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OF THE

Thirty-second Annual Conference of the

California Mosquito Control Association, Inc.

AT THE

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W. DONALD MURRAY, *Chairman*

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Dedicated To The Memory Of

HAROLD FARNSWORTH GRAY
1885-1963

Honorary Member and Past President
American Mosquito Control Association
California Mosquito Control Association

Internationally recognized authority in the field of environmental health; parasitologist, civil engineer, malariologist; district health officer, mosquito control program administrator, consultant; author, editor, teacher. A dynamic, independent, creative thinker. A distinguished public servant, a warm and gentle human being, a genuine friend.

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CALIFORNIA MOSQUITO CONTROL ASSOCIATION

FIRST SESSION

MONDAY, JANUARY 27, 9:00 A.M.

DAVID E. REED, *President, presiding*

Ladies and gentlemen, it is with great pleasure that I now declare the Thirty-second Annual Conference of the California Mosquito Control Association to be in session. At this time I would like to call on Dr. James R. Douglas, trustee of our host agency, the Sacramento County-Yolo County Mosquito Abatement District.

Dr. Douglas: Ladies and gentlemen and distinguished guests. I am pleased to be here this morning and to have this opportunity to extend a warm welcome to the California Mosquito Control Association on behalf of the Sacramento County-Yolo County Mosquito Abatement District. It has been eleven years since we have had the pleasure of acting as your host. During this period mosquito control in California has made giant strides as a result of the tremendous increase in our knowledge of biology and technology. It is our hope that your presence here will add significantly to the dissemination and exchange of information which will lead to even greater progress in the years ahead. Great emphasis at this meeting is placed on the operational phases of mosquito control and it is a pleasure for me to see a large number of staff personnel present to participate in this aspect of the program. Also of particular interest to me is the increased participation by the trustees. I hope that you, the trustees, will play an active part, particularly within the session beginning tomorrow morning at the trustees breakfast.

I would be derelict, I think, as a member of the faculty of the University of California if I did not mention that the state-wide University is sincerely interested in your problems. We have a vigorous and productive research program in fields of interest and importance to mosquito biology and control and we assure you of our continued interest and cooperation.

Again on behalf of the Sacramento County-Yolo County Mosquito Abatement District, we welcome you and wish you a pleasant, stimulating and informative meeting. Thank you.

Pres. Reed: Thank you, Dr. Douglas. It is now my privilege to call upon Mr. Frank Mesple, Cabinet Secretary in the office of the Governor. Mr. Mesple.—

Mr. Mesple: Thank you, Mr. Reed, it is my pleasure to bring you the personal greetings of Governor Brown. He had hoped to be here himself but Senator Edmund Muskie of Maine is in our state today holding hearings on the problem of air pollution and smog control. Governor Brown had promised that he would appear before that congressional committee and give testimony on what we in California are doing toward the solution of that problem.

Almost everywhere one looks throughout our rapidly growing state the problems of air pollution and mosquitoes are increasingly evident responses to the changing ecology. The fact is, this state is growing so rapidly we are having to disturb much of the natural balance which prevailed in the past. It has been reassuring to see you people carry on the fight in the field of mosquito control. As we move ahead on the state water plan and redistribute the water resources of this state (as I understand it, mosquitoes have an affinity to water) it means you are going to have to play an increasingly important role. You may be assured we are very much aware of this problem. Dr. Malcolm Merrill is going to be on your program this morning and he will tell you more about the state's role, so I shall not try to move farther into that area. The Governor did ask me to assure you that if there is any assistance he can provide from his office, please call upon him at any time. I personally believe it is commendable that you have represented here an outstanding operational staff, you have excellent technical support from state organizations, and you have the political leadership within your Association which is so necessary in keeping your program moving on a state-wide basis.

Bill Rusconi was telling me that when he first put this program together he had hoped that it would be possible to please at least fifty percent of the people and that his estimate was now down to about ten per cent; but I have the hunch as I look it over that this is the sort of program that will be of real value to every one of you. I know Dr. Merrill and the other state people here follow your proceedings carefully. Often with conferences of this kind, the printed results don't come out for several months, or sometimes not until the next meeting the following year. So we have asked that the Governor be informed of those matters of special importance just as quickly as they can be transmitted to us.

So, President Reed, I want to extend, on the Governor's behalf, very best wishes for this conference. I happen to know that Dave Reed is from Firebaugh. I was born and raised just a little ways away, over in Clovis, and I think mosquito abatement would be a rather natural profession for anyone who grew up in that area. I believe the results have begun to tell, however; I know as a young boy it was not at all unusual to have people in the community being struck down with encephalitis. Sleeping sickness was a matter of annual concern, rather perennial concern, so the fine work that you people are doing on all fronts is highly commendable and to be given all possible support and encouragement. Thank you very much.

Pres. Reed: Thank you, Mr. Mesple. It is a great honor, at this time, for me to introduce to you a man, born in Iowa, but who has lived in Tulare County, California for over fifty years. For forty of those years he has been in the business of farming, processing, and marketing oranges and olives. Our speaker has been a director of both the National Canners Association and the California State Olive Association and has served as Governor of the California-Nevada-Hawaii District of Kiwanis International. I present to you, Mr. Stary Gange, Public Relations Representative for the Southern California Gas Company, our keynote speaker. Mr. Gange.—

GOVERNMENT: SERVANT OR MASTER

STARY GANGE
Southern California Gas Company, Visalia

Thank you very much Mr. Reed. May I also extend greetings to the officers and directors of your association, to the trustees that are here representing the various districts, to your associates from allied industries who are responsible for the impressive exhibits, and especially to the lovely ladies who are here. It is always good to have a few ladies in a group such as this.

As your first speaker here this morning, I think it would be well to start with something we can all agree on. I'm glad that I'm alive! I can't think of anything more exciting than being here to experience these wonderful, crazy, mixed up days in which we live. The next most exciting thing to me is to have been born to the freedom that is ours as American citizens. I had the further good fortune to have parents smart enough to bring me out west to California with a one-way ticket some fifty-five years ago.

I went back there a few weeks ago to the little town of Waterloo, Iowa where I was born. It was nineteen degrees below zero—and I'm an orange grower! But move over, the rest of them are coming too—ready or not. We must expect almost 2000 new people for breakfast every morning here in California, or 4000 new kids ready for school every Monday morning the year round. This means 200 new classrooms have to be completed every Monday morning just to take care of the recent arrivals.

I was talking to a senior citizens' group not long ago, some people call them Rotarians. Dave Reed is the youngest one I have ever met. Anyway, I mentioned some of these figures to them and suggested that they be alert and responsive to this dynamic, changing environment in which we live. But I had the feeling these figures were not getting across to this group as well as I had hoped. I suggested they go down to their favorite shopping center in the late afternoon when the young married housewives were doing their shopping and check *their* figures if they didn't think we were growing.

I hadn't planned to talk too much about mosquitoes, but I am impressed that they don't know where the city boundary is, or the county boundary, or the district boundary. Some of them don't even know where the state boundary is. I know that mosquitoes are not the only thing you are interested in, and when you upset the balance of nature just a little, you sometimes have even a bigger problem, don't you?

We got into that kind of trouble in our business a few years ago. We thought we had finally found the answer to citricola scale and to our thrip problem, only to learn that we were killing the lady beetles which had been taking care of the soft brown scale that even the old timers had forgotten about. Before long we had soft brown everywhere—and then all of a sudden we were culturing lady beetles to get them back in there to straighten things out for us. This is a wonderful, exciting business. You will never quite win the battle but you will have a lot of fun if you can keep your balance and a sense of humor as you go along.

We are living in a period of rapid and dramatic change. Everything seems to change except the basic fundamental principles which are the foundation for what we know as the American way of life. In this federal republic, our government is based on the premise that it works best at the community level. When government gets much beyond the community level it has a tendency to weaken. When it gets as far back as Washington, D.C., it sometimes seems to have lost much of its vitality.

So, to the degree that we can, we should work as individuals, recognizing that each of our cherished individual liberties ends at the point where we turn our work over to a group. This confines us a little, doesn't it? At the same time, we have to recognize that there are certain things that the individual cannot do or that the family can better do; there are things that a family cannot do and that the community must do, and things that the state must do and things that the federal government must do. It must also be clear that some things must be done on an international level if we are going to survive in the years ahead. My point, however, is that I want to fight for maximum individual liberty and freedom because this is the substance from which our great country was built. Each in his own way and all of us in the American way must do everything in our power to seek our individual and common destiny.

That I as an individual can go broke in a business of my own choosing—this is still a vital and exciting thing about living in America. This means we are living in a free country, doesn't it? It means that you or I can climb the ladder of success as high as we can carry our own weight, and stay there or fall off, depending on our own ability. Nobody twisted my arm to get me into the orange or olive business, and no one is twisting it to get me to stay. I may wish now that I was out of olives and more into oranges, but in the thirties I got out of oranges and into olives because it looked like a good idea—on my own—and I liked it. I liked the hazards that go with farming. I never wanted to go to a football game with only one team on the field, I want a run for my money.

So I believe we can all agree that we want to be individuals. Committees can carry out ideas, but no committee ever had an idea; only individuals have ideas. There are certain things you can't delegate to a committee or to others. You can't delegate your religion, you can't delegate your integrity, you can't delegate your individual freedom. These are the substances of which we are made. I remember as a boy, when I was going to Sunday school regularly, a teacher one day said that in all the world there are no two people alike. That was the most exciting thing I had heard up to then. I remember racing home to tell my mother there was only one of me, and on the way I thought of all the neighbors who would also be glad there was only one of me. But this didn't matter, because "I was me!" and the world would never be the same because I had lived. Maybe you have to be older and more philosophical before you realize this is true. Will it be a better world because each of us has lived? This is the test, each of us in our own way making a contribution worthy of the new tomorrow.

Who can help but be amazed at the fantastic changes that are taking place all around us. I flv a lot—over 700,000 miles up to now. I think it is the safest, most wonderful way to travel, but I am getting impatient with the four hours it takes to cross the United States. I want to do it quicker than that. At the turn of the century everyone was excited with the thought of going around the world in eighty days. The astronauts did it in eighty minutes. I have a feeling that may be slow in the years ahead. We have already seen an experimental, manned plane traveling almost seven times the speed of a bullet from a Colt 45. That's rolling, isn't it?

Everything is changing. Did you ever consider how limited progress would be if every generation had to discover the wheel, or discover fire? We are making tremendous progress today for one reason—92% of the greatest scientists who ever lived are alive today. This is why tomorrow is going to be so different from today. You don't like change? Forget it, you're going to see it anyhow. If you can waken in the morning, throw the window up and say "Good morning, Lord, thanks for another day," you'll be happy in the years ahead. But if you waken in the morning, open one eye and say "Good Lord, it's morning!", you might just as well stay in bed.

I was telling a group of high school kids that 46 years ago I too was taking geometry, and before the year was out they had convinced me that a straight line was no doubt the shortest distance between two points. I believed them. Then Einstein's theory of relativity came along just to prove this wasn't true. This can shake you up—the only thing I can remember about geometry isn't true anymore. I also remember taking a year of physics. One of the basic laws of physics was that everything that went up would always come down. Not any more. They shoot 'em up and they never come down.

Did you read about Telstar a few months ago? It was on the back page. All these exciting things are on the back page now because they've been on the front page once and, of course, if they're on the front page once they never make it again unless they break down. But here are all the exciting things on the back page of these newspapers. I was on the east coast a few weeks ago talking to a group, including one of the men from American Telephone and Telegraph who'd had an active part in putting up the Telstar. He told me much about this fantastic development. Here was a wonderful example of cooperation—the kind we need between the federal government and industry.

Our government was established, based on a premise that the government would always be the servant of the people and never would it be the master of the people. Sometimes we have to move a little slower. It may sometimes look like dictatorships around the world are in some ways more efficient and moving faster than we. But all the energy in the world cannot equal the dynamic potential of a group of free people working with united purpose towards a common goal. This we must never lose sight of.

As an American farmer I cannot help but be impressed by the fact that there is not a communist nation in the world today that can adequately feed, clothe, or house its people. Only the free nations of the world are accomplishing this. Hunger is the number one problem of the world. It is a little awesome to live in a country where all the problems of food and fibre are problems of overabundance rather than scarcity.

We are told that the world's population will double in the next 45 or 46 years. Back in the time of Christ it took about 500 years for the world's population to double. At about the time when America was discovered by Columbus it took about 300 years. In the year 2020 we can expect 48 million people in this state of California, 25 million in Los Angeles County alone. I wonder where we'll put them, don't you? Higher and higher apartments? The fact is, I did some arithmetic on this and it is not so many—only 6,600 per square mile. In Manhattan there are 77,000 per square mile. Now I don't particularly like instant neighbors but I may have to get used to the idea. At the present time there are about three billion, two hundred million people in the world, and by the year 2020 there may be double that. What might America's position be in the years ahead with three billion people hungry and on the march and we're the only ones with surplus food? You know, 30 to 35 years ago half the people of the world went to bed hungry every night thinking it was the common lot of man. Those people may go to bed hungry now, but knowing this isn't true. We send our people around the world telling them it isn't true. Now they want to eat regularly and they want their children to eat regularly. So the biggest problem on this rapidly shrinking little dried apple on which we live will, in the years ahead, be food and fibre, and the health of humanity. Oh, we've got a job to do. But never in America do we seem to solve any major problem until it gets big enough to challenge the imagination of our finest minds and our busiest people. They are the ones who change problems into opportunities. And this is what is happening in America.

Again, I say that the government must always be the cooperator, the servant of the people, but never let it become the master. This is one of our greatest problems today—at all levels. Little cities are too frequently sending the "city hall" back to Washington. This is not the right answer. Keep city hall in your own community. When you have a problem too big to handle, then is the time to go to the next level of government and, if necessary, the next level after that —with the federal government as the last resort. This does not depreciate the vital functions of federal government, but let's keep them vital by reducing them to the very minimum. Let's work at the community level whenever possible. This is where we can be the most effective. This is where America was built and this is where we can rebuild the moral and spiritual values that are the foundation of this great country of ours.

Thank you very much for the invitation to participate in your conference. This is a new and enlightening experience for me, and I am especially pleased to have this opportunity to share with you some of my thoughts on a subject that is particularly close to my heart.

Mr. Reed.—Thank you very much Mr. Gange. I am sure you have caused us to look at the future with renewed enthusiasm, and perhaps we shall be able to see more of our own problems as opportunities.

WORLD ROLE IN MOSQUITO CONTROL

Donald R. Johnson[1]

Mosquito control as carried out in California and many other areas of the United States is considered to be a prerequisite to comfortable modern living, high agricultural productivity, profitable tourism and healthy environs. A few other nations, such as Canada and some of the European countries plus a scattering of cities around the world, also consider it important — but in the world today the vast majority of the 3 billion plus human beings must for the present at least live in the continuous misery of mosquito annoyance and hazard of mosquito-borne disease. For them, mosquito control *per se* is not even contemplated. They cannot seriously think of such luxury when rice and dried fish to feed the family, fuel for the tiny fire, medicine for a sick person, or a piece of cloth to make some new article of clothing all too often are beyond their means. After all, many of the people of our world have a fatalistic philosophy that man was born to live in misery and unless the gods deem it otherwise man must accept the depredations of mosquitoes and other pestiferous creatures.

Nevertheless, mosquito control will become a reality to many of these people some day. A substantial start already has been made, although the world has attacked only a small segment of the overall mosquito problem thus far. Helen Sollers-Riedel (1963) annually has presented a summary of global mosquito control and those who want additional details may refer to her latest paper. Also, Micks (1963) indicates what the future holds for vector control after malaria is eradicated. The present operations to which I am referring are being carried on in the developing regions of the world but usually are not being directed at pest mosquito measures. These programs are aimed at the control of vector-borne diseases. The usual objective, therefore, is disease elimination rather than vector control *per se*. Thus, a campaign aimed at stopping a dengue outbreak in a tropical country frequently is labelled as a "dengue fever control program" even though the operation probably is directed solely against the *Aedes aegypti* mosquito.

In most campaigns in these developing countries only certain species of mosquitoes are the object of the attack, depending upon the disease problem. The emphasis, of course, usually is on the diseases which are most important to the economy of the country. We here in the United States frequently forget that in vast regions, especially in the tropics, the important diseases still are those carried by mosquitoes and other arthropods. We Americans are apt to think principally in terms of the various arboviruses found in the United States when we speak of vector-borne disease, but elsewhere the emphasis is more often on malaria, yellow fever, dengue, or filariasis.

It is obvious that in any given country the available funds should be utilized to find solutions to the highest priority problems. Yellow fever in Trinidad, dengue in Puerto Rico or just plain pest mosquitoes in Jamaica, have had serious economic consequences because of adverse effects on tourism. Health programs frequently occupy subsidiary positions on the priority lists of many countries, even though in some instances certain health problems may seriously retard economic progress more than is realized. When this happens suddenly in the form of a disease epidemic, high priority may be given quickly to a certain program. The tragic malaria epidemic in Ethiopia during 1958 (Fontaine *et al.* 1961) is an excellent example. An estimated 150,000 persons died in that dramatic epidemic. Malaria eradication thereafter assumed an even greater degree of importance, not only in Ethiopia but in all countries having a potential for a similar epidemic.

Dr. C. M. H. Mofidi (1963), who is Director of the Institute of Parasitology and Malaria in Teheran, Iran, pointed out that certain public health measures have greater potentialities than others for raising the general standard of health and thereby release energy for productive purposes. He indicated that the most important of these health measures is the control of insect-borne diseases, because such control has the most far-reaching consequences. It is encouraging that in the developing countries key individuals such as Dr. Mofidi recognize the great importance of these vector-borne diseases and are taking positive action to bring them under control. The world is thus accepting some of its responsibility in mosquito control.

As mentioned earlier, control of specific diseases most frequently is the mosquito control objective in the world today. One interesting exception to this broad generalization is the *Aedes aegypti*[2] eradication campaign in the Western Hemisphere. This notorious mosquito can be responsible for transmission of dread yellow fever, debilitating dengue fever, disfiguring filariasis and others, such as Philippine hemorrhagic fever. It can also transmit certain diseases of animals such as heartworm *(Dirofilaria)* in dogs and bird malaria *(Plasmodium gallinaceum)* of fowls (Christophers 1960).

[1] Acting Chief, Malaria Eradication Branch, Agency for International Development, Department of State, Washington, D. C. (Present address: Communicable Disease Center, U. S. Public Health Service, Atlanta, Georgia.)

[2] As a matter of interest, Sir Rickard Christophers (1960) believes that *Aedes aegypti* is responsible for the popularization and common acceptance of the word "mosquito." Although of apparent Spanish or Portuguese America origin, the scientific name, *Culex mosquito*, was given by Robineau-Desvoidy in 1827 to the mosquito now known as *Aedes aegypti*. The word mosquito thereafter gradually came into popular use, replacing the word "gnats," the old English designation for mosquitoes.

In order to understand more fully the present Western Hemisphere emphasis on *A. aegypti* eradication we must go back to the beginning of the twentieth century. Yellow fever, of course, was at that time a subject of major interest. William C. Gorgas, as a result of the findings of Walter Reed and the Yellow Fever Commission in 1900, had been using anti-mosquito measures to control yellow fever in Havana, starting in February 1901, with dramatic success. By September of the same year, after having been a constant threat to Havana for 150 years, yellow fever had been completely eradicated (Strode 1951). The Panama Canal success story with the conquest of yellow fever (and malaria) followed immediately after the Havana campaign. The accomplishments must have seemed to be miracles at that time and undoubtedly gave major impetus to the development of improved and intensified mosquito control measures.

In 1902 another significant event occurred – the predecessor agency of the present Pan American Health Organization (PAHO), then called the International Sanitary Bureau (later changed to Pan American Sanitary Bureau), was founded. Among its various responsibilities, it was charged . . . "to encourage and aid or enforce in all proper ways . . . the destruction of mosquitoes and other vermin."

Yellow fever continued to be a major threat to many countries for several decades. In 1905 an epidemic of 3,384 cases with 443 deaths occurred in New Orleans. This was the last epidemic of this disease in the United States. Serious outbreaks continued to occur in other countries of the Americas. As a result of experience in Brazil, Fred L. Soper and D. B. Wilson made their plea for species eradication, with *A. aegypti* as the target. Their plan, which they applied in Brazil, was a brilliant success against *A. aegypti*, even though jungle yellow fever transmitted by other species of mosquitoes continued to persist outside of urban areas.

Hemisphere-wide eradication of *A. aegypti* was proposed in 1943 at the Pan American Sanitary Conference, but it wasn't until 1947 that a resolution was passed which entrusted the Pan American Sanitary Bureau with developing the solution to the eradication of urban yellow fever based upon the eradication of *A. aegypti*. Up to the present, *A. aegypti* has been eradicated from Bolivia, Brazil, Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, British Honduras, French Guiana and the Canal Zone. The United States, usually a leader in such activities, as recently as last year still had not undertaken *A. aegypti* eradication, probably because of the absence of yellow fever and its immediate threat to the U.S. Finally, however, after years of discussion and development of international agreements, the United States, thanks to the good progress elsewhere and consequent urging of other nations, has embarked upon a campaign to eradicate *A. aegypti* from this country.

Last February, President Kennedy emphasized the importance of this program when he stated as follows to Congress: "A problem of particular significance in the Western Hemisphere is that of yellow fever. Many countries of the Americas have conducted campaigns to eradicate the mosquito which carries yellow fever but the problem of reinfestation has become a serious one, particularly in the Caribbean area. We have pledged our participation to eradicate this disease-carrying mosquito from the United States, and the 1964 budget provides funds to initiate such efforts. This will bring this country into conformity with the long-established policy of the Pan American Health Organization to eliminate the threat of yellow fever in this hemisphere."

This program now is under way and is to give first attention to Puerto Rico, the Virgin Islands, Florida, and Texas along the Mexican border. During the next fiscal year extensive surveys and other preliminary measures will be undertaken in the remainder of the so-called yellow fever receptive area – Alabama, Arkansas, Georgia, Louisiana, Mississippi, South Carolina and Tennessee. The newly established *Aedes aegypti* Eradication Branch, Communicable Disease Center, Public Health Service, in Atlanta, Georgia, is the nerve center of this newest mosquito control program. A mimeographed document describing the program is available from CDC (Anon. 1963).

Another important program in the world today is the control of filariasis, caused by *Wuchereria bancrofti* and *Brugia malayi*. This program is not as well organized as either malaria or *Aedes aegypti* eradication programs. At present there is much pressure throughout the world to do something about this mosquito-borne disease which causes disfiguring elephantiasis. The social stigma caused by the grotesque malformations of the unfortunate sufferers of elephantiasis is sad indeed. I personally recall the strong plea made to me in 1959 by the then Minister of Health in Ceylon, Her Excellency Vimala Wijewardene. She stated that malaria had been almost conquered in Ceylon but that filariasis still continued unchecked. She felt that filariasis was a more important problem in Ceylon than was malaria at that time. Indeed this is true, not only in Ceylon but in certain parts of India, Burma, Thailand and other countries, which are so unfortunate as to have both diseases present. It is possible that malaria may be eliminated in certain areas of countries even though large multitudes of people in the malaria-free areas still are exposed to filariasis and suffer from elephantiasis.

The control of this disease is far more complex and the efforts less rewarding than malaria control. Filariasis has a long incubation period. After infection occurs, many years may elapse before any physical manifestations of the disease are evident, but once the deformities of elephantiasis appear, they usually remain with the individual for life. The drug (diethylcarbamazine) treatment frequently results in a severe reaction and often leads to hostility on the part of the population. As a result of drug administration even those persons without apparent symptoms may develop an unpleasant foreign protein reaction caused by destruction of the microfilariae.

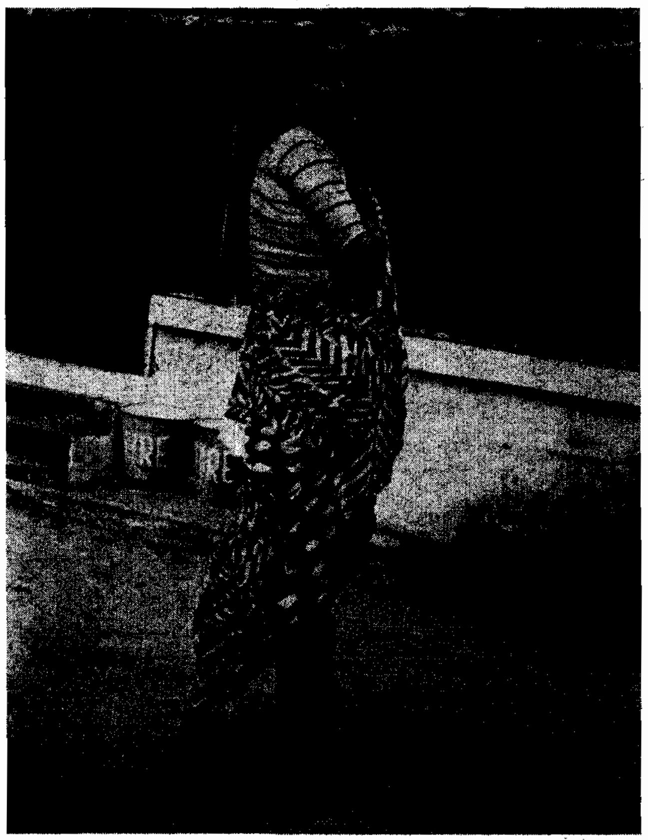
Because of the multiple vectors of filariasis, mosquito control measures often must be directed against several species, including the most abundant pest mosquito, *Culex quinquefasciatus* – or *C. fatigans* as it is known in many countries. Difficult to control species of *Mansonia* may be involved. Usually a general sanitation program is required to stop vector breeding and, although such would be commendable, this will be out of the question for years to come in some parts of the world where sanitation is still a thing of the future due to high cost and lack of understanding of basic sanitation. This, incidentally, reminds me of an actual report which recently came in from a Far East country:

> "Sanitary conditions are quite primitive. It is now the law that there must be a toilet in every brick house built. This has resulted in most people building their houses out of other materials."

In countries where sewerage systems consist of cesspools and where standing water is everywhere, all of which may breed millions of potential filiarisis vectors, control of this disease is not practical, for the time being at least. George J. Burton (1960) has presented a valuable series of papers on the bionomics of filariasis vectors in India; included are many remarkable photographs of the disease manifestations (fig. 1) as well as habits of the mosquito larvae especially *Mansonia* species (fig. 2). John F. Kessel of the University of California, Los Angeles, and Emile Massal of the Institute of Medical Research in Tahiti (1962) have prepared an interesting account on the control of filariasis on Pacific Islands. They felt that at present, bancroftian filariasis can best be controlled by diethylcarbamazine administration, folowed by a mosquito control program. Mosquito control alone was not practical in the islands under consideration; in fact, the drug administration appeared to them to be the most effective of the two measures.

Today, the world is doing something about its worst mosquito problem. Malaria eradication, the greatest health program ever undertaken in the history of mankind, is underway. It is a dramatic effort and for the most part is a gigantic mosquito-control campaign. It undoubtedly is doing more to improve the health and well-being of the human race than could any other program presently within the capabilities of the nations of the world. [As an incidental sidelight, those of us who collect stamps are well aware of the malaria program, for recently 101 nations and territories issued postage stamps commemorating malaria eradication (Johnson and Fritz 1963).]

This dramatic worldwide anti-malaria program was born during World War II and can be considered as one of its beneficial byproducts. When American GI's and troops of other nations went to tropical areas far from home, many quickly fell victim to the mosquito-borne disease, malaria. On Guadalcanal the U. S. Marines suffered more casualties from malaria than from enemy action. Malaria control units suddenly became an absolute necessity to all troops in malarious areas. The discovery of the potent properties of DDT in 1943 made the task possible and must be credited with the saving of many lives. The work of the malaria control units certainly was a very positive factor in the winning of that war. However, the malaria control efforts also introduced modern malaria control techniques into many parts of the world. The Institute of Inter-American Affairs funded by the U. S. Government was assisting various Latin American countries with malaria control work starting in 1943, thus laying the foundation for the post-war programs.



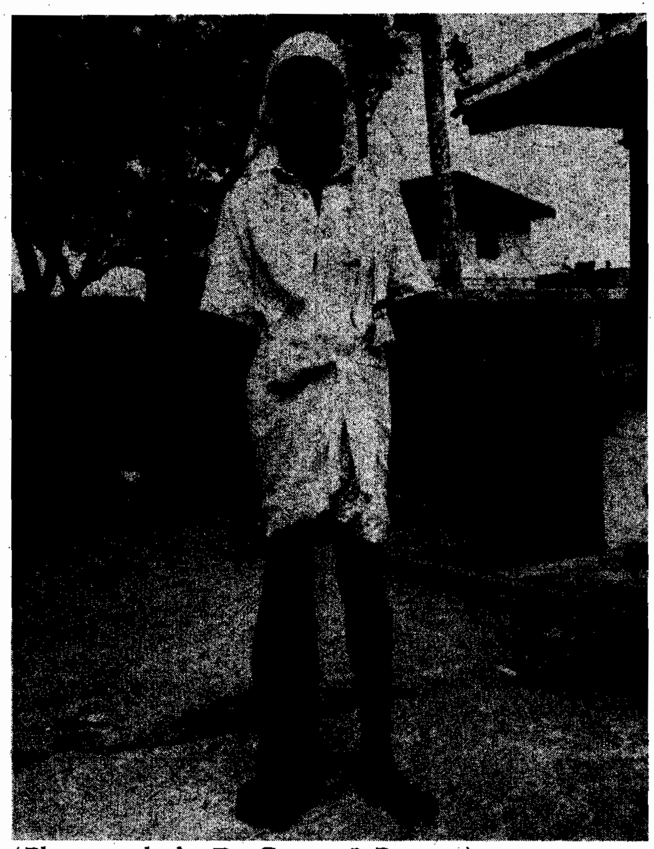


Figure 1. Advanced elephantiasis – India. (Photographs by Dr. George J. Burton.)

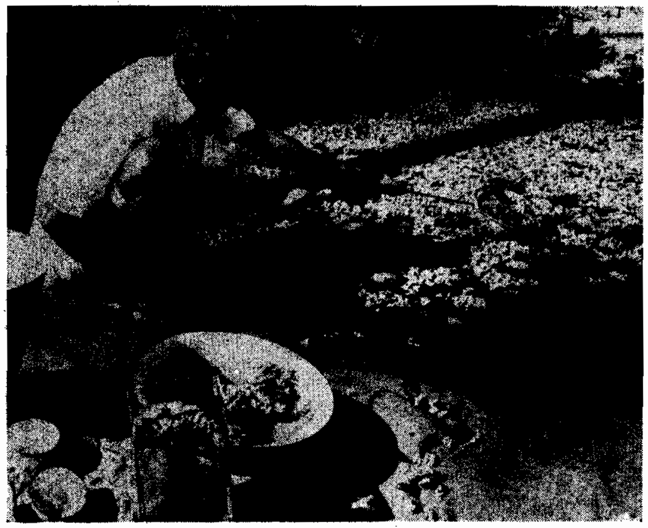


Figure 2. Searching for *Mansonia* larvae – India filariasis control program. (Photograph by Dr. George J. Burton.)

Figure 4. Team on water skates carrying motorized duster across Nicaraguan swamp.

After the war ended, the World Health Organization (WHO) was founded and selected malaria as one of its targets, just as the Pan American Sanitary Bureau had done in the Americas. The expanded worldwide effort against this disease soon was started. Malaria was the most serious infectious disease of man at that time, accounting for some 200,000,000 cases annually, with 2,000,000 deaths. The United States, through intensive anti-anopheline measures eradicated malaria within a few years. The Marshall Plan and President Truman's Point IV program made U. S. funds available to many countries of the world in order that they might get back on their feet. With U. S. assistance malaria was one of the problems attacked by many lesser developed nations in the early 1950's with dramatic success. Encouraged by many such successes, the World Health Assembly in Mexico in 1955, following the lead of 1954 action of the Pan American Sanitary Conference,

Figure 3. Nicaragua malaria control advisor G. A. Bevier (from California) and C. Espinosa, supervisor of larviciding, examining water skates.

Figure 5. Unloading DDT and spray equipment at a long house in the high plateau area of Darlac province in Vietnam.

directed WHO to promote the eradication of malaria. The United Nations Children's Fund (UNICEF) made funds available for purchase of insecticides and other commodities needed for this joint world wide effort.

One of the little known stories of that era was the part played by a prominent Californian in this dramatic story. In 1956, there existed what was called the "International Development Advisory Board," (IDAB). Its members had been appointed by President Eisenhower to advise a predecessor agency of A.I.D., (then called the International Cooperation Administration or ICA), on ways to make most effective use of foreign aid. The only expert in public health on IDAB, which, incidentally was headed by the late Eric Johnston, was the late Wilton L. Halverson, M.D., formerly Director of Public Health for the State of California. Dr. Halverson, in consultation with Henry van Zile Hyde, M.D., Chief of the Division of International Health, Public Health Service, made

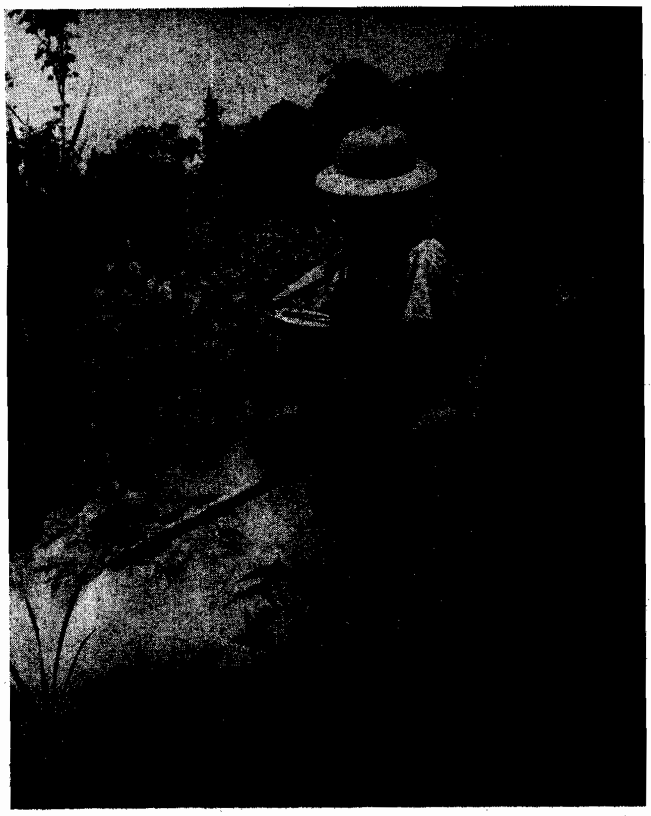


Figure 6. Manual application of Paris green dust formulation on rim of swamp in Vietnam.

a strong proposal to Mr. Johnston that the U.S. redirect its efforts from malaria *control* to an intensified malaria *eradication* campaign. Dr. Halverson, as Chairman of a Special Committee, was asked by Mr. Johnston to make an expanded study of this proposition, with the assistance of Paul F. Russell, M.D. and the Public Health Service, Division of International Health. The resulting IDAB document (1956) became the basis for the present A.I.D. malaria eradication program. Dr. Halverson indeed should long be remembered and credited as one of the key individuals in this spectacular health undertaking.

It is not my intent today to attempt to give all the details of this great campaign, for time is too short. You and I as taxpayers are helping to make the global program possible. As a result of Congressional action, starting in 1958, approximately $30 million annually of U. S. funds have been used to finance direct contributions to some 28[3] countries as well as to the Pan American Health Organization and the World Health Organization. Basic and applied research pertinent to this program is being carried out by our government both here and abroad (Quarterman 1963). A few examples of A.I.D. malaria eradication activities are shown in figures 3-6. About 70 American technical staff members are overseas with A.I.D. in the eradication program itself, and as all of you are so well aware, many now with the program, or previously with it, are California mosquito control workers. Actually, California has made a greater contribution to this program than any other state in the country. On behalf of A.I.D., I wish to thank the State of California for this. As a result of the high standards insisted upon by your State, California is a world leader in the field of mosquito control. The liberal policies and progressive leadership in California, which have made it possible for many of your well-trained experts to be utilized by the U. S. Government in malaria eradication work, have been a tremendous help to the program.

Also, we are grateful that California has welcomed the many foreign malaria program trainees whom we have sent here as observers. You have been gracious hosts, and as a result of your kindness, many malaria workers around the world are good friends of California and its mosquito control workers. The observations of your activities have proven to be invaluable demonstrations of American "know-how" in action.

Let me illustrate the magnitude of the malaria eradication program by just a few statistics. Table 1 gives

[3] Since the program started in 1957, the following countries (arranged by A.I.D. regions) have received U. S. assistance:
Far East – Cambodia, China, Indonesia, Laos, Philippines, Thailand, Vietnam.
Near East, South Asia – Ceylon, India, Iran, Jordan, Nepal, Pakistan.
Africa – Ethiopia, Liberia, Libya.
Latin America – Bolivia, Brazil, Colombia, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Paraguay, Peru.

TABLE 1.—Status of global malaria eradication (population in thousands).[a]

A.I.D. Regions	*Total Population*	*Original Malarious Area*	*Eradication Claimed (Maintenance phase)*	*Eradication programs in process*				*Eradication program not yet started*
				Consolidation phase	*Attack phase*	*Preparatory phase*	*Total*	
Far East	371,581	230,175	17,399	9,528	95,857	10,355	115,740	97,018
Near East & South Asia	696,556	630,904	7,109	301,394	230,169	19,162	550,725	73,070
Africa	257,129	223,535	3,421	1,505	1,184	-------	2,689	217,425
Europe	643,418	256,340	250,717	5,623	-------	-------	5,623	----
Latin America	436,213	157,599	60,593	40,384	42,548	13,084	96,016	999
Total	2,407,897	1,498,553	339,239	358,434	369,758	42,601	707,793	388,521
	(3,161,121)[b]	100.00%	22.63%	23.92%	24.67%	2.84%	(51.43)	25.94%

[a] Includes the estimated population (of 753,224 thousands) of mainland China, North Korea, and North Vietnam from which no additional information is available.

[b] From World Health Organization, Document EB 33/4, Sept. 30, 1963 (Processed).

the latest information as to the world-wide status of this program. Of the 3.2 billion persons in the world today, 1.5 billion (plus an unknown number in mainland China, North Korea and North Vietnam for which no information is available) live in areas that either are or recently were malarious. Of these, about 340 million are living in areas where eradication is complete. Nearly 360 million more have almost achieved eradication as they are in the consolidation phase, during which time spraying operations for the most part are terminated. This means that at least 700 million people previously exposed are now malaria-free. About 730 million more receive protection by active attack measures which for the most part consist of residual spraying of their houses with DDT water-dispersible powder in water. Dieldrin, benzine hexachloride and malathion are used in areas of DDT resistance. (Quarterman *et al.* (1963) and Schoor *et al.* (1963) discuss dichlorvos as a residual fumigant; dichlorvos appears to be a promising insecticide for use in double resistance areas.)

