated from the post-treatment counts. The younger larvae (1-2) were not included in these calculations, but their numbers are presented in the tables to give an idea of the breeding potential of the ponds.

Nontarget organisms found in the ponds were larvae and adults of diving beetles (Dytiscidae, Hydrophilidae), naiads of Odonata (Aeshnidae, Coenagrionidae——mostly *Anax* spp.) and mayflies (Baetidae). These organisms were counted in each sample in a counting tray under a dissecting microscope. The numbers of these organisms, whenever present, are given in the table without determining the extent of reduction.

RESULTS AND DISCUSSION

Mosquitoes:

The initial biological activity of several currently used and experimental oil formulations was determined by the standard laboratory procedure. The LD_{50} and LD_{90} as well as characteristics of the films are presented in Table 1. None of the oils when used without a surfactant spread over the water surface. It therefore became obvious that addition of a suitable surfactant is necessary for spreading and increased biological activity of the oils.

The most effective formulation of Toxisol FLC was with the addition of a small amount of the surfactant Arlatone G. Comparing the same formulations, Toxisol FLC from various refineries manifested essentially the same level of activity, except the sample from Chicago, Illinois, which was somewhat more active. Due to the variability in composition and other physicochemical properties of the same fraction from various regions, this slight variation in activity is to be expected. The activity of ARCO LO (Atlantic Richfield Larvicidal Oil) with an undisclosed surfactant was lower than the other formulations of the base material in this proprietary product. When Toxisol FLC was formulated with 1% of each of 16 of Brij series of surfactants, the formulations showed only slight activity.

Sunland auto diesel 1 showed good activity with Duomeen L-15, a cationic surfactant; but a nonionic surfactant (Pluronic L-101) made the formulation much less active.

Chevron Aromatic Oil A, containing an undisclosed surfactant, did not show good activity. However, when

Table 1.–Biological activity of various petroleum oil formulations against 4th-stage larvae of the mosquito ***Culex P. quinquefasciatus.***

			24-hr Dosage[b] (ul/cm^2)		Film characteristics[c] Film		Coverage	
Oil fraction	**Surfactant (%)[a]**		LD_{50}	LD_{90}	**0 hr**	**24 hr**	**0 hr**	**24 hr**
FLC Chicago	DL-15	0.5	.034	.105				
		5.0	.020	.060				
	Arlatone G	1.0	.036	.078	P	none	C	––
	PL-101	1.0	.049	.115	P	P	F	I
	PL-121	1.0	.047	.100	P	P	F	I
	PL-122	1.0	.047	.114	P	L	F	F
FLC Texas	DL-15	0.5	.042	.140				
FLC Wyoming	DL-15	0.5	.04					
FLC Wyoming	DL-15	0.5	.056	.140				
FLC Penn (arosene)								
	DL-15	0.5	.039	.120				
ARCO LO	with [d]	––	.113	.284	U	L	I	I
Sunland Auto	DL-15	0.5	.061	.160				
Diesel 1	DL-15	5.0	.015	.038				
	PL-101	1.0	.086	.910	no spread, no film			
Chevron Aromatic								
	with[d]	––	.16	〉1.0	no spread, no film			
Oil A	PL-102							
Oil A	PL-101	1.0	.064	.200				
	PL-121	1.0	.067	.170	P	P	F	I
Chevron Absorbtive								
	PL-101	1.0	?	?	no spread, no film			
Oil 2	PL-121	1.0	.116	.412	poor spread			
	PL-122	1.0	.263	.288				
Flit MLO	with[d]	––	.061	.198				
Esso 5334-38	with[d]	––	.024	.046				
Esso 5334-37	with[d]	––	.024	.050				
Esso 5337- 2	with[d]	––	.021	.043				
Hancock Auto	DL-15	5.0	.021	.064				
diesel	PL-101	1.0	?	?	no spread, no film			
	––––	––	?	?	no spread, no film			
Hexadecane	PL-101	1.0	.263	7.329	no spread			

[a] None of the oils spread over water surface without a surfactant.

[b] 0.1 ul/cm^2 approximately equals one gallon/acre.

[c] C = complete, P = patchy, L = lenses, I = incomplete, U = uniform.

[d] These oils had 0.5-1% of an undisclosed surfactant.

either one of three nonionic surfactants was included in the oil, its activity increased materially. The same three surfactants yielded entirely different results when they were added to Chevron Absorptive Oil 2.

FLIT MLO showed considerable activity but less than that of Toxisol FLC containing optimum surfactant. Three ESSO experimental oils were quite effective, about twice as active as the best FLC formulation. However, in subsequent tests the activity of the three fractions was similar to that of the best FLC formulation.

Hancock auto diesel showed good activity with DL-15. Most of the activity of this formulation is due to the inherent toxicity of the surfactant. This diesel as the Sunland diesel did not perform well with the nonionic surfactant PL-101. Hexadecane also did not spread with this surfactant.

From the data presented here, it is apparent that the selection of a surface active agent for oil formulations is an important consideration. Each oil has its own requirements in terms of the kind and concentration of a surfactant. When the relationship between concentrations of the surfactant Pluronic L-121 in Toxisol FLC and the activity of the formulation was studied, 1, 5 and 10% concentrations showed the highest activity. There was no significant difference between these concentrations. The 0.1 and 0.5% concentrations of this surfactant were inferior to the higher concentrations.

Two experiments were conducted on FLIT MLO and Toxisol FLC against mosquitoes breeding in ponds in Midgeville and Oasis. In the first test, both oils were applied at 0.5, 1.0 and 2.0 gal/acre. FLIT MLO gave good to excellent control at all three rates (Table 2). Toxisol FLC with 1% surfactant (Pluronic L-101) also produced good control of mosquitoes at the two higher rates. The material without the surfactant also gave good control at two gal/acre. In clean water, FLC without a surfactant sometimes achieves good spreading.

In the second test, at Midgeville, the same volumes of application were employed. In this test, both FLIT MLO and Toxisol FLC with a surfactant essentially produced similar levels of reduction initially (Table 3). Toxisol FLC without a surfactant yielded good but delayed control, two weeks after treatment. Although level of reduction in the treated ponds was quite high, three weeks after treatment, noticeable reduction in the population of untreated ponds was also noticeable as compared to the pre-treatment population in these ponds.

From the data in Tables 2 and 3, it is apparent that both FLIT MLO and Toxisol FLC with a suitable surfactant are more or less equally effective. This confirms earlier results obtained with these two commerically available petroleum oils (Mulla et al. 1969).

Nontarget Organisms:

In the experiment conducted in Oasis ponds, none of the nontarget organisms sampled suffered any reduction in their numbers due to the petroleum oil treatments (Table 4). Among the nontargets, mayfly naiads were quite abundant, followed by dragonfly and damselfly naiads, in that order.

In the second experiment, conducted in ponds at Midgeville, only mayfly naiads were abundant; and these did not suffer any reduction in their numbers due to the petroleum oil treatments (Table 5). Diving beetle larvae were found only in small numbers, and no definite conclusion can be made regarding effects of treatments on these organisms. However, in the previous test, where fair numbers of diving beetle adults occurred in the ponds, their numbers were not suppressed by the oil treatments. These experiments again confirmed the results obtained in earlier studies (Mulla et al. 1969).

Table 2.–Evaluation of petroleum oils against mosquito larvae and pupae in experimental freshwater breeding ponds. (Oasis, 10-13-70).

Oil and formulation	Dosage gal/ac	Avg. No. larvae and pupae/5 dips pre and post-treatment (days) Pre-treatment 1-2	3-4	P	1 (10/14) 1-2	3-4	P	(%R)	7 (10/20) 1-2	3-4	P	(%R)	14 (10/27) 1-2	3-4	P	(%R)
Flit MLO	0.5	28	32	2	23	15	1	47	94	4	2	82	59	19	1	40
Flit MLO	1.0	77	88	8	13	6	1	93	144	6	0	94	181	31	2	66
Flit MLO	2.0	105	91	1	12	8	2	89	82	1	1	98	80	21	0	77
Toxisol FLC w (1%)	0.5	66	34	1	62	42	2	0	298	37	2	0	200	43	16	0
Pluronic L-121	1.0	54	61	1	8	1	1	97	145	17	1	71	102	27	11	49
Pluronic L-121	2.0	53	40	2	8	2	1	93	86	0	0	100	76	61	0	0
Toxisol FLC	2.0	20	39	4	2	2	2	91	157	4	0	91	169	63	0	0
Check	––	104	57	16	125	40	18	20	256	43	11	26	141	49	3	29

Table 3.—Evaluation of various petroleum oils with or without surfactant against mosquito larvae and pupae in experimental freshwater breeding ponds. (Midgeville, 10-19-70).