I am sorry to add however, that there still are 388 million people who do not yet have any protection whatsoever from malaria. The largest portion of these live in Africa where the campaign is not yet underway. We all hope that someday the program will be extended to all people everywhere so that the cruel chills, fevers and debilitation of malaria no longer will be a millstone around the neck of these people. It has been shown frequently that when this weight is removed, excellent economic and social progress has been made in many countries.

We have many problems in the program, such as insecticide resistance of certain anopheline species, poor administration in some countries, lack of well-trained personnel in others, and insufficient funds in most. It is unfortunate that in certain quarters the principles of good mosquito control are not always observed, for some think of this only as a medical program and tend to lose sight of the fact that the goal must be reached principally through the avenue of vector control. In some countries there is still a lack of adequate knowledge and understanding of malaria eradication principles, as well as a scarcity of well-trained, experienced national personnel. The world has had these and other problems of setbacks, but despite the deficiencies the program is progressing fairly rapidly. As experience is gained and as people everywhere realize what this effort does for all countries and its inhabitants, the world will demand complete elimination of malaria from all nations. Through such measures the world is learning that freedom from disease — and from mosquitoes — is possible.

All of us benefit either directly or indirectly from the role that world mosquito control is playing. These benefits may be those derived from technological advances in the field of mosquito control developed in other countries — or merely because other people are able to live more productive, healthy lives. The improved economic productivity of these people brings about a higher standard of living which eventually benefits world trade and social progress.

All of us involved in mosquito control work should be proud of the part each of us has played either directly or indirectly in this humanitarian global program which is doing much to help draw nations more closely together. We fervently hope that these and other worthwhile improvements in the way of living of all peoples will make this a better world in which to live.

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NATIONAL ROLE IN MOSQUITO CONTROL

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To be perfectly frank, until I began searching the literature, I was unaware of the tremendous amount of activity that is being carried on at the national level in regard to mosquito control. Normally, I don't believe most of us think in such broad terms. We are inclined to be more concerned with what transpires in our immediate surroundings. Being a member of the military service, I have been aware of an accelerated insect and vector control program throughout the Defense establishment, with particular emphasis on mosquitoes. Entomologically speaking, we in the military have more to fear from the mosquito vectors than all the other groups of insects combined.

For the purpose of this discussion, I am dividing mosquito control at the national level into three main categories: (1) the role of our national professional societies, (2) the role of our colleges and universities, and (3) the role of the Federal Government.

I think it should be noted that there is no clear separation between these three national segments. In many ways they are inter-related and dependent upon each other.

Since I am most familiar with the Federal Government, and particularly the military, the major portion of this discussion will be centered on this aspect.

On the national level, contributions made by our two major professional societies, the American Mosquito Control Association and the Entomological Society of America, are very important. Long before the "bugaboo" of the dramatic *Silent Spring* was forced upon our consciousness there were numerous discussions in our national meetings and in papers published in our journals on the subject of safe handling of pesticides and avoidance of undesirable contamination of the environment. We were very much aware of the possible harmful effects of these toxicants when improperly used.

A concrete example of AMCA encouragement of mosquito control programming throughout the nation was the publication in 1961 of Bulletin No. 4, *Organization for Mosquito Control,* in which methods of achieving such organization, of developing it once instituted, and of avoiding pitfalls in both the establishment and the operation of mosquito control programs were thoroughly discussed. Such states as New Jersey, Florida, Virginia, and California, where mosquito control organizations are the most advanced, have exchanged personnel, technical data, and moral support over the years, and were instrumental in achieving the national scope of the AMCA. There are now some 193 regularly constituted mosquito abatement districts in the United States. Some are operating under different titles, others are functioning as divisions of Public Health agencies. In addition, there are an undetermined number of programs of a less formalized nature in operation, totaling at least twice this 193 figure. There is no question but that our national professional societies have played a vital role in fostering and selling the abatement district concept throughout all areas of our country.

The Entomological Society of America has been a very influential organization in fostering mosquito control research. A significant contribution made by this society was the recent publication of the *Synoptic Catalogue of the Mosquitoes of the World.* A large number of the scientific papers appearing in the ESA publications deal with culicidology. As an example, over 25% of the papers presented in Section D (Medical and Veterinary Entomology) at the recent 1963 St. Louis meeting were on the subject of mosquitoes.

The timely contributions made by our colleges and universities is well documented. Almost daily these institutions are adding to our knowledge of mosquitoes, primarily in such fields as taxonomy and distribution, bionomics, genetics, physiology, morphology, laboratory techniques, dispersal phenomena, disease agent relationships, and physical, chemical, and biological control.

Mosquito research and control activities of the Federal Government are mainly confined to the departments of Health, Education and Welfare, Agriculture, Interior, and Defense.

In the Federal Government, as one would logically expect, the Public Health Service of the Department of Health, Education and Welfare has been a leader and a prime contributor in all aspects of research on mosquitoes. To single out some of their more important achievements we would have to mention the role that Communicable Disease Center played as coordinator of the very successful wartime malaria eradication program. In fact, CDC probably owes its existence to this eradication program. Likewise, we must mention the voluminous research on the arboviruses which is being carried on in Florida, Colorado, and here in California at Bakersfield. Of great importance is the recent discovery at the Public Health Service Savannah laboratories of dichlorvos as a residual fumigant and the application of this principle to control mosquito breeding in catch basins and as a means of controlling *Anopheles* in living quarters in malarious areas. CDC also proposes the use of dichlorvos for the disinfection of long range transoceanic aircraft. These are all noteworthy contributions which can have far reaching consequences.

And now a new nation-wide insect eradication program has emerged on the horizon. A very ambitious undertaking of eradicating the yellow fever mosquito from our national boundaries has been assigned to CDC in cooperation with state health departments. On October 8, 1963, Donald J. Schliessmann, formerly the Deputy Chief of the Center's Technology Branch, was appointed Chief of the new *Aedes aegypti* Eradication Branch. An economy minded Congress earlier this spring had rejected funds for this program, but recently it reversed itself and appropriated the sum of 3 million dollars to launch this campaign for fiscal year 1964.

You may be interested in the proposed five year financial breakdown for this program.

	Federal Support	*State Support*	*Total*
1964	3 million	1.928 million	4.928 million
1965	6 "	4.211 "	10.211 "
1966	14.6 "	3.494 "	18.094 "
1967	14.7 "	2.481 "	17.181 "
1968	12.2 "	2.881 "	15.081 "
TOTAL	50.5 million	15.475 million	65.975 million

I think it should be pointed out that epidemics of dengue fever, estimated at 20,000 cases, currently in progress in Puerto Rico and Jamaica, and the importation of clinical cases of dengue from these epidemic areas into the United States, had a lot to do with the final Congressional approval of the eradication program. One might even conclude that these epidemics had a very timely occurrence.

The *A. aegypti* eradication program will be part of an international effort to eliminate this mosquito from the Western Hemisphere, an attempt that had its beginning almost forty years ago in Brazil. It should be noted that *A. aegypti* populations have already been cleared from most countries in the Western Hemisphere. Some of our neighboring nations have pointed out that yellow fever mosquitoes in the United States might be a possible source of accidental reinfestation of their countries. Recognizing the possibility of this is another reason supporting this program.

The Department of Agriculture, through its Insects Affecting Man and Animals Branch, has in the past and is currently making major and important contributions to our nation-wide mosquito control effort. Probably the most noteworthy among these are the research studies conducted at the Beltsville, Maryland and Gainesville, Florida laboratories. The development of the chemosterilant concept of control, which was so ably described to this group by Dr. Donald E. Weidhaas a year ago, is certainly revolutionary in all its ramifications. Likewise, the development of that very effective repellent called deet, or diethyltoluamide, is another outstanding accomplishment from which I can personally assure you the military is deriving a great deal of benefit.

We are all aware that the U.S. Department of Interior, through its Bureau of Sport Fisheries and Wildlife, is responsible for conservation of wildlife. Through passage of U.S. Public Law 85-582 this agency was assigned the responsibility of evaluating the effects of pesticides on wildlife and assisting in the development of chemicals and techniques to minimize losses. Starting with the President's Committee on Pesticides, and on down through the various echelons of government, continued concern is being expressed for the possible effects of pesticides on our wildlife resources. Numerous contacts and discussions with members of the Bureau of Sport Fisheries and Wildlife have left me thoroughly convinced that they have a logical and justifiable interest in our mosquito abatement activities. We in the Federal Government look to them for advice and guidance in conducting mosquito control programs.

I have a feeling that the extent of mosquito control activities in the Department of Defense and its various armed service components is not fully realized nor understood. Most people do not know that the military spends millions of dollars each year on insect research through subsidies, grants, and contracts with foundations and universities as well as other governmental agencies. For example, the major portion of the funds required to operate the USDA Insects Affecting Man and Animals laboratory at Gainesville, Florida comes from the Department of Defense. Likewise, studies on the detection of insecticide residues and insect resistance to insecticides at the Beltsville laboratory are funded in part by DOD grants. As previously mentioned, the military is more concerned about one insect, the mosquito, than any other vector. This concern is substantiated in many ways.

Actually the mosquito was a menace to the military long before it was recognized as a carrier of disease. Percy Ashburn's *A History of the Medical Department of the U.S. Army* (Houghton Mifflin Co., Boston, 1929) records many interesting entomological observations. One of these referred to a Captain Macauley who, writing of his experiences while stationed at Fort Abraham Lincoln, North Dakota, in 1885, describes the enormous numbers of mosquitoes that made life miserable for both man and animals. He states that "smudges" made by burning half dried grass in both officers' quarters and enlisted men's barracks were necessary to render the quarters inhabitable, and that heavy riding boots, thick trousers, leather gauntlets, and a thick "cache nez" tucked under the helmet and collar of the tunic had to be worn on the target range because of the mosquitoes.

The importance of the actual destruction of the *Anopheles* mosquito as a means of controlling malaria cannot be over emphasized. I stress this point because of the recent appearance of resistant strains of malaria plasmodium parasites to the two previously effective chemotherapeutic drugs, chloroquine and primaquine, in our troops in Southeast Asia. This problem is now so serious that it has became necessary in some instances to revert back to the use of quinine to treat the illness. It is feared that this is just the beginning. There are predictions that if this resistance trend becomes widespread, and there are indications this may happen, that it will stagnate the World Health Organization malaria eradication program for years to come. This is just another prime example of why the elimination of the vector is the only sure and lasting means of controlling the vector-borne diseases.

There is now realization among our military commanders that vector-borne diseases, and particularly the mosquito transmitted types, do play a vital and sometimes conclusive role in the success or failure of military campaigns. We need only to reflect back to World War II when such diseases as malaria, dengue, filariasis, and encephalitis incapacitated more of our fighting men than did all the weapons of the enemy. Military commanders were finally forced into realizing the need for some effective means of protecting our troops against these illnesses.

Data from World War II manpower losses attributed to mosquito-borne disease serve to remind us of how important and serious this problem actually was. During the four year period, 1942-1945, there were approximately 850,000 cases of malaria, dengue, and filariasis reported in our armed forces. This resulted in a total of over 14 million man-days lost. In some instances these were very precious lost days—at a time when we could ill afford to spare a single man. These figures, coupled with another 1,100,000 cases of other arthropod-borne diseases, suggest the magnitude of this problem.

What is the current status of entomology in the military today? How well prepared are we to face our responsibilities in case of another world-wide conflict?

The armed forces at the present time have 88 entomologists on active duty. These are divided among the services as follows: the Army has 52, 22 are in the Navy, and the Air Force has 14. For the most part, these entomologists represent a highly trained and coordinated professional pool, instantly available whenever and wherever needed. In addition, these 88 active duty personnel are backed up by a large reserve contingent who, in a short period of time, could be recalled to active duty with only a minimum of indoctrination and training required. We also have available a large group of highly trained technicians and sub-professional personnel. Considerable emphasis by all three services has been placed on vector control training programs.

The paucity of equipment and supplies which plagued our entomological units during World War II and the Korean conflict should not happen again. Significant progress has been made in developing and making available better dispersal apparatus for adulticiding and larviciding. This includes all categories of hand-operated equipment, small and large power type units, as well as aerial dispersal apparatus for use on various kinds of aircraft, including jet propelled types.

In spite of the seriousness of the resistance problem we have better toxicants for mosquito control than ever before. We have more effective and longer lasting repellents. Our greatly expanded training program for both the professional entomologist and the enlisted technician is an area where we have made great progress.

The "horse and buggy" era of insect control in the military is no longer with us. The stigma of the two-gallon sprayer, which has haunted us for years, we hope has ended. With the tools, the knowledge, and the personnel we now have available there is no question that we are well equipped to face whatever tasks lie ahead.

Very briefly, I have attempted to impart to you the extent of mosquito control activities at the national level. Some aspects may have been omitted—if so this was unintentional. I think all will agree, however, that our total national mosquito control effort has been considerable and that the general public is more aware of this fact today than at any time in our history.

STATE ROLE IN MOSQUITO CONTROL

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It is a pleasure once again to participate in your Annual Conference, as has been my privilege several times in the past. On other occasions my contributions have tended to be somewhat technical; but today we are concerned primarily with administrative considerations, particularly as related to international, national, state and local relationships and responsibilities. Such administrative relationships are not new to us in public health.

Before getting into the assigned subject, however, I should like to pause briefly to pay tribute to a departed leader from the state, national, and world mosquito control scene. Harold Farnsworth Gray was the kind of person—generous with his many valuable contributions to this field—who by his very philosophy helped the environmental health program of California. Today I repeat my expression of gratitude for his many rich technical and professional contributions to public health, while adding my personal feeling of sorrow over the great loss of California's senior statesman in mosquito control.

The latitude contained in this subject necessitates to define the state role in mosquito control, while contributing directly to its effectiveness. As most of you know, Harold Gray was an ardent exponent of home rule, a rugged individualist in behalf of local government. His expert technical advice furnished over the years on this kind of a foundation materially helped us in the conduct of our relationships with local California mosquito control agencies. At your 25th Annual Conference, following Harold Gray's retirement, I paid tribute to him as a founder and mainspring of your Association, as well as for his many assists in shaping my identifying at least the principal organizations and interests which have a state role in mosquito control. Historically, the University of California, particularly through the outstanding early contributions of Herms, Freeborn and Gray, initiated vital studies and demonstrations and extended invaluable technical advice and training in behalf of California mosquito control. The University role in recent years has expanded in a variety of areas, through its Schools of Agriculture, Engineering and Public Health, as well as the Agricultural Experiment Station and Extension Service. The State Department of Public Health, with U.S. Public Health Service assistance, began anti-malaria activities in the early 1920's and has broadened and accelerated its mosquito control program appreciably during the last quarter century. The State Department of Water Resources, in conjunction with correlated federal water resources development activities, also plays a preventive role in California mosquito control. The Department of Fish and Game, through its program of wildlife conservation, particularly in waterfowl areas, has a distinct interest in the mosquito control picture. The Department of Agriculture, in a variety of ways, ranging from pesticide regulation to crop management practices, is involved with mosquito control. Your Association, in fulfillment of its stated objectives and functioning as the statewide coordinating influence upon local mosquito control activities, has perhaps the most prominent state role in mosquito control.

It would not be going too far in this regard to mention also such other concerned agencies as the State Irrigation Districts Association, and the State Soil Conservation, Reclamation, and Flood Control programs. Even the State Chamber of Commerce becomes aroused when, as in 1952, a bumper occurrence of mosquitoes is identified with a major outbreak of encephalitis, which in turn may significantly affect the state's economy. In essence, every state agency which has a relationship to water would appear to have a direct or indirect role in mosquito control.

Perhaps the most important aspect of this subject is that of understanding the liaison responsibilities of the state between local and national programs of mosquito control. This has been a matter of continuous concern to our Department in virtually all areas of public health. A great deal of discussion and joint planning is necessary in order to avoid duplication or conflict. This is also a matter of concern to us within the various programs at the state level. Throughout its history California has been characterized as primarily a home rule state; this pattern of operation has unquestionably served the state well in the past. Strong local government has provided maximum accountability and the closest kind of public awareness of services received, with corresponding willingness to pay the costs of governmental services. At this point in California's growth and development, however—in full respect for our strong form of local government—it is becoming increasingly apparent that considerably more state and regional planning and action will be required if California is to accommodate its future population, its agriculture, and its industry, while leaving ample space for enjoyable and safe recreation. Even as you meet here today, a most significant conference, "Man in California: 1980's," is in progress, also in Sacramento. That conference is addressing itself to the long-range management needs of California, both physical and social. The Department of Public Health is taking a prominent role in those deliberations. I doubt that even Horace Greeley realized the full implication of his advice about going west as it relates to our population gain in California, which now exceeds 1500 persons daily.

Turning now to the Department's specific interest in mosquito prevention, our Bureau of Vector Control is attempting to review every major water resource development being planned throughout the state before construction begins, in order to minimize the future mosquito potential. In line with California's long-range water resources development program and in view of the growing demands for water, it is foreseeable that even greater emphasis will have to be placed upon ways to conserve this vital resource. No doubt such an increased emphasis would meet with the hearty support of this audience.

Turning next to the state's activities in behalf of mosquito control, it seems to me that the recent history of mosquito control in California is a most dramatic story in itself. As recently as the mid-40's the statewide program for mosquito control was comparatively scattered. At the close of World War II, in the face of a possibility that returning servicemen could introduce certain exotic mosquito-borne diseases into California, the Legislature responded by virtually matching those funds available through your collective local agencies. Since 1946 the approximately 30 local mosquito control agencies have nearly doubled in number, the territory under organized mosquito control has increased from about 5,000 square miles to over 35,000 square miles, and your state-wide budgets have grown from approximately a half million dollars to well over six million dollars in the current year. This spectacular increase in organized mosquito control has been supplemented by extensive mosquito surveys and continuous consultation by our Vector Control staff in order to furnish various localities technical and fiscal information required in planning successful mosquito control programs.

Associated with this rapid growth of mosquito control in California has been another sign of progress which our Department looks upon with real satisfaction. Between 1946, when there were 30 agencies, and 1964, with the present 60 agencies, the number of graduate engineers and biologists in local mosquito abatement programs has increased from 2 to 62. With the growing complexity of your your program, this is certainly a significant development. Without question, the Standards and Recommendations for Local Mosquito Control Agencies, adopted by the State Board of Health in 1949, have contributed to this advance.

The encephalitis crisis of 1952, which has already been referred to, subsequently led to increased emphasis upon epidemiological as well as entomological surveillance, with implementation of a standardized mosquito sampling system and reporting program. While this system lacks the degree of precision that all of us would like to see in this type of disease intelligence operation, it has nevertheless furnished mosquito occurrence indexes which have provided early documentation of abnormal *Culex tarsalis* production. Also associated with the 1952 episode was the fulfillment of a unique state role in mosquito control—that of emergency state mosquito control operations in localities without organized control and subject to high risk of encephalitis. The assistance provided by the U.S. Public Health Service Communicable Disease Center at that time is also significant in that it brought into full play the resources of the three levels of government—federal, state, and local.

Another service which is available from the state, which has been used effectively but less extensively, is program evaluation. Every local agency contracts for at least one fiscal audit annually, but only a few agencies have requested comprehensive technical program reviews. On the other hand, the dissemination of technical information about mosquito control and the extension of mosquito control training are state functions which seem to register high in demand and acceptance.

Research directed toward technological development is undoubtedly the area of state responsibility which has received the most attention from your agencies. During the past 20 years we have witnessed the astounding adaptive capacity of mosquitoes to two distinct groups of modern organic insecticides, the chlorinated hydrocarbons and the organophosphorus materials, resulting in continuous operational insecurity. We have further witnessed an aroused concern about pesticide contamination of the environment. In these two areas—that is, in technological progress and environmental health and safety—we find perhaps the most important state roles in mosquito control. We are particularly pleased to acknowledge the most effective kind of collaboration with the University of California in both areas. As most of you know, a Joint Committee of the State Department of Public Health and the University of California on Research on Arthropods of Health Importance has been functioning with rewarding success now into its second year. All vector control research activities of the State University and our Department are reviewed by this Joint Committee. It is composed of equal University and Department membership. We are fortunate to receive through this Committee the technical consultation of such distinguished scientists in the University as Dr. Richard M. Bohart, Dr. Glenn E. Carman, Dr. William C. Reeves, and Dr. Ray F. Smith on all aspects of our vector control technical development activities. Equally fine collaboration is being achieved in our relationship with the University on program relating to environmental health and safety. In fact, a very important University-Department cooperative research program is now in the blueprint stage, an Environmental Sciences Center, to be situated on the campus of the University of California at

Davis. We look forward to this kind of integrated program as the most effective way to fulfill the state role, not only in mosquito control but in a great range of subject areas of critical importance to the orderly growth and development of our rapidly changing state.

Reflecting somewhat more directly on the nature of the state's role in mosquito control, certain conclusions appear unmistakably clear. Certainly we are not in a position to relax or wait upon developments occurring elsewhere which might be employed directly or adapted in time to our needs. It is imperative that we aggressively attack our own California problems. This calls for a continued pioneering role for the protection and security of an area that is uniquely diversified geographically and is characterized by a rapidly expanding population, an aggressive agricultural development, a spectacular industrial growth, and extensive and expanding recreational resources. Thus, we visualize the state role in mosquito suppression as being primarily the improvement of the reliability and effectiveness of control technology in collaboration with local operations. Our objective is to provide a balanced program of technological research and development, surveillance, assistance with education, training and information dissemination, program evaluation as needed, and consultation—all in the interest of developing the most effective and economical mosquito control obtainable.

Although my subject specifically pertains to mosquito control, I am impelled, in closing, also to bring into focus several other vector problems to which your organization might well be giving serious thought as possible future responsibilities. I refer specifically to the growing gnat and domestic fly problems. Both aquatic and terrestrial gnats bid to become of greater public concern in response to the many and diverse artificial changes occurring throughout the state. The domestic fly problem is gaining significance in California in direct ratio to the progressively increasing organic by-products. Although time does not permit my elaborating today upon the administrative or operational aspects of achieving control of these noxious insects, it is my recommendation that joint discussions be developed between mosquito abatement districts, local health departments, and local agricultural agencies with respect to assessing their present and possible future significance in your respective localities. In our judgment these problems will require active initiative and participation of a variety of local agencies if they are to be effectively met through the most important and economic public health technique known—namely, prevention.

SECOND SESSION

MONDAY, JANUARY 27, 1:30 P.M.

FREEBORN HALL, UNIVERSITY OF CALIFORNIA, DAVIS

J. D. WILLIS, *Presiding*

Mr. Willis: It is my pleasure at this time to present Dr. Chester O. McCorkle, Professor of Agricultural Economics and Vice-Chancellor of the University of California, Davis, who is here to extend the official word of welcome.

Dr. McCorkle: Thank you, Mr. Willis. Ladies and gentlemen, on behalf of Chancellor Mrak and the faculty at Davis, I want to extend a most cordial welcome and to wish you success in your Thirty-second Annual Conference.

The strength which the College of Letters and Science has achieved in the short time of existence on this campus can be traced in large measure directly to the strong foundation in teaching and research built on the principles of basic scientific emphasis which the faculty of the College of Agriculture had so carefully constructed. In fact, many of the people who formed the nucleus of the new College of Letters and Science in 1951, had been members of the staff of the old College of Agriculture and of course have not ceased to keep their ties with the college even though they are now designated in Letters and Science.

But today we are moving off in new directions. The Regents at just their last meeting, named the new dean for our law school which does not yet exist but which shortly will be a reality here at Davis. They will take their first students in the fall of 1966. Detailed planning is now getting under way to build and staff a medical school at Davis. This is certainly a logical outgrowth in view of the history of this campus. Those of you familiar with the physical character of the Davis campus recognize great changes as you pass through, I am sure. First of all you may have seen the new addition to the library which will be occupied this next semester. Robbins Hall which houses our Entomology Department, with which I am sure you are all familiar, is now in full operation. Hutchison Hall, the five story science building located south and west of here, has recently been occupied. In the basement of that building, if you are interested, is a very elaborate computer facility equipped with an IBM 7040 unit. Our National Primate Center, now occupying temporary quarters on the campus, has received its first contingent of a little over three hundred primates. You would be interested to know that there are facilities out there for producing disease transmitting mosquitoes in very large numbers, this being a part of the research function of the Primate Center. The Faculty Office Tower, a conspicuous new campus landmark, actually a nine story office building (affectionately referred to as the "Top of the Mrak" — for obvious reasons), is now in full use.

Our Alumni Association is now an independent body for the first time, with its own secretary, John Hardy. John is working very actively to weld together the alumni of Davis in order to provide long needed strength which such an organization can provide to our campus.

In spite of the growth taking place in other areas, agriculture continues to exert a strong and healthy influence on this campus. We are striving to retain this influence, but I assure you it's not an easy task. While undergraduate enrollment in agriculture as a whole has shown a healthy increase in the past year, this growth has not been shared by all departments, nor by all disciplines. Part of this is due, I am sure, to the increased emphasis in high schools toward the teaching of physical and biological sciences. I suspect this is a desirable shift for the most part. I think another part of it is due to the wide-spread misconceptions on the part of the general public as to the role of agriculturally trained people in what they erroneously believe to be a totally industrial society. We need help in attracting good students into agriculture. There are more jobs than can be filled, the salaries are good, and the opportunities for advancement have never been better.

The misconception held by many in our society toward agriculture is beginning to have another effect on agricultural teaching and research in the university — I must say a very unhealthy effect. For the past several years, the funds made available for these purposes by the state have been virtually unchanged. The arguments offered are that the teaching loads are heavier in other fields and that research projects in agriculture never seem to end. The facts are that the agricultural faculty is contributing significantly to teaching the students in other subject matter areas and will do more of this in the future. It is working with large numbers of undergraduate and graduate students, but particularly graduate students at the present time, and is attempting to meet the ever present requests for research. Teaching in our other colleges on the campus is not entirely out of choice; however, members of the agricultural faculty are qualified for such service and they want to teach. With respect to the charge that projects in agriculture never seem to end, I can assure you that projects are concluded and closed but nobody ever hears of this.

When problems requiring research increase faster than the faculty and staff can solve them, many organizations such as yours come up with excellent research suggestions; but we too often cannot begin appropriate study as soon as you, or as soon as we would like. Under the financial constraints of recent years it has become even more difficult. But in spite of these difficulties, I assure you that the College of Agriculture will continue to serve the state of California, the nation and the world by one way or another. Dean Meyer has a faculty committee engaged in a soul searching review of our entire teaching, research and public service function to see how we can better utilize the resources that we have in coping with the agriculture of the future.

Apart from agriculture there are many other difficulties experienced by a campus suffering from growing pains as we are. We have class enrollments now that are too big for the largest classrooms we have on the campus. This year the zoology and physiology classes both exceeded the biggest classroom we have except for this auditorium. We are just about to the point where our chemistry laboratories will be filled morning, noon and night six days a week. We have the opportunity to schedule one more class if we schedule Wednesday night and late Saturday afternoon. That is the kind of space use we are getting in certain areas now. Even with the rate of building that we are trying to achieve we are falling behind in our space. Advancing student enrollments in both the undergraduate and graduate levels for the campus as a whole are also taxing our housing facilities, not only for the campus but for the community. We are striving to find ways and means of providing residence halls for students where the monthly charges for board and room can be kept within reasonable limits. This is not easy. As our student population on campus grows, it is necessary to provide certain types of recreational activities, for such activity in the vicinity of Davis is limited. The cost of nearly every facet of the educational experience we endeavor to provide for our students is rising.

There is an inadequate supply of first rate instructors and researchers. The competition is intense for top quality people, the kind upon which the University of California has built its reputation in the past. There is also a greater need than ever to find ways and means of retaining a cohesive spirit of friendliness and unity that goes with a campus the size that Davis has been in the past.

We are working to find solutions to these problems and to implement these solutions. It is our greatest interest to provide young men and women with the highest quality of educational experience possible, whether these be undergraduate students or graduate students. We will also continue to serve as a major full spectrum research center and public service agency. In meeting these commitments we recognize that there are financial constraints under which any tax supported institution must rightly operate and we know that there is never enough money to do everything we need to do, let alone what we might want to do. In any case we are all willing to work to exceed our commitments in whatever area they may be. With the understanding and support of groups such as yours, this task can be made much easier.

The Davis campus is yours for the rest of the day and I hope you have an opportunity to look around a little. Best wishes for a highly successful conference and we certainly hope that the Cal Aggie spirit catches you sometime during the day. Thank you.

VECTOR CONTROL AND RELATED RESEARCH AT THE UNIVERSITY OF CALIFORNIA, RIVERSIDE

GLENN E. CARMAN
Department of Entomology

Although vector control and related research studies were initiated on the Riverside campus little more than a decade ago, we now have a creditable number of staff members devoting all or a significant part of their research effort in this area of critical investigation and could already recite an array of notable contributions that have emerged from their collective endeavors. These are a matter of record in appropriate scientific publications so it is our more purposeful aim at this time to acquaint you with the scope of current studies and the trend of recently reported results.

Our ensuing discussion will encompass the toxicology screening and resistance studies on mosquitoes, mosquito and *Hippelates* eye gnat control investigations, aquatic midge studies and the biological control studies on eye gnats and chironomid midges. The studies reported have been directed by Dr. R. L. Metcalf, Dr. G. P. Georghiou, Dr. M. S. Mulla and Dr. L. D. Anderson of the Department of Entomology and by Dr. E. C. Bay and Dr. E. F. Legner of the Department of Biological Control. More detailed and additional information concerning the studies conducted by Dr. Mulla and Dr. Bay will be presented by them in discussions scheduled in later sessions of this conference and accordingly our review of their work will be somewhat limited.

STAGE I SCREENING FOR WORLD HEALTH ORGANIZATION (R. L. Metcalf)

This extensive project is supported by the World Health Organization to implement a fundamental screening program in search of new insecticides suitable for use in the malaria eradication program of this organization and for other vector control programs. While the major emphasis is a quest for compounds negatively correlated for resistance to DDT and dieldrin, it is also envisioned that the screening procedure may disclose effective compounds to which flies and mosquitoes cannot develop resistance. Potentially useful materials revealed by this screening program are subsequently examined in supplementary laboratory tests and, insofar as available in suitable quantities, in preliminary field larvicidal tests.

During the past year, 166 new compounds were completely evaluated by the Stage I screening procedures. Compounds demonstrating unusual toxicity to mosquitoes (or other interesting properties) included five acylated carbamates with very high toxicity to adult mosquitoes, four organophosphorus compounds with very high activity as mosquito larvicides, and four organotin compounds with good activity to adult mosquitoes. In addition, a compound whose identity is as yet withheld was found to be an especially interesting synergist for carbaryl and other carbamates. The compound is more active as a synergist (for carbaryl and other carbamates) than piperonyl butoxide and gives good synergism with carbaryl at a 1:1 ratio.

This continuing program will capitalize on the availability of biologically active materials synthesized in industrial and other research laboratories and provide valuable direction and guidance to the mosquito control studies we are conducting in southern and central California.

Resistance Studies on Mosquitoes
(R. L. Metcalf and G. P. Georghiou)

These studies have been continued during the past year as a part of a multifaceted effort to characterize this biological phenomenon and to develop whatever means may be employed to circumvent its implications. While it would not be purposeful in this discussion to elaborate on the many areas of investigation under way, we would like to provide some insight into one of the more interesting studies.

By far the most intriguing aspect of the genetics of resistance is the possibility of discovering pleiotropic genes producing negatively correlated resistance to pairs or groups of insecticides. Since 1960, Dr. Metcalf and Dr. Georghiou have been investigating the carbamate resistance potential of a dieldrin/DDT resistant strain of *Anopheles albimanus* and of a susceptible strain of *Culex pipiens quinquefasciatus*. Selective pressures on these strains with *m*-isopropylphenylmethyl carbamate for 21 and 30 generations, respectively, resulted in a 2.7-fold increase in tolerance to the selective agent in *Anopheles* and a 2-fold increase in *Culex*. Susceptibility to the related methyl carbamates, *o*-isopropylphenyl, *o*-isopropoxyphenyl, *m*-sec-butylphenyl, *m*-tert-butylphenyl and 4-methylthio-3,5-xylyl, remained virtually unchanged (less than 2-fold at the median lethal concentration) except for carbaryl which was 5.2-fold less effective against *Culex* than initially. The selective pressure is being continued and intensified in order to ensure maximal expression of the resistance potential.

When the response of the carbamate-selected strains to dieldrin and DDT was investigated, it was found that while the *Culex* strain was as susceptible to dieldrin and DDT as before selection, the *Anopheles* strain showed almost complete loss of resistance to these compounds. During the same period, the resistance level of the unselected control strain of *Anopheles* showed only negligible regression of resistance to dieldrin and DDT. The frequency of the dieldrin-resistance gene was .68 before carbamate selection, .09 after 21 generations of selection, and .55 in the unselected control strain. This regression of dieldrin resistance cannot be attributed to chance inclusion of an unduly large number of susceptible genotypes in the initial sample (in view of the large size of the sample taken) or to contamination (since no susceptible strain of *Anopheles* is maintained in our laboratories). These observations lead to the formulation of the hypothesis that the observed regression of dieldrin resistance is a consequence of the selection by the carbamate, either as a true expression of negatively correlated toxicity, or due to some deleterious effect of the carbamate environment on dieldrin *RR* genotypes, such as a reduction of oviposition or egg hatch, so that *rr* genotypes eventually predominate.

The significance of these studies may be far-reaching and continuing investigations are being supported by a research grant from the U. S. Public Health Service.

Mosquito Control Investigations
(M. S. Mulla)

This phase of our work involves the evaluation of new materials against mosquito larvae in both laboratory and field tests. Materials showing promise in the laboratory are tested in the field primarily against *Culex tarsalis*.

Over 50 new compounds were evaluated in the laboratory during the past year. Of these, 22 compounds manifested higher biological activity than that of DDT and malathion. Six compounds, namely AC-52160, SD-9020, SD-9320, CL-43913, Bayer 47940 and SD-8803 showed higher biological activity than parathion. Four other compounds, namely AC-47921, Bayer 52957, SD-9321 and Cela S-1942, had activities similar to that of parathion.

In field tests conducted against *C. tarsalis* these compounds were highly effective, with the rates required for complete kills ranging from 0.01 to 0.1 lb per acre. Most of the highly effective compounds mentioned above are characterized by low mammalian toxicities. The acute oral LD_{50} of AC-52160, the most effective larvicide tested, last year, is over 300 mg/kg while that of Cela S-1942 is 3000 mg/kg, similar to that of malathion.

Studies on the relationship of these new compounds to fish, amphibians and predaceous invertebrates indicated a good margin of safety. At larvicidal rates these compounds did not manifest any acute toxicities.

Studies on mosquito resistance which were initiated two years ago when DDT treatments failed to control a strain of *Culex p. quinquefasciatus* in the Coachella Valley have been continued. This strain which was colonized in the laboratory and tested for susceptibility pattern was found to have moderate resistance to DDT, and slight resistance to dieldrin, malathion and Ortho 5353, a carbamate insecticide. No resistance in this strain to methyl parathion, fenthion, parathion, Sumithion® and two carbamates, namely AC-5727 and Ortho 5305, was apparent.

A strain of *C. tarsalis* from southern San Joaquin Valley was found to be resistant to DDT, but not to 8 organophosphorus type compounds tested against this strain. *Aedes nigromaculis* from the southern part of the Valley was found to be resistant to DDT, dieldrin, parathion and malathion. No appreciable resistance in this strain to AC-52160, CL-43913, SD-7438, fenthion, methyl parathion and Sumithion was recorded. Although these studies were limited in scope, they do point out that parathion resistant *A. nigromaculus* are susceptible to certain phosphates, especially AC-52160 and CL-43913.

Hippelates Eye Gnats.—Laboratory and field investigations on the development of soil larvicides were continued. In the laboratory it was found that only a few compounds showed residual larvicidal activity in the soil. Four of these were tested in the field and only one, Bayer 37289, was found to produce seasonal control with one soil treatment.

Soil treatments have a limited potential for eye gnat control. Therefore, emphasis has been shifted to cultural control measures. Since noncultivation through the use of weed oil to control weed stands has found wide acceptance, other avenues in this respect were explored. Weed stands treated with weed oil one to six days before disking produced excellent control of eye gnats. Similarly, treatment of the soil surface immediately after the disking of heavy cover crops provides excellent control of the gnats. Treatment of disked soil is easier than the oiling of weed stands before disking. The amount of oil needed to provide satisfactory control is about ½ to ⅓ of the amount needed for the pre-disk treatments. Both of these new approaches will be applicable to vegetable and field crops where it is contemplated to disk under the crop residues. These measures will suitably supplement the noncultivation measures already in operation.

For the purposes of understanding the biological effects of sterilizing chemicals and of evaluating the effectiveness of attractants in the field, studies were initiated to elucidate the reproductive biology and physiological aging of eye gnats. The female reproductive system was found to be notably different from that of closely related Diptera.

Each ovary contains 10-16 ovarioles. Each oögonium separating from the germarium divides, yielding 15 nurse cells and an oöcyte. The development period of the follicle is divided into 10 stages. Growth and disintegration of nurse cells, oöcyte development, differentiation of follicular epithelium, appearance of nonchorionic cells, and the size of these structures were used in determining various stages of the gonotropic cycle. Transfer of sperm from spermatheca to the seminal receptacle located in the common oviduct was also used to aid in age determination. Criteria for separating parous and nulliparous females were developed.

Mated females isolated from males lay decreasing number of eggs with decreasing viabilities. The egg viability in females mated once is completely lacking in a few days. Since the females lay several batches of eggs, repeated matings are necessary for the production of a maximum number of viable eggs. Male eye gnats on emergence are capable of mating. However, the females do not mate until they are over 48 hours old. Mating activity in females starts when Stage V to VI of the gonotropic cycle is reached. These relationships are partly controlled by external factors such as light and temperature.

It is hoped that added information on the basic reproductive biology of eye gnats will provide new guide lines for formulating and exploring additional measures for the abatement of eye gnats which are a particularly serious nuisance problem in southern California. Measures now employed to minimize the intensity of gnat populations are still far from adequate.

Aquatic Midge Studies

(L. D. Anderson)

These studies under the capable direction of Dr. Anderson continue to expand and diversify. Much of the work is conducted at 'Midgeville,' a pond farm and field laboratory complex located on the Riverside campus. Of the 28 test ponds completed in this installation 10 are being used in fish-midge studies, 12 for the evaluation of midge production in relation to nutritional background, 1 for biological control studies, 1 for stock culture production and 4, which are equipped with screened enclosures, are being used in control tests or for the production of segregated species. In addition, 24 field aquaria mounted on cement platforms and supplied with either filtered or source water are available for both fish and midge type tests.

Additional studies involving survey, monitoring, evaluation of control methods and screening of candidate insecticides are in progress in San Diego, Oceanside, Whittier, Ontario, Palm Springs and Lancaster.

The identification, classification and distribution of midge species in the southern California area continue to receive careful study. It is presently indicated that as many as 30 species may be found in this area and 26 in 14 genera have been differentiated. Efforts are also being made to characterize the larval stages of the dominant species. Life history studies show that the minimum cycle from egg to adult varies from 14 to 19 days among the species studied.

The availability of essential nutritional requirements appears to be limiting and may largely determine distribution of species. As an example, dominant species (*Chironomus fulvipilus* and *C. stigmaterus*) in the Ontario area where as much as 9.5 ppm of available phosphate is present in the pond water are not found in waters at Riverside with 0.02 ppm of available phosphate. Increasing the phosphate level in Riverside ponds to 2.0 ppm resulted in the production of significant numbers of these same species. Pond-midge productivity studies revealed that more midges were produced in ponds that were dried and then rewet than in ones kept continuously wet.

Fish-chironomid association studies showed large mouth black bass, *Micropterus salmoides*, to have no effect on midge populations. Mosquito fish, *Gambusia affinis*, caused an increase in midges whereas redear sunfish, *Lepomis microlopus*, often, but not consistently, caused a reduction in midge production.

Midge-insecticide studies involved approximately 20 candidate materials. Emulsifiable concentrates of parathion and several other organophosphorus type compounds were the most effective in controlling midge larvae, with LD_{50} values reported in the range of ¼ to ½ ounce per acre.

Assaying on fish populations the effect of pesticides used to control midges has become an essential corollary to these insecticide studies. In tests utilizing rainbow trout it was found that the maximum amounts that could be used without injury to 7 to 9 inch trout in terms of pounds per acre of parathion, Sumithion, Geigy 30494, fenthion, malathion and Ethyl Guthion® were 4, 4, 2, 2, 1.5, and 1/8 to 1/16 pounds respectively. Wettable powder formulations generally appear to be more toxic to trout than emulsions or emulsifiable concentrates and granular formulations are the least toxic. One to 2-inch trout were several times more susceptible to the pesticides than the 7 to 9 inch trout.

Biological Control of *Hippelates* Eye Gnats and Chironomid Midges

(E. C. Bay and E. F. Legner)

Hippelates research in 1963 was mainly concerned with parasite search and evaluation in the Coachella Valley of southern California by Dr. E. C. Bay and in the West Indies by Dr. E. F. Legner.

By field exposing containers of grass seedlings infested with *Hippelates* eggs Dr. Legner discovered a dozen parasitic species and strains of Hymenoptera in Puerto Rico and Jamaica. Five of these have been successfully cultured at Riverside and will be field tested in 1964.

In addition to *Hippelates* parasites, Dr. Legner collected four species of parasites from house flies. These also are being reared in Riverside in preparation for 1964 field evaluation.

In the Coachella Valley Dr. Bay found one new parasite, a cynipid wasp, *Trybliographa* (Didyctium) sp. This parasite which was recovered on two occasions was obtained by infesting soil plots with eye gnat eggs produced in the laboratory. Some soil plots thus infested produced up to more than 100 times as many gnats as checks. This would indicate that the eye gnat problem could, in fact, be much worse than it is. Natural factors responsible for eye gnat suppression are to be given further study during the coming season.

Biological control of chironomids during 1963 was largely devoted to developing mass rearing techniques for chironomid larvae. Substantial success has been achieved in mass rearing two important species, *Tendipes californicus* and *Tendipes fulvipilus.*

Studies on the use of fish as a means of controlling midges were conducted cooperatively with Dr. Anderson and have been reported earlier in this paper.

In the field of insect pathology a microsporidian parasite (*Gurleya* sp.) of chironomid larvae was discovered during the summer of 1963. An intensive study of this disease organism will be undertaken by Mr. Kent Hunter, a graduate student associated with the aquatic midge project and the worker responsible for first detecting this pathogen.

MOSQUITO AND RELATED ARTHROPOD CONTROL ACTIVITIES—UNIVERSITY OF CALIFORNIA, BERKELEY

Deane P. Furman
Department of Entomology and Parasitology

The research program in entomology and parasitology was initiated at Berkeley over 75 years ago. Because of a favorable combination of academic climate, population increase, and relevance of insects to agriculture and health, the department flourished. By various analyses and reports it has been rated since World War II one of the "distinguished" departments in the University.

Having achieved this stature is not enough. The position of the Department of Entomology and Parasitology, like other distinguished departments on the Berkeley campus, must be maintained and improved by emphasizing significant areas and by filling openings as they occur with the best possible scientists and teachers. In recent years the Department at Berkeley has devoted increasing attention to the significant area of insect vectors and related arthropods affecting the health of man and animals, both from the standpoint of strengthening the research program as well as from the standpoint of recruiting top scientists and teachers. It is our goal to develop a balanced teaching and research unit that covers the full spectrum of parasitology.

At the meeting of the California Mosquito Control Association held two years ago, Dr. Ray Smith discussed the research activities of the Department of Entomology and Parasitology. Thus it seems appropriate to limit my remarks today to some of the developments since that time.

Insect Toxicology and Physiology

As many of you know our world renowned insect toxicologist, Dr. William Hoskins, joined the emeritus ranks this last year, leaving a serious gap in our active staff. We have been most fortunate however in that another internationally respected insect toxicologist, Dr. John Casida, formerly Professor of Insect Toxicology at the University of Wisconsin, has joined the Berkeley staff as his replacement. Dr. Casida comes to us with an active research program. Included in his current work are studies on metabolism of DDT, dieldrin and a variety of carbamates in relation to resistance. Most of this work is being conducted on houseflies; some utilizes mosquitoes. His plans for future work include studies on the general toxicology of newer insecticides of interest in mosquito abatement. He also will be working on the mode of action of synergists such as carbamates and pyrethroids. If any of you encounter any abnormal responses (such as decreased hatchability of eggs, or decreased longevity) in mosquitoes which seem to be associated with natural products, such as plant juices, Dr. Casida would appreciate hearing from you.

Dieldrin Metabolism in Mosquitoes. — Other continuing research activities in insect toxicology and physiology at Berkeley recently have produced results basic to the development of more effective mosquito control measures. Until recently it was believed that dieldrin was not metabolized by mosquitoes. This has been disproved by Oonithan and Miskus (J. Econ. Entomol. In press) working with radioactive (C^{14}) dieldrin and dieldrin resistant female adult *Culex quinquefasciatus*. Metabolism of dieldrin in mosquitoes is very slow however, compared to that in house flies. Using paper chromatographic techniques to resolve dieldrin and metabolite, it has been found that the metabolite is excreted without storage in the body. Work on the nature of the metabolite is continuing.

Genetic Nature of Resistance to Dieldrin in Mosquitoes. — Susceptible and resistant strains of *C. quinquefasciatus* mosquitoes were established by discriminating concentrations of dieldrin in the fourth larval instar. By crossbreeding, hybrids of intermediate susceptibility were obtained. By repeated crossbreeding and elimination of susceptibles it was shown that resistance to dieldrin is controlled by a single inheritable factor which is neither fully recessive nor dominant in the hybrid genotype. Cross resistance was shown to lindane but not to malathion nor to any of three carbamates. (J. T. Pennell and W. M. Hoskins. Bull. W.H.O. In press.)

Similar work with adult females of *C. quinquefasciatus* produced results in line with those from larvae. Data were obtained supporting the hypotheses that neither rate of pickup of dieldrin nor metabolism of dieldrin is the controlling process in dieldrin resistance.

Detection of Micro Amounts of Insecticide Picked up by Mosquitoes. — The WHO adult mosquito test method was specifically devised to detect physiological resistance to insecticides. If physiological resistance is to be correctly diagnosed, it is necessary to know that the amount of insecticide entering the insect is a known function of the dosage and exposure time. Using adults of a *C. quinquefasciatus* strain homozygous for resistance to dieldrin, experiments have been conducted using electron capture detection with gas chromatography. Results suggest that the pickup of insecticide by mosquitoes resting on treated paper varies directly with the concentration on the paper as well as with duration of exposure (Pennell, Miskus and Craig. Bull. W.H.O. In press.)

With reference to WHO test kits it is of interest to note that Dr. Mauro Martignoni of our Division of Invertebrate Pathology is collaborating with the WHO in designing a new type of field kit, with quite a different immediate objective in mind from that sought with insecticide resistance test kits. The goal is to develop a pocket sized unit enabling small initial batches of any conceivable parasites and pathogens of vectors to be preserved for dispatch and diagnosis.

Tolerance to Organic Phosphates. — As part of a general study of differences in proteins and enzymes in susceptible and resistant strains of flies and mosquitoes, experiments have been conducted to determine electrophoretic properties of esterases (cholinesterases, aliphatic esterases, aromatic esterases). The results lend support to the theory that resistance to organic phosphate insecticides such as malathion is related to higher phosphatase activity (Menzel, Craig and Hoskins. 1963. J. Insect Physiol. 9:479-493). The adenosine triphospatase level in resistant flies is positively correlated with the level of resistance.

Systemic Acaricides for Control of Ectoparasites. — For many years entomologists have been intrigued with the idea of controlling arthropod parasites, or their biting by means of feeding chemicals to their intended hosts, either as pills or as feed additives. Most of the attempts have failed, but in recent years there have been notable successes, as for example the control of cattle grubs through use of systemic insecticides. We have been working along this line with poultry and their mite parasites. The most recent work indicates that a material which has been used by poultrymen for several years to suppress or control some common poultry diseases will also control infestation of the northern fowl mite, *Ornithonyssus sylviarum.* The drug, sulfaquinoxaline, has been found to be effective when added to the feed at a level of 0.033% and fed to the birds on a continuing basis over a 5-week period (D. P. Furman and V. S. Stratton. 1963. J. Econ. Entomol. 56:904-5). Work is continuing on ramifications of this problem.

Systematics of Arthropods of Medical and Veterinary Importance

In 1963 a new staff member, Dr. James Oliver, joined the Berkeley Department. Dr. Oliver is an acarologist with particular research interests in cytogenetics. He is studying the chromosomal picture in ticks, a field of great significance to us in its potential for clearing up problems of species complexes. For example, recently a Russian worker presented convincing evidence that the tick called *Argas reflexus,* actually consists of 3 distinct species. This approach may help to explain some of the behavioral and varying pathogen-vector potentials of different strains, or populations of a tick "species." Dr. Oliver also plans to continue hybridization studies of closely related species of ticks along the lines of work he has started with *D. andersoni* and *D. variabilis.* He would be happy to receive living specimens of any of our California ticks for these studies.

Many of you are aware that Dr. Usinger has been conducting similar studies with bedbugs, as reported two years ago here by Ray Smith. This work is continuing to clarify additional problems of speciation in the Cimicidae. Other active systematic research includes Reduviidae (Usinger and Wygodzinsky), parasitic mites (D. P. Furman and F. J. Radovsky) rhagionids, simuliids, and *Phlebotomus* (J. A. Anderson, M. Pastermack, B. Chaniotis).

Pathogen-Vector Studies

A long unexplained mystery in California is how an eyeworm, *Thelazia californiensis,* commonly found in deer, manages to get from host to host. The parasite occurs also in dogs, sheep, rabbits and a variety of other mammals, including man. At present we have an active research program investigating the possibilities of transmission by various kinds of biting and non-biting flies (D. P. Furman, C. J. Weinmann, J. R. Anderson and W. M. Longhurst). We are now able to maintain the parasite for periods up to several months in the laboratory. With reasonable luck we hope to have the answer to the problem of transmission within the near future.

Other studies include transmission of blood parasites of game birds and mammals by blood-sucking arthropods; developmental patterns of tapeworm larvae in fleas (Siphonaptera); and carrion feeding arthropods as transport hosts for *Trichinella spiralis,* the causal agent of trichinosis in man.

Ecology, Behavior and Control of Arthropods of Medical and Veterinary Importance

Richard Garcia has recently completed a major research project on the ecology of the pajaroello tick, *Ornithodoros coriaceus,* widely known as the most venomous tick in California. One of the most intriguing aspects of his work lies in the demonstration for the first time that carbon dioxide not only causes immediate activation of ticks but that it serves as an effective attractant for some species (R. Garcia. 1962. Ann. Entomol. Soc. Am. 55:605). Garcia made effective use of this development in collecting large numbers of ticks in the field. While most of the ticks collected were the pajaroello, other ticks were attracted as well.

Paul Catts (1963 Ph.D. thesis) has completed a thorough investigation of the biology of a rodent bot fly (Cuterebridae). This represents the most thorough investigation of biology in this group of parasitic flies ever made. We have already put to use some leads which the *Cuterebra* study gave us in working out the habits of related forms, cattle grubs which cause great economic loss to the livestock industry. Catts found that males of rodent bots have definite aggregation sites where they set up jealously guarded territories and wait for female flies. Similarly it appears that adult males of common cattle grubs, *Hypoderma lineatum*, have definite aggregation sites. It is conceivable that treatment of limited aggregation sites in the spring of the year could reduce effectively the cattle grub population for the following year (Catts, Garcia and Poorbaugh. MS.).

A major project is underway on the hosts and feeding habits of bloodsucking Diptera (J. R. Anderson and J. B. Hoy). With all the work which has been done on mosquitoes to date it is amazing how little is known about the host-range and feeding behavior of most blood-sucking flies. Even for most mosquitoes relatively little is known of host range beyond that of man and some of his domesticated animals. These studies are being conducted by trapping engorged flies from experimentally exposed mammalian and avian hosts as well as by identifying, through precipitin tests, the blood meal sources of wild caught flies. In preliminary work with experimentally exposed deer in northern California there have been taken three species of mosquitoes (Culicidae), three species of biting midges (Ceratopogonidae), two species of horse flies (Tabanidae), two species of snipe flies (Rhagionidae), and the stable fly (*Stomoxys calcitrans*). The significance of this type of work is apparent in assessing the potential role of blood-sucking flies as vectors of disease agents.

John Anderson will report later on his work on the ethology, ecology, and control of filth flies. In addition to that work he is involved in studies on the overwintering of the little house fly, *Fannia canicularis*, and on the ovipositional stimuli affecting it.

In this same general area falls a complex ecological study of the faunal succession and population dynamics of Diptera inhabiting and associated with undisturbed cattle droppings. The role of this type of breeding medium as a fly production source will be studied with particular attention to the factors such as intra and inter-specific competition which may affect populations.

In conclusion I should mention a very basic research area which has been underway for about three years. This has to do with the factors governing external parasite poulations on hosts such as mammals and birds. Carl Mohr and Al Stumpf have already demonstrated a definite relationship between size and shape of the home range of certain rodents and their populations of ectoparasites. They have also demonstrated a basic linear rather than circular characteristic of most home ranges of host rodents. While they still have a long way to go, their ultimate goal is to gather enough data so that they can develop an arithmetic statement of the various host factors and spacing which influence the incidence and intensity of infestation.

MOSQUITO AND RELATED ARTHROPOD CONTROL ACTIVITIES–UNIVERSITY OF CALIFORNIA, DAVIS

R. M. BOHART, *Department of Entomology*

In a survey of the calendar year's activities, I am always surprised to find that we have so many people at University of California, Davis, who are doing research in the area of today's subject. In mosquito investigations alone, we can claim 14 or 15 individuals who have made significant studies on problems in which they are especially interested. This does not include a number of others who performed mainly as assistants.

In order to give a picture of our activities, I will go through the list briefly. First, with respect to flies, the work is being carried on by Ed Loomis and Vern Burton of Agricultural Extension and Sam Hart of Agricultural Engineering. Dr. Loomis will be discussing the fly problem later in the program. Secondly, Norm Akesson is heading the work on mosquito control equipment. Professor Akesson, of the Agricultural Engineering Department, also will speak later.

This brings us more particularly to the subject of mosquitoes. Stan Bailey will report on the mosquito flight range study in the Sacramento Valley. Dr. Bailey has shifted his interests slightly, although they are still in the realm of ecology. He is making an intensive study of the seasonal movements of *Anopheles freeborni*. Much scattered information is available from previous workers but Bailey is trying to assemble a more complete picture. He has been able to follow the mass movement into the hills on either side of the Valley, but especially the west side, and then has observed local movement by marked mosquitoes. The mass movement starts in September and is largely complete by the first of December. Local movement takes place whenever temperatures rise into the range of 57°-59° F.

Charles Judson has been continuing his work on the hatching of mosquito eggs since his transfer from the State Department of Public Health to Entomology at Davis. Dr. Judson has been able to prove that the hatching response is not purely a mechanical one and has shown the involvement of the nervous system of the embryo in a specific area of the egg. He has been manipulating hatching by inducing it with carbon monoxide and this opens up intriguing avenues of further study. Tests are being made also with dichlorvos and its toxic action on eggs in the laboratory and under field conditions.

Andy McClelland is a recent addition to our staff from England by way of Indiana, where he worked at Notre Dame. Dr. McClelland's particular interests are the inter-relationships of mosquito ecology and genetics. He has a number of publications to his credit in this field already and we are expecting great things of him.

Dr. Michele Lavoipierre of the Hooper Foundation left Davis this past summer and is now doing research on mosquitoes in Singapore. We hope he will resume his work here in a year or so. While at Davis, he investigated the feeding mechanisms of mosquitoes in relation to the transmission of filariasis of dogs. Dr. Lavoipierre was also a constant source of encouragement to our graduate students.

A new development on the campus is the Primate Center. Dr. Richard Rossan is in charge of the studies on transmission of monkey malaria and he has a functioning colony of *Anopheles freeborni* already.

Bob Washino of the Bureau of Vector Control has been concentrating on rice fields with respect to their role as mosquito producers. Much has been done in the past by a succession of investigators and Bob has attempted to draw all of the past findings together and add some of his own to give us a more meaningful picture of the rice field habitat. Under investigation are such factors as water temperature, dissolved oxygen, concentration of chlorophyll in plankton, diatoms, conchostracods, snails, distribution of various species of algae, and predators of all kinds. The seasonal pattern of mosquitoes in the rice fields is being followed closely and this work will complement that of Dr. Bailey and his co-workers.

Also assigned to Davis by the Bureau of Vector Control is Yosh Hokama who has been assisting Dr. Judson in his egg hatching studies on a cooperative basis.

Another man who has worked in this area of factors controlling embryonic development is Ali-Navvab, a graduate student under Dr. Judson's direction.

Fred Iltis is a graduate student under my supervision who is now well along with his study of the relationships of *Culex pipiens* and *quinquefasciatus* on the Pacific Coast. Interesting sidelines of this project have been the discovery of two naturally occurring mutations, one a red-eyed form and the other a male with deformed palpi which has been previously known in the literature from radiation experiments.

Chet Moore is working toward his Ph.D. on an ecological problem involving *Culex tarsalis*. During the year, he published a paper on the seasonal variation in autogeny in *Culex tarsalis*. He found that the incidence of autogeny as well as the size of the egg rafts, was greatest in May and June. The degree of autogeny and number of eggs laid autogenously reached a low level in September and October. Also being studied is the succession of species in field ponds in relation to pollution, temperature, and autogeny.

One of the most intriguing studies being carried out by graduate students is the question of solid-sugar feeding by mosquitoes. Don Eliason under the supervision of Dr. Bailey has been illuminating this problem and has published a paper on the subject. Several researchers in different parts of the world have already taken advantage of his discoveries to further their own studies. Briefly, he has found that mosquitoes of both sexes and many different species produce saliva and dissolve dry soluble materials much as house flies are able to do. This puts the habits of mosquitoes into an entirely different light and forces us to change our old ideas that male mosquitoes subsist on nectar from flowers and females must seek blood. Certainly, dried-up honeydew and other sugary residues must now be considered important sources of nourishment for mosquitoes. Aside from this, we now have a new tool for studying mosquitoes in the laboratory, their longevity, food requirements, and the use of baits.

Another development in Veterinary Science has been the work of Al DaMassa, a graduate student with Dr. J. R. Douglas. He is planning to continue with mosquito studies after having completed his Master's degree last June. In his thesis he demonstrated that *Culex tarsalis* could be, and likely is at times, an important vector of fowl pox in poultry.

Buzz Hoffman has been taking a Master's degree with Dr. Bailey and has completed a thorough seasonal study of the mosquitoes of Yolo County. He is now beginning an ecological-distributional investigation on the various species of California *Anopheles*.

A relative newcomer to the ranks of medical ecology is Dave Baerg. He has had experience in the flight range study and will pursue some mosquito problem when he becomes a graduate student this spring.

As for my own mosquito work, it has been practically at a standstill during the past year. In collaboration with Bob Washino, I have now started a revision of the Freeborn and Bohart bulletin on *Mosquitoes of California*. It is our intention to do it over completely, bring it up-to-date and make it more useful in every way.

In conclusion, I can say that mosquito and related arthropod activities are definitely on the increase at the University of California at Davis.

THE BEHAVIOR AND ECOLOGY OF VARIOUS FLIES ASSOCIATED WITH POULTRY RANCHES IN NORTHERN CALIFORNIA

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The poultry ranch habitat is an artificially created part of our environment and one of its most important components (from the viewpoint of one concerned with flies) is the presence of accumulated chicken droppings, without which virtually the entire arthropod fauna associated with a ranch would be deprived of a place to feed, grow and develop. In addition to the fly larvae which develop in this medium, we also find such other invertebrate animals as nematodes and other worms, centipedes, millipedes, pseudoscorpions, mites, spiders, earwigs, beetles, moths, predaceous and parasitic wasps, and a host of other organisms. Some prominent vertebrates are mice, rats, and wild birds.

On a typical poultry ranch in northern California one could expect to find representatives of some 15 to 20 families of flies, and at any given time from May through October we might find 30 to 50 species of flies.

Recent studies on the behavior and ecology of flies (Anderson and Poorbaugh 1964) have been concerned with where different fly species and associated insects are found about the ranches during the day as opposed to their noctural distribution, and what the flies are doing at various sites (e.g., mating, feeding or ovipositing). Primary emphasis has been given to the house fly, *Musca domestica* L., the little house fly, *Fannia canicularis* (L.), and certain of their natural enemies because these flies are most commonly involved in nuisance complaints.

Methods of Study

All studies were carried out in Sonoma County on 6,000 to 8,000 bird ranches of the suspended cage type laying operation (fig. 1). Since the problem of estimating numbers is basic for most field work in ecology, three different methods of sampling were used (visual counts, sticky fly-tape, and vacuum machine catches) as means of double and triple checking population fluctuations.

Figure 1. Vacuum sampling machine in use between rows of caged hens.

A D-Vac[1] back-pack vacuum sampling machine (figs. 1, 2) with a collecting orifice of one-half square foot was used to capture flies from the following sites about the ranches: (1) over the accumulated droppings under stretch wire cages, (2) down the aisles between rows of cages, (3) in vegetation between houses and adjacent to the two outermost houses, (4) in vegetation under and surrounding trees and shrubs near poultry houses, and (5) from the branches of trees and shrubs within about 20 to 100 feet from the poultry houses.

Daylight collections were obtained between 11:00 a.m. and 5:00 p.m., and nocturnal collections were made between 10:00 p.m. and midnight (P.s.t.).

Figure 2. Collecting flies from shrubs and trees near chicken houses.

Sticky fly-tapes[2] were hung indoors near the ceilings of the poultry houses and outdoors in nearby trees and shrubs. Visual fly counts (per unit area of ceiling, etc., or per Scudder grill) were made at the areas within the poultry houses at which flies congregated, but which could not be sampled by using the vacuum machine because of various physical restrictions in the architectural designs of the buildings.

The Behavior and Dispersal of Various Species About the Ranches

The different methods of sampling usually showed similar changes in the population fluctuations of *F. canicularis* and *M. domestica*, but weekly changes in magnitudes detected by the different sampling methods often varied considerably from one method to another. The advantages and disadvantages of the different methods of sampling have been discussed by Anderson and Poorbaugh (1964).

In counts and observations confined to *F. canicularis*, *M. domestica*, and six other large, easily recognized flies, it was found that fly populations of these species were widely dispersed about the ranch premises during the day. At night, however, in striking contrast to the flies' widespread diurnal dispersion, the "outdoor" aggregations of all except one species were found predominantly in the branches of trees and shrubs.

Ninety-eight and 97% of the *F. canicularis* and *M. domestica* captured in the "outdoor" noctural vacuum collections were obtained from the branches of trees and shrubs, whereas night visual counts within the houses showed that almost the entire "indoor" population rested on or near the ceiling. The flies remained at these nocturnal resting sites for 12 to 16 hours. At no other time in a 24-hour period were such large segment of these populations aggregated at only two principal sites.

[1] D-Vac Co., 1462 Callens Rd., Ventura, Calif.

[2] Aeroxon Products Inc., 9 East 38 Street, N. Y. 16, N. Y.

Subsequent quantitative sticky tape samples obtained within houses versus those hung outside in nearby trees and shrubs showed that 85% of the *F. canicularis* and *M. domestica* were caught within houses. Conversely, however, more than 90% of the *Ophyra leucostoma* Wied. and certain ichneumonid wasp parasites were captured outdoors on the "tree tapes" (Anderson and Poorbaugh 1964). *O. leucostoma* is commonly known as the black garbage fly and its developing larvae are predaceous on those of other fly larvae in the droppings.

It is felt that the sticky tape data (85% of the *F. canicularis* and *M. domestica* caught indoors and 90% of certain parasites and predators caught outdoors in trees and shrubs) constitute good criteria for estimating where the total ranch populations of these insects are congregated at night. However, until we find a way to account for every fly on a ranch we will never know precisely how representative our samples are of the absolute ranch populations. Nevertheless, the marked difference in the nocturnal dispersion of *F. canicularis* and *M. domestica* and some of their insect enemies, suggests one potential means of initiating more effective fly control programs through more selective application of insecticides designed to keep the mortality of certain natural enemies at a minimum. Insecticides applied to trees and shrubs adjacent to poultry houses in the previously cited study area probably kill no more than 10% (or less) of the total ranch populations of these two principal nuisance flies, and, in fact, may instead be destroying most of the total populations of certain beneficial biological control agents.

In studying the dispersion and density of flies within and outside the houses during the day it was found that *F. canicularis* was predominantly an "indoor" species which, except for early spring and late fall, avoided areas directly exposed to sunlight. *M. domestica* and the other species studied were more active outside in sun-exposed areas. In enclosed houses, swarms of *F. canicularis* males were most dense at the ends of the houses, the areas of greatest light intensity. In the more open type of houses, where there was little difference in the light intensity throughout, *F. canicularis* males were uniformly dispersed throughout.

In laboratory experiments Nieschulz (1935) has shown that *F. canicularis* becomes active and reaches its maximum activity threshold at lower temperatures than *M. domestica*, and Parker (1962) found that in a tropical environment the onset of *M. domestica* activity in the morning was delayed by low minimum temperatures, and that the activity of females ". . . almost always started later in the morning than that of the males, and rose fairly gradually to a high level, the maximum reading being obtained during the afternoon." Recent field studies indicate similar temperature influenced activity patterns of these species on northern California poultry ranches (Anderson and Poorbaugh 1964). Here, *M. domestica* adults were not generally very active until about 11:00 a.m. or noon, and both sticky tape and vacuum catches showed that the largest aggregations of individuals occurred on the south and west sides of the ranches. The house flies tended to "follow the sun" and remained most active in the sun-exposed areas. They also occurred in the vegetation between houses in numbers equal or greater than on the droppings.

During the past year studies were made on the diurnal activity of flies and some of their parasites on the droppings by making vacuum collections over the surface of the droppings at half-hour intervals from early morning to dusk. On different days either one or two major peaks in fly activity were found, and these activity peaks appeared strongly influenced by temperature. On warm days (78°F. by 11:00 a.m.) there was a small peak of activity around noon to 1:00 p.m. and a major peak from about 4:00 to 6:00 p.m. On cold days (less than 65°F. by 11:00 a.m.) there was a single well defined peak of activity between about 1:00 and 4:00 p.m., but regardless of whether a day was warm or cold, the greatest fly activity on the droppings occurred from early- to mid-afternoon. Various wasp parasites of the flies, on the other hand, were caught in equal or greater numbers during the morning than in the afternoon. As some ranchers flame the droppings as a method of fly control, it appears that they could obtain a maximum kill of flies and a minimum kill of the beneficial parasitic wasps by flaming around 4:00 to 5:00 p.m. However, as we do not yet know what adverse effects flaming the droppings might have on the many other natural enemies of flies which live in the manure, this method of control might conceivably be as disadvantageous to the natural enemies of flies as spraying the droppings with an insecticide. By dissecting and examining the ovaries and diverticulae of the flies caught over droppings I have been able to determine whether the females had come to the droppings to oviposit or feed or both. It was interesting to find that most *F. canicularis* and *M. domestica* fed shortly before settling down for the night; perhaps this explains (in part) why such large segments of these populations are found resting within houses at night as opposed to surrounding grasses and trees.

Another interesting fly associated with poultry ranches is the stable fly, *Stomoxys calcitrans* (L.). As many as 50 ovipositing females per 1,000 square feet of dropping surface have been collected in vacuum samples taken over accumulated manure (Anderson and Poorbaugh 1964). On the basis of total dropping surface area on a 6,000 to 8,000 bird ranch, this figure indicates that there were approximately 300 to 400 females ovipositing during the few minutes in which a sample was obtained. If this level of activity is typical for only a few hours during the afternoon, then stable flies are indeed numerous on northern California poultry ranches. Although other workers (Mitzmain 1913, Bos 1934) have experimentally fed stable flies on chickens in the laboratory and Bishopp (1913) reported they had been seen feeding on the combs of chickens under field conditions, we have not seem them feeding on chickens in California. Precipitin tests[3] on six engorged flies caught on one poultry ranch in November revealed that all these flies had fed on Bovidae, the nearest bovids being cattle pastured one-half to one mile from the ranch. At the moment, it appears as if poultry ranches serve as a source of stable flies which disperse in search of

[3] These blood meal analyses were made by Dr. C. H. Tempelis and Miss M. F. Lofy, School of Public Health, University of California, Berkeley.

hosts other than chickens, and then later appear on poultry ranches where the females subsequently oviposit.

Natural Enemies of Flies

One aspect of the studies on some of the interrelationships between flies and their natural enemies has been the recovery and identification of several species of parasitic wasps from both *F. canicularis* and *M. domestica.* The differential night resting behavior of these flies and certain of their wasp parasites has been discussed previously. Other wasp parasites have been recovered from 5 other fly species.

Still other natural enemies of flies, which occur in the droppings, are the European earwig, *Forficula auricularia* L., a species of staphylinid beetle, and the mites *Macrocheles muscadomesticae* (Scopoli) and an unidentified species of the genus *Fuscuropoda* Vitzthum. Under laboratory conditions all of these arthropods fed on either the eggs or both the eggs and first instar larvae of *M. domestica, F. canicularis,* and the false stable fly, *Muscina stabulans* Fall. Some natural enemies which feed on the adults of many fly species are spiders (the jumping species which occur on the droppings and the web spinners found near the cealings) and birds. The western kingbird, western flycatcher, cliff swallow and barn swallow were all observed "hawking" flies on the ranches whereas Brewer and red-winged blackbirds, house sparrows, mockingbirds, and white-crowned sparrows were seen feeding on fly larvae. Flies killed by the fungus, *Entomophthora muscae* (Cohn), were found on all ranches.

To date our most extensive study on natural enemies has been on the effects of the predaceous larvae of *O. leucostoma* on the larvae of the house fly, the little house fly, and the false stable fly. Under different laboratory conditions individual *Ophyra* larvae have killed as many as 20 *M. domestica,* 10 *M. stabulans,* and 2 *F. canicularis* larvae per day during four and five day observation periods.

Although *Ophyra* larvae can develop as rapidly in media containing no prey larvae as when they feed on other fly larvae, they have always attacked and fed on other fly larvae whenever prey larvae were present (fig. 3). When contained with a superfluous number of prey they always killed many more per day than they could possibly eat. The beneficial result of this behavior is that the superfluous prey larvae killed by *Ophyra* are eaten by the remaining living prey species. House fly larvae, for example, in preference to other food in their developmental medium, are rapidly attracted to and devour members of their own kind which have been killed and left by *Ophyra* larvae. As no larval cadavers remain when the *Ophyra* are ready to feed again, they kill and feed on the remaining living prey larvae.

Observational evidence indicates that *O. leucostoma* kills its prey by injecting a toxin into the body cavity, and it appears that the speed with which the attacked prey dies depends on the amount of toxin injected. This is one aspect of these studies still being investigated. In any event, the injected toxin soon paralyzes the prey and causes its body fluids to liquefy so that the attacked larva becomes flaccid.

Figure 3. Larva of *Ophyra leucostoma* feeding on larva of *Musca domestica.*

The impact of the various individual natural enemies of flies will be difficult to evaluate under natural field conditions, but I feel we should continue to investigate and consider methods of sparing maximum numbers of them to aid in our overall fly control programs. Before spraying the droppings with an insecticide then, we should recall that certain natural enemies such as the parasitic wasps and predaceous spiders and mites spend as much or more time on the droppings than the flies. Unlike fly larvae, many of the beneficial arthropods associated with manure are surface dwellers and are therefore more exposed to the insecticides than are the developing maggots.

Prospects for Nuisance Fly Control

The ultimate and obvious means to eliminate fly production on poultry ranches is to dispose of the manure before the flies have access to it, to render it unattractive to ovipositing females, or to prevent larval development after the flies have laid their eggs. However, until this can be done practically and economically further studies on the behavior and ecology of the poultry ranch fauna should produce even further leads as to how we might more effectively control nuisance flies.

In northern California, female house flies and little house flies must survive for approximately 5 to 10 danger-fraught days before they are ready to lay their first batch of eggs. We need, therefore, (through further studies on the behavior and ecology of the poultry ranch fauna) to determine more precisely those parasite- and predator-free sites in which these females flies spend their time. By selectively applying insecticides to only the above sites it may prove possible (with smaller quantities of insecticide) to kill maximum numbers of flies but minimum numbers of natural enemies, and thereby benefit from an integrated program of chemical and biological control.

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AGRICULTURAL SANITATION AND THE DOMESTIC FLY PROBLEM

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The fundamentals of fly control were presented by Dr. John A. Rowe (1948) of the U.S. Public Health Service at your 16th Annual Conference. At this early date, Dr. Rowe indicated the complexity of a fly control program and stressed three points worth repeating: (1) education, (2) preventative measures, and (3) success of a program being dependent on the desire of the pople to have a program. It was not until 1956 that the subject of domestic flies was again presented before your Association. At that time, everyone was eager to hear of the comparative success of fly control programs as conducted by a mosquito abatement district and by a county health department. For the past four years the California Mosquito Control Association has scheduled presentations on various aspects of arthropod control aside from the main topics of mosquitoes and gnats. The subjects of fly control and agricultural waste disposal were included on three of the past four programs.

Presented with this background information, it appeared advisable to review at least some of Dr. Rowe's fundamentals in action. The title, as read, describes the role of agriculture in the community-wide problem of WASTES — wastes of living, and wastes of making a living.

Our particular aspect of sanitation is concerned with the wastes of agricultural production in both rural and urban areas. For this reason, the Agricultural Extension Service has established a broad goal of sanitation as a permanent horizontal-line activity within county programs. Particular emphasis has been placed on those regions where rural-urban pressures and conflicts have grown in proportion to rapid increases in population, and in relation to changing agricultural methods which are necessary to maintain high levels of animal and crop production. At the present time our activities are concerned with the fly, dust, and odor problems which are associated with poultry, cattle feedlot, and dairy industries. Many of these agricultural groups have recognized their responsibility to the community as well as to themselves, and are beginning to appreciate that certain things can be done. There are increasing numbers of farmers living far from urban developments, who realize that they can enjoy an environment which is relatively free from flies, dusts, and odors.

The Agricultural Sanitation Program is divided into three main activities: education, cooperation, and demonstration — all of which are supported by basic research conducted in the Experiment Stations and by field investigations at the county level. Program elements are not the sole responsibility of any one group but are the joint responsibility of interrelated specialists representing agronomy, animal and poultry sciences, economics, entomology, engineering, range improvement, and soils.

Educational activities are concerned with in-service training of staff members, particularly those at the county level. Our poultry farm advisors already have been exposed to training sessions in the sanitation program. Extension of this training is then carried over to meetings with producers and growers, field servicemen, and with personnel from closely related governmental agencies, industries, and commerce. Equally important are the publications produced for statewide and county use. New publications are beginning to appear in the recently titled series, *Agricultural Sanitation*. The first in this series is *Poultry Manure Management* by Robert Curley and William Fairbank (1963); other manuscripts on *Poultry House Construction* and *Dead Bird Disposal* are in press. The revised format of *Fly Control on Dairies* has now stressed the importance of manure sanitation. Other publications, *Fly Control on Poultry Ranches* and *Dust, Odor, and Fly Control on Cattle Feedlots* will include sections on ranch sanitation. Newsletters from specialists and county farm advisors form another important link in education and communications. Nearly all publications of this type contain brief articles on various aspects of agricultural sanitation. For example, Fairbank (1963) has included in the *Engineer's Reports* a discussion on the mechanics of "Poultry Manure Disposal Lagoons." Of interest to mosquito abatement workers is the paragraph dealing with "loading rates" and the relationship to natural mosquito control. Likewise, the paragraph on levee construction includes in the recommendations an eight foot roadway which is necessary for inspection and maintenance. A much needed county publication by William Martin, et al. (1962) on *Facts About Chicken Manure as a Fertilizer* had led to a better understanding of crop use and timing of application, as well as some insight on why the supply may exceed the demand.

If the nuisances derived from wastes are a problem of community dimensions, then they are of interest and concern to agencies other than the University of California. Good interagency relationships, supported by good community attitudes, are necessary to achieve cooperation. Closer working relationships have developed between the University and the State Department of Public Health, and in some instances between these agencies and individuals representing county health departments and mosquito abatement districts. Of particular interest, are the studies conducted by the Imperial County Health Department, the State Department of Public Health, and the Agricultural Extension Service on dust and fly production from cattle feedlots.

The two-year litigation by the City of Pomona and two cattle feedlot operators in Los Angeles County was finally dismissed with the district attorney accepting a six-point odor control program jointly offered by the University of California, the Calfironia Cattle Feeders' Association, the State Department of Public Health, and other interrelated agencies.

On the subject of cooperative activities in southern California, the Orange County Health Department has received a federal grant through the State Department of Public Health for conducting a research project on flies associated with poultry ranches. The research director of this project is assisted by an advisory committee representative of the County Health Department, the State Department of Public Health, the United States Public Health Service, the Berkeley-Davis-Riverside Campuses of the University of California, and the Orange County Agricultural Extension Office. The project has been so outlined that it is complementary to research conducted by the University of California and other agencies.

In other regions of the state, there has been greater participation on basic program planning in Fly Control Advisory Committee meetings. Personnel from the University of California, county health departments, the State Department of Public Health, and local mosquito abatement districts are lending technical assistance to representatives from industry, commerce, agriculture, and civic groups. This form of cooperation is basic to the solution of the problems whether they are immediate or long-term, localized or community-wide.

The problems of fly breeding, dusts, and odors involve a relationship of great complexity. Since no two ranches are alike and since successful methods of control and abatement are often dependent upon local economics, demonstrations and field investigations must be repeated in nearly all regions.

What does it cost a poultryman to engage in an agricultural sanitation program involving manure management and fly control? The average cost of 7.4 cents per bird year on poultry ranches was determined from a study of 10 ranches in four northern California counties in 1962. Expenditures included in the study were labor, equipment, and materials. This study was continued in 1963 and preliminary results indicated an average cost slightly higher than the 1962 expenditure. These results are interesting since insecticides were not used in the 1963 study. Data on weekly manure cleanout costs from other regions in California were obtained from 25 ranches representing 8 different types of poultry housing. Expenditures for labor alone averaged 7.5 cents per bird year (range: 2 to 24 cents). Differences of house design did not greatly influence the average cost. Mechanization, however, appeared to influence the cost as shown by average expenditures of 4.2 cents per bird year for the 10 ranches completely mechanized, compared with 11.6 cents per bird year for the 7 ranches using shovels and wheelbarrows.

Second year results from space trials on cattle feedlots in Tulare County have shown that 75 square feet per head may be optimum for dust control in that area. Minimum fly production resulted in pens where animals were crowded below 100 square feet per head. These results are supported, in part, by observations made in Imperial County where a few feedlots practice animal crowding methods. Odor problems in these latter feedlots were encountered at maximum spacing of 90 square feet per head, and fly production was as great as on lots where animal crowding was not practiced. The costs of satisfactory dust and odor control for cattle feedlots range from 75 cents to $1.50 per head. The capital investment usually includes the construction of an overhead sprinkler system in each corral through which a deodorant chemical can be applied with the water.

Other mechanical and physical methods for fly control have been successfully demonstrated on dairies and poultry ranches. Second year results from investigations by the Delta Mosquito Abatement District show that harrowing manure at the rear of the cement feeding platform for dairy cows may reduce fly breeding. Whether or not this technique will be economically feasible for other dairies and whether or not insecticide applications can be reduced on these dairies remains to be determined.

Screening poultry houses has been a question of economics, but poultry health and egg production may be even more important considerations. Weekly inspections of a completely screened 70,000 layer house in Ventura County showed that fly control and problems of manure management were greatly minimized. Odors, however, proved a nuisance to workers despite late season construction of an overhead exhaust-fan system. This study will continue on the problem of odor control. Fringe benefits from screening out wild birds included reduction of feed loss and prevention of northern fowl mite infestations.

In addition to the efforts placed on manure removal and disposal, there have been a number of demonstrations conducted on manure use. Numerous trials using poultry and steer manure on crop and rangelands were continued or started in several counties in 1963. More promising were the results from first year rangeland studies using poultry fertilizer in San Diego County, second year data from rangeland studies with poultry manure in San Luis Obispo County, and first year cotton yield studies with steer fertilizer in Imperial County. Collaborative studies for this type by research staff and Agricultural Extension personnel have helped stimulate manure cooperatives as well as individual livestock and poultry operators to process their animal wastes into suitable form for field application and fertilizer use.

The demonstrations and field investigations already outlined are only a few of the many studies underway. The examples given were selected to show the diversity of work projects involved with the coordination of an agricultural sanitation program. In over-all effort, the University of California has gone far in deploying and adding resources for this program. Dr. John Anderson has already outlined project goals and some of the promising results from studies made on Sonoma County poultry ranches. Second year data from this research have already shown that insecticide applications should be revised according to new information on the habits of domestic flies. Here at Davis, Dr. Hart of the Department of Agricultural Engineering is concluding the third year of research on sanitary engineering applied to livestock manures. Several principles established by Dr. Hart have been placed in actual practice and techniques modified in the fields of manure handling equipment and the management of dry and liquid wastes to fit particular problems at a local level.

The Department of Entomology at Riverside has conducted field work in close cooperation with the Extension staff in many counties. Research staff have made numerous studies on fly biology, particularly in the areas of insecticide resistance and biological control. Dr. Georghiou has outlined a project on the study of resistance to diazinon and other insecticides commonly used for fly control on poultry ranches. Dr. Hall has followed the role of *Bacillus thuringiensis* in poultry feed for successful fly control. In the latter case, more promising results have been obtained against the house fly and poor results against the little house fly. Some of the new approaches to insect control now under study may prove of value on work with chemosterilants and sex attractants.

It is very encouraging to see the progress made during the past few years. Of particular significance is the gradual change in attitudes and the growing evidence of rural-urban interest and cooperation in attacking the problems of flies, dusts, and odors. Since the problems outlined here are a result of California's rapidly growing population, they are bound to increase in magnitude. Completely satisfactory community waste management and a relatively fly-free environment can be attained only through greater resources devoted to research and development and to a more extensive program leading to better public education and cooperation.

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THIRD SESSION

TUESDAY, JANUARY 28, 9:00 A.M.

TECHNOLOGICAL DEVELOPMENTS

JOHN H. BRAWLEY, *Moderator*

BACILLUS SPHAERICUS NEIDE AS A PATHOGEN OF MOSQUITOES[1]

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SUMMARY

The possibility of using various bacteria in the biological control of mosquitoes was suggested over sixty years ago. This possible application of microbial insecticides, however, received relatively little attention prior to the widespread development of insecticide resistance and concern over problems of toxic residues. The successful development of *Bacillus thuringiensis* Berliner and *B. popilliae* Dutky for controlling certain agricultural pests has provided additional impetus for re-evaluating the possibilities of utilizing pathogenic microorganisms in mosquito control.

Most bacteria reportedly associated with mosquitoes are not pathogenic and apparently are of little value for the development of microbial culicides. The majority of such reports have concerned members of the Spirochaetaceae which are relatively common in the lumen of the gut and Malphigian tubules of larval and adult mosquitoes. Although spirochetes have been reported in dense concentrations in mosquitoes, they have not been observed to influence hosts adversely.

Recently there have been reported many observations on the gut flora of larval and adult mosquitoes, but generally such investigations have been primarily concerned with elucidating the normal bacterial flora associated with mosquitoes reared under laboratory conditions. There have been relatively few records of pathogenic bacteria in mosquitoes and, in general, these have been poorly documented. In our laboratory we have examined large numbers of mosquito larvae with bacterial infections; this report concerns one of these parasitic bacteria which has been identified as *Bacillus sphaericus* Neide.

B. sphaericus was isolated from moribund fourth-instar larvae of *Culiseta incidens* (Thomson) collected near Fresno. It is a gram-variable, aerobic spore-former which has proved highly pathogenic to several different species of mosquitoes in laboratory tests. The bacterium invades larvae via the alimentary canal and is capable of producing a fatal septicemia in seven days at a dose of about 500 ppm of dried spores. First detectable signs of infection, apparent loss of normal turgor and motility, occurred about 3-5 days after exposure to bacilli. As infections progressed, larvae became dark brown and frequently died remaining attached to the water surface. Tests were performed with larvae from laboratory colonies of *Culiseta inornata* (Williston), *C. particeps* (Adams), *Culex tarsalis* Coquillett, *C. pipiens* Linnaeus, *C. peus* Speiser, *C. erythrothorax* Dyar, *Aedes sierrensis* (Ludlow), and *A. aegypti* (Linnaeus). All species tested were susceptible to the bacterium.

It is hoped that improved cultural methods and selection will lead to increased levels of virulence which may make it economically feasible to use the bacterial insecticide in the field.

[1] A complete report will appear in the Journal of Insect Pathology.

RICE FIELD MOSQUITO ECOLOGY PROJECT PROGRESS REPORT, 1963[1]

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State Department of Public Health
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In an effort to develop alternative control methods which might be applicable to rice field habitats, studies on the ecology of rice field mosquitoes were resumed by the State Department of Public Health in the summer of 1963.

In the eight years since the last report was made on rice field mosquitoes at a CMCA meeting, rice acreages have remained high in California, with an estimated 326,000 acres under production in 1963. Due to the time elapsed since the last report, the activities through 1956 will be summarized as they relate to our current objectives and work plans.

Gerhardt (1961) presented a resume of studies on rice field mosquito ecology and discussed the activities through 1956 under the following topics: blue-green algae studies, *Gambusia* investigations, limnological studies, and investigation of predator-insecticide relationships. Current activities will be discussed under the first three topics.

Blue-green Algae Studies. – Purdy (1924) observed a rice field in Butte County that did not differ from other fields except that it had very few mosquitoes and, in addition, supported a heavy growth of *Tolypothrix*, a blue-green alga. After two years of study, he concluded that the lack of mosquito breeding was related to the presence of the blue-green alga.

[1] Cooperative Vector Studies, Bureau of Vector Control, State Department of Public Health and the Department of Entomology, University of California, Davis.

Purdy's observations were confirmed and extended by Gerhardt (1953, 1955, 1956) except that the latter found that *Anabaena* and *Aulosira* were the dominant blue-green algae in fields with little or no mosquito breeding. Further studies in the field and laboratory indicated that (1) the blue-green algae could be successfully transplanted from one field to another; (2) the mosquito toxicant was probably a photometabolite.

Our current interest in blue-green algae was renewed by observations made at the Rice Experiment Station at Biggs. Of the three rice fields under observation from May through September, all were negative or showed light concentrations of *Culex tarsalis*. *Anopheles freeborni* was not found in any of the three fields. Biweekly plankton sampling indicated abundant blue-green algae in all fields from the latter part of June through September. *Anabaena* was dominant, *Aulosira* noted only occasionally, and *Tolypothrix* not observed at all. In view of the earlier studies of Purdy (1924) and Gerhardt (1956), it appeared that the low mosquito population might be due to the algal growth. An attempt will be made to repeat our observations in the same fields, but with plans to treat one or more fields with copper sulfate so as to permit comparisons of fields situated alongside one another, but differing in algal density.

In the laboratory, preliminary screening of blue-green algae toxicity is currently being conducted by exposing laboratory colony mosquito larvae to various filamentous algae. No mortality has been observed in first instar larvae of *Culex tarsalis* after 36-48 hours' exposure to species of the following genera of algae: *Anabaena, Nostoc, Oscillatoria, Hydrodictyon, Ulothrix, Cladophora,* and *Oedogonium*. Slight mortality was observed with a species of *Tolypothrix*, collected from an oxidation pond at the Richmond Field Station. However, none of the algae tested so far were originally from rice fields, but were obtained as raw cultures from the Botany Department, University of California, Davis, or from local aquatic situations. The algae collected from rice fields are being reared in soil-water cultures and will be tested at a later date.

Gambusia Investigations. — Gerhardt (1961) discussed the advantages and limitations of using *Gambusia* fish for mosquito control in rice fields. More recent developments are being discussed by other speakers at later sessions today and tonight.

Although our studies did not include a comprehensive program on *Gambusia*, portions of our limnological studies did have possible bearing on the efficiency of *Gambusia* as mosquito predators in rice fields.

Work by Darby (1962) had previously indicated that considerable diurnal fluctuation of dissolved oxygen may occur in a rice field. Since the oxygen concentration may fall below the minimum level of 2 ppm recommended for maintaining coarse fish populations (Tarzwell 1958), the possibility of oxygen as a potential limiting factor for *Gambusia* had to be considered.

In our oxygen studies, very little fluctuation was observed in May and June; starting in July, however, dissolved oxygen concentration decreased to approximately 1 ppm during the early morning hours. In August, five one-cubic-foot cages were placed in the rice field and ten *Gambusia* fish placed in each cage. These cages were inspected every four hours over a 24-hour period and concurrent readings on temperature and dissolved oxygen concentrations were made.

While none of the caged fish died, almost all became quite sluggish during periods of minimal oxygen concentration. One compensating factor was that the period of low oxygen concentration coincided with the period of low temperature so that the fish population probably had a reduced oxygen demand during this critical period. However, additional studies are necessary for further clarification on the relationship of *Gambusia* and dissolved oxygen.

Limnological Studies. — From the numerous studies on the relationship of water quality and mosquito breeding, one of the more promising observations for possible use in mosquito control appeared to be the negative relationship between the presence of reduced forms of dissolved nitrogenous substances and mosquito breeding (Senior-White 1928; Beattie 1932; Mehta 1934; deJesus 1936). Supporting field evidence was convincing enough to consider biological control through raising the ammonia content of rice field waters (Senior-White 1928). More recent work in California rice fields by Gerhardt (1957) did not confirm this relationship, but it must be noted that Gerhardt's negative findings were with *Culex tarsalis* while all of the earlier positive investigations were with anopheline mosquitoes. Studies will be initiated this summer to determine whether any such relationship can be detected in *Anopheles freeborni*.

Relationship of Cultural Practices to Mosquito Breeding. — Efforts are being made to seek certain modifications in rice cultural practices which may result in reduced mosquito breeding. Although no major changes in cultural practices can be anticipated at this time, it is possible that lower water depth will be recommended eventually for improved rice yields. Studies conducted in 1963 produced evidence that the shallower fields were biologically more productive. Studies to verify this and to determine the effect on mosquitoes will be continued in 1964.

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THE REACTION OF MOSQUITO LARVAE TO LIGHT

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Abstract

The orientation of mosquito larvae by light and their positive and negative response to light was studied in 20 species of mosquitoes commonly found in California. A special tank was designed to aid this study and visual as well as photographic records were made of their behavior when they were stimulated to sound or surface along beams of lights.

Both negative and positive phototaxis were examined in 3rd and 4th instar larvae of each species. The results showed that there were three general types of orientation to light. The most common pattern was the alternated pattern of photonegative and photopositive response. When stimulated by light or vibration while resting at the surface, the sounding larvae moved directly away from light. Orientation is parallel to the light beam and phototaxis overruled geotaxis. Following a short resting period the larvae became photopositive and swam toward the light source. During the positive swim phase an external tactile stimulation or light induced stimulus will reverse the positive phase to negative. The negative phase could not be reversed by external stimuli. Another and a less common phase of reaction was associated with the anophelines. An external stimulus did not produce a distinctly noticeable negative reaction. When stimulated, larvae of this type descend passively without body movement and become strongly photopositive only when attempting to swim to the surface. Since this behavior pattern shows only one sign, larvae under these conditions were classed as photopositive. The third class of reaction was demonstrated in only a few species. When stimulated to sound they became photonegative and continued to be photonegative until they either floated to the surface or swam to the surface at a point some distance from the light source. No positive reaction was observed in this group. These were classed as photonegative. This group could sometimes be induced by laboratory treatment to show the commonly observed photonegative and photopositive reversal of sign reaction. This suggested that physiological conditions will influence behavior patterns.

The response of larvae to light was used to develop an underwater larval sampling device, a separator to isolate larvae from pupae and to separate species of mosquitoes.

CURRENT KNOWLEDGE OF THE FEEDING HABITS OF CALIFORNIA MOSQUITOES[1]

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The feeding habits of different species of hematophagus arthropods are usually studied because of their importance in transmission of diseases to man. In studying the feeding habits of California mosquitoes, our primary interest has been to learn more of *Culex tarsalis* as this mosquito is known to be the principal vector of Western equine (WEE) and St. Louis encephalitis (SLE) viruses in California. Field observations, such as exposure of different host species in traps, are not always successful in accurately detecting host preferences of mosquitoes. For this reason immunologic tools for the identification of arthropod blood meals have been used for a number of years. We have now identified the blood meals from approximately 15,000 mosquitoes; and while our primary interest was in *C. tarsalis*, a number of other species have been tested and included: *Culex quinquefasciatus*, *Culex peus*, *Culex thriambus*, *Anopheles franciscanus*, and *Culiseta inornata*.

Materials and Methods

Mosquito collections were made at weekly intervals from rural areas in Kern County, California, from a variety of resting places (farmyard sheds, porches, redbox shelters, bridges, culverts, and public rest rooms). Special efforts were made to collect *C. tarsalis;* other species were collected incidentally.

Methods of collecting, handling, shipping, and testing mosquitoes were reported by Tempelis and Lofy (1963). The antisera were prepared in rabbits, chickens, and pheasants (Tempelis 1962; Tempelis and Reeves 1962; Tempelis and Lofy 1963). In brief, the mosquito abdomens containing the blood meals were shipped to the laboratory in gelatin prescription capsules. Each abdomen was crushed in 1.0 ml of saline. The suspension was cleared by centrifugation and then reacted with antiserum in a capillary tube.

Results

Initially, all blood meals were tested against antisera reacting respectively with serum from a wide range of species of birds or mammals known to be in Kern County with the exception of rabbits and opossums. We have found that *C. tarsalis* feeds predominantly on birds (Table 1). In the summer (May-October), 84.4% of the feedings were on birds; while in the winter (November-April) this increased to 98.0%. With the onset of the summer there was an increase in mammal feedings. This increase in mammal feedings was most evident from July through September.

Analysis of these mammal and bird feedings with more specific antisera showed that *C. tarsalis* had an overwhelming preference for passerine birds, especi-

[1] These investigations were supported in part by a research grant AI 03028-05 from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service.

ally in winter (Table 2). In the summer, the feedings on birds became more evenly distributed among chickens, doves, and passerine birds. The 10% mammalian feedings observed during the study were mainly on cattle. The only wild mammals that were fed on frequently were rabbits.

In addition to *C. tarsalis*, three other *Culex* mosquitoes (*C. thriambus*, *C. peus*, and *C. quinquefasciatus*), *A. franciscanus*, and *C. inornata* were studied. The three *Culex* mosquitoes fed heavily on birds. Passerine birds were the predominant host for *C. thriambus* and *C. peus*; chickens were, for *C. quinquefasciatus*. Three *C. thriambus* and three *C. quinquefasciatus* had fed on rabbits; these were the only mammal feedings found among these three *Culex* species.

TABLE 1.—Precipitin screen tests on *Culex tarsalis* collected in Kern County, California, November 1, 1960 through October 31, 1961.

Time period	*Reactors*[a] *Mammal*		*Reactors*[a] *Bird*		*Nonreactors*		*Total no. of mosquitoes tested*
	No. pos.	*Percent Pos.*	*No. pos.*	*Percent Pos.*	*Number*	*Percent*	
Winter							
Nov. 1, 1960- April 30, 1961	16	1.4	1,080	98.0	6	0.6	1,102
Summer							
May 1, 1961- Oct. 31, 1961	309	13.9	1,865	84.4	38	1.7	2,208
Totals	325	9.7	2,945	88.9	44	1.4	3,310

[a] Double feedings are indicated by the difference between total number of mosquitoes tested and the sum of the nonreactors, mammal feedings, and bird feedings.

TABLE 2.—Summary of percent[a] distribution of feedings on hosts by season for all areas in Kern County, California.

	May-October (Summer)		*November-April (Winter)*		*All seasons*	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Birds						
Chicken	592	27.1	203	18.5	795	24.2
Dove	426	19.5	27	2.5	453	13.8
Passerine	772	35.3	792	72.1	1,564	47.6
Unidentified	86	3.9	59	5.4	145	4.4
(Subtotals)	(1,876)	85.8	(1,081)	98.5	(2,957)	90.0
Mammals						
Bovine	194	8.9	10	0.9	204	6.2
Dog	30	1.4	5	0.5	35	1.1
Horse	29	1.3	0	0.0	29	0.9
Rabbit	47	2.1	1	0.1	48	1.5
Cat	2	0.1	0	0.0	2	<0.1
Skunk	1	<0.1	0	0.0	1	<0.1
Citellus sp.	2	0.1	0	0.0	2	<0.1
Unidentified	5	0.2	0	0.0	8	0.2
(Subtotals)	(310)	14.2	(16)	1.5	(326)	10.0
Total positives	2,186	(100.0)	1,097	(100.0)	3,283	(100.0)

[a] Based on total feedings.

A. franciscanus fed almost entirely on mammals. Over 66% of the feedings by this species were on rabbits and/or hares. The only bird feedings were on chickens.

Except for three bird feedings, all *C. inornata* fed on mammals (Table 3). This species showed a high preference for domestic mammals with 75% feeding on cattle. The only wild mammals fed on were rabbits (4.4%).

TABLE 3.—Summary of *Culiseta inornata* feedings in Kern County, California, 1960-1963.

Host animal	*Number feedings*	*Percent Positive*
Cattle	207	75.8
Horse	43	15.7
Rabbit[a]	12	4.4
Dog	4	1.5
Mammal[b]	3	1.1
Chicken	2	0.7
Bird[c]	1	0.4
Negative[d]	1	0.4
Total	273	100.0

[a] Represents feeding on both cottontail and jackrabbits.

[b] Samples reacted with our screening mammalian antiserum but not with 10 more specific mammalian sera.

[c] Sample reacted with our screening bird antiserum but not with 8 more specific bird sera.

[d] Failed to react with any screening or rabbit antisera.

A more thorough discussion of the studies on *C. inornata* has been published (Washino *et al.* 1962), and the studies on *C. thriambus, C. peus, C. quinquefasciatus* and *A. franciscanus* will soon be published (Tempelis and Reeves 1964).

Discussion

These studies on the feeding habits of six species of California mosquitoes have increased our knowledge of their host preferences. Of the six species, only *C. tarsalis* is known to be of major importance in the transmission of viruses in California (Reeves and Hammon 1962). However, it should be remembered that both WEE and SLE viruses have been isolated from *C. quinquefasciatus*, and WEE from *C. peus* (Reeves and Hammon 1962). In laboratory and field studies of *C. quinquefasciatus* it was concluded that at best this mosquito was a secondary vector of SLE virus in California (Reeves and Hammon 1962); and *C. peus* has never received much attention as a potential vector.

The seasonal changes in feeding patterns present some insight into the biology of *C. tarsalis* and may be significant epidemiologically. In the summer over 22% of the fedings on birds were on doves. While a bird census in the area was not undertaken, it was not our general impression that doves were this common. Rather, it indicated that *C. tarsalis* preferred this host even when it was available in relatively small numbers. This high incidence of dove feedings coincided with the season when these birds were nesting and roosting in trees around farmyards (McClure *et al.* 1962). The drop in dove feedings to 2.5% in the early fall coincided with the doves' fall migration from the area, beginning in September (McClure *et al.* 1962).

The decrease in *C. tarsalis* feedings on mammals in the winter period could not be correlated with any major changes in availability of mammals as most feedings were on domestic species that did not vary greatly in numbers or habits with the season.

The general patterns of host preference confirmed and extended the earlier studies done with *C. quinquefasciatus* and *C. thriambus* (Reeves and Hammon 1962). Reeves and Hammon (1962) reported that over 65% of the feedings of *C. peus* from 1943-1946 were on mammals. This is in contrast to the present findings that this mosquito fed only on birds in 1962 and 1963 (Tempelis and Reeves 1964). This probably reflects differences in collecting sites and numerous environmental changes that have taken place since the earlier study. These changes could well have influenced the apparent shift in feeding patterns for *C. peus*.

Earlier reports on the feeding habits of *A. franciscanus* collected from a number of areas of California indicated it was predominantly zoophilic (Reeves 1944; Hammon *et al* 1945; Belkin 1951). Our studies confirmed this and also demonstrated that *A. franciscanus* has a high preference for rabbits and/or hares. Reeves (1944) and Hammon *et al.* (1945) reported a high attack rate on domestic mammals but also a high percentage of blood meals showed no reaction. These nonreacting samples could well have been rabbit feedings because no anti-rabbit serum was used in their test system.

C. inornata are most abundant during the colder months in Kern County. They feed primarily on mammals (98%) and prefer the large domestic mammals. Their relationship to the transmission of WEE and SLE has been discussed in an earlier publication (Washino *et al.* 1962).

Mosquitoes feeding on more than one host for a complete blood meal (double feedings) comprised less than 0.5% of specimens. The test utilized in our laboratory is not sensitive enough to detect double feedings that may have occurred on passerine birds.

In addition to the studies in Kern County, further studies are being made on *C. tarsalis* collected from the Sacramento Valley, Colorado and Texas in cooperation with the Bureau of Vector Control of the California State Department of Public Health and the Disease Ecology Section of the Communicable Disease Center, United States Public Health Service, Greeley, Colorado. In this regard it will be of particular interest to see if geographic and climatic differences alter the feeding patterns of this important mosquito. Along with *C. tarsalis*, six species of *Aedes*, three *Culex*, three *Culiseta*, and three *Anopheles* have been collected in these areas.

This improved serologic tool offers new information for correlating mosquito feeding habits with other epidemiologic and biologic data.

Summary

The feeding habits of five culicine and one anopheline mosquitoes were studied in Kern County, Califor-

nia, by identification of blood meals with precipitating antisera. *Culex tarsalis, Culex thriambus, Culex quinquefasciatus* and *Culex peus* fed heavily on birds. *C. tarsalis* showed the most variable feeding pattern, including seasonal changes in host preferences. In the winter it fed almost exclusively on passerine birds and there was a significant shift to doves and mammals in the summer. *Anopheles franciscanus* fed almost exclusively on mammals, particularly rabbits. *Culiseta inornata* fed on domestic mammals, showing the greatest preference for cattle.

Acknowledgments

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TEMPERATURE AND SALINITY RELATIONSHIPS OF *AEDES NIGROMACULIS* AND *A. MELANIMON*

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Since the resurrection of *Aedes melanimon* Dyar from synonomy (Barr 1955), several papers have appeared in which the relationship of this species to others has been reported. Bohart (1956) reported on the identification and distribution of it and *A. dorsalis* (Meigen), with which it had been synonomized, in California. Chapman (1960) reported observations on *A. melanimon* and *A. dorsalis* in Nevada and included some notes on *A. nigromaculis* (Ludlow). Telford (1958), whose paper is primarily concerned with *A. dorsalis* and *A. squamiger* (Coquillett), reported some observations on the ecological relationships of *A. melanimon* and *A. nigromaculis*.

Inasmuch as both *A. nigromaculis* and *A. melanimon* are important pests in the Central Valley of California, they have been studied from the standpoint of behavior and ecology by us for the past several years. In this region *A. nigromaculis* is typically produced in irrigated pastures where it comes off in broods geared to the irrigation cycle. *A. melanimon,* a species of less widespread importance though important in some local situations, is often produced in irrigated pastures similar to those producing *A. nigromaculis*.

It has been observed that *A. nigromaculis* and *A. melanimon* may occur in the same area though their relative abundance varies throughout the season. In those pastures producing both species, *A. melanimon* appears first in the spring, is replaced or overshadowed by *A. nigromaculis* during the warmer summer months, and reappears toward the end of the season. In other areas of the San Joaquin Valley, notably western Fresno County, irrigated pastures and other *Aedes* producing sources are reported to yield *A. melanimon* almost exclusively. The seasonal and geographic distribution of these two species suggests that temperature and perhaps salinity are important in regulating the presence and density of populations of these mosquitoes. The earlier appearance of *A. melanimon* in situations where both species occur was noted by Telford (1958) who suspected that temperature played a role in this type of seasonal distribution.

Experiments which have been made in our laboratory on the relative temperature preference and tolerance of larvae of these two species of *Aedes* and some observations on their salinity relationships are presented here. The results of these laboratory experiments are not to be taken as representative of temperature preferences or tolerances in nature since such factors as acclimation and shock of rapid temperature change enter into our experiments. The purpose of these experiments was to determine the response of these two species with respect to each other.

Temperature preference tests were conducted in a plastic trough approximately 3 cm wide, 1 cm deep, and 122 cm long with a nylon screen bottom which was embedded in sand contained in a larger chamber of aluminum material. The entire chamber was filled with water so that the water depth in the plastic test chamber, into which larvae were placed, was about 1 cm deep. Such an arrangement provided a suitably stable temperature gradient when heated at one end and cooled at the other.

Test larvae which were field collected and held at room temperature for at least 24 hours were placed into the gradient chamber at the point where the temperature was identical to that of the water from which they were taken, and allowed to remain undisturbed for 15 minutes, at which time their locations in terms of temperature were noted. There were ten 4th instar larvae per test and tests were replicated.

The distribution of larvae in the gradient is shown in Table 1. There were 35 replicates for *A. nigromaculis* and 53 replicates for *A. melanimon*. Variation in location in terms of temperature was significantly greater among the *A. nigromaculis* larvae than among

To test the relative tolerance of these two species to high and low temperatures, larvae were isolated in small plastic containers approximately 3 cm in diameter and 2.5 cm deep having nylon screen bottoms.

TABLE 1.—Distribution of larvae at various temperatures in a gradient.[a]

Temperature °C	Percent of Larvae *A. melanimon*	*A. nigromaculis*
4.4 – 7.1	0.0	0.0
7.1 – 9.8	0.6	0.0
9.8 – 12.5	1.7	2.6
12.5 – 15.3	5.7	4.9
15.3 – 18.0	10.5	6.0
18.0 – 20.8	15.2	8.6
20.8 – 23.6	26.8	12.9
23.6 – 26.4	18.6	17.0
26.4 – 29.2	10.6	15.2
29.2 – 32.0	7.0	14.4
32.0 – 34.7	3.0	12.9
34.7 – 37.4	0.2	4.6
37.4 – 40.1	0.0	0.9
40.1 – 42.8	0.0	0.0
Mean ± SE	22.5 ± 0.21	25.7 ± 0.34

[a] Ten larvae in each replicate; 35 replicates of *A. nigromaculis*, 53 of *A. melanimon*.

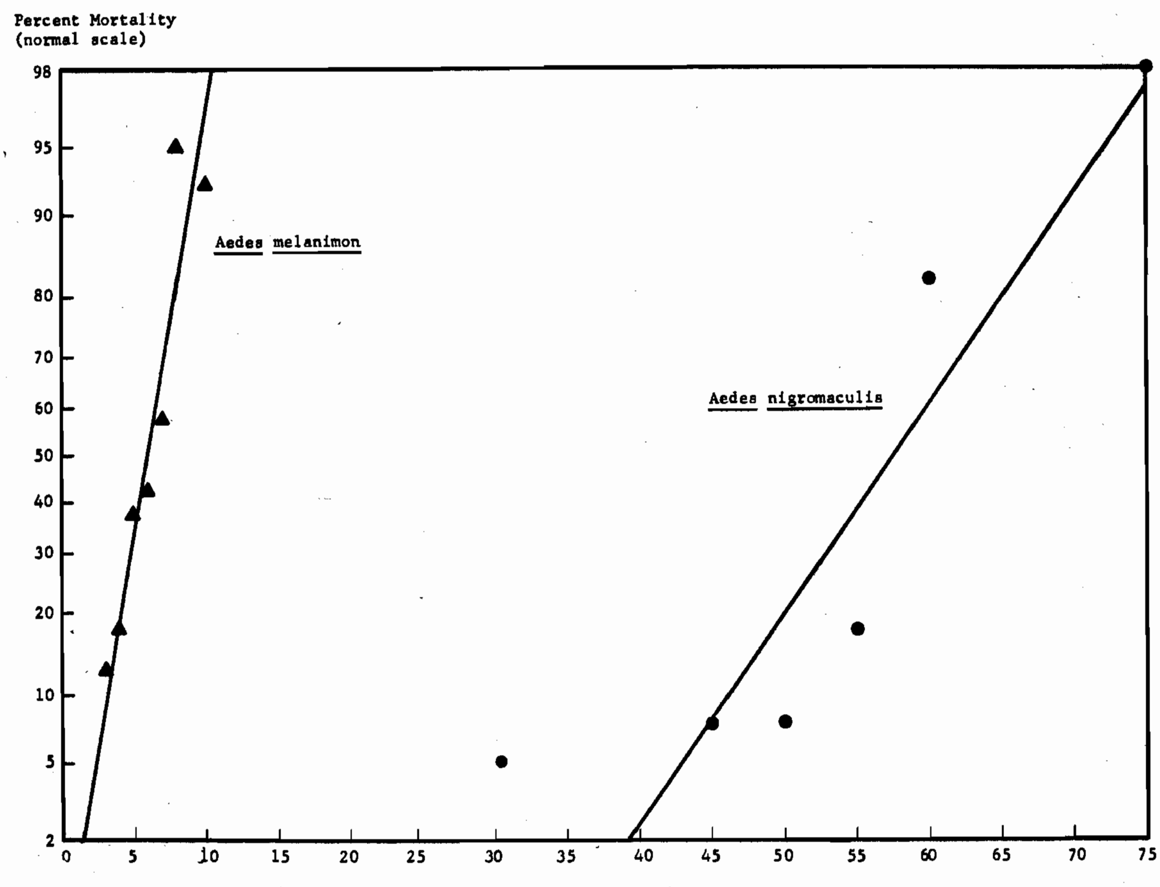

Fig. 1. Probit regression of mortality on time exposed to a temperature of 0°C of *Aedes nigramaculis* and *Aedes melanimon* larvae.

A. melanimon. The average location was at 25.7°C (78°F) for *A. nigromaculis* and at 22.5°C (72°F) for *A. melanimon*. The Fisher-Behrens test of the data showed this difference to be significant at the .01 level.

Several of these were placed in a rack which was removed from room temperature water and placed into a water bath of the desired high or low temperature. The small cups were then removed at intervals, placed back in room temperature water, and mortality was noted 24 hours later. There were three replicates of ten 4th instar larvae for each time interval and a control accompanied each test. As in the gradient tests larvae were field collected and held at room temperature for at least 24 hours.

In these experiments *A. melanimon* larvae were less susceptible to low temperatures than were larvae of *A. nigromaculis;* Figure 1 shows this relationship. The variability of response (slope of the line) was also significantly greater among *A. melanimon.* The LT50 (the estimated exposure time required to kill 50% of the larvae in a sample) for *A. melanimon* was 27.3 hours as compared to 4.4 hours for *A. nigromaculis* at a temperature slightly above 0°C. This difference and differences in the times required for all higher percent kills were significant at the .001 level.

Conversely, with larvae from the same population, *A. nigromaculis* survived longer at 43°C (110°F) than did larvae of *A. melanimon,* and showed significantly greater variability of response. Figure 2 shows this relationship. The ranges of exposure time required for 2 to 98% kill for the two species did not overlap, and the differences in time throughout the range were significant at the .001 level. The LT_{50} for *A. nigromaculis* was 57.5 minutes as compared to 5.9 minutes for *A. melanimon.*

To determine whether salinity might be a factor in the geographical distribution of these species in nature, water samples were collected from several areas known to produce exclusively or predominantly one or the other of these species. Total chloride content was determined by the mercuric nitrate titration method. Water from "*A. nigromaculis* areas" had a lower chloride content then water samples from "*A. melanimon* areas". A pasture near Piedra, Fresno County, for example, had an average total chloride content of 20 mg/liter for 10 samples from various parts of the field. These samples ranged from 12 to 44 mg/liter. This pasture produces *A. melanimon* early and late in the season but during the main part of the season *A. nigromaculis* was by far the dominant if not the only species present. A pasture near Tulare, which apparently produces only *A. nigromaculis* had a mean chloride content of 3.85 mg/liter, and a range of 24 to 52 mg/liter for 10 samples. *A. melanimon* producing areas, on the other hand, yielded higher total chloride readings. In the duck club area of western Merced County where the behavior of adult *A. melanimon* has been studied for two seasons, total chloride content of many water samples ranged from 112 to 1485 mg/liter. Water samples from a pasture near Dos Palos, which, according to mosquito abatement personnel, produced *A. melanimon* almost exclusively, tested from 252 to 260 mg/liter.

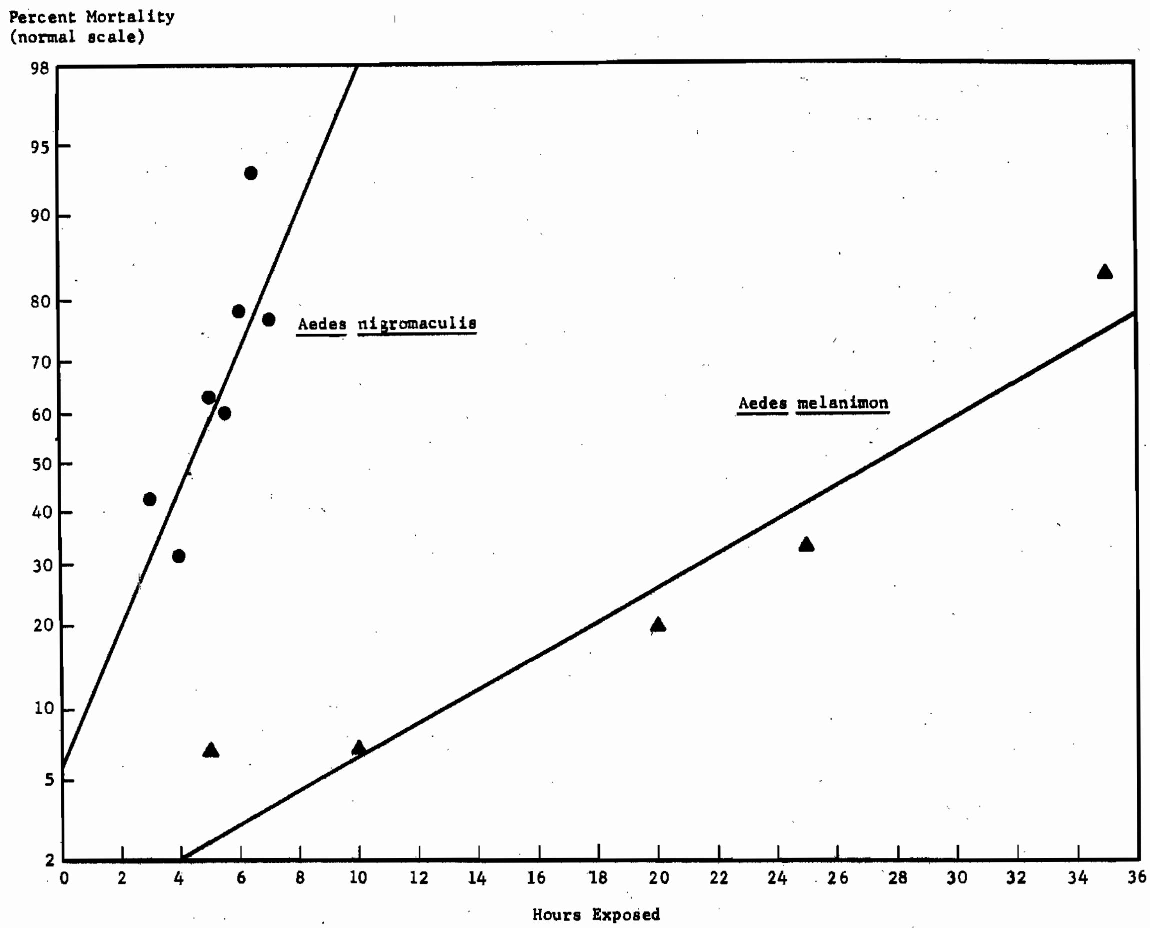

Fig. 2. Probit regression of mortality on time exposed to a temperature of 43°C of *Aedes nigromaculis* and *Aedes melanimon larvae.*

Based on these observations, *A. nigromaculis* is less common in water of high salinity than is *A. melanimon*. This is an agreement with the observations of Chapman (1960) who found that in Nevada *A. nigromaculis* inhabited water having chlorides ranging up to 391 mg liter, while *A. melanimon* inhabited water ranging up to 17,750 mg/liter.

Summary

The seasonal and geographical distribution of *A. nigromaculis* and *A. melanimon* in California suggests that temperature and perhaps salinity influence the presence and density of populations of these mosquitoes.

Laboratory tests showed that *A. nigromaculis* larvae were able to survive longer at high temperatures than were larvae of *A. melanimon*; conversely, *A. melanimon* survived longer at low temperatures than did larvae of *A. nigromaculis*. In temperature gradient experiments *A. nigromaculis* larvae "preferred" a mean temperature about 3°C higher than the mean temperature "preferred" by *A. melanimon*.

Field observations on salinity showed that *A. nigromaculis* larvae occurred in water ranging in total chloride content from 12 to 260 mg/liter, and that *A. melanimon* larvae occurred in water ranging from 12 to 1,485 mg/liter.

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PROBLEMS IN THE DEVELOPMENT OF NEW MOSQUITO LARVICIDES

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Problems associated with the development of new mosquito larvicides are essentially the same as those recognized about a decade ago. However, most of these problems have attracted greater attention from the general public today than before.

Although many inter-relationships and problems are associated with the development and use of new mosquito larvicides, only the most important and currently much discussed points will be elaborated upon here.

Safety

During the early stages of the development and use of the organochlorine mosquito larvicides, mosquito abatement agencies were well aware of the safety requirements of mosquito larvicides. Every effort was made to protect the public as well as the spray operators from harmful effects of these toxic agents. These agencies with constant vigilance and proper educational efforts have been able to set a record in the safe and proper use of some highly toxic compounds such as parathion, methyl parathion, EPN and others. Notwithstanding these achievements, the mosquito abatement agencies in California and elsewhere seek larvicides characterized with low mammalian toxicities.

As a result of this demand, time and energy have been directed toward the development of compounds which will have favorable mammalian toxicities. Results of these efforts are gratifying, since numerous highly effective mosquito larvicides with low mammalian toxicities have been evaluated. Bayer 37343, AC-52160, Cela S-1942, SD-7438, fenthion, Sumithion and CL-43913 are a few of the compounds which have outstanding biological activities against larvae and very favorable mammalian toxicities. Under proper use conditions, the use of such materials as well as other materials having low mammalian toxicities in mosquito abatement programs will result in practically no problems relating to toxic hazards to the public as well as operators. Hazards arising from misuse or accidental exposures are, however, possible, but long safety records of mosquito abatement districts in the use of pesticides has precluded and would diminish the occurrence of such hazards.

Residues

Residues of pesticides in or on food and forage crops are coming under more severe and intense scrutiny. This development in some ways will slow down the arrival at the scene of highly effective and yet safe materials to wildlife and man. The ultimate result of such a scheme would be the continuation of currently used less effective and less desirable materials. Although mosquito abatement and other similar districts are charged with the responsibility of promoting public health through vector suppression, they also have the responsibility to practice measures commensurate with public safety.

The problem of hazards of residues in food and forage crops due to larvicidal treatments can be greatly diminished by using less toxic materials and proper formulations of these. It might be easier to obtain legal residue tolerances for a safer material than for a highly toxic compound. Formulations such as granules that would reach the water without leaving residues on plant parts may alleviate the problem further.

Pesticides-Wildlife Relationships

Much has been said on the relationship of mosquito larvicides to fish, game and wildlife species. It is widely accepted that the organochlorine larvicides persist and accumulate in food chain organisms. These compounds, although present in very low concentrations in water and the substrate, are magnified in certain organisms through the mechanism of food chain cycles. Fortunately, these persistent materials have been mostly abandoned as mosquito larvicides in California and are being replaced by organic phosphate insecticides.

The organophosphate materials, on the other hand, are generally less stable materials. They readily degrade in water, soil, and most plant and animal tissues.

No cases of accumulation and magnification of these compounds have been reported in animal tissues. These compounds therefore mainly bring about acute responses in organisms exposed. Beyond the acute manifestations, chronic developments may be absent.

In studying the relationship of mosquito larvicides to fish, game and wildlife species, distinction should be made between the toxicity of a compound and its hazards under actual field conditions. A compound proven to be toxic in the laboratory may not pose any serious hazards to the species under the conditions of usage in the field. On account of this situation, most of our studies in California on the relationship of mosquito larvicides to fish and wildlife have been conducted in the field.

Of the more than 100 organophosphate and carbamate insecticides evaluated against the top feeding minnow *Gambusia affinis*, in excess of 50% of the compounds appeared to be innocuous to this fish at mosquito larvicidal rates. Most of the new and highly effective mosquito larvicides were safe at much higher rates. Similar safety range was indicated for invertebrate predators such as dragon fly, may fly naiads, diving beetle larvae and adults, and other aquatic predaceous insects. Frogs and toads are especially tolerant to these groups of insecticides.

There are indications that the mosquito fish and certain Cladocera in California have built up immunity to the organochlorine insecticides (Mulla, unpublished data). Development of tolerance to these compounds in other predaceous insects is a likely possibility. It is altogether possible that natural selection brought about by the organophosphate insecticides pressure is leading to resistant strains of all kinds of organisms, whether they are pest species or beneficial and predaceous organisms.

The relationship of pesticides to wildlife species is indeed a complex one. More complex yet are the inter-relationships among the various species inhabiting similar habitats. Introduction of a new predaceous species (general feeder) for biological control of mosquito larvae or other vectors, for example, may have much subtle effect on the equilibrium level of community numbers. Such an effect may have permanent manifestations and may be observable over the entire range of the displaced species. Competitive displacement between ecological homologues is a well known fact (DeBach and Sundby 1963) which could readily take effect in aquatic niches. Pesticides, by their nature, are hardly conceived of to eradicate a species (even the one against which they are used) over its entire range. They might alter the equilibrium level of community members temporarily, and then only in the treated area which generally comprises a very small portion of the total habitat of the affected organism.

From 1948 to 1958 in Southern California (over 4000 square miles), *Aphytis lingnanensis*, a newly introduced red scale parasite, completely displaced *A. chrysomphali*, another red scale parasite. These two species were ecological homologues and this competitive displacement was detected because the later species was well studied for many years (DeBach and Sundby 1963). Without such studies this displacement would have gone undetected in the realm of biology. A similar situation, for example, could develop by the introduction of exotic fishes such as species of *Cynolebias* and *Notobranchius* annual fishes and others. Although these fishes hold unusual promise for mosquito control (Hildeman and Walford 1963), they might eliminate some nonpest invertebrates and vertebrates, thus producing biological vacuums. It is on this account that the inter-relationships of exotic species are thoroughly studied before they are introduced into a new area.

Coming back to pesticides, one might say that the impact of pesticides used in mosquito control programs upon wildlife species could be lessened by proper programming. Nontarget species may be affected adversely in restricted locations or certain special types of habitats, but recognition of such problems by agencies concerned has aided much in the alleviation of such problems.

Resistance

Development of resistance in mosquitoes and other insects to insecticides has created some serious problems. The problem of insect resistance poses a great challenge to the creative thinking of all biologists. Although much progress has been made in understanding some of the underlying factors leading to the resistance problem, much more has to be learned about the physical, chemical and biological basis of resistance development and progress.

It is generally agreed that resistance to organochlorine insecticides does not result in resistance to organophosphate and carbamate insecticides. Further information on this aspect of resistance was obtained on DDT resistant *Culex p. quinquefasciatus* from the Coachella Valley and DDT resistant *Culex tarsalis* from southern San Joaquin Valley (Table 1).

Table 1. Comparison of the susceptibility levels of fourth instar larvae susceptible and DDT resistant strains of *Culex p. quinquefasciatus*.

Insecticides	*S (laboratory)*	*R (Coachella Valley)*	
	LC_{90} (ppm)	*LC_{90} (ppm)*	*Ratio*
methyl parathion	0.0054	0.0047	1.0
fenthion	0.0074	0.0094	1.3
parathion	0.008	0.015	2.0
dieldrin	0.009	0.05	5.5
Sumithion	0.009	0.015	1.7
AC-5727	0.026	0.038	1.5
Ortho 5353	0.038	0.10	3.0
DDT	0.045	1.20	27.0
Ortho 5305	0.07	0.082	1.2
malathion	0.09	0.25	3.0

It should be noted that the resistant strain in the Coachella Valley has been exposed to a variety of organochlorine and organophosphate insecticides. Notwithstanding this fact, the species has not become resistant to any of the toxicants studied except DDT and dieldrin.

The susceptibility pattern of a DDT resistant field strain of *C. tarsalis* and parathion resistant strain of

Aedes nigromaculis, both from southern San Joaquin Valley were studied (Table 2).

TABLE 2. Susceptibility pattern of field collected 4th instar larvae of *Culex tarsalis* and *Aedes nigromaculis*.

Material	LC_{90} (ppm)	
	A. nigromaculis[a]	C. tarsalis[b]
AC-52160	0.0065	0.003
CL-43913	0.009	0.007
SD-7438	0.013	0.008
fenthion	0.015	0.011
methyl parathion	0.03	0.000
Sumithion	0.03	0.009
malathion	0.15	———
parathion	0.30	0.0056
dieldrin	1.0	———
DDT	3.0	>1.0

[a] Parathion and DDT resistant strain.

[b] DDT resistant only.

It is of interest to note that parathion resistant *A. nigromaculis* were also resistant to malathion, dieldrin and DDT. Malathion and DDT were the two materials used in the early 1950's against mosquitoes in the San Joaquin Valley. It is very likely that this species was exposed to dieldrin and other cyclodiene organochlorine insecticides which might have been used for agricultural insect control. This parathion resistant strain of *A. nigromaculis* manifested slight tolerance to the other phosphates, but the strain cannot be considered as having a high degree of tolerance to the newer phosphates.

C. tarsalis resistant to DDT did not manifest any degree of tolerance to the organophosphate insecticides, including parathion. Parathion has been used for the control of this species for about 8 years and thus far no appearance of tolerance has taken place.

NEW MATERIALS

As a result of search for more effective materials having low mammalian toxicities, safety factors to nontarget species and wildlife, numerous experimental mosquito larvicides have been tested in the field and laboratory. Over 20 compounds evaluated during the 1963 season showed larvicidal activity greater than that of malathion. Among these AC-52160, SD-9020, SD-9320, CL-43913, Bayer 47940, SD-8803, AC-47921 and Bayer 52957 showed similar or greater activity than that of parathion.

Some of these compounds were evaluated in the field against *C. tarsalis.* AC-52160 and CL-43913 had outstanding performance. Other compounds such as AC-47921, Bayer 52957, Cela S-1942, Cela S-2225 and Bayer 37342 also indicated a high degree of performance in the field. It is obvious that the number of compounds which have a great potential for use as mosquito larvicides is rather impressive. Compounds which have biological activity in the range of 5 to 1/5 times that of parathion and which were studied during the past three years number about 40. Of these, some compounds have high mammalian toxicity, and therefore cannot be used routinely. Some others have a high degree of toxicity to fish and these could not be used in habitats containing fish. On the whole, most of the compounds, however, have favorable mammalian toxicities and a good deal of safety margin to nontarget species. The effectiveness of most of these compounds against parathion resistant *A. nigromaculis* has yet to be determined. It is possible that some of these new compounds might be effectively used against resistant strains.

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THIRD SESSION (CONCURRENT)

INTEGRATION OF MOSQUITO CONTROL OPERATIONS

EUGENE E. KAUFFMAN and FRED A. COMPIANO, *Co-moderators*

PUBLIC RELATIONS IN RURAL MOSQUITO CONTROL

LOUIS SOHNREY
Butte County Mosquito Abatement District

Mosquito control operators have a key role in public relations. Operators meet the public daily and have much closer contact with individual property owners than anyone in the organization. When the operator goes out into farming areas, in the eyes of the public he *is* the district. The reputation of the district depends upon the impression he makes. The operator who knows his job and at the same time is capable of leaving a good personal impression with the public is a real asset to the district. On the other hand, an operator who makes a poor impression on the public can cause the whole program to suffer.

Sound technical training of field personnel is extremely important. Operators should be thoroughly familiar with the insecticides they are using, including rates of application and the reasons for different methods of application. They should have a good general knowledge of the district's entire operations and working policies. The public can come up with a wide range of questions, and only a carefully trained operator will be capable of providing informed, intelligent answers. If an operator is asked a question that is beyond his range of knowledge, he should tell the person that he will look up the information desired, or he should refer the individual to someone who is qualified to answer the question. The operator should never bluff or give out misinformation which could be damaging to the program.

It goes without saying that the public should be treated with respect at all times. When working with ranchers there are some important rules of etiquette. Property should always be left as you find it. If a gate is closed, be sure to leave it that way. If you notice any sick or dead animals on the property, or anything out of the ordinary that might be important to the farmer, it only takes a few minutes to call it to his attention. This kind of approach to the job can be a vital factor in maintaining good public relations.

If there is a problem between the operator and a rancher, this should be brought to the attention of the foreman, the source reduction consultant or the manager, depending on what kind of help is needed.

If a district is to have an effective program, every operator has to be able to meet the public and to represent his agency in the best light. If the operator, who is in constant contact with property holders, does not maintain good public relations, the entire organization will be in trouble. I believe that a good control program and a successful district must give high priority to the training of all of its personnel on the principles and practices of effective public relations.

PUBLIC RELATIONS IN URBAN MOSQUITO CONTROL

JACK FIORI
San Joaquin Mosquito Abatement District

The application of the principles of good public relations plays an important part in successful urban mosquito control. The first impression left by an operator on a farmer or city property owner is especially important. When an operator enters upon a property and introduces himself to the owner, he is actually selling himself as well as the work of the district. Many people are inclined to make a judgment, based on their first reaction to such seemingly unimportant things as the way the operator enters the premises, the way he is dressed, or even by the way he introduces himself. Because we represent a governmental agency, there is apt to be some initial suspicion. Some may associate us quite directly with their tax bill, and it is up to us to convince them that they are getting their money's worth when it comes to mosquito control. They may have some apprehension that we might try to force them into making costly repairs on their property, such as correcting open drains or improperly-covered septic tanks. These are the kinds of situations where good public relations becomes an important part of our work.

It almost always pays immediate dividends to greet individuals with a friendly smile and a good word. We must be well informed technically and be able to express ourselves in a simple, direct manner. If we do not know the answer to a question it is best to say so, indicating that the information will be obtained and furnished to him promptly.

The San Joaquin Mosquito Abatement District does a great deal of work in urban areas. We do a large number of house-to-house inspections. In fact, during the summer months we hire 8 to 10 college students for this type of work. In the past four years, we have averaged between 25,000 and 30,000 inspections on individual premises. As a result of these activities we have gained a great deal of experience. In our daily inspections of premises, our field personnel locate many potential mosquito sources, such as open cesspools and septic tanks, improperly sealed tanks, and open wash drains. We make every effort to explain to property owners how they can correct their problems the easiest and most economical way. This is greatly appreciated and the response is good. The men are instructed not to discuss with others sources they have located in an area in the neighborhood. This can cause bad relations between neighbors as well as with the mosquito abatement district.

Answering service requests from people being bothered by mosquitoes is a real test of good public relations. One must learn to work with every type of individual. Whether it be a person of upper or lower socioeconomic class, a friendly individual or an abusive one, it is important that we treat people as we would like to be treated. A genuine effort should be made to correct any mosquito problem they may have. The person should be asked to notify the district office in a day or two if the situation is not significantly improved.

We should never forget that we are representatives of a service organization. This is where management plays an important part. During the months of February and March we conduct training sessions. One phase of our off-season training program is devoted to premises surveys and public relations. I should like to read just one paragraph from our training manual, which is issued to all employees.

"It must be remembered that you, as a District employee, will be dealing with the general public, and a good appearance and proper conduct is of paramount importance. Remember, you are the representative of the District to the many people you will see. Their impression of the District will be the impression you will leave with them, so make it a good one. A friendly smile, a pleasant greeting, and a helpful attitude will create a good impression of you, and make a good reputation for the District. The efficiency with which you find these mosquito sources will determine the degree of health and comfort of the people in the neighborhood. The manner in which you do this work will determine the attitude of the general public toward the District. The elimination of mosquitoes should produce a favorable attitude, but on the other hand, should there be any mosquitoes? The disapproval can be just as wide-spread."

The San Joaquin Mosquito Abatement District covers an area of 1,039 square miles. This area is divided into 24 zones with one mobile unit and field man assigned to each. If every one of these operators speaks to ten people a day, this quickly adds up to a total of 240 people per day, 1,200 per week, and over 5,000 per month. This is why we feel effective public relations is important in good mosquito control.

MOSQUITO SOURCE REDUCTION IN RICE FIELDS

CALVIN D. ROURKE
Sacramento County-Yolo County Mosquito Abatement District

Within the confines of the lower Sacramento and San Joaquin Valleys, 99.96% of the rice of California is produced. There are 325,000 acres, or a little more than 500 square miles of rice grown. Within this area live 2½ million people. These figures alone would suggest that a great amount of energy should be expended in the form of an effective source reduction program related to rice culture. In the Sacramento County-Yolo County Mosquito Abatement District, 12% of the states' rice is grown. This figure also includes the rice acreage of Placer County, which we control because of the close proximity to the communities of Sacramento County. This represents approximately 60 square miles of shallow, warm water covered with very dense vegetation and a generally continuous humid condition. The mosquito potential is certainly there and if left in this unnatural state, produces countless millions of mosquitoes.

People throughout the world associate mosquitoes with rice fields and this was probably true within our own Mosquito Abatement District until a few years ago. It was about this time we conducted a flight range and air current study from which we determined that the warm north winds, which are usually quite frequent in the summer months, would blow from the rice belt directly across the areas of greatest population. It was also noted that the rice field mosquito densities in our light traps increased during these north wind patterns. With this knowledge, the following year an extensive airplane larvicide program was embarked upon, supplemented by personal contacts with the rice growers.

We presented our case to the growers armed with a booklet which we made entitled, "Rice Fields and Good Mosquito Control Practices." This booklet contained photographs showing good and poor cultural practices. It also contained simple drawings, to accompany the photos, giving cross sections of existing conditions—good and bad. This booklet also makes reference to the items we consider basic with respect to good rice field culture, including (1) proper land preparation, (2) adequate border checks, (3) drainage of seepage water, (4) proper water management, and (5) weed control.

Under "proper land preparation" we discuss, in addition to the common things that go into preparing a field for growing rice, the idea of eliminating high or low areas. Neither is desirable from the agricultural standpoint since rice will not grow in deep water and the very shallow places, sometimes tapering to infinity, are conducive to growing weeds—and creating a high mosquito potential. We also recommend that a means for winter drainage be provided. This consists of a shallow drain ditch, the bottom of which is below the levee borrow pits. This ditch normally goes across the entire field bisecting the interior levees. At the end of the growing season the levees are blown out at these intersections forming a complete ditch which drains the field quickly and completely. If the field goes into rice the following year this ditch serves to drain off the spring rain water, allowing the grower to cultivate the field earlier than if no drainage were provided. This also eliminates the early season mosquito potential.

Adequate border checks should be considered along with land preparation; the objective here is to encourage building substantial levees to prevent seepage or to keep it at a minimum. If this is not successful, provision should be made for drainage for the seepage water. We usually observe larvae in seepage water 5 to 6 weeks before any are seen in the rice checks, so we are very concerned about seepage control.

It is generally accepted that it is to the grower's advantage to control his water carefully. An average accumulative total of 5 feet of water is used to grow a crop of rice in this area. With the rising cost of water and water application, it is not economical to keep a rice field at high water; that is, deeper than 8 inches. This is particularly important in our area where, during flooding adjacent farm lands. On the other hand, hold-the early stages of rice growth, it is not uncommon to have high winds; also, levee washouts sometimes occur, ing the water at a low state (below 6 inches) encourages growth of water grass and has cost many rice growers an average of 5 sacks of finished product per acre.

Weed control, as we discuss the subject, is concerned with weeds on the levees and outside the perimeter of the field. We consider this to be one of the most important topics discussed in our booklet, and it takes on added significance when the field goes into rice for two consecutive years. Unless the first year's weed growth is burned or cultivated out, the rank growth will provide excellent breeding grounds for future generations of mosquitoes.

Some growers are using sheep in their weed control programs. Sheep are fenced off in a portion of the field where they forage down the check levees, and they do this quite effectively. Levee compaction is also attained which helps eliminate a possible seepage problem. Occasionally, however, the sheep may compact the levee to a point where the water runs over the top. When this happens the rice grower wishes he had never thought of using sheep. In general the advantages of this practice apparently outweigh the disadvantages, particularly if the rice grower uses older ewes which do not need constant attention. An average of 5 sheep per mile of levee is recommended and grazing should begin when the weeds reach a height of 4 to 6 inches. If further growth is permitted, the sheep will not be able to keep up with them, and the practice then becomes a matter of doubtful value.

Our booklet is an effective means of communicating with the rice grower. We believe it is fundamentally accurate and we have had many compliments on it. It is in the process of being revised and should be printed by early spring.

An interesting and fairly recent development in rice culture, which looks very promising, is the use of plastic levees for the management of water. This use has been shown to be economically feasible, although at this time most rice growers are still using the earth levees. When the use of plastic levees is contemplated, it is necessary first to determine where the contours should be placed, just as if the earth levees were to be used. A furrow is then plowed on this contour. Stakes are then driven into the ground 2.5 to 4 feet apart depending on the thickness of the plastic used. The plastic is then attached to the stakes and the lower part of the plastic is covered by backfilling. This technique when perfected could be most beneficial to mosquito control, as well as to the rice grower. Despite the higher annual installation expense of the plastic levees, compared with earth levees, increased rice production can result in earnings of about one and one-half times the extra cost. Earth levees usually take from 5 to 16 feet per lineal foot of land out of production. By changing over to plastic levees this loss of productive land is virtually eliminated, since rice will grow all the way up to the plastic wall. Harvesting problems are minimized because the plastic levees and stakes can be laid down so the harvester can drive over them. The obvious benefit to mosquito control is the elimination of hundreds of miles of weed covered levees. Equipment for levee installation is still to be perfected, but it has been estimated that within ten years 20% of the rice grown in California will have plastic levees, and that this system will ultimately make soil levees obsolete.

What about the future role of rice cultural practices in California? I raise this question because of a circumstance which took place in our area last spring. Late spring rains prevented some of the rice growers from completing routine soil preparation and levee construction. It was a race against time and as the cutoff date for planting rice approached some of the growers saw they could not meet the deadline with properly prepared fields so they flooded them anyway. As a result many checks which were flooded were covered with dead, dense vegetation making it immediately an ideal breeding area for *Culex tarsalis*. Needless to say, we in mosquito control take a pretty dim view of this sort of practice. This practice of course does not conform to the recommendations of agricultural experts or mosquito abatement agencies; much to almost everyone's surprise, however, the crops produced apparently were quite good. This makes one wonder just how much seedbed preparation is necessary. Has this set a precedent for future rice cultural practices? We hope not. When the results of a survey being conducted by the Agricultural Extension Service are in and evaluated, we should then know.

There is an old saying to the effect that "... impossibilities recede as experience advances." I would like to relate very briefly our experience with mosquito fish in rice fields. I like to think of this as a method of source reduction even though we are not eliminating the potential source area. I know that the use of *Gambusia* is not new in mosquito control, but with the adverse publicity we all have been receiving relative to the use of highly toxic insecticides, our district embarked on an extensive biological control project using fish. The results were almost phenomenal. We were able to plant only 83 rice fields with mosquito fish; of these, however, only 5 needed minor chemical control work. It would require approximately 6,000,000 fish to plant all our rice fields and we know we shall not reach that goal this year. We plan, however, to expand our facilities because we feel we are on the right track. This practice has the wholehearted approval of the rice grower since at certain stages of rice growth many of the farmers do not want any type of insecticide applied. I mentioned earlier that last year some of the growers flooded land for rice in which levees had been thrown up in a hurry with no time at all for preparing the checks. This created a most unusual problem; however, it was in this type of problem that our mosquito fish appeared to do their best. A balance had apparently been reached and we felt quite relieved. We are not offering this fish planting program as a panacea to your rice field problem, but we have been impressed with our results. This is all I want to say at this time about our fish planting program. Two other speakers later in the program will elaborate on other phases of the subject and present some very interesting data.

Rice growers, in general, are easy people to deal with. This may be true for several reasons. They realize they are spreading tremendous amounts of water over the countryside and may possibly feel indebted for the work we are doing. Also, they usually have equipment on hand so that it is no real problem to cooperate in response to our requests. We appreciate their consideration of the mosquito problem. There are times though when we have to live with poor land preparation, unscheduled flooding, and other unusual conditions. We expect these problems occasionally, but we have also learned that there is no substitute for good cultural practices. Well planned, properly managed rice fields are a prerequisite for successful mosquito control.

MOSQUITO SOURCE REDUCTION IN ORANGE COUNTY URBAN AREAS

ALBERT H. THOMPSON, JR.
Orange County Mosquito Abatement District

Source reduction in Orange County includes several types of operations designed to meet the specific problems of this rapidly developing urban area of over 1,000,000 people. Broadly speaking, our source reduction program is based on close cooperation and the furnishing of technical information for the control and prevention of mosquito sources.

Flood control is one of the more important operations directly affecting the operations of the Orange County Mosquito Abatement District. For this reason we work in close cooperation and collaboration with the Orange County Flood Control District in the design of new channels which will not produce mosquitoes.

A few years ago we surveyed all existing flood control channels. This revealed many pockets created by faulty construction in which mosquitoes were breeding. Based on these findings, in cooperation with the Flood Control District and its maintenance field staff, we corrected the existing faulty structures. In some channels, for example, we recommended a V-slope, so that water is concentrated into the smallest possible area. In other channels the bottom is flat.

The Flood Control District has a very good weed control program. When channels become choked with weeds, the maintenance division clears them with heavy equipment. The V-sloped concrete bottom may become filled with dirt and debris; this is also cleared with heavy equipment. After all this work is accomplished, it is still necessary at times to use our jeeps and power spray equipment to treat remaining sources on channel bottoms.

For treatment, we use fenthion granules and a granule gun. The operator either rides or walks down the channel, depending on the channel width.

We work in direct cooperation with the 24 city street departments throughout our district on community street drainage. This type of drainage often calls for sumps from which excess water is pumped into a flood control channel. Sumps are potential mosquito producers at all times.

Water spreading operations in Orange County sometimes create problems. With the shortage of water in this area, we get a continuous flow into our district from the Colorado River. Again, in cooperation with the Orange County Water District, we assist in the design and operation of water spreading systems in order to minimize mosquito sources. Percolation into the underground is obtained in areas such as the Santa Ana River bed or in special retaining basins. We introduce *Gambusia* fish into the basins as soon as they have water, and as a result we have never had any significant mosquito problem in them. We do have trouble with other insects, particularly chironomids. We do not assume responsibility for chironomid control, but we do work in conjunction with the Flood Control District in helping them in the control of these pests.

When silt accumulates in the retaining basins, water will not percolate into the underground. Because of this the basins are periodically drained and allowed to dry, thereby eliminating chironomid larvae. Bulldozers are used to remove the silt. When this operation is completed, the basins are refilled. On one occasion a holding basin was filled without our knowledge, and we got complaints from the surrounding area which contained some 15,000 people. As an emergency operation we did spray this one. The Water District then came in, drained the pond, and cleaned out all weeds including those on the banks; since then we have not had any further problem.

A county disposal site for logs and other refuse has given us some trouble. Originally it covered an area of 30 acres. A large power company originally came in to build a plant and considerable fill was required for this construction. The company dug a large pit about 50 feet in depth. Subsequently it was filled with water, at which time we planted *Gambusia* in it. As long as it remained in this condition there was no problem. In time, however, the pit was turned over to the county for use as a disposal area. All kinds of trash, junk and logs were brought in. By working with the County Trash Disposal Department we have managed to keep this pond reasonably free of mosquitoes, although we did have to spray it. It is several thousand feet around this pond, so it is important that we get our spray equipment to the edges for effective treatment. This is made possible by the County Trash Disposal Department's use of a bulldozer to push the material into the pond; we follow behind and spray the edges. We also use a mist blower in order to reach the central areas of the pond.

With the population growth in Orange County, dairies are moving out one by one. Sometimes a dairy goes out of business, but some of the old installations remain. We have had to keep these places under surveillance, and in so doing have found huge catch basins and irrigation lines with heavy mosquito breeding.

Disneyland cooperates closely with our organization. We make necessary inspections and provide a training service. It is not necessary for us to do any spraying in the area; Disneyland personnel who are trained by our staff do all of the control work that may be required.

Back yard sources are a severe problem in our area. In Orange County I would estimate that there are 50 to 100 swimming pools constructed each month. As the new pool is built, the contractor wets the concrete and lets it stand with water in it for several weeks to cure the concrete before he returns to plaster it. Frequently we have a pool filled with water on the property with a vacated home. While the home is vacated the electricity is off, there is no filtration, and no acid is added to the water. The pool becomes stagnant, and soon the entire top will be covered with larvae and pupae, and adult mosquitoes will soon be seen all around the area. Our program is to spray the pool with a fly spray formulation and plant *Gambusia*. The zone operator records this place in a book and inspects it every two weeks until the home is occupied, after which it is no longer scheduled for routine inspections.

Plastic pools are frequently a problem. There is no way to drain the water from these pools except to let it run out on the ground.

Finally, I might mention that the Orange County Mosquito Abatement District operates an exhibit at the County Fair each year. Our theme is "Mosquitoes Can Develop in Your Back Yard." We have a motion picture, "Life Cycle of the Mosquito," which is shown every 15 minutes. We also show a Walt Disney color film. At the exhibit we have the various stages of the mosquito life cycle, from egg to adult, and we demonstrate mosquito fish in action. Incidentally, we also take service requests.

ESSENTIAL SAFETY MEASURES IN APPLYING MODERN INSECTICIDES

Jack Fiori
San Joaquin Mosquito Abatement District

Mosquito abatement personnel working with insecticide sprays, such as the organic phosphates, must be very cautious when handling and applying these toxic materials. It is most important that operating personnel be guided by rigid rules and regulations, and that they be provided proper equipment for handling these kinds of formulations. Spray equipment should be in top working condition and should have proper hose connections to prevent any leakage which might result in the exposure of humans or animals. Vehicles should be fully equipped to carry insecticides with complete safety to and from the field, both concentrates and emulsions. Each vehicle should be equipped with a pair of heavy-duty rubber gloves and plenty of soap. The gloves should be inspected periodically for small cracks or holes.

Some districts using parathion only find it satisfactory to carry emulsions in their field units. This eliminates extra handling and reduces the possibility of operators becoming contaminated. Under these procedures it is necessary to establish sub-stations throughout the district equipped with large tanks for filling. There are undoubtedly both advantages and disadvantages in this system.

In the San Joaquin Mosquito Abatement District, we have been using organic phosphates, mainly parathion and malathion, for several years. During this period we have been very fortunate not to have any serious accidents. The District has strict rules and regulations which it expects operators to follow in handling and applying these insecticides. A simple but thorough training program to demonstrate correct methods for handling and loading insecticides is basic to any responsible abatement program. It is very important for district administrators and supervisors to be completely aware of the work habits of all personnel. When a group of men are handling insecticides, there is always the possibility that someone will become careless. This is the reason most accidents occur, and such individuals require close supervision; they should be observed while loading their spray tanks, while checking their equipment, and even to see that they wash after loading.

Clean clothing is very important. During the larviciding season, spray operators should be encouraged to change clothing and shower daily.

Everyone working with insecticides should be taught the importance of reading labels carefully before handling or applying these toxic materials.

It is most important to have proper facilities for the disposal of empty containers. Under no circumstances should empty containers or bags be left in the field.

Each man should know exactly what to do in case of accident. For example, a hose may break, spraying the operator with emulsion, or he may spill concentrates on his clothes. Office personnel must also be thoroughly briefed on what to do in case of an emergency. Proper antidotes should be available at all times. The district should make arrangements with several physicians, as well as with local hospitals so that any emergencies due to insecticide poisoning can be met without delay. In our agency blood tests are given to employees before each spray season and again mid-way through the summer in order to detect any possible significant changes in cholinesterase levels.

When operators are spraying in the field, there are many potential dangers. Each man must be certain that his spray equipment is in good condition. Proper nozzle arrangement and proper pressure are important considerations, and will reduce the possibility of overdosing. It is very important that the operator possess a thorough awareness of surrounding crops, as well as poultry and other livestock. The presence of beehives in the area will, of course, require special precautions.

If one uses common sense and follows directions when handling and applying insecticides, he can expect to remain healthy. It is the individual who becomes careless, or thinks it unnecessary to follow rules and regulations, who is apt to create a problem.

CONTROL OF TREE-HOLE MOSQUITOES IN ALAMEDA COUNTY

Thomas Brannan
Alameda County Mosquito Abatement District

The tree-hole mosquito, *Aedes sierrensis*, is one problem that most of us here have in common. There is no question about this being a high priority control need in the San Francisco Bay Area.

In Alameda County, in the late 1940's and early 1950's, it became apparent that a large percentage of our service requests were for tree-hole mosquitoes. We tried a number of control techniques; the best at that time appeared to be one of filling the holes with sand and cement. The project started with the tree-lined streets of Alameda, Berkeley, Oakland and San Leandro. It was not long, however, before we determined that this was not the answer. First, this procedure took too much time, and also we began to find that the holes continued to decay around and under the concrete and breeding was as bad as ever in many of the holes.

In 1956 this, plus the movement of so many people into the Oakland and Berkeley hills, made it obvious we had to come up with a more efficient and effective control program. We divided the area into three parts, each to be treated every three years. Starting with the areas from which the most service requests had been received, we dusted the holes with 50% wettable DDT powder. This resulted in good control, but on windy days it was a hazard to have the powder blowing in the operator's face. Next we tried pellets. They, too, gave good control, but could not be readily seen in the tree-holes. This made it almost impossible to avoid some duplication of work. The next material tried, and the one still in use, is a special 100-mesh 50% wettable granular DDT. This material does not blow around so easily and can be seen in the tree-holes.

We found *Aedes sierrensis* breeding in almost all types of trees, as well as in tin cans, watering troughs, old tires, pits, boats, and many other interesting locations, including a nature camp. The worst breeding in the hill areas is found in the second growth *Eucalyptus* stumps.

Each operator is furnished a pair of coveralls with letters, three inches high, spelling "Mosquito Control", on the back for identification. Also furnished is a canvas bag, a tablespoon to measure applications, and a stick about three feet long to clean the debris out of holes. This is all the equipment that is needed for this type of mosquito control.

We have had good control for three years in all areas but one. This area had been burned and we found breeding the second year after treatment. We find that this type of control operation for the hill areas (where you have to be part monkey and part mountain goat to cover the area) works very well. In 1957 we did not receive a single service request in the area treated, and last year received only two.

Each operator can treat about 250 holes a day. Last year we treated over 20,000 holes, using 700 pounds of 50% DDT.

On the tree-lined streets where we formerly used sand and cement, we have found the best control to be a 25% DDT emulsion, applied every three years. Equipment includes a 25-gallon compressed air tank and a 15-foot aluminum wand with a swivel, nondrip nozzle. With the operator standing in or on the truck, and with a pressure of 15 to 20 psi, we can reach a spray height of 25 to 30 feet.

This spray program has become quite standardized and does not change very much from year to year. The residential areas are extending out further into the hills each year, however, so we just move our tree-hole treatment operations out enough to keep up with this expanding problem.

THE USE OF *GAMBUSIA* FISH IN THE CONTROL OF RICE FIELD MOSQUITOES

Jack Fowler
Sacramento County-Yolo County Mosquito Abatement District

Fish husbandry is older than the written word. It was practiced in China more than 4,000 years ago. Of particular interest, the Chinese incorporate fish raising with rice growing in the rice paddies. With each rice harvest a substantial yield of fish per acre is also harvested. As a result, if the supply of fish from rice fields were suddenly cut off, the diet of millions of people would be severely affected.

The technology of mosquito abatement has benefited in another way through the use of fish *(Gambusia affinis)* in rice fields. The result has been a means of naturalistic control of mosquitoes. It is possible that *Gambusia* may offer some additional advantages, such as providing a source of fertilizer for rice production.

The present goal of the Sacramento-Yolo District is to control mosquito breeding in rice fields through the exclusive use of mosquito fish. During the past year we greatly expanded this phase of our control program. Our only limitation was the number of fish available for planting. We believe this to be the most desirable method for control of mosquitoes in rice culture. During the 1963 season approximately 35% of our rice fields were planted with an estimated total of 1,257,300 *Gambusia*. This program has been an outgrowth of a more limited effort by the District dating back to 1957.

There are several factors which have influenced our decision to intensify the use of fish in rice fields for mosquito control. Prominent among these considerations has been the desire to (1) minimize chemical spray operations, (2) reduce costs by eliminating repeated chemical treatments, and (3) provide the most effective control possible.

In our increasingly complex environment the elimination or substantial reduction of chemical insecticide use, whenever possible, is a desirable goal. In the hot rice growing regions an enormous adult mosquito population can usually be anticipated. Larval counts can increase rapidly, necessitating repeated chemical applications. In the Sacramento-Yolo District we have sprayed many rice fields five times or more in one season. When a rice field is inspected and the larval count justifies treatment, there are often by that time four stages of mosquitoes present.

Our experience has shown that in fields adequately planted with *Gambusia*, large mosquito populations do not develop. For example, of 83 rice fields planted with *Gambusia* in 1963, only five developed an average larval density of as much as 0.5 per dip during the long rice growing season. Although mosquito larvae were found in some of our fish-planted fields, pupae were very rarely seen. This maximum of 0.5 larvae per dip was observed once in each of four fields surveyed and twice in a fifth field.

Successful control using mosquito fish in rice fields is contingent upon two important factors: (1) elimination of significant mosquito sources adjacent to the rice field, and (2) good rice farming practices by the grower, including proper disposal of waste water.

The importance of proper handling and planting of *Gambusia* cannot be overemphasized. Our experience has shown that certain methods and techniques are essential in assuring maximum numbers of active fish by the time the rice plants emerge above the surface of the water. Some of the more important requirements are (1) adequate feeding of fish in the winter holding ponds, (2) good fish recovery areas in ponds, (3) proper seine sizes to collect only adult fish, (4) fast and careful transporting of collected fish, (5) proper distribution of fish in the rice field, and (6) controlled feeding of planted fish for a limited period in some situations. Under ideal conditions, 200 mature *Gambusia* planted in a rice field will result in 4,000 to 8,000 fish within a 30-day period.

In a large fish planting program there should be a salvaging program in the fall in order to restock winter holding ponds. Again, certain methods should be followed for efficiency and to avoid failure. Choice of nets and minnow traps, and selection of the best collection areas are important considerations. Methods of separating *Gambusia* from rough or game fish, if they are present, before restocking the winter holding ponds also require careful planning. All of these points that I have barely touched upon are extremely important. Proper equipment and precision timing are essential and may mean the difference between success and failure in the use of fish for the control of mosquitoes in rice fields.

To illustrate the continuing husbandry necessary, at the present time (January) we are seeding *Gambusia* in temporary rain pools, drains that are normally dry until this time of year, and any other water that may provide potential mosquito sources in the early spring. Roadside ditches are planted as soon as they contain water. This is true also for intermittent streams that otherwise would have to be hand-sprayed every ten days. In some instances these same areas are used as sources of *Gambusia* for the rice field mosquito control program.

In the paper which will follow, Dick Russell will discuss in greater detail some of the operational phases of the fish planting program.

OPERATIONAL CONSIDERATIONS IN A LARGE *GAMBUSIA* PLANTING PROGRAM

Richard Russell
Sacramento County-Yolo County Mosquito Abatement District

It is a pleasure to have this opportunity to talk to you on the techniques employed in the Sacramento-Yolo District's *Gambusia* program. This is the phase of mosquito control that I take greatest interest in and try to facilitate in every way possible.

Since Jack Fowler has only generally covered the use of fish by our District, I will given some details on the rice field program. This past season the District expanded its fish program with the goal one of planting as many rice fields as possible, limited only by the number of fish available. As mentioned by the previous speaker, this planting included some 35% of our rice fields.

A program of this magnitude presents many problems. There is the matter of a source of supply for the number of fish needed, the methods and equipment for collecting and transporting fish with minimum mortality, and the matter of determining the number of fish per acre that will be required to effect satisfactory control. The experience gained from handling fish over the past five or six years has, we believe, given us the answers to most of these questions.

In the third week of May last year we started planting fish in rice fields. Fish were taken from our hill reservoirs along the west side of the district; these had been planted with fish in April of 1962. Our fishing crews consisted of three men, two using a seine and the third transferring the fish as they were caught over to the pickup truck where they were counted and placed in transporting containers. Our equipment for this recovery phase consists of a 4 by 15-foot seine with a 3/16-inch mesh. A seine of these dimensions allows the men to move through the water fast enough to trap the larger fish, while those ½ inch or shorter are allowed to escape.

With this method of seining the crew works along the edge of the reservoir up to the inlet channel or to the shallow end. When sufficient fish are caught in the seine, they are poured into commercial minnow buckets and taken to the transporting vehicle. A 4-inch kitchen sieve will hold about 500 medium sized fish. This has been found to provide a reasonably accurate count.

Two types of transporting containers have been found satisfactory. One procedure is to use two 50-gallon drums with the top cut out; these are wrapped with burlap to reduce temperatures. We have found that from 25,000 to 30,000 fish may be held in each drum. In lieu of this, we have also used either four or six 10-gallon milk cans with lids. Each can will hold 5,000 to 6,000 fish.

Air is supplied by either a small motor-driven compressor or by an electric fuel pump. Plastic tubing or windshield wiper hose may be used to convey the air from the source of supply to aeration stones in the bottom of the containers. A surgical hose clamp placed near the top of each tube acts as an air metering device. The optimum amount of air emitted from each stone will be seen as a heavy stream of small bubbles. Too much air will create a heavy turbulence, with very little oxygen being dissolved in the water. Time becomes a very important factor at this stage. We have found on hot days, even with aeration, that fish will begin to die in about one hour.

The number of fish per acre needed for adequate control in rice will vary with circumstances. Our experience has shown that if a rice field has been carefully cultivated and its levees or checks are clean, and if there is no emerging vegetation in the seed bed, an initial planting of 150 fish per acre will give very good control. On the other hand, in a very dirty field, or one with high grass or weeds on the checks and a poor seed bed, even 250 to 300 fish per acre may not give good mosquito control. Thus it can be seen that the cultural practices observed by the farmer play a very important role in any control program utilizing predatory fish.

For a fast, efficient job of fish planting a three man crew is imperative. Considering the number of specific tasks in collecting, transferring, transporting, and planting, this is a minimum personnel requirement if you want to stay safely within the recommended maximum one hour holding period. It is well to leave time to plant a few fish in seepage areas outside the rice field. Careful advance planning of the route to be taken to the rice area will help to reduce the holding time.

Close contact with the rice grower should be maintained during the first four to six weeks after planting fish in his field, since it is during this period that he may have to spray for pests, or undertake chemical weed control. Some of the chemicals commonly used are, of course, toxic to fish. This contact with the farmer sometimes enables us to suggest a chemical that is nontoxic to fish. As a last resort, we can plan a replanting program. A weekly check on the progress of the fish should be maintained throughout the season. All drainage water from the rice field should also be inspected. Fish will move into these drains and in most cases larviciding will not be necessary. For example, last season I had planted fish in all of the rice fields within my zones. Around the middle of July a survey of the dispersal of the fish showed an estimated 57 miles of ditches and sloughs that did not have to be larvicided. Based on a ten-day zone circuit, a very substantial saving can be realized in this way. Also, some of the fish will collect at the lower side of the last spill box; these provide a good source of supply for any additional planting to be done in the area.

Since we are working with hundreds of thousands of fish in our rice program, a salvaging or recovery operation in the fall is very important. The purpose of this program is to restock to capacity all available overwintering holding ponds to insure an adequate supply of fish for the coming rice season.

The method of recovering fish from the rice fields differs from the planting operation. A long handled dip net, or scat net, is used instead of a seine. Collecting is done at the lowest point in each check, and a careful inspection is necessary to separate rough or game fish from the *Gambusia.* In some areas minnow traps can be used in the spill ditches leading from the fields or in adjacent culverts. From 10,000 to 20,000 fish have been trapped in this manner during a four hour period.

The final consideration that should be mentioned in connection with an effective fish program is the importance of adequate holding ponds. Since our district utilizes reservoirs in the hills, a snag clearing program is conducted in the fall. This calls for removing trees and snags and piling the brush well above the high water mark.

Also, a weekly feeding program is started when the ponds are stocked to capacity. This program continues until heavy rain run-off is observed. Feeding is resumed three or four weeks prior to the spring fish planting program. This encourages the fish to move into the seining areas.

It is our belief that in *Gambusia* we have a useful, natural control weapon. It is up to those of us engaged in mosquito control to put this tool to work in the most effective way possible.

To those agencies who may wish to embark on a large-scale fish planting program such as ours, we wish to say that the records, experience, and what knowledge we have will be available to you at any time.

FOURTH SESSION

TUESDAY, JANUARY 28, 1:30 P.M.

William L. Rusconi, *Presiding*

PANEL: WHAT NOW IN CHEMICAL MOSQUITO CONTROL

T. G. Raley, *Moderator*

ORGANOPHOSPHORUS RESISTANCE IN CALIFORNIA MOSQUITO LARVAE

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California, while recognized for its contributions to mosquito control technology, also occupies a prominent position in respect to insecticide resistance. Resistance to mosquito larvicides in California has become a real and immediate problem in some areas, particularly with the pasture mosquito, *Aedes nigromaculis* (Ludlow).

Resistance was observed shortly after the chlorinated hydrocarbon insecticides had attained widespread use following World War II. DDT resistance was first reported in California in 1949 in Kern County (Smith 1949). Later the same year resistance to this insecticide was confirmed for *A. nigromaculis* larvae from Tulare County (Bohart and Murray 1950). By 1951, resistance in both *Culex* and *Aedes* had been confirmed for DDT, toxaphene, lindane, and aldrin in treated areas of the southern portion of the San Joaquin Valley (Gjullin and Peters 1952). After this, organophosphorus compounds gradually replaced the chlorinated hydrocarbons as larvicides in California.

The first confirmation of organophosphorus resistance in mosquitoes came from Fresno County in 1956. Larvae and adults of *Culex tarsalis* Coquillett from several locations in Fresno County were found to be highly resistant to malathion after about two and one-half years of use (Gjullin and Isaak 1957). The first recorded resistance of *A. nigromaculis* to parathion was reported from Kings County in 1958 after about six years of use (Lewallen and Brawley 1958). The following year, tests on the same species confirmed resistance to parathion in both Tulare and Kings counties (Lewallen and Nicholson 1959). Since this time, resistance of *A. nigromaculis* to organophosphorus compounds has been confirmed for Kern, Tulare, Kings, Fresno, Stanislaus, San Joaquin, and Sutter counties.

During 1963 a survey was made to determine the extent and degree of resistance to parathion, methyl parathion, fenthion, and malathion in California. Effort was directed primarily toward *A. nigromaculis* larvae in the Central Valley. Limited testing of *Culex peus* Speiser, *C. pipiens* L., *C. tarsalis* and *Aedes melanimon* Dyar was also done.

Recorded susceptibility levels of mosquitoes in California have been reviewed for the 11 year period, 1949 to 1960 (Barr 1962). Much of the information presented in the review was gathered from selected areas. The larvae tested were either known control problems and resistant, or were from untreated sources and assumed to be susceptible. During the present survey, where possible, larval collections from controlled areas included both problem and nonproblem sources. The information presented here was based on sampled areas only and does not include all cases of resistance suspected. The purpose of the investigation was to determine the general levels of susceptibility in treated populations, as well as the extent of the resistance problem in California.

Testing Procedure

Larvae were collected in the field and transported to the nearest available laboratory for testing. Susceptibility levels were determined for fourth instar *Aedes;* some late third instar larvae were included in the tests on *Culex*. Tests were conducted as described by Lewallen and Nicholson (1959).

Resistance Levels

Base line information used for comparison in determining levels of resistance, where possible, was established by testing larvae known to be susceptible. *A. nigromaculis* and *A. melanimon* have not been colonized, thus necessitating the use of field-collected larvae. Because of extensive use of insecticides in agriculture as well as mosquito control, it was difficult to obtain susceptible larvae; therefore base lines established several years ago were used. Susceptible colonies of *C. tarsalis* and *C. pipiens* are maintained at the Fresno laboratory for comparative purposes. Although variations as great as ten-fold have been found for different susceptible colonies of the same species (Lewallen 1961), comparable results are obtained when larvae from the same source are used routinely. Comparatively little testing of *Culex* larvae was done in 1963. From results obtained for the three species tested, organophosphorus resistance apparently was not widespread. Resistance was found only in isolated areas and at low levels. The highest ratios of resistance, for the species of *Culex* tested, were to malathion—and these only five or six-fold at the LC_{50} level.

Culex peus.—Larvae of *C. peus* have not been extensively tested and base line information for untreated populations is not available. The levels used for comparison are the lowest recorded for larval collections from treated areas.

Table 1 is a summary of LC_{50}'s recorded for C. *peus* in 1963. The highest and lowest recorded level for each insecticide is given, as well as a ratio of the the two. There was no evidence of a high degree of resistance to any of the compounds tested. Larvae from the Hayes Avenue location (Fresno County) were found to have an LC_{50} of 0.072 ppm to malathion. A low level of resistance may be indicated by this six-fold increase in tolerance, compared with larvae from King County.

Culex pipiens.—In 1963 the highest recorded levels for *C. pipiens* came from larvae in the Fresno and Turlock (Stanislaus County) districts (Table 2). The increases in LC_{50}'s vary from two-fold for methyl parathion to five-fold for malathion.

Larvae from the Fresno Sewer Farm, while showing a low ratio of resistance in the laboratory, were not readily controlled in the field with parathion or malathion. The LC_{50} of fenthion for *C. pipiens* larvae was comparatively high, yet control was possible using this insecticide. The high organic content of the water at this location may have made control more difficult. The superiority of fenthion in this situation is compatible with laboratory tests which showed that this material was more effective in polluted than in tap water (Lewallen and Wilder 1963).

Table 1.—*Culex peus*—LC_{50}'s (ppm)

	Parathion	Methyl Parathion	Fenthion	Malathion
Highest recorded level—1963	0.0041	0.0044	0.0054	0.072
Control agency identification	Fresno Hayes Ave.	Turlock Steen Strip	Turlock Steen Strip	Fresno Hayes Ave.
Lowest recorded level—1963	0.0015	0.0016	0.0019	0.012
Control agency identification	N. San Joaquin Victor Road	N. San Joaquin Davis Road	N. San Joaquin Davis Road	Kings Armona Rd. & 198
Ratio = highest / lowest	3	3	3	6

Table 2—*Culex pipiens*—LC_{50}'s (ppm)

	Parathion	Methyl Parathion	Fenthion	Malathion
Highest recorded level—1963	0.0060	0.0045	0.0070	0.14
Control agency identification	Fresno Sewer Farm	Turlock Linwood	Fresno Sewer Farm	Fresno Sewer Farm
Base line Bakersfield (lab. colony)	0.0015 (1958)	0.0023 (1962)	0.0023 (1959)	0.026 (1958)
Ratio = highest / base line	4	2	3	5

Table 3.—*Culex tarsalis*—LC_{50}'s (ppm)

	Parathion	Methyl Parathion	Fenthion	Malathion
Highest recorded level—1963	0.0043	0.0049	0.0064	0.098
Control agency identification	Consolidated Carreiro	Sacto-Yolo Howard	Tulare Beaver Slough	Fresno Hayes Ave.
Base line lab. colony	0.00047 (1957)	0.0020 (1962)	0.0010 (1959)	0.016 (1957)
Ratio = highest / base line	9	2.5	6	6 (LC_{90}-41)

Table 4.—*Aedes melanimon*—LC_{50}'s (ppm)

	Parathion	Methyl Parathion	Fenthion	Malathion
Highest recorded level	0.018	0.0038	0.0030	0.071
Control agency identification	Tulare (1961)	Diablo Valley B. F. Porter (1962)	Colusa Terhel (1963)	Sutter-Yuba Betty Ranch (1963)
Base line (susceptible)	0.0008	0.0019	0.0023	0.034
Source identification	Merced Duck Club (1961)	Colusa Butte Creek Farm (1963)	Colusa Harbison Rd. (1963)	Colusa Harbison Rd. (1963)
Ratio = highest / base line	22.5	2	1.3	2

Culex tarsalis.—High levels of resistance to parathion, methyl parathion, and fenthion were not detected by tests conducted this year on *C. tarsalis* (Table 3). Resistance to malathion was confirmed for the Hayes Avenue strain. This area was one of five treated areas in Fresno County found to be highly resistant in 1956 (Gjullin and Isaak 1957). At the LC_{50} the larvae were only five times as resistant as the laboratory strain, but at the LC_{90} they were 41 times as resistant. Higher ratios at the LC_{90} were not found for other *Culex* tested.

Aedes melanimon.—Organophosphorus resistance of *A. melanimon* was not encountered in 1963. The only record of such resistance in this species is a parathion resistant strain from a pasture in Tulare County tested in 1961 (Table 4). At this time the LC_{50} was 0.018 ppm, which was about 23 times as great as that of larvae from an area in Merced County used for comparison. The larvae from Sutter-Yuba were a mixture of *A. melanimon* and *A. nigromaculis.* This population was also found to have an LC_{50} of 0.01 ppm to parathion, an increase of 12-fold, but were not considered a control problem by the district. The larvae from the Merced Duck Club are from a controlled area, but at the time of testing had been treated infrequently. The larvae from the Colusa location are from uncontrolled areas.

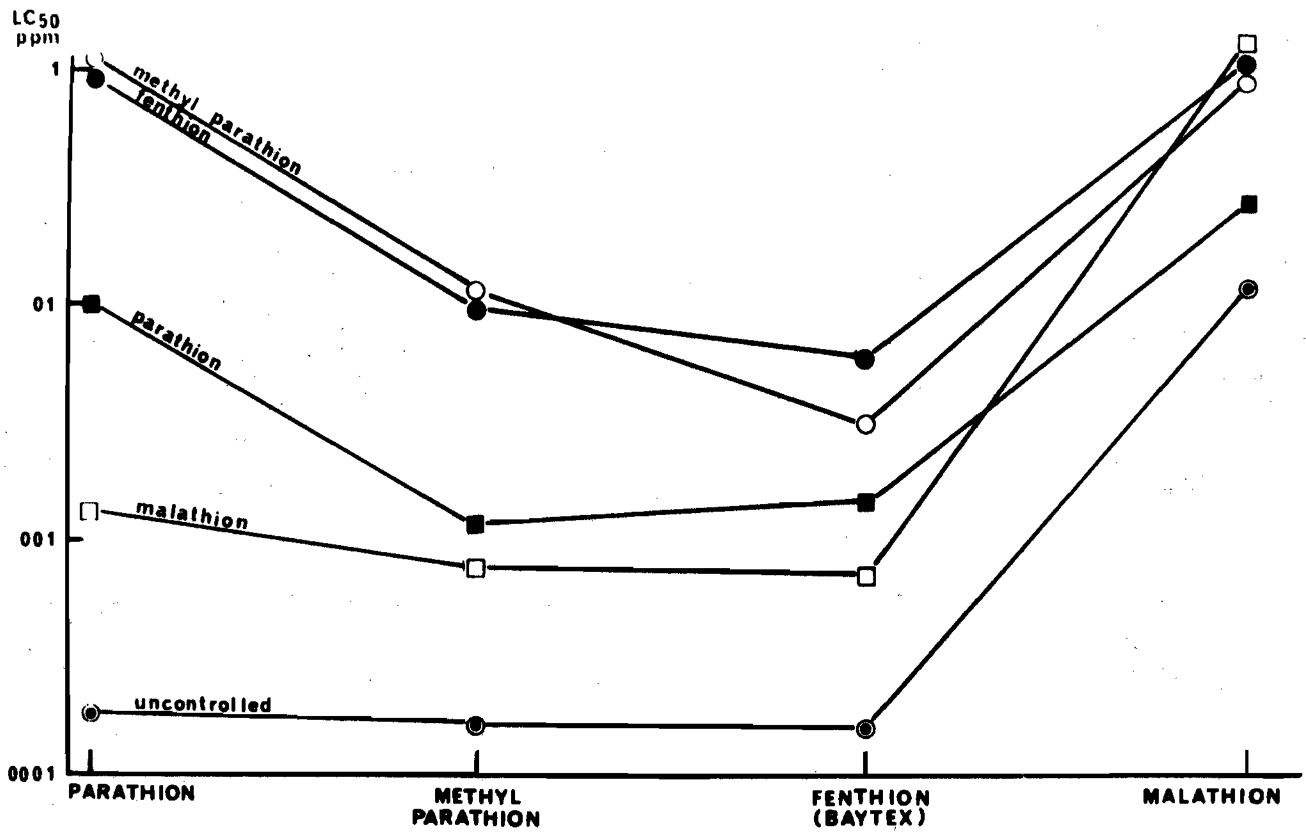

Fig. 1—Cross-resistance levels of *Aedes nigromaculis* larvae treated with four organophosphorus compounds.

Aedes nigromaculis.—Resistance of *A. nigromaculis* to parathion, methyl parathion, and malathion was confirmed in 1963 for certain areas. Fenthion was used as a substitute insecticide in several problem areas, and while there has been an increase in tolerance as great as 27-fold, there have been no apparent control failures.

The highest over-all levels of resistance originated in areas with a past history of organophosphate resistance which have been treated with several compounds (Fig. 1). Shown are LC_{50}'s of five different populations to four organophosphorus compounds. Each line represents a population treated with a different insecticide, as well as the levels of a susceptible population from an uncontrolled area.

Resistance in *A. nigromaculis* has been shown to be nonspecific in that it extends to all four of the organophosphorus compounds. Resistance to any one of the compounds will induce tolerance to the others (Brown, Lewallen, and Gillies 1963). *C. tarsalis* differs from *A. nigromaculis* in that its resistance to malathion did not extend to the other organophosphorus compounds tested (Darrow and Plapp 1960).

Treatment of larvae with malathion resulted in increased tolerance to all four compounds, but especially to malathion, with resistance of 12-fold over the susceptible population shown. The line given as an example of the susceptibility when parathion was used as a larvicide shows a moderate degree of resistance to parathion, about 37-fold. Higher LC_{50}'s were again found for the other compounds tested. The susceptibilities shown for the populations treated with methyl parathion and fenthion are almost identical except for the difference in susceptibility to fenthion. Both populations tested were highly resistant to parathion, methyl parathion, and malathion.

In 1963 parathion resistance was confirmed for *A. nigromaculis* in Sutter-Yuba, East Side, Turlock, Fresno, Delano, and Kern mosquito abatement districts (Fig. 2). Kings, Delta, and Tulare districts changed to methyl parathion several years ago because of parathion resistance. Populations with an LC_{50} of less than 0.005 ppm were considered susceptible, LC_{50}'s in the range of 0.005 to 0.01 ppm as moderately resistant, and levels greater than 0.01 ppm as highly resistant. In the northern portion of California parathion resistance appeared to be restricted to small areas and the degree of resistance was much less than was found for *A. nigromaculis* in southern San Joaquin Valley where resistance to parathion has been apparent since 1958.

Methyl parathion resistance of *A. nigromaculis* has been confirmed for the three districts shown, Tulare, Kings, and Delta, as well as for Kern (Fig. 3). On the map shown LC_{50}'s of less than 0.003 ppm represent susceptible populations, those of 0.003 to 0.005 ppm represent populations with a low degree of resistance, and those with LC_{50}'s greater than 0.005 represent populations which are consistently difficult to control.

Resistance to methyl parathion was first recorded in 1961 from two pastures near Ivanhoe in the Delta Mosquito Abatement District; populations from these areas at that time had LC_{50}'s of 0.0040 and 0.0082 ppm. In 1963 one of these had an LC_{50} of 0.010 ppm, 32 times as great as a susceptible strain. In 1962 the Kings District reported control difficulties. The LC_{50} was found to be 0.0056 ppm. At the beginning of the 1963 season, an LC_{50} of 0.0030 ppm was determined for the same pasture, which was still a control problem. From this it would appear that failures are first experienced at an LC_{50} of about 0.0030 ppm when methyl parathion is applied at 0.1 lb/acre.

Methyl parathion resistance has only been confirmed south of Kings River, along the Kings-Tulare county line. The area is intensively controlled by three adjacent districts, its soil is alkaline, and its principal crop is irrigated pasture. High levels of resistance were found in the areas controlled by the three districts, yet comparatively susceptible populations were found which had been treated in the same manner as those from resistant areas. Some of the populations with LC_{50}'s of less than 0.003 ppm were no more tolerant to methyl parathion than were susceptible larvae from uncontrolled areas. This was particularly evident in much of the Kings District. Fenthion is being used as a larvicide by Kings and Delta districts in the highly resistant areas and is still effective. If increases in tolerance to the insecticide continue, control difficulties may be experienced during the 1964 season.

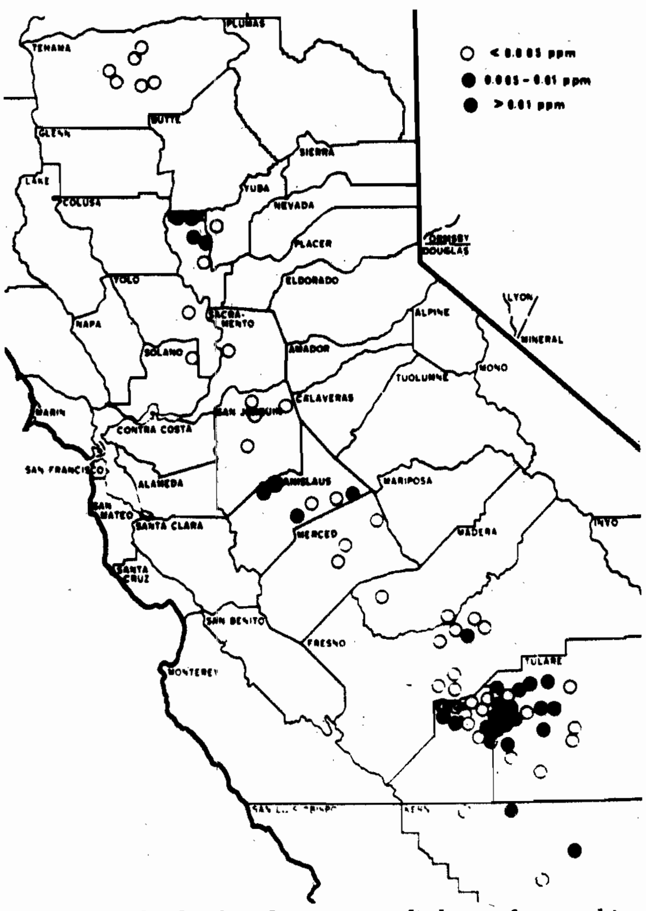

Fig. 2—LC_{50} levels of *Aedes nigromaculis* larvae for parathion in California, 1963.

Test Kits

Susceptibility test kits, containing a wide range of parathion concentrations were made available to Cali-

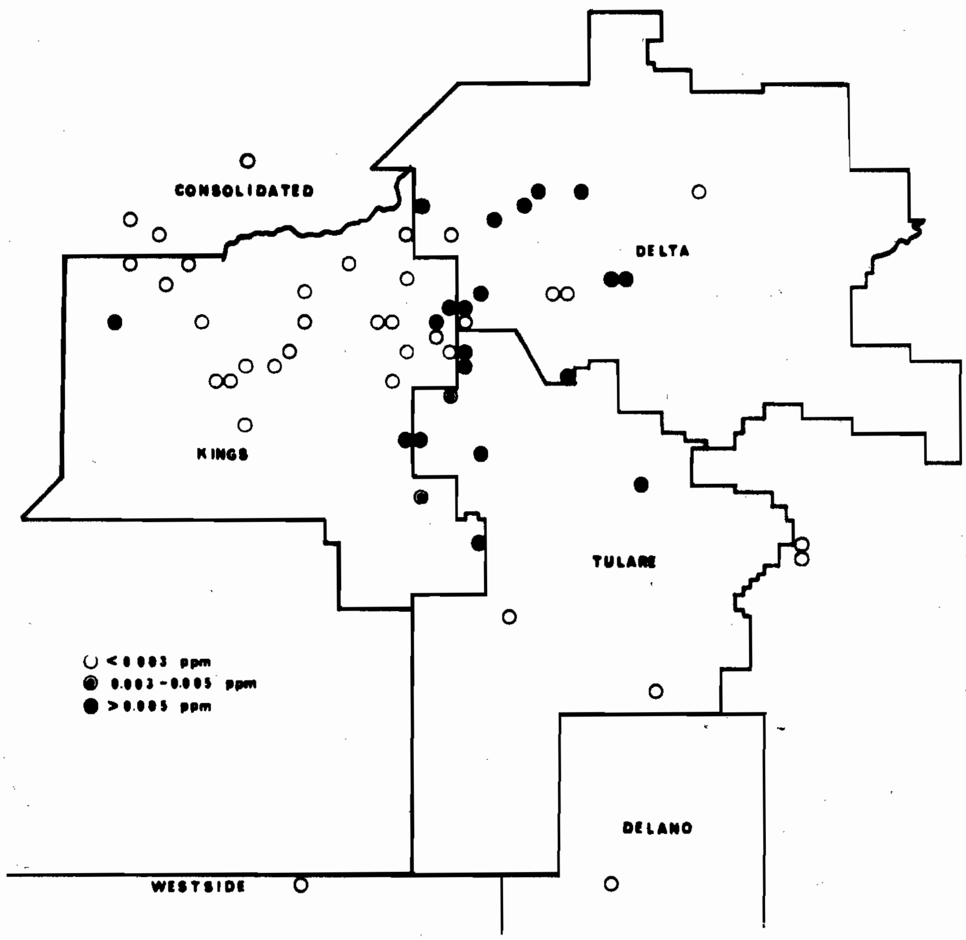

Fig. 3—LC_{50} levels for *Aedes nigromaculis* larvae to methyl parathion in Tulare and Kings counties; adjoining areas in Fresno and Kern counties are also shown. Names on the map refer to the mosquito abatement districts represented.

fornia districts this year. With *A. nigromaculis* the susceptibility to methyl parathion, fenthion, and malathion may also be roughly ascertained since they are related to that of parathion in this species.

The test kit is useful in distinguishing control failures due to inadequate application from those due to true resistance. It will also detect increases in tolerance and aid in anticipating control problems. If resistance is present, the test kit may be used to measure its magnitude and extent. It will aid in delineating areas where substitute insecticide may be indicated.

Substitute Insecticides

Failure of fenthion against *A. nigromaculis* in the near future could present difficulties. Although other larvicides are available, heavier applications, higher costs, and increased mammalian toxicity limit their use. Other organophosphorus insecticides may become available in the future but, with knowledge of the nonspecific organophosphorus resistance to the compounds now in use, there is doubt that they would be effective long against highly resistant populations of *A. nigromaculis*.

With the carbamate insecticides now available, application rates and costs are limiting factors. The botanicals, such as pyrethrum and barthrin, as far as is known, are effective against resistant mosquito larvae, but are expensive. Oils are useful larvicides in many situations but are generally toxic to plants.

Some possibilities for future mosquito control include chemosterilants, hormonal agents, negatively correlated insecticides, and the use of naturally occurring predators and parasites. At this time the feasibility and effectiveness of these different approaches are not fully known. Through continued research on the nature of resistance, and the development of new approaches to meet this problem, it is hoped that satisfactory methods of control will be found.

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CANDIDATE INSECTICIDES AND ALTERNATE METHODS FOR MEETING THE RESISTANCE PROBLEM IN MOSQUITO CONTROL

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Chemicals used in mosquito abatement programs must meet several criteria before they can be considered for wide-scale use.

THE COMPLETE CULICIDE

The ideal chemical for mosquito control should kill the target insect without killing predators of the target insect or other beneficial organisms. There are many instances cited in the literature of unexpected increases in pest species as a result of a program to eliminate another pest. For example, in the late 1950's, an extensive campaign was waged in Kenya against mosquitoes, using the chlorinated hydrocarbon, dieldrin. It was a completely successful program; however, it was noted that a few months later there was a tremendous increase in the number of house flies in the areas treated previously with dieldrin. An investigation disclosed that the fly problem probably arose as a result of the destruction of lizards, natural predators of the flies, during the mosquito abatement program.

The ideal chemical should be economical to use. California mosquito abatement programs use only about 1% of the total pesticides employed in the state. Thus mosquito abatement programs are largely dependent upon agriculture for the large-scale development of pesticides. Pesticides that do not have large-scale use are not produced in quantity and are therefore expensive.

The mosquito control chemical should pose minimal occupational hazard. Pesticides used in any program, ideally, should be nontoxic to the applicator, or, more realistically, should be capable of being applied effectively in a manner that presents no danger to individuals using them. Dr. West will be discussing the safety aspects of pesticide use so I shall not elaborate on this at the present time.

The ideal chemical should not harm plants or wildlife, or leave a residue that will create a problem. DDT, for example, even if the development of physiological resistance did not impose restrictions upon its use, could not be employed in areas of milk production because of the zero tolerance for DDT in milk established by the Food and Drug Administration.

The chemical should not produce resistance in the target insect. Mrs. Gillies has already spoken to you about the problems of resistance that are developing with the organic phosphates. An insecticide may be a perfect mosquito control chemical in all respects, but if insects develop a tolerance for it, it may become valueless, depending upon the degree of such tolerance. Some strains of mosquito larvae have shown an increase in resistance to parathion by approximately 4000 x. In such cases, parathion, formerly effective at 0.1 lb per acre, would have to be applied at an impossible rate in order to achieve control.

The organic phosphate insecticides are currently widely used as mosquito larvicides. However, the development of resistance and cross resistance to the organic phosphates in certain areas forebodes an increase in this problem with the possible result that these materials may become useless in mosquito abatement programs. It is important to this group, therefore, that consideration be given to other chemicals that will be effective and available in such an eventuality.

ALTERNATE METHODS

Before looking at other chemical candidates, let us consider first some of the nonchemical methods of control. Basically there are two categories of nonchemical control: (1) physical or cultural control, and (2) biological control.

Physical or cultural control includes methods that physically interfere with or prevent the production of mosquitoes. This concept basically requires the gift of imagination as well as knowledge and should provide a great challenge to all mosquito abatement district personnel. No two districts have exactly the same problems, and measures that might be applicable in one area might not be effective in another. It goes much beyond the elimination of nonfunctional water collections that serve as breeding sites for mosquitoes. It may, for example, call for modifications of agricultural practices that would not be detrimental to crop production but would interfere with the life cycle of the mosquito. It may point to a need for changes in irrigation patterns, special land preparation, or changes in the condition of the water. It obviously calls for education of the farmer so he will use only the required amount of water in irrigating his crops. Water conservation is a benefit not only to mosquito abatement programs but to the farmer and to the state as a whole.

Biological control is the suppression of pest species through the action of other living organisms. In recent years, with advancements in biochemistry, the definition has also come to include suppression by means of substances produced by living organisms. There are several categories of biological control; the oldest and most widely used, though still far from being well understood, is the use of predators and parasites.

A predator is a living organism that feeds upon another organism. In the case of insects, it may be another insect, a bird, reptile, or mammal or, in the case of aquatic insects, a fish. It kills by direct attack and may devour several or many individuals at a feeding. The classic mosquito larva predator is the mosquito fish, *Gambusia*. Representatives of the Sacramento-Yolo County District discussed the use of *Gambusia* for mosquito control at this morning's session.

Parasites are organisms that live, grow and reproduce at the expense of the insect pest. Parasites that are effective in controlling insect populations destroy the insect pest in the process. Parasites may be other insects, bacteria, viruses, protozoa, or fungi. Some very excellent and promising research in the control of mosquito larvae by use of parasites is presently being conducted at the Bureau of Vector Control laboratory in Fresno. A paper was presented this morning by Dr. Kellen dealing with one phase of this work.

When effective, the use of predators or parasites in insect control presents some advantage over the use of chemicals. Since predators and parasites are living organisms, once they are successfully established they tend to be self-perpetuating. This self-perpetuation of an efficient biological control agent can result in a substantial saving of money despite the fact that the initial outlay necessary to discover, develop, and establish the organisms may be quite high. Predators and parasites of insects are usually quite specific in their attack, and if they do prey upon or parasitize more than one species they almost always limit their prey to other insects. Thus, they present minimal hazard to the health of man, plants, or animals.

The use of predators and parasites also presents some disadvantages and difficulties. As mentioned earlier, very little is known about the complex relationships between beneficial and detrimental species. Once a predator or parasite is found, one of the chief difficulties is in getting them established in sufficient numbers to be effective. It is also true that once established, they seldom completely control an insect population. As the insect population is reduced in numbers, so too are the numbers of the predators; thus, when the pest population becomes very low the predators may die out completely. Another difficulty is that the predators and parasites may require an alternate host to sustain them during periods when the primary host is not available.

Other methods of biological control include the use of sex attractants or chemosterilants. Sex attractants are chemicals emitted from the bodies of the females of certain insect species to help the male in locating a mate. These chemicals extracted from the bodies of the females, or synthesized in the laboratory, can be used to trap or, when used in conjunction with insecticides, to kill large numbers of males and thereby reduce the insect population potential.

Chemosterilants are chemicals that destroy the reproductive capacity of insects. In order to be effective they must not interfere with the competitiveness of the males in mating behavior. Certain species of mosquitoes have been sterilized under laboratory conditions; however, practical methods of using chemosterilants against mosquitoes have yet to be developed. These chemicals are nonspecific and some are highly toxic to man.

Because biological control methods have not yet been developed to the point of wide practical application, and it is improbable that many will be effective as sole means of insect control, the concept of integrated control has been advocated. Integrated control is the employment of various measures, cultural, chemical, and biological, concurrently or successively in a single control program. Each insect pest population will pose unique and specific problems for an integrated control program.

Candidate Insecticides

Taking an optimistic view of the value of most biological control measures, they are apt to serve primarily as adjuncts in reducing insect populations. It appears probable that chemicals will always be necessary for an adequate abatement program. So let us now look at some of the chemicals, other than organic phosphates and chlorinated hydrocarbons, that may become candidates in mosquito abatement programs.

Pyrethrins.—These are naturally occurring complex organic compounds obtained from the flowers of a family of plants that includes the garden chrysanthemum and the daisy. Four separate but related compounds have been found to be active ingredients of the pyrethrins. In recent years synthetic pyrethroids have been produced in the laboratory, including allethrin, barthrin, and cyclethrin. The pyrethrins are toxic to insects. They act upon the nervous system, causing intense irritation, paralysis and death. And while being toxic to insects they are relatively nontoxic to mammals, plants, and fish. The mean lethal dose for all animals tested is 1,500 mg/kg of body weight; compare this with a mean lethal dose for parathion of 4 mg/kg. Although relatively nontoxic to humans, allergy and dermatitis does develop in some people who work with the concentrated pyrethrin material. It is not known at this time whether these reactions are due to the pyrethrins themselves or to insecticidally inactive components of the flowers.

With respect to cost, pyrethrum production is economic only in countries where labor is fairly cheap. Mechanical harvesting of pyrethrin flowers thus far has been unsuccessful because of the necessity to differentiate between buds and open flowers, the latter containing higher insecticide content. The processing of the flowers is also fairly expensive. However, new impetus has been given to the pyrethrin insecticides in recent years because of their low mammalian toxicity. This may lead to development of more economical methods of production, natural or synthetic.

Resistance to the pyrethrins is known, however evidence obtained thus far indicates that the degree and extent of resistance to pyrethrins is much less than that found for the chlorinated hydrocarbons or for the organic phosphates. It is not yet known whether resistance to the pyrethrins will become a significant problem.

Rotenone.—Rotenone is another botanical that is an effective insecticide with low mammalian toxicity. It is, however, highly toxic to fish. Problems of resistance have not been demonstrated with rotenone, but it has not been used on a large scale basis.

Carbamates.—This is a class of synthetic organic compounds that, while not chemically related to the organic phosphates, affect the same biochemical system as the organic phosphates. They vary in toxicity, but in general are quite toxic to insects; they are only moderately toxic to mammals and fish and apparently are nontoxic to plants. They are less toxic to mammals than organic phosphates because they are rapidly metabolized to nontoxic products. Some information is available indicating that flies develop physiological resistance to these compounds.

Phenothiazine.—Phenothiazine has been known for 30 years to be a very effective mosquito larvicide. It has never been widely used because of limited availability and high cost. Phenothiazine has been employed principally as a human and veterinary drug for the treatment of intestinal and other parasites and for urinary tract infections. It has a very low mammalian, fish, and plant toxicity. Humans can ingest up to 15 grams over a two-week period with no apparent ill effect. Oxidation products of phenothiazine, however, do render the skin sensitive to light and cause dermatitis; thus the applicator must exercise care in handling quantities of the material.

Petroleum oils.—As a final candidate for use in mosquito abatement programs, I would like to mention one of the oldest known mosquito larvicides, the petroleum hydrocarbons. Diesel and aromatic oils are presently used very effectively in areas where plant toxicity presents no problem. The possibility that the phytotoxic and insecticidal principles of these oils are contained in separate fractions suggests that a highly refined fraction containing only insecticidal properties may eventually be produced. In this event the use of petroleum oils would find much wider application.

A considerable amount of time and money is currently being spent on research into chemical and nonchemical methods of mosquito control, and much more research is needed. But equally as essential is an appreciation of the magnitude of the problem of insect control, and an open mind to the many potential new approaches which offer possible solutions.

SAFETY CONSIDERATIONS IN MOSQUITO CONTROL OPERATIONS

IRMA WEST
California State Department of Public Health
Bureau of Occupational Health, Berkeley

ABSTRACT

An analysis of the experience of mosquito abatement districts in California during the 1952-1962 period (Table 1) points up the following general trends:

1. There has been no improvement over the past ten years as far as the number of reports of occupational disease is concerned.
2. Cases of dermatitis have increased steadily—malathion specified most frequently.
3. Cases of poisoning are being reported in about the same number—most are mild and involve parathion.
4. In over ⅓ of the reports, the employee does not seem to know the chemicals with which he works.

TABLE 1.—Review of occupational disease from pesticides experienced by employees of mosquito abatement districts in California 1952-1962.

Year	Total Number	Poisoning	Dermatitis	Other
1952	5	0	3	2
1953	7	6	1	0
1954	4 }	2 }	1 }	1
1955	5 } 19	2 } 12	2 } 4	1
1956	10 }	8 }	1 }	1
1957	7 }	3 }	4 }	0
1958	14 } 27	7 } 15	5 } 10	2
1959	6 }	5 }	1 }	0
1960	9 }	1 }	6 }	2
1961	7 } 26	3 } 10	4 } 14	0
1962	10 }	6 }	4 }	0
Total	84	32	43	9
Average	8	3	4	1

Fatalities – 1961 (worker, parathion, probable suicide)
1957 (child swallowed pesticide originating from M.A.D.)

In summarizing the safety considerations for mosquito control workers (see safety rules appended), the following points are emphasized:

1. Employees should be personally acquainted with each chemical they handle—its name, its degree of toxicity, and how it gets into the body; its capacity for irritating the skin, eyes, or breathing passages; whether it is apt to sensitize, whether it is a photosensitizer, and its possible long-term effects; precautions for protection against any of these hazards; and what is to be done if a person is affected.

2. The increasing number of dermatitis cases should receive attention. It may mean that workers are careless about protecting the skin from contact and not washing afterward. It may also mean that some are becoming sensitized to certain chemicals they have been working with for some time. It should be pointed up that pesticides can be more readily absorbed through damaged skin, and persons with skin already irritated by chemicals are not good candidates for handling toxic pesticides. Attention should be directed toward designing work procedures to prevent skin contact, toward adequate protective clothing, and toward adequate utilization of good washing facilities.

3. Employers are responsible for safe handling of a toxic chemical from the time they receive it to its final disposal. Included is the protection of children from improper storage or disposal of chemicals. Included also is placing these materials only in the hands of responsible employees. Persons who are not technically competent or are emotionally or mentally disturbed are not good candidates for work with chemicals (e.g., suicide with parathion—see Table 1).

4. The handling of toxic concentrates is the most critical operation. Closed systems for loading and mixing are much safer than pouring from cans and bottles.

Safety Rules for Working with Pesticides

1. Before working with pesticides operators should be informed of the risks to themselves and others and should receive instructions for safe handling. READ THE LABEL!

2. There should be on-the-job safety supervision. New employees and those not trained in handling chemicals need constant supervision. No one should work alone with a hazardous chemical.

3. Plans for handling emergencies must be made in advance with the doctor. Medical supervision should be provided for all work with hazardous materials.

4. Pest control equipment should be of proper design, well maintained and regularly cleaned so as to minimize spills or other pesticide exposure to operators or maintenance personnel.

5. Whenever there is a choice, the less hazardous chemical should be used — and no more than is necessary.

6. Washing facilities should be readily available and any spills or splashes of chemicals should be immediately washed from the skin and the clothing changed. Hands should be washed before smoking or eating. Lunches and tobacco should be kept away from the chemicals. A shower followed by a change of clothing after each day's work is mandatory. Work clothes should be cleaned separately and not taken home for laundering.

7. The employer should provide, maintain and clean whatever protective clothing or equipment is needed for safe work with chemicals. Different pesticides may require different kinds of protective equipment.

8. Special care is necessary in handling concentrated pesticides. It is at this point that the greatest hazards lie, particularly if the chemical is readily absorbed through the skin. In the transferring of concentrates from drums, either threaded taps or drum pumps should be used. Measuring and pouring from jars and cans is asking for trouble.

9. Pesticide containers should be properly labeled and stored under lock and key. No pesticide chemicals or their containers, empty or otherwise, should be left around where children or pets have access. Emptied containers should be burned, buried or decontaminated without delay.

TUESDAY, JANUARY 28, 2:30 P.M.

ANNUAL BUSINESS MEETING

Presiding: DAVID E. REED, *President*

Mr. Reed: The business meeting of the California Mosquito Control Association is now in session. Voting will be limited to one vote for each corporate member. Corporate members in good standing have paid their dues through 1963 or to date in 1964. Chairmen of committees are requested to summarize their reports in as few words as possible and submit the written reports to the Secretary-Treasurer. Any action relative to general reports will be made at the conclusion of the reports. Specific action on requests by the committees will be made during or immediately after the report of the committee. I should like now to call for the report of the Secretary-Treasurer.

(A roll call by Secretary Murray assured that a quorum of corporate members was present.)

Dr. Murray: The auditor for CMCA has prepared his audit. Details of his report follow. I might note that we overspent our income again as we did last year, although by not quite so much.

M. FREEDOM MEEKER
CERTIFIED PUBLIC ACCOUNTANT
P.O. Box 211
Exeter, California
January 2, 1964

Board of Directors
California Mosquito Control Association, Inc.
1737 West Houston Avenue
Visalia, California

Gentlemen:

We have examined the balance sheet of the CMCA, Inc., as of December 31, 1963, and the related statement of surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. Our report includes the following financial statements:

Exhibit A — Balance Sheet, December 31, 1963.

Exhibit B — Statement of Surplus, Year Ended December 31, 1963.

Schedule 1 — Schedule of Expenditures with Budget Comparison, Year ended Dec. 31, 1963.

General activities revenues were $585.62 more than the budget estimate of $4,621.00, and conference activities revenues were $242.23 less than the budget estimate of $2,379.00. Schedule 1 shows the amounts by which the budget was under-expended. Although no transfers were made to clear the four accounts which were over-expended, there were ample funds in the unappropriated reserve to supply the $375.74 needed. Available surplus derived from general activities decreased by $871.03, while that derived from conference activities increased by $385.68. The secretary reports 1,223 saleable publications on hand, from which he recovered $1,162.00 which was expended as "Committee Expenses" during 1962 and 1963. $122.00 will also be received from 61 of those publications which were printed for the association by the State Health Department.

In our opinion, the accompanying balance sheet and statement of surplus present fairly the financial position of the California Mosquito Control Association, Inc., at Dec. 31, 1963, and the results of its operations for the year then ended in conformity with generally accepted governmental accounting principles applied on a basis consistent with that of the preceding year.

Respectfully submitted,
signed/M. Freedom Meeker
Certified Public Accountant

EXHIBIT A
BALANCE SHEET
December 31, 1963

ASSETS

Petty Cash		$ 52.31
Cash in Security First National Bank, Visalia:		
Commercial Account		251.90
Savings Account		4,000.00
Fixed Assets (Note 1)		173.01
Total Assets		$4,477.22

LIABILITIES AND SURPLUS

Liabilities		-0-
Deferred Revenues (1964 Surplus)		$ 575.00
Surplus Invested in Fixed Assets		173.01
Available Surplus (Exhibit B)		
derived from general activities	$1,643.26	
derived from conference activities	2,085.95	3,729.21
Total Liabilities and Surplus		$4,477.22

Note: 1: The fixed assets consist of a tape recorder purchased in 1961. The cost of a filing cabinet purchased several years ago is not now known to the secretary.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.
STATEMENT OF SURPLUS
Year Ended December 31, 1963

EXHIBIT B

	Budget Estimate	Derived From: General Activities	Derived From: Conference Activities
Balance Available, January 1, 1963		$2,514.29	$1,700.27
Add Revenues			
Corporate Member Contracts	$3,900.00	$3,848.00	$
Associate Member Dues	21.00	42.00	
Sustaining Member Dues	450.00	250.00	
Sale of Publications	200.00	634.62	
Miscellaneous	50.00	432.00	
30th Conference Registrations	780.00		$ 830.00
30th Conference, Exhibits	300.00		200.00
30th Conference, General	1,299.00		1,106.77
Total Revenues	$7,000.00	$5,206.62	$2,136.77
Total Available		7,720.91	3,837.04
Deduct Expenditures (Schedule 1)		6,077.65	1,751.09
Balance Available, December 31, 1963		$1,643.26	$2,085.95

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.
Schedule of Expenditures with Budget Comparison
Year Ended December 31, 1963

SCHEDULE 1

Classifications	Budget As Amended	Actual Expenditures	Under-Expended
Administration			
Advertising	$ 108.00	$ 108.00	$
Communications	300.00	219.85	80.15
Office of Secretary	600.00	600.00	
Office Supplies	150.00	67.36	82.64
Proceedings Publication	2,300.00	2,355.60	(55.60)
Committee Expenses	1,670.00	1,786.40	(116.40)
Auditor	100.00	100.00	
Fidelity Bond	125.00	125.00	
Travel Expenses	500.00	421.71	78.29
Contingencies		293.73	(293.73)
Total Administration	$ 5,853.00	$6,077.65	$(224.65)
Conference, general expense (note 1)	$ 1,600.00	$1,751.09	$(151.09)
Reserves			
Unappropriated Reserve	1,159.82	-0-	1,159.82
General Reserve	3,000.00	-0-	3,000.00
Total Reserves	$ 4,159.82	$ -0-	$4,159.82
Total Budget and Expenditures	$11,612.82	$7,828.74	$3,784.08

Note 1: The State Health Department performed the services of recording and transcribing the conference proceedings.

Mr. Reed: Before starting on the committee reports, I would like to make a few comments relative to this Association during the past year.

First, I believe that our present actions on research are beginning to take fruit. I believe that we as an association should have intimate contact with the research agencies and institutions of the state so they will better understand the needs that we have in local programs. This year we have taken great strides in this direction.

The second point I wanted to make is in regard to a study now in progress which may continue for the next year or two. This is the matter of expanding the active membership of our Association to incorporate a tremendous potential of human resources available to us within this state. We are also making good progress toward resolving this matter.

We will now call for committee reports.

REPORT OF THE AIRCRAFT COMMITTEE

In January this committe met to finalize its recommendations to the Federal Aviation Agency concerning new regulations governing agricultural aircraft operations. These recommendations were subsequently adopted by the CMCA Board of Directors and mailed to the Docket Section, Federal Aviation Agency in Washington, D. C. A copy of that letter has been sent to all CMCA members. At this meeting we also planned our part in the April equipment show at Salinas, co-sponsored by the Operational Equipment and Procedures Committee.

Following this April 5th equipment show, the committee did not meet again until October, at which time we reviewed our aircraft operations form and with slight revisions submitted it for inclusion in the Year Book.

In December our committee acted as co-sponsors, along with the University of California Davis Campus, the State Department of Public Health and the CMCA Operational Equipment and Procedures Committee, in presenting a one-day conference on recent developments in ground and air spray techniques and equipment.

For the year 1964 this committee recommends:

1. that the CMCA Board of Directors approve plans for a demonstration of ground and aircraft equipment to be held in Visalia on April 3, 1964, in co-sponsorship with the Operational Equipment and Procedures Committee,

2. that existing projects mentioned above be continued.

Burten Fentem	James Snyder
Edward Lewis	Norman B. Akesson, Technical Consultant
Robert E. Porter	Robert E. Turner, Chairman

REPORT OF THE BYLAWS COMMITTEE

Early in the year President David E. Reed charged the Bylaws Committee with the responsibility of determining whether or not the Bylaws in their present form were serving fully the varied interests of the Association. This activity was a continuation of previous Bylaws Committee responsibilities, but greater emphasis was directed towards completing such a study during the year.

Working closely with the Ways and Means Committee, this study was initiated. The results of the study and the final recommendations of the Bylaws Committee have been filed with the Board of Directors for whatever action they deem necessary. We wish to thank the members of the Ways and Means Committee for their excellent cooperation in carrying out the assigned responsibilities.

John H. Brawley	T. G. Raley
Robert H. Peters	Howard R. Greenfield, Chairman

REPORT OF THE EDUCATION AND PUBLICITY COMMITTEE

The main activity during the year was the reporting to "Pest Control Magazine" a story about the Equipment and Aircraft Meeting held in Salinas in the spring. Publicity for the 1964 Conference was handled by the Local Arrangements Committee.

T. G. Raley
Richard F. Frolli, Chairman

REPORT OF THE ENTOMOLOGY COMMITTEE

The committee sponsored the 1963 Entomology Seminar at Fresno State College on March 29th and 30th. Topics covered included mosquito physiology, mosquito larval habitats, entomological photography, and a laboratory session on adult mosquito age determination.

Early in 1963 "A Field Guide to the Domestic Flies" was printed and distributed. This was closely followed by the second edition of "A Field Guide to Common Mosquitoes of California." These two projects were initiated and most of the work completed in 1962.

Meetings were held June 7th and September 26th to formulate and continue projects including the next Entomology Seminar, a project to disseminate information collected by the committee on the biology of mosquito larvae predators, and a form for reporting larval mosquito species occurrence correlating habitat and seasonal history. These items have been started and will continue into 1964.

Our last meeting was held December 6th at Santa Ana for the main purpose of completing plans for the next seminar, to be held at the University of California at Riverside on April 3rd and 4th, 1964. The topics are to be the biology of Chironomidae, Chaoboridae and *Leptoconops*, and a discussion on statistical approaches and aids to laboratory and field tests. There also will be a tour of the midge testing area at the University.

The committee wishes to thank all of those who helped on the various projects.

Roy Eastwood	Embree G. Mezger
Jack Fowler	John G. Shanafelt, Jr.
Richard F. Frolli	Douglas O. White
Eugene E. Kauffman	Bryan T. Whitworth
Thomas H. Lauret	Richard M. Bohart, Technical Consultant
James Mallars, Vice Chairman	Harry L. Mathis, Chairman

REPORT OF THE FISH AND WILDLIFE COMMITTEE

During the past year the Fish and Wildlife Committee engaged in two major activities, which the incoming Committee undoubtedly will wish to continue. One group has worked with the State Department of Public Health and the Department of Fish and Game in formulating plans for a second Wildlife Management-Mosquito Suppression Conference to be held at Yosemite National Park on March 3-6, 1964. Since Proceedings of the Second Conference will also be published, it should be of interest to all to know that the Proceedings of the First Conference have been well received, with copies having been sold to date in 29 states, the District of Columbia, and two Provinces of Canada.

The second major activity of the Committee called for conferences with representatives of the Bureau of Vector Control and the Department of Fish and Game to plan one, and possibly two, Wildlife Management-Mosquito Suppression Demonstration Areas, to be financed largely by Federal and State grants. The purpose of these proposed demonstration areas would be to develop improved methods of coordinating effective mosquito control activities with approved game management practices. It is hoped that one of these proposed demonstration areas can be established in a fresh water environment, and the other in a brackish water situation subject to tidal action.

S. F. Cook, Jr.	Dennis Ramke
Jack H. Kimball	William L. Rusconi
H. C. Pangburn	Oscar V. Lopp, Chairman

REPORT OF THE INSECTICIDE COMMITTEE

Only one meeting of the committee was held during the past year. The proposed guide on insecticides and weedicides to be developed by the committee is still under study. It is the general feeling of the committee that a complete review of the objectives and the text of the guide must be effected before this publication can be completed. There has been considerable change in materials and procedures since 1961 when work on this publication was initiated.

The committee now has some doubt about the original plan for one publication and is now considering separate handbooks on insecticides and weedicides. No definite conclusions will be made until a complete review can be undertaken by the committee.

William E. Hazeltine	Embree G. Mezger
Eugene E. Kauffman	Gordon F. Smith
James Mallars	Thomas H. Lauret, Chairman

REPORT OF THE INSURANCE COMMITTEE

The Insurance Committee met during mid-year with an insurance broker and thoroughly analyzed the matter of a CMCA sponsored health insurance plan for association members.

It was the unanimous opinion of this committee that the plan would present numerous new problems and would result in no clear advantages to the membership as a whole. The committee therefore recommends that all member agencies endeavor to meet their requirements on a local basis.

H. C. Pangburn	William L. Rusconi
T. G. Raley	Robert H. Peters, Chairman

REPORT OF THE LEGISLATIVE COMMITTEE

The Legislative Committee was quite active in 1963 and accomplished most of its goals. When the Legislature was in session, members of the committee made six trips to Sacramento to attend legislative hearings. The committee issued four communications to the CMCA membership, assisted in the passage of two mosquito bills, and was instrumental in the defeat of Senate Bill 1466. Senate Bill 1466 pertained to the withdrawal of cities from the mosquito abatement area by resolution of the city council. As a result of vigorous protest by various mosquito abatement agencies the author of this bill withdrew it from the committee.

During the year, the Legislative Committee tried to keep the membership informed of proposed legislation on the use and application of insecticides and was successful in having Assemblyman Petris make amendments to his original Bill 2233, and further assisted various farm organizations in having this piece of legislation placed under committee study for the next two years.

As requested by the CMCA, two legislative bills, AB 497 and AB 543 were introduced into legislation during the first part of the year. The committee is indebted to Assemblyman Carley Porter who prepared these bills, and was responsible for their introduction into both Houses of Legislature. Both of these bills were signed by the Governor and went into effect 90 days after the adjournment of Legislature. AB 497 concerns the amendment of Section 2202 of the Health and Safety Code, and Section 38508 of the California Government Code exempts mosquito abatement districts from the District Investigation Laws of 1933.

AB 543 pertains to changes in boundaries between mosquito abatement districts, making it permissible for two local mosquito boards to change boundaries by resolution if both parties are agreeable.

The committee wishes to thank the CMCA membership for the excellent support during this past year on legislative matters.

For the coming year, the Board of Directors and the membership should consider two points: (1) the type of legislation that should be prepared on possible state assistance to local mosquito abatement agencies; and (2) any needed legislation on the use and application of insecticides by mosquito abatement districts. If any changes or proposals are to be made in these two fields, work should be started now if we expect to have recommendations ready for the next session of Legislature.

Norman F. Hauret	E. Chester Robinson
G. Paul Jones	T. M. Sperbeck
Gardner C. McFarland	Lester R. Brumbaugh, Chairman

REPORT OF THE OPERATIONAL EQUIPMENT AND PROCEDURE COMMITTEE

The committee wishes to acknowledge the outstanding Equipment and Aircraft Show arranged by last year's committee in cooperation with the Aircraft Committee. This show was held on April 5, at the Salinas Airport with local arrangements by the Northern Salinas Valley MAD.

During 1963 the committee started issuing equipment bulletins as a means of communication to members of the Association. It also co-sponsored the special Ground and Airspray Conference held at the University of California, Davis, on December 5. The committee has already completed plans for the 1964 Spring Equipment Show to be held at Visalia.

CMCA Equipment Bulletins: During the year the following three bulletins were prepared and distributed.

1. April 13, 1963 *Magnetic Clutch.* For belt-driven pumps and air compressor. Contributed by A. H. Thompson, Foreman, Orange Co. MAD.
2. Dec. 3, 1963 *Wagner Belt-Driven Rotary Air Compressor.* Supply air to pressurized spray tanks. Contributed by S. M. Silveira, Manager, Turlock MAD.
3. Dec. 3, 1963 *Electric Solenoid Valve.* To control liquid flow to mist blowers. Contributed by S. M. Silveira, Manager, Turlock MAD.

Committee Recommendations for 1964: The committee recommends that the proposed Equipment and Aircraft Show be approved by the Board of Directors. It is also recommended that the 1964 committee continue to develop the Equipment Bulletin as a means of communicating new ideas to all agencies. The above activities have been carried out by the committee without cost to the Association.

Robert W. Cochran	Stephen M. Silveira
Jack Fiori	Louis Sohnrey
E. L. Geveshausen	Kenneth G. Whitesell
Chet Owens	Albert H. Thompson, Jr., Chairman

REPORT OF THE PROCEEDINGS COMMITTEE

The Proceedings were printed at the same basic price as in 1962. Delays due to lateness in receiving approved papers, to pressures of other business, etc., resulted in the late publication date of December 11.

The 1963 Proceedings have been distributed to all California mosquito control agencies, University and College libraries, faculty members, and other cooperating individuals and agencies in the State. In addition, they have been distributed to libraries, Universities or other agencies or individuals in 50 states, Washington, D.C., 5 Canadian provinces and 11 foreign countries.

All copies were distributed free. No formal policy has ever been declared by the Association on this matter; however, this practice has been followed for years without dissent. To assist in the determination of the justification of this accepted policy, the editor developed the following information.

Obligations to the districts, conference registrants, speakers, etc. required that about 427 copies be prepared. To supply the libraries and other agencies, and to maintain a nominal reserve, the Association ordered 850 copies printed. The costs of printing 427 copies as compared with 850 are contrasted below.

Item	*Cost/427*	*Cost/850*	*Paid by*
Printing	$1,951.10	$2,067.60	CMCA
Paper, binding materials, etc.	193.00	288.00	CMCA
Total paid by CMCA	$2,144.10	$2,355.00	
Clerical:			
Labor—240 hours at $2.50	600.00	600.00	BVC
Graphic Arts:			
Labor—16 hours at $3.00	$ 48.00	$ 48.00	BVC
Materials & commercial services	30.00	30.00	BVC
Editing:			
Labor—216 hours at $6.00	1,296.00	1,296.00	BVC & Editor
Transportation—400 miles at 6¢	24.00	24.00	BVC
Telephone	16.00	16.00	BVC
Stationery & postage	10.00	10.00	BVC
Grand Total	$4,168.10	$4,379.60	

The committee believes that through the Proceedings the objectives of the CMCA in communicating with mosquito control workers locally and throughout the world are met at an unusually nominal cost to the CMCA and the BVC by the distribution to agencies and libraries in other states and countries.

W. Donald Murray
John R. Walker, Editor
James St. Germaine, Chairman

REPORT OF THE PROGRAM COMMITTEE

The Program Committee met five times during 1963 as a committee and also had several meetings with the Local Arrangements Committee to coordinate the program for the 1964 Conference at Sacramento. The program was formalized by September and by December the Association members had been sent advanced copies of programs. The committee wishes to thank everyone who helped with the program, especially the Local Arrangements Committee and those who helped in selecting the speakers. We also express our appreciation to the Sacramento Convention Bureau for printing the programs.

Betty Gebauer	J. D. Willis
James St. Germaine	Richard F. Peters, Technical Consultant
W. Donald Murray	William L. Rusconi, Chairman

REPORT OF THE PUBLICATIONS COMMITTEE

(Note by W. D. Murray: Norman Hauret could not be present at the Conference, but sent the following as a suggested report for the committee to review. Since it was impossible for the committee to develop this further in the time available, we are submitting Mr. Hauret's suggestions for consideration of the Association membership.)

These proposals are made in the interest of reducing costs, reducing work for the Secretary, and for the purpose of streamlining the distribution of printed material.

1. Proceedings of the Annual Conference:

A mailing list of those persons and agencies receiving Proceedings should be reviewed and approved by the Board. This list should be reviewed annually. Free distribution should be limited to this list. All other copies should be sent at no less than cost.

The contents of the Proceedings should be reviewed. Only papers presented at the conference should be included. The following should be deleted: minutes of the business meeting, welcome addresses, committee reports, and perhaps others. If needed, these could be mimeographed and mailed to member agencies.

Perhaps the papers that are presented at the Conference could be published in *Mosquito News*, thereby eliminating the need for the Proceedings.

2. Publications by Committees:

Publications by a committee should be limited to material that cannot be found in other textbooks or literature. Although bulletins such as "A Field Guide to Domestic Flies" are excellent, similar material may be found in other sources. Perhaps we should use the other sources rather than print our own.

An outline of the contents of a publication, costs, the reason for the publication, availability of material from other sources, and proposed distribution, should be submitted to the Board for approval prior to starting a project.

3. Year Book:

The Year Book is excellent and should be retained, but perhaps portions could be deleted such as (see 1963 issue):

Page 40-41 Bureau of Vector Control information
Page 42-43 California State Department of Fish and Game
Page 44-49 University of California

Those agencies that wish to contact the above can readily learn how to make the contact they wish. Mailing of the Year Book should be done in the same manner as the Proceedings.

C. Donald Grant
W. Donald Murray
Norman F. Hauret, Chairman

REPORT OF THE RESEARCH COMMITTEE

Mr. Gordon Smith, Chairman: This committee over the years has been bogged down in various ways by lack of funds, by conflicts of interest, and a good many other things. This year I think we have made some progress. The Joint Committee of the State Department of Public Health and the University of California on Research on Arthropods of Health Importance was established to consider research on mosquito and related vector control. This committee will attempt to get needed projects under way and otherwise to expedite research in this field. The goal that the CMCA Research Committee set this year was again to survey the mosquito abatement agencies in order to determine the research needs as seen by the agencies, both specific needs and areas of need, and to present these proposals to the SDPH-UC Joint Committee.

The committee members, one from each region of the state, were individually charged with surveying their areas and gathering together the needed information. This was compiled and sent to the Joint Committee. Originally we had requested that one member of the CMCA be made an ex-officio member of the Joint Committee. This was turned down by that committee, so we do not have anyone on it as such. The compilation was sent to the Joint Committee, and at a subsequent meeting Don Murray and I were invited to attend and discuss the summary with the committee.

Just last week, actions were promulgated, in part on the basis of a questionnaire sent out by the CMCA Board of Directors, requesting guidance on the use of subvention monies for research purposes. I would like now to ask Dick Peters to report on the actions taken at the last Joint Committee meeting, then I will finish my report after he has spoken.

Mr. Peters: I will try to make this brief, although it is quite complicated. First of all, I would like to take this opportunity to acquaint the members of your Association with all of the advantages, as my Department sees it, of working with and through this Joint Committee. On this committee are four members of our Department—an assistant director, a member of our Division of Research, the Chief of the Division of Environmental Sanitation, and myself. Then there are the heads of the three Departments of Entomology in the three major entomological programs of the University of California, namely Dr. Ray F. Smith from Berkeley, Dr. Richard M. Bohart from Davis, and Dr. Glenn E. Carman from Riverside. The Public Health side of research is represented by Dr. William C. Reeves of the University School of Public Health.

Inasmuch as there has been a considerable amount of question with respect to these words called duplication, conflict and overlap of research, this was the first question to which this committee addressed itself. Inasmuch as the Legislative Analyst has been asking these questions for two consecutive years and is about to ask them again in the next session of the Legislature, we aim to be prepared. Therefore a subcommittee was established for the express purpose of inquiring into whether or not there is, infact, overlap, duplication and conflict among the programs in vector research between that going on in the Bureau of Vector Control and the University of California. I would like to read two paragraphs from the report of the subcommittee consisting of Dr. Ray F. Smith, Chairman, Dr. Richard M. Bohart, Dr. Glenn E. Carman, and myself.

"As a result of this investigation, it is the opinion of the subcommittee that, although there is similarity in the long range major objectives of the research program of the University of California and the Bureau of Vector Control, there is no unsupportable overlap of effort between the specifics of the Fresno Bureau of Vector Control research program and that on any of the University of California campuses. The extremely wide range of candidate chemicals available to be screened, the variations in soils and waters from area to area, the differences in mosquito habitats and species available for testing throughout the regions of the state, and the desirability of comparison data under divergent conditions, explain the absence of duplication or conflict in the respective insecticide testing activities.

"Nevertheless, it would seem advisable that some additional informal coordination and synchronization of effort be developed between Riverside and Fresno. It has been acknowledged that the greatest amount of uncertainty and probably lack of as minute coordination as might exist is the case between the Riverside program and that of the Fresno program."

So, I submit this as documentation. This is the report of the subcommittee to the full committee. It has been adopted by the full committee unanimously. There was a meting on January 17th, at which time this subcommittee report was adopted and a full review of the action taken by your Association in the October vote on research. As you know, the vote that was taken of the individual members of every mosquito abatement district in California came out of 23 votes expressed, 18 recommending that it would be preferable to use the existing subvention funds for vector research and to take the necessary action to achieve this in the ensuing fiscal year.

The full Joint Committee, having reviewed the vote, and also not having had an opportunity to meet since the vote, was unable to participate as a group in developing the proposal of how to use this $101,000, in the event it were converted to research. The State Department of Public Health did make recommendations, and the full committee report gives this proposal in detail. This proposal was understood to be subject to modification, not only now but into the future. It was moved by Dr. Ray Smith and seconded by Dr. Richard Bohart and unanimously carried that this plan of utilizing nine proposed additional positions for mosquito control research in lieu of surveillance be endorsed in principle as presented. I think that is the essence of it.

Mr. Smith: This concludes our report with one exception. In line with what has just been presented, and also in line with the results of the letter poll requesting guidance as to whether or not subvention funds in their entirety as we presently have them are to be used in research, I have a resolution which the committee would like to present.

RESOLVED, That

WHEREAS the California Mosquito Control Association, with membership comprising the vast majority of local mosquito control agencies in California, did in October, 1963, take a vote of all local California mosquito control agencies regarding their individual preference for use of future state subvention funds now designated for mosquito control purposes, presently divided about equally between mosquito surveillance and research to strengthen mosquito control technology; and

WHEREAS the vote was overwhelmingly in favor of utilizing the funds currently applied to mosquito surveillance for expanded mosquito control research on a basis approved by the Joint Committee of the State Department of Public Health and the University of California on Research on Arthropods of Health Importance; and

WHEREAS the Joint Committee has unanimously approved in principle a plan of collaborative use of these subvention funds in the amount of $101,000 for mosquito control research, involving both the University of California and the State Department of Public Health; and

WHEREAS a substantial number of local mosquito control agencies have agreed to continue their participation in the state-wide mosquito surveillance program without state financial assistance, provided currently available state surveillance funds are applied in fiscal year 1964-65 to expanded mosquito control research,

THEREFORE BE IT RESOLVED that this Association go on record as advising the Governor, the Legislature, the State Department of Finance, the Legislative Analyst, the University of California, and the State Department of Public Health that it is the wish of this Association that the state subvention for mosquito control currently in amount of $209,463 for fiscal year 1963-64 be used in full budgeted amount during FY 1964-65 exclusively for mosquito control research purposes.

Mr. President, I move this resolution be adopted.

Mr. G. Paul Jones, Marin County MAD: I second the motion.

Mr. Reed: (following lengthy discussion) I shall now ask for a roll call vote on the resolution presented by the Research Committee.

Yes	23
No	3
Abstain	3

Mr. Reed: Motion carried.

REPORT OF THE WAYS AND MEANS COMMITTEE

The Ways and Means Committee held three meetings during the year. Two of these were joint meetings with the Bylaws Committee to discuss revision of the CMCA Bylaws. The Bylaws Committee will report on these activities.

The following actions were taken by the Committee during the year:

1. Discussed the matter of a Code of Ethics and expressed a majority opinion that it was unnecessary to have a formal Proclamation of Principles of Code of Ethics. A minority opinion held that the idea should be studied at the regional level.

2. Recommended to the Board of Directors that there should be no arbitrary limitation on the number of meetings of various groups within the Association and that the Board of Directors should continue the current practice of holding regular quarterly Board Meetings with consideration to combining with other CMCA activities whenever possible.

3. Considered the question "Should the Health and Safety Code be revised to have MAD's allow 5% for delinquency instead of 15% as now provided." It was

generally agreed that this matter could be worked out at a local level and that revision of the Health and Safety Code was unnecessary at this time.

4. Recommended to the Board of Directors that the present method of setting contractual payments and dues be continued.

5. Recommended that the office of Secretary-Treasurer be continued as one office.

6. Recommended to the Board of Directors that all local mosquito control agencies in California be asked, in writing, to express their attitude concerning the alternate use, for research, of State funds in the amount of $101,000, currently allocated to approximately two-thirds of the agencies for mosquito surveillance and reporting.

7. Recommended that the Association encourage more meetings within the five regions so that the thinking, the activities, the needs, and the desires of the regions could be better expressed to the CMCA.

8. Recommended that the University and State College facilities be used for the CMCA Annual Conferences when available but not restricted to these facilities.

9. Recommended that the Board of Directors make further study of subvention funds on a matching basis for districts over a 15¢ tax rate; also, that the Legislative Committee study this matter and make its services available in case some districts wish to develop a legislative bill for subvention funds.

10. Recommended that the 1964 Ways and Means Committee make a further study of the CMCA Policies and Procedures.

11. No funds are requested for this Committee for the 1964 budget.

Lester R. Brumbaugh	E. Chester Robinson
James St. Germaine	Gordon F. Smith
Howard R. Greenfield	Kenneth G. Whitesell
William E. Hazeltine	Bryan E. Whitworth
Melvin L. Oldham	John H. Brawley, Chairman

REPORT OF THE YEAR BOOK COMMITTEE

Mr. Jack H. Kimball, Chairman: This is, I think, the 8th Year Book. The first six John Shanafelt printed on his own press. The last two years we have gone to commercial printing but John is still the consultant on how to do it and why. The cost last year was $700.00 for some thousand copies, so the Year Book costs about 70¢ each.

The actual mechanics of putting the Year Book together is quite simplified now, due to the way the information comes in. Everything that pertains to the Association, membership, committees, etc., comes in through Don Murray, automatically. Names and addresses of public officials are sent in by the respective agencies. So with all these things coming in, even without requests, it is simply a matter of putting them together and getting them to the printer. The other source of information is the regular data section with which you are familiar. It is more or less standardized now and every district has been furnishing its records in commendable fashion. The information on these questionnaires is automatically recapped on tables that John Shanafelt prepares for our office secretary to type. Our office secretary does all the typing. We enjoyed doing the Year Book at Orange County. Our Board of Trustees each year has approved our time and effort on this project. We are glad the Association continues to want the Year Book.

Mr. Reed: Thank you, Jack, for that excellent report. That concludes the reports from standing committees. Next is the report of the Resolutions Committee.

REPORT OF THE RESOLUTIONS COMMITTEE

Mr. Robert H. Peters, Chairman: Mr. President, I am the sole member of this committee, and as such I can tell you that unfortunately I have in general, an extreme distaste for resolutions. However, I do have one important formal resolution to present.

RESOLVED, that we dedicate this 32nd Annual Conference in the memory of the recently deceased father of mosquito control in California, Harold Farnsworth Gray.

I suggest that appropriate evidence of this dedication be sent to Mrs. Gray.

I propose that we have no resolution on the following matters but rather that a letter of sincere thanks be sent to the following:

1. The Sacramento Co.-Yolo Co. MAD trustees and manager for their important part in the very fine conference which we have all enjoyed.

2. The Convention Bureau, and to the particular attention of Bert Geisreiter who so amicably has carried out his function.

3. The University of California at Davis for making their portion an effective part of our Conference.

4. The Sacramento Inn for the very fine service and assistance that they have given us.

5. Our sustaining members and commercial exhibitors.

6. The Southern California Gas Co. for the very fine keynote speaker, Mr. Stary Gange.

REPORT OF THE NOMINATING COMMITTEE

Mr. Robert H. Peters, Chairman: The Nominating Committee presents the following names for offices in the CMCA for 1964:

President:	J. D. Willis
President Elect:	William L. Rusconi
Vice President:	Oscar V. Lopp
Secretary-Treasurer:	W. Donald Murray
Trustee Representative:	Carl W. Muller

As Chairman of this committee, if there are no more nominations at this time, I move that we cast a white ballot for those nominated.

Mr. Gordon F. Smith: I second the motion.

Mr. Reed: Carried unanimously. May we now have a report from each of the Regional Representatives on representatives selected for 1964.

Sacramento Valley:	Melvin L. Oldham
Coastal:	Ernest Campbell
Southern California:	James W. Lane
So. San Joaquin:	Theodore G. Raley
No. San Joaquin:	Lester R. Brumbaugh

FIFTH SESSION

WEDNESDAY, JANUARY 29, 9:00 A.M.

GARDNER C. MCFARLAND, *Presiding*

REPORT ON UTAH MOSQUITO CONTROL – FISH AND WILDLIFE MANAGEMENT COORDINATION COMMITTEE

DON M. REES
Division of Biological Sciences
University of Utah, Salt Lake City, Utah

The Utah Mosquito Control – Fish and Wildlife Management Coordination Committee was organized in November 1962 following the "Conference for Coordinated Program on Wildlife Management and Mosquito Suppression" which was held in October of that year in Yosemite National Park, California. The committee members were appointed after consultation and with the mutual agreement of the officers of the Utah Mosquito Abatement Association, Utah State Fish and Game Department and U. S. Fish and Wildlife Service. The committee is composed of: Jessop B. Low, Wildlife Biologist, Fish and Wildlife Service, Chairman; Donald A. Smith, Supervisor of Waterfowl, Utah State Department of Fish and Game; and Don M. Rees, Chairman, Division of Biological Sciences, University of Utah.

The committee, shortly after its appointment, met and prepared (1) a list of associated agencies that are directly concerned with this problem, (2) a statement of the objectives of the program, (3) an outline of the areas of coordination, and (4) a proposed program of procedure for 1963. These plans and objectives were patterned in part after those prepared and adopted by the National Mosquito Control – Fish and Wildlife Coordination Committee but were extended to meet particular needs in the State of Utah.

The plan and objectives of this program as prepared by the Utah Committee were presented to the members of the Utah Mosquito Abatement Association and personnel from other agencies concerned who were attending the 16th Annual Meeting of this organization, held on March 8-9, 1963 at Utah State University, Logan, Utah. After some discussion and minor changes the following plans and objectives were adopted by a unanimous vote of those present at these meetings.

COMMITTEE REPORT

Associated Agencies:

1. Utah Mosquito Abatement Association
2. Utah Department of Fish and Game
3. Bureau of Sport Fisheries and Wildlife
4. Utah Wildlife Federation
5. Wildlife Society (Utah Chapter)
6. University of Utah
7. Utah State University
8. Utah Department of Health
9. Various city and county health departments

Objectives of the Committee:

1. To work with the National Committee in further serving the aims and objectives of the National Committee on the state and local level.

2. Coordinate mosquito control and fish and wildlife management programs and policies on state and local levels.

3. Gather and disseminate relevant information and suggest standards on mosquito control, techniques consistent with sound fish and wildlife management objectives.

4. Gather and disseminate relevant information and suggest standards on fish and wildlife management techniques consistent with sound mosquito control objectives.

5. Stimulate needed research and demonstration projects relating to mosquito control and fish and wildlife management practices.

6. Sponsor suitable meetings and cooperate with agencies, organizations, and all others whose activities and interests may relate to those of this committee.

Areas of Coordination:

Coordinated control between the two groups – mosquito control and wildlife management interests – is highly desirable to achieve mutual benefits.

1. Promote mutual understanding of the problems and methods involved in mosquito control and in wildlife conservation. Mosquito control and fish and wildlife conservation share the same goal – the public benefit.

2. Standardize procedures in the fields of both mosquito control and wildlife conservation. New chemical insecticides are being developed yearly. They must be tested thoroughly before use. Additional research for standardization must be sought in other mosquito control possibilities, such as fish which feed on mosquito larvae, insect predators, algae, and parasites. Wildlife and fisheries biologists need further research toward standardization in the manipulation of water levels on controlled marshes, location and sizes of developments, and growth of desirable vegetation, all of which undoubtedly have a bearing on mosquito production.

3. Cooperate on legislative and administrative matters which may include right-of-way, ownership responsibilities, and legal decisions.

4. Share the responsibility of educating and disseminating facts to the public. Modern-day living causes numerous stresses. The need for more rest and relaxation is greater than in the past. Outdoor recreation in mosquito-free scenic areas is becoming more popular, even a necessity. Mosquitoes discourage millions of people from enjoying outdoor recreation. Many public recreation areas are not used because of mosquitoes. Furthermore, these pests transmit several important

diseases of man and animals. These pests have been responsible for depressing land values in resort areas. They also adversely affect residential and industrial development as well as agriculture and forestry in some areas. Most of the current mosquito control operations are designed to protect urban and park and recreation areas.

5. Mutually work out plans to hold and further develop public confidence in and support of joint mosquito control and fish and wildlife management projects.

Nobody really loves mosquitoes. Abatement workers, whether striving to control these insects for reasons of health or because they are just plain nuisances, have a big job to do. Every year new impoundments are created for fishing, irrigation supply, sewage disposal, drinking water, wildlife development, electric power, navigation, and flood control. Road building, residential and industrial development, and farm irrigation may also create new breeding areas. It is no wonder then that mosquitoes have little trouble finding new places to breed.

The heart of the matter is man-to-man cooperation and agency-to-agency coordination.

6. Cooperatively encourage demonstration areas for control of mosquitoes by methods not detrimental to fish and wildlife resources. And, to manage fish and wildlife by methods not conducive to mosquito production.

Sometimes carelessness in the use of measures to control mosquitoes has been harmful to fish and wildlife. Fish and wildlife have been killed with insecticides. Wildlife water areas have vanished wherever drainage and earth fills were held more important. The food of fish and wildlife has sometimes been destroyed by chemical sprays.

When chemicals are used, water levels are damaged, or the breeding places of mosquitoes are manipulated, the environment of fish, birds, and beneficial insects is endangered.

Some methods of managing water for irrigation or wildlife development may result in more mosquitoes and consequent damage to the health and well-being of man.

7. Encourage management agencies concerned with developing either mosquito control or wildlife development projects to seek the advice of the other prior to project initiation for suggestions and ideas advantageous to wildlife and disadvantageous to mosquito production.

Proposed Program of the Committee for 1963:

1. Complete the committee assignments including area or district organizations that may be deemed necessary.

2. Prepare a list of agencies and groups interested in the subject of mosquito control-wildlife management programs and problems.

3. Establish a calendar of meetings of the committee and related group meetings that may be brought to the attention of the membership.

4. Conduct one or more field days on areas of problems or on demonstration programs showing progress toward solution of problems.

5. Establish a calendar of associated events and meetings where the subject might be introduced, entertained, or brought to the attention of those present.

6. Serve as a clearing house for problems of this nature and serve as a source of information dissemination to those wishing mosquito control and wildlife management information.

7. Promote a research program that will assist in closer understanding of the mosquito and wildlife management programs.

8. To prepare information and maps showing the mosquito abatement districts as presently constituted and the areas of developed and natural wildlife interests.

* * *

The above report, prepared by the Utah Committee, is published in the Proceedings of the Sixteenth Annual Meeting of the Utah Mosquito Abatement Association.

On reading the first stated objective, you will note that the Utah organization proposes to work with the National Committee on the state and local level. We are of the opinion this can be accomplished without regional organizations comprising several states in an area but we are willing to become affiliated in a regional organization should such an arrangement, in cooperation with the National Committee, prove to be more effective in attaining these common objectives.

The other stated objectives are not new concepts in the State of Utah but a reaffirmation of objectives that have been previously declared and cooperatively worked upon for many years by agencies and groups concerned with wildlife management and mosquito suppression in this state.

Many of the specific objectives and related aspects of this plan for coordinating mosquito abatement activities and fish and wildlife management programs in Utah are currently incorporated into a cooperative research project which has been in operation in Utah since September 1, 1961. As reported at the Yosemite Conference in 1962, the purpose of this cooperative program is to develop and field test physical facilities and techniques for multi-purpose management of "re-usable" water available along the margins of the eastern shores of the Great Salt Lake before the water enters the lake. At the Yosemite Conference it was explained there were, at that time, four federal agencies and three state agencies actively participating in this program. The three members appointed to the Utah Committee are also the representatives of three of the agencies engaged in this cooperative program and are closely associated as such in this cooperative endeavor. Since its inception this cooperative program has continued with gratifying results.

In addition to the four federal and three state agencies that were serving as collaborators in 1962, the Soil Conservation Service, Water Resource Division of the Geological Survey, and the Hydrology Section of the Weather Bureau have joined as collaborators.

The most significant thing about this cooperative program involving so many different federal, state, private organizations, and individuals, has been the willing acceptance of each to serve as collaborators, and more important, the active participation of the personnel of all collaborating organizations and individuals in the program. During the past year all have taken part in planning the program and in field or laboratory functions or both. Some of these agencies have conducted extensive, highly specialized investigations as their contribution to the program.

In a meeting held December 20, 1963 at the University of Utah, representatives of all collaborators were present to discuss in general the results of the study during 1963 and the proposed program for 1964. An annual report on activities and results of this investigation for 1963 is being prepared and will be available by March 1, 1964.

In addition to the joint work being done on the cooperative research project, members of the committee in Utah and other collaborators have been working diligently during 1963, with associates in their own respective fields, to promote a better understanding of joint problems of fish and wildlife management and mosquito suppression.

In addition, the Utah committee has recently prepared (1) a mailing list of the agencies, groups and individuals in the state that are interested in mosquito abatement-wildlife management programs and problems, (2) a map of Utah showing the boundaries of existing organized mosquito abatement districts and other areas where mosquito control programs are in operation and the principal areas of developed and natural wildlife interests, (3) a list of the research projects in the state pertaining to this problem, (4) a calendar of meetings and events relating to the program, and (5) other pertinent information on the subject that can be mailed to those concerned.

The members of the Utah Mosquito Control – Fish and Wildlife Management Coordination Committee and others in Utah associated with this program are pleased with and enthusiastic about the progress that was made in 1963 in developing some of the objectives of this program. We are all looking forward to greater accomplishment in this work in Utah during 1964.

REVIEW OF MOSQUITO CONTROL PROBLEMS IN UTAH IN 1963

Glen C. Collett[1] and Jay E. Graham[2]

Mosquito control operations were initiated in two additional areas in Utah in 1963. A control program under the direction of the Logan City Health Department was conducted in Logan and in an area from three to five miles around the city. The City-County Health Department in Provo City and Utah County conducted a county-wide mosquito control program. At present, serious difficulties exist in both programs that could be best corrected by the formation of mosquito abatement districts as provided by Utah State Law. Among the difficulties so far encountered in these control programs have been interference in control procedures by political authority in Logan, and a lack of assurance of stability in the budgets. Adequate mosquito control in Utah County would require more money than is currently being spent for the other operations of the Health Department combined. This fact adds to the reluctance of the County Commission to provide the proper budget. The other mosquito control programs in Utah are hopeful that progress will be made in these new areas.

Mosquito control problems in Utah in 1963 were greater than usual. During the winter, snowfall in the mountains was below normal and on March 8th Governor Clyde announced the appointment of a committee to work on problems that were to develop from drought conditions in the state. April of 1963 was one of the wettest Aprils recorded and snowfall in the mountains was heavy. May was dry but above normal precipitations fell during June and coincided with the annual spring "run-off" from melting snow in the mountains.

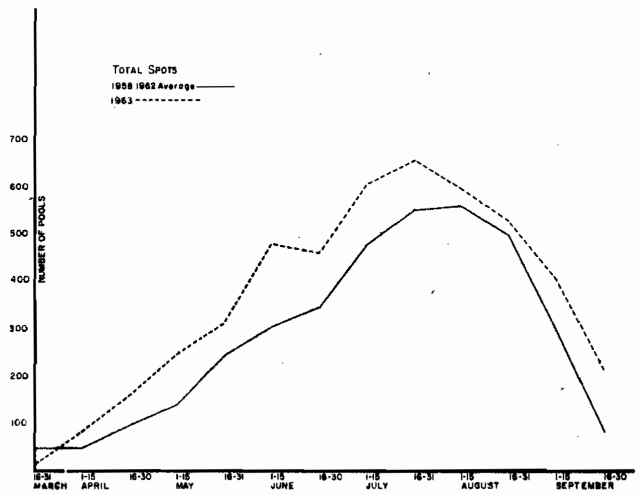

Fig. 1.—Total pools with mosquito larvae in 1963 compared with the average of the past five years.

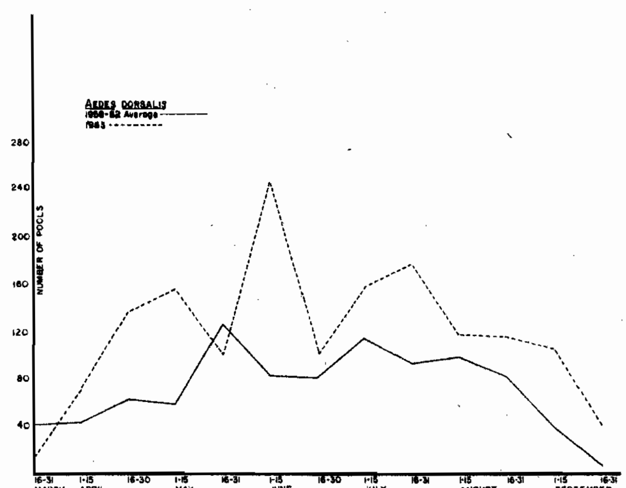

Fig. 2.—Pools with larvae of *Aedes dorsalis* in 1963 pared with the average for the past five years.

[1] Salt Lake City Mosquito Abatement District.
[2] South Salt Lake County Mosquito Abatement District.

These alternate periods of drying and flooding were conducive to the production of large numbers of *Aedes dorsalis* (Meigen) in the marshes along the eastern shore of Great Salt Lake and the pastures from Cache to Utah Counties. The larvae emerging from April's precipitation were successfully controlled in most areas but the combination of the "run-off" and above normal precipitation in early June caused control problems in excess of the capacity of the districts to contain them in the time available. During the latter part of June, large numbers of *A. dorsalis* moved from the marshes to the populated areas along the base of the Wasatch Mountains, including all of the major cities, and numerous complaints were received for a period of ten days to two weeks.

Larval records collected in the South Salt Lake County Mosquito Abatement District are probably typical of conditions in other parts of the state. Figures 1 and 2 show the increase in all pools with larvae and pools with *A. dorsalis* in 1963 as compared with the past five years. Similar increases were noted in light trap catches of *A. dorsalis* in the Salt Lake City and South Salt Lake County Districts.

Light trap catches (Table 1) show that a larger percentage of the mosquitoes trapped in 1963 were *A. dorsalis* than in the three previous years.

TABLE 1.—Percentage of *Aedes dorsalis* taken in light traps in Salt Lake County (1960-1963).

Year	*Salt Lake City*	*S. Salt Lake Co.*
1963	18%	16%
1962	4%	2%
1961	7%	3%
1960	4%	3%

In addition to complaints about mosquitoes, several complaints were received regarding biting gnats of the genus *Leptoconops*. The complaints occurred during the last half of May and the nuisance persisted in limited areas for about a week. In some areas misting for adult *Leptoconops* reduced the problem.

The importance of research activities in maintaining effective and economical programs is great and is widely appreciated in Utah. Such activities in Utah continued during 1963. These activities are conducted by the University of Utah, some of the mosquito abatement districts, and by cooperative efforts between the districts and the University. Studies included control techniques, resistance, measurement of larval and adult populations, ecology, distribution, taxonomy, the transmission of encephalitis, relationships of control of wildlife, and other studies. The United States Public Health Service maintained two new sentinel flocks of chickens in Utah in 1963 to obtain data regarding transmission of encephalitis.

NEWER DEVELOPMENTS IN ARTHROPOD-BORNE VIRUSES IN CALIFORNIA[1, 2]

WILLIAM C. REEVES
School of Public Health,
University of California, Berkeley

I have been given the challenging task of summarizing the newer knowledge on arboviruses in California for an audience that has a deep interest and considerable knowledge of a portion of the problem. All mosquito control personnel in this state have a comprehensive working knowledge of the basic epidemiology of western equine (WEE) and St. Louis (SLE) encephalitis and the importance of *Culex tarsalis* control. You have had more than a little experience in controlling this mosquito. The meetings of this Association for more than 20 years have devoted a great deal of time to detailed presentations of new knowledge on these viruses and today we are at the stage where these prior scientific discoveries are common knowledge and even taken for granted, as if we have always known them. We have every evidence that this background of knowledge is reliable, as your successful efforts to control *C. tarsalis* populations are directly reflected annually in a continuous decrease in the number of confirmed WEE and SLE cases in man and horse in California.

I hope that no one is forgetting our epidemic experiences in 1952 (Longshore 1953, Longshore et al. 1956) and the epidemic threat in 1958 (Reeves et al. 1964), and it is only through a continued intensive effort at control and continued research effort that we have future assurance of living comfortably with these viruses, as they still exist in their basic cycles in wild animals and mosquitoes throughout the Great Central Valley, as well as other parts of this state.

The objective of current research on WEE and SLE viruses and on *C. tarsalis* is to gain an even more comprehensive knowledge of transmission cycles and how to better control this mosquito. Let's take a quick and general look at current highlights of this effort.

C. tarsalis should feel like a chorus girl at a Las Vegas nightclub. It certainly has been scrutinized from every angle and with a variety of thoughts by a sufficient audience. The scientific publications on the secrets of this mosquito's private life rival the best efforts of a hungry press agent. So, today, for *C. tarsalis* we have an ever increasing knowledge of:

(1) its utilization of various types of water for reproduction (Reeves et al. 1962);
(2) various means of physically modifying these environments to reduce its reproduction (source reduction) (Whitten 1960);
(3) its susceptibility and/or resistance to a wide

[1] This investigation was supported in part by a research grant AI 03028(C5) from the National Institutes of Health, U. S. Public Health Service.

[2] Original data in this report represent information from a cooperative research project of the School of Public Health, University of California; the Bureau of Vector Control, California State Department of Public Health; and the Disease Ecology Section, Communicable Disease Center, U.S.P.H.S.

range of chemical agents (Reeves et al. 1962, Barr 1962);

(4) its possible control with biologic agents (Kellen and Wills 1962, Kellen et al. 1963, Kellen 1963);

(5) the influence of various climatic conditions on its reproductive rate and longevity;

(6) what hosts it feeds on and when (Dow et al. 1957, Reeves and Hammon 1962);

(7) how far will it fly, when, and where (Reeves et al. 1948, Bailey et al. 1965?);

(8) how to examine the ovaries of a female and tell if she is virgin or nonvirgin (Kardos and Bellamy 1961, Burdick and Kardos 1963);

(9) its ability to mature eggs without a blood meal (Bellamy and Kardos 1958);

(10) which females will survive the winter period (Bellamy and Reeves 1963);

(11) the virus infection and transmission rates of field populations (Reeves et al. 1961).

I could go on expanding and extending this list for the rest of the morning. However, suffice to state that each of these studies and pieces of information have either increased our ability to control *C. tarsalis* or have clarified our understanding of its relationship to the transmission of human pathogens. It is my belief that we have still only scratched the surface of learning how to best and most economically control this mosquito, and it is my hope that the research will continue unabated and that the mosquito and associated diseases will continue to be abated.

With reference to our understanding of the epidemiology of WEE and SLE, our present knowledge is sufficient to allow us to effectively prevent epidemics. However, research must continue on the "Sixty-four dollar questions" of the basic reservoirs and methods by which these viruses overwinter. Progress in this area has been slow and difficult. Today we can report that by an intensive search, these viruses can be found in *C. tarsalis* (Reeves et al. 1958), and in wild birds or rodents (Reeves, unpublished data) in the winter period. However, we still are uncertain if these isolations represent a low level of continuous transmission or a long-term persistence of the viruses in individual vectors and hosts.

The preceding has been a thumbnail sketch of what we have believed were our primary concerns with arboviruses in California. I would now like to turn to some viruses and problems that I believe will be new to you and perhaps of considerable concern in the future.

TABLE 1. Arboviruses known to be or probably in California as of January, 1964.

Virus	Isolated from	Serologic evidence only	Associated human disease somewhere	Vector in California	Reference
WEE	Mosquitoes, vertebrates	—	Yes	*C. tarsalis*	Reeves & Hammon 1962a
SLE	Mosquitoes, vertebrates	—	Yes	*C. tarsalis*	Reeves & Hammon 1962a
Colorado tick	Ticks, rodents		Yes	*D. andersoni*	Eklund et al. 1955, Eklund et al. 1961, Johnson 1960a
Bluetongue	Sheep		No	*Culicoides*	McGowan & McKercher 1954, McGowan et al. 1956
Rio Bravo	Bats		No	Unknown	Johnson 1960a, 1960b
Modoc	*Peromyscus* mouse		No	Unknown	Johnson 1960a, 1960b
Powassan	Ticks, man	In Calif.	Yes	Unknown	Thomas et al. 1960, McLean et al. 1961, Reeves (unpublished data)
California	Mosquitoes		Yes	*C. tarsalis* *A. melanimon*	Hammon & Reeves 1952
Buttonwillow	Rabbits, *Culicoides*		No	*Culicoides*, Mosquito?	Reeves (unpublished data)
Trivittatus	Mosquitoes		No	*C. inornata*	Reeves (unpublished data)
Cache Valley	Mosquitoes	In Calif.	No	*C. tarsalis*	Reeves (unpublished data)
Turlock	Mosquitoes, birds		No	*C. tarsalis* other *Culex*?	Lennette et al. 1957
Hart Park	Mosquitoes, birds		No	*C. tarsalis*	Johnson, H.N., (personal communication)
Kern Canyon	Bats		No	Unknown	Johnson, H.N., (personal communication)

New Frontiers in the Arbovirus Field

There has been a rapid expansion of interest in and research on arboviruses in many parts of the world in the past 10 years (W.H.O. 1961). If you do not commonly read a wide range of scientific journals, it may shock you to learn that there are now over 150 viruses that are believed to be transmitted by arthropods. Most of these are newly discovered viruses, yet a number have already been associated with large epidemics in Africa, Asia, and Latin America (W.H.O. 1961). However, time limitations preclude my developing this international picture, and I want to devote the remaining time to bringing you up-to-date on the viruses we know occur in California or nearby western states. In the past ten years, new research technology has begun to be directed towards a search for additional arboviruses in California and we have opened a "Pandora's Box". In California there are at least 14 distinct viruses that may be transmitted by blood-sucking arthropods, and the search has only begun. Our knowledge of the natural history and possible public health or veterinary importance of most of these agents is very limited. I will briefly introduce you to each of the 12 viruses other than WEE and SLE, to acquaint you with their names and to indicate our need for a future interest in them (Table 1).

Two well-known agents occur commonly in California, yet we tend to forget about them or to remember they are transmitted by arthropods. These are Colorado tick fever (Eklund et al. 1955, Eklund et al. 1961) and bluetongue of sheep (McGowan and McKercher 1954).

Fortunately, there has been a resurgence of interest in Colorado tick fever at the State Health Department, and Dr. H. N. Johnson (1960 and personal communication) and other members of the staff have gone far in defining the areas of Northern California where the virus occurs and the basic reservoiring mechanisms in rodents and ticks. The number of human cases occurring each year is still poorly defined.

Bluetongue virus, which is transmitted by *Culicoides* gnats, created a considerable veterinary problem when it appeared in sheep in western United States (McGowan and McKercher 1954). It previously was largely restricted to Africa. Fortunately, a relatively effective vaccine was developed (McGowan et al. 1956) and this virus posed no public health problem, so control against the vectors was not necessary.

For many years, we thought SLE virus was the only so-called Group B virus in California. Other mosquito-borne viruses in this group, such as yellow fever, the dengues, Japanese B encephalitis, and the tick-borne Russian spring-summer encephalitis (RSSE) viruses did not occur here. However, we now know that we have at least three Group B viruses in addition to SLE in California.

Rio Bravo virus was first isolated from the salivary glands of bats collected in Kern County (Johnson 1960a, 1960b). This virus is a scientific anomaly, as it would appear that a virus such as SLE virus has become adapted to the bat as a host and has now changed its characteristics and can be transmitted directly from bat to bat. There is no evidence that it requires a mosquito or other arthropod as a vector; and at this stage, we do not know if this virus commonly infects other animals.

Another Group B virus, Modoc virus (Johnson 1960a, 1960b), was isolated from the breast tissue of a white-footed mouse (*Peromyscus maniculatus*) in Modoc County by Dr. H. N. Johnson. Again, we know very little about this virus at this time. There is evidence that it also occurs in rodents in Kern County, but we know nothing about its mode of transmission or possible transmission to man or domestic animals.

The final Group B virus to be mentioned is Powassan virus (McLean et al. 1961). This virus was originally isolated from the brain of a child that died of encephalitis in northeastern Canada. Considerable excitement ensued when this virus was found to be closely related to the RSSE tick-borne virus complex. This complex of viruses poses a major public health and veterinary problem in many areas of Russia, Asia, and Europe (W.H.O. 1961) and no virus in this group was known from North America. Studies in Canada (McLean et al. 1961) and Colorado (Thomas et al. 1960) have revealed that this virus is widespread geographically and is carried by ticks. We now have fairly convincing serologic evidence that this agent is in rodents and rabbits in Kern County (Reeves, unpublished data), although the virus has not been isolated nor have human cases been recognized in California.

California virus was originally isolated from *C. tarsalis* and *Aedes melanimon* in Kern County and associated with three human encephalitis cases (Hammon and Reeves 1952). The most recent isolation of this virus was in 1944, and in recent years there hasn't been much interest in it. However, recent surveys in Kern County reveal that around 40% of the people and a number of small rodents and rabbits have been infected (Reeves, unpublished data). In addition, this virus or closely related ones have been found over wide areas of the United States and it may yet prove to be of some public health significance. We have made four isolations of a new virus from rabbit bloods collected in Kern County; it is slightly related to California virus but distinct and is called Buttonwillow virus (Reeves, unpublished data). Its possible importance is unknown as of now, but it also has been isolated from *Culicoides* gnats. Still another virus in this complex was isolated from *Culiseta inornata* in Kern County (Reeves, unpublished data). This virus appears to be Trivittatus virus, which was originally isolated in Montana.

A virus related to Cache Valley virus (Holden and Hess 1959) has now been isolated from *C. tarsalis* in Kern County (Reeves, unpublished data). This virus was first recognized in Utah and now is known to be widely distributed in the United States. Some people in Kern County have antibodies indicating previous infection.

Turlock virus (Lennette et al. 1957) has not been mentioned to this audience since 1955 when Dr. E. H. Lennette first announced its isolation from *C. tarsalis*. This virus is a prime candidate for further study. It has been isolated many times from *C. tarsalis* and occasionally from other *Culex* or birds in widely separated areas of California and potentially should be transmitted to man and domestic animals as frequently as WEE or SLE viruses. At this time, we know almost nothing about this virus other than its identity and association with *C. tarsalis*.

The other arboviruses from California that I could mention are Hart Park (H. N. Johnson, personal communication; Casals 1961) (isolated from *C. tarsalis*), Kern Canyon (H. N. Johnson, personal communication) (isolated from bats), and a considerable number of other viruses isolated from arthropods or animals and stockpiled at our laboratory and the Viral and Rickettsial Disease Laboratory of the State Health Department that are awaiting their turn for identification and further study.

I hope you found this quick review of the range of possible disease agents that may be transmitted by mosquitoes or other blood-sucking arthropods in California as worrisome and challenging as I have. I haven't mentioned many similar new agents from other areas of the United States. There is a great deal of research to be done before we can speak intelligently of the biologic cycles of these viruses or define their public health and veterinary importance.

The principal challenge to mosquito abatement districts is still to control *C. tarsalis* effectively and prevent epidemics or even sporadic cases of WEE and SLE in man and horse. This state and every mosquito control agency in it can be proud of the current record in this task. I foresee that in the future we will find some of the myriad of other arboviruses are of sufficient public health importance that we may have to develop equally intensive control programs for other mosquitoes, gnats, or ectoparasites that we consider today are of no importance or are only pests.

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CALIFORNIA CHIRONOMIDS

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In 1959 the Los Angeles County Flood Control District besieged by an essentially harmless, nonaggressive insect sought information throughout the country on ways to combat it. The district was, in fact, fearful for its continued spreading ground operations in the Whittier Narrows. Despite the vital aspects of spreading ground operations in water-short southern California, local residents were not prepared to tolerate the water spreading basins as insect breeding sources.

In June of 1961 an elderly man stood up at a citizen's protest meeting in Oceanside, California, and shaking, almost on the verge of apoplexy, read a lengthy petition on behalf of more than 100 similarly irate people demanding that these same insects be rid from Buena Vista Lagoon.

A year later another organization, the Los Angeles County Sanitation Districts, similarly disturbed requested that a midge study be made at its Lancaster sewage oxidation ponds. This study resulted in 120 acres of oxidation ponds being removed from summer operation in the middle of the Mojave Desert.

In 1963, a completely enclosed subterranean municipal reservoir in Beverly Hills was drained and idled for nearly four weeks because of bright red worms found swimming about in the settling flasks of a nearby X-ray processing plant.

The insects bothering all of these parties were chironomid midges. A very excellent discussion of chironomid midges as a nuisance is that by Mr. Gail Grodhaus (1963) which appeared last year as a two part series in *California Vector Views*. Another worthwhile discussion is that by Whitsel *et al.* (1963).

The midge problems which I have mentioned here in the way of introduction are among the more interesting of several which Dr. L. D. Anderson (Professor of Entomology, University of California, Riverside) and I have studied since 1960. These studies have been supported by several organizations including the Los Angeles County Flood Control District, the Los Angeles County Sanitation Districts, and currently the National Institutes of Health.

This morning I simply intend to review the more significant midge problems on which we have worked and bring you up to date on their present status.

The first problem, that at the Los Angeles County Flood Control District spreading grounds, first became a serious concern during the late spring and summer of 1958. The preceding winter (1957-58) rainfall had been 167% of the annual norm and spreading basins were kept filled to capacity. As the water warmed to spring temperatures, chironomid midges, of the species *Chironomus californicus* Johannsen and *C. attenuatus* Walker emerged in mass. These midges overwhelmed surrounding residential areas and infiltrated local paint and plastics industries where they contaminated these industries' products.

The problem recurred at the spreading grounds the following year (1959) when an immense emergence took place during a midwinter warm spell near the holidays.

The University of California was given a grant by the Los Angeles County Flood Control District to study the problem beginning in the fall of 1959. Soon thereafter it was established that the rotational wetting and drying of batteries of basins prevented midges from completing their development and emerging.

Tests with a number of insecticides showed that most chemical treatments were extremely short lived, and that midge reinfestations which followed were usually more severe than before treatment. Parathion high release granules were found to be the most effective and acceptable treatment in small areas of temporary water. These treatments were effective between 0.1 and 1.0 pounds of actual material per acre, depending on the habitat where used.

Where large, more or less permanent bodies of water were concerned, it was found that carp (*Cyprinus carpio*) were very useful in midge control. Carp populations of 150 pounds per acre and higher were shown to be extremely effective in suppressing midge populations and also filamentous algae.

An equally important discovery, however, was that after initial outbreaks midge populations usually remained equally low with or without carp.

Except for a few localized midge disturbances there has been no significant problem with midges in the vicinity of the Whittier Narrows spreading grounds since 1960. During 1963, only two small scale (less than four acres) precautionary treatments were applied with parathion granules.

Not all chironomid problems stem from new or intermittent water situations. A case in contrary is the Oceanside problem. Buena Vista Lagoon, from a distance, is truly a picturesque lagoon. Situated between the towns of Oceanside and Carlsbad, a short distance from the ocean, this lagoon is highly regarded by many area residents as a wildfowl refuge. However, other residents who occupy the lovely patioed homes which crown the surrounding slopes of the lagoon regard it less affectionately. These persons are less bird watchers than midge watchers and during the summer of 1961, much to their distress, they watched midges ascend from the lagoon as many as 600 per square foot of water surface per day. Patios became useless and festoons of midge-laden spiderwebs were everywhere.

At the water's edge the lagoon is anything but picturesque. The water is extremely shallow, pea green in color, and conceals a bottom of sticky black mud which is the consistency of pudding. In this bottom ooze midge larvae of the genus *Tanypus* and *Chironomus stigmaterus* Say, numbered from 3,000 to 30,000 per square foot during the summer of 1961. Contributing to the nourishment of these larvae was the combined inflow of nearly one million gallons of sewage effluent per day from the towns of Vista and Carlsbad.

In cooperation with Mr. Harvey I. Magy, of the State Bureau of Vector Control, and Mr. Richard A. Mackie, of the San Diego Health Department, a field trial of malathion on urea prills was made at one pound per acre. The results were completely negative.

Permission was requested of the State Department of Fish and Game to stock the lagoon with carp, or at least to test the availability of these fish to control midges in this type of environment, but this permission was denied.

Additional work has not been conducted at Buena Vista Lagoon, but the problem there seems at least temporarily to have subsided. Continued contact with Mr. John Slater, Carlsbad City Manager, keeps us abreast of the situation there. Midge complaints were reported to be considerably less in 1962 than they were in 1961. In 1963 there were again a few complaints, but nothing to compare with 1961. It may be significant that 1961 followed an atypically warm, dry winter and that the summer of 1962 followed a very cool, wet winter. The winter of 1962 was again fairly dry. Warm dry winters could conceivably encourage algae growth and early midge breeding activity.

The Santee water reclamation plant, near San Diego, has had a similar but lesser experience with midges breeding in its oxidation ponds. The Santee plant, for reasons which are not well understood, has had no serious midge complaints since 1961. A contributing factor here is that in 1961 the Santee ponds were relatively new, and have since had an opportunity to become established.

At Ontario, however, much the same situation has occurred without benefit of new ponds. The oxidation ponds at Ontario which ornament a beautiful golf course produced large numbers of *Chironomus fulvipilus* Rempel and *Tanypus* species during the late summer of 1961, but not since. Meanwhile, larval populations persist at 3,000 to 5,000 per square foot, Consequently, the site has been an excellent one at which to screen larvicides.

During 1960 and 1961, *Tanypus* species and *C. stigmaterus* scourged the environs of the Palm Springs sewage disposal plant. Permission was obtained from the State Department of Fish and Game and carp were stocked in 5 acres of oxidation ponds early in 1961. These carp have thrived and midges at Palm Springs are no longer a problem. It is not known what the present carp population is in the Palm Springs oxidation ponds, but it is certain that they have propagated. The fish are sport-fished by plant employees and also their feeding depressions are readily visible from the banks of the ponds.

The Lancaster midge problem, unlike that at other sewage effluent sites mentioned, has been an annually recurrent problem until this past season. As at most sewage oxidation ponds studied, the predominant midge species at Lancaster are *Tanypus* species and *C. stigmaterus*.

The problem at Lancaster developed when 240 acres of desert near the junction of U.S. Highway 6 and California Highway 138 were diked and flooded with treated sewage water. Since these water impoundments were several miles from the nearest populated area, midge complaints came not from property owners, but from passing motorists. Midges swarming over the highways obscured the windshields of passing vehicles, thereby causing hazardous driving conditions.

Through an agreement with the Los Angeles County Sanitation Districts, the University of California during the summer of 1962 conducted a survey of the eight 30 acre Lancaster oxidation ponds. The results of this survey showed that 90% of the midge production was coming from the four terminal oxidation ponds nearest U.S. Highway 6, or from 50% of the total pond area. Thus, it was recommended and accomplished that by June of 1963 these four ponds were drained and left dry for the remainder of the summer. The midge complaints from motorists thereafter ceased.

During the Lancaster studies carp were studied in pens in the second from last oxidation pond, but they failed to survive for more than nine days. A low dissolved oxygen content (less than 1 ppm) during the early morning hours, together with high alkalinity (pH 9.5), is believed to have caused these carp to die.

At the La Cienega reservoir, in Beverly Hills, water contamination by *Chironomus* larvae has been a sporadically recurrent problem for many years. The treatment in the past had been to fumigate the reservoir chamber with burning sulfur. However, this treatment has had a very destructive effect on the concrete interior of the reservoir and has exposed the steel reinforcement in many places. Within the past few years, a consulting engineering firm has supervised sealing the reservoir to make it insect proof. Despite this effort during the spring of 1963, midge larvae within the reservoir again became a problem. This time the reservoir was completely drained and residual puddles of water were treated with concentrated high test calcium hypochlorite.

Although the design of the plant and its water source were carefully discussed with the plant superintendent and consulting engineer, the source of larval contamination was not discovered.

When no living midge larvae could be found it was recommended that the reservoir be filled and that a fine screen box-trap be inserted in place of one of the concrete access plugs in one side of the reservoir. This was done and no adult midges were captured. Yet larvae still appeared from a tap leading away from the bottom of the rapid sand filters to the reservoir. Finally, it turned out that water used to back flush the filters was stored in a large uncovered tank at an elevated point within the main building of the plant. It was reported that no midges were ever observed around this tank, but that after it was covered by a fine screen at the suggestion of a plant employee larvae were no longer recovered either from beneath the filter or from the reservoir. No one is willing to insist that this was a cause and effect result, but at least the problem now seems to be solved.

Such is the status of the more important midge problems in southern California. Some of these problems we feel are well under control by our recommendations and others we know are quiet only by a whim of nature. These we expect to encounter anew at some future date. Meanwhile, through the cooperation of the California State Bureau of Vector Control, various mosquito abatement districts, and other organizations we are constantly learning of new midge problems. At the same time, through controlled experimental facilities at Riverside we are seeking a better understanding of various conditions which favor midge outbreaks and ways to prevent them.

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PRESIDENTIAL MESSAGE

J. D. WILLIS, *President*
California Mosquito Control Association

Members and guests of the California Mosquito Control Association, ladies and gentlemen. We are about to wrap up our 32nd Annual Conference. These conferences have continued to be the highlight of each year's activities of our Association.

Through the years since its formation, we have seen many changes as the California Mosquito Control Association has attempted to keep pace with our expanding economy and the extensive agricultural and industrial development that has characterized California. On December 16, 1930, representatives of 14 mosquito abatement districts and other interested agencies, responding to an invitation issued by the late Harold F. Gray, met informally to discuss mutual mosquito control problems. Because of a clear desire to continue these meetings, this group met again the following year, at which time officers were elected. This was the beginning of what is now known as the California Mosquito Control Association. Except for two years, during World War II, this Association has met annually.

At the present time we have 46 corporate members out of a total of 54 districts and health departments in the state engaged in mosquito control activities. I would like to see all of these agencies become members of our Association. About 70% of the present corporate member agencies are participating in the Association by way of their representatives serving as officers, committee members, and area representatives. Personnel of the State Department of Public Health, Bureau of Vector Control, as well as the University of California are also active, serving as technical consultants and supplying our membership with valuable research information on mosquito biology and behavior, epidemiology of mosquito-borne diseases, insecticides, and other current problems which affect all of us. I would like to see more of the corporate member agencies that are not active at the present time participate in some way in the activities of our Association.

If you examine the past record of our organization you will find that for many years there were six or seven Board of Directors' meetings each year. During the past few years, however, there has been a real effort to keep these meetings at a minimum, at the same time being alert and responsive to our many problems and administrative responsibilities. Meetings of our committees, which have become more and more active and productive, have been scheduled as often as possible to coincide with Board meetings. It is my hope that this policy will be continued.

I think it is important from time to time to consider the future of this Association. I personally believe that the Association is going to be playing an increasingly important role, and that it will be looked to by our State Legislature, as well as others who are concerned about mosquito control, as a primary source of information in this field. We must be prepared and willing to supply this information. I believe that all of the mosquito control agencies in the State stand together to serve the best interests of the public. This was proven this past year when an attempt was made to pass legislation which could weaken the structure of many abatement districts. It was gratifying to see all of the districts, including those not in the Association, work together to defeat this ill-conceived bill.

It is my hope that during 1964 we can make significant progress. The Board of Directors must take the initiative to see that the University and the Bureau of Vector Control are fully aware of the research needs of local mosquito abatement agencies in California and that the most critical problems are given highest priority.

Now let us look at some of our problems.

Pesticides.—We must be prepared to counter in an informed and positive manner those who would restrict the use of pesticides to such an extent that we would be unable to conduct effective mosquito control programs. We must be certain that the Legislature and other official agencies concerned with pesticide use understand our problem and realize that we are using pesticides with scientific precision, observing every possible precaution to assure the safety of man, domestic animals and wildlife.

Just a few weeks back there was a hearing before a Legislative interim committee on the use of pesticides in California. After reading the report of this hearing and the testimony presented, I am convinced that we should consider ourselves very fortunate that we have men in our Association who can prepare a report that presents the position of our collective program in an enlightened and constructive manner.

Research.—I have been convinced for some time that we should have a much more extensive research program than we have had in recent years. During the past two years, the research program has been intensified considerably. The University of California and the Bureau