Oil and	Dosage	Avg. No. of mosquito larvae and pupae/5-dips sample																		
					Post-treatment (days)															
		Pre-treatment			2 (10/21)				7 (10/26)				14 (11/2)				21 (11/9)			
formulation	gal/ac	1-2	3-4	P	1-2	3-4	P	%R	1-2	3-4	P	%R	1-2	3-4	P	%R	1-2	3-4	P	%R
Flit MLO[a]	0.5	26	179	2	42	160	6	8	11	77	65	20	5	4	7	94	1	2	4	97
Flit MLO[a]	1.0	58	95	4	36	57	3	39	9	13	5	82	0	12	5	83	2	4	4	92
Flit MLO[a]	2.0	51	170	12	10	7	0	96	7	8	2	96	3	0	2	99	1	1	0	99
Toxisol[a] FLC (w)	0.5	109	638	0	36	548	12	14	10	76	172	61	0	280	145	34	2	19	7	96
Toxisol[a] G FLC (w)	1.0	35	92	12	39	53	22	47	7	18	7	76	9	22	9	70	0	4	1	95
Toxisol[a] FLC (w)	2.0	43	152	5	4	19	6	84	2	8	8	90	4	16	15	80	2	6	7	92
Toxisol FLC (w/o)	0.5	12	229	1	24	232	12	0	5	135	133	0	4	80	84	29	2	25	44	30
Toxisol FLC (w/o)	1.0	32	72	5	24	48	4	33	16	72	20	0	4	12	4	79	4	3	3	92
Toxisol FLC (w/o)	2.0	45	156	28	52	60	20	57	7	21	49	62	12	15	3	90	19	36	13	74
Check	--	12	193	1	28	227	2	0	8	128	113	0	4	89	86	10	0	47	37	57

[a]Flit MLO contained 1% of an undisclosed surfactant FLC contained 1% of Pluronic L-121.

Table 4.—Effect of various petroleum oil formulations with and without (1%) surfactant PL-121 on non-target organisms in fresh water ponds. (Oasis, 10-27-70).

Petroleum oil and	Dosage	Avg. No. of non-target organisms/5 dips sample pre and post-treatment (days)															
		Diving Beetles				Mayflies				Dragonflies				Damselflies			
surfactant	gal/ac	Pre	1	7	14	Pre	1	7	14	Pre	1	7	14	Pre	1	7	14
Flit MLO	0.5	2	3	2	2	71	55	46	26	4	1	5	5	0	0	4	0
Flit MLO	1.0	13	8	9	1	76	91	32	20	11	9	8	4	3	2	4	0
Flit MLO	2.0	8	4	12	4	76	34	78	85	5	7	10	6	3	4	3	2
Toxisol FLC W	0.5	5	1	4	5	49	51	48	68	9	6	7	8	3	0	5	2
Toxisol FLC W	1.0	5	4	6	4	95	40	98	52	1	4	3	6	0	0	1	3
Toxisol FLC W	2.0	9	5	8	3	128	88	61	53	12	13	5	5	3	2	4	4
Toxisol FLC W/O	2.0	6	5	2	0	52	23	32	52	4	7	1	9	2	1	1	3
Check	--	8	7	5	2	61	39	40	31	7	8	4	9	1	2	2	2

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Table 5.–Effect of various petroleum oil formulations with or without a surfactant (1% Pluronic L-121) on non-target organisms in freshwater ponds. (Midgeville, 10-19-70).

		Avg. No. non-target organisms/5 dips pre and post treatment (days)									
Oil and	Dosage	Diving Beetles					Mayflies				
surfactant (%)	gal/ac	Pre	2	7	14	21	Pre	2	7	14	21
Flit MLO	0.5	0	2	0	2	0	28	53	10	1	2
Flit MLO	1.0	2	1	1	1	0	26	43	12	3	1
Flit MLO	2.0	3	4	5	0	1	42	47	22	8	1
Tox. FLC W 1% PL-121	0.5	0	0	0	1	0	10	0	4	26	3
Tox. FLC W 1% PL-121	1.0	3	2	0	0	1	38	27	11	7	5
Tox. FLC W 1% PL-121	2.0	0	2	1	0	0	12	32	8	13	1
Tox. FLC W/O PL-121	0.5	0	0	0	0	1	8	9	9	26	8
Tox. FLC W/O PL-121	1.0	5	3	2	1	0	19	17	9	2	5
Tox. FLC W/O PL-121	2.0	0	0	1	0	3	16	40	9	9	7
Check	––	0	0	0	0	2	9	2	7	25	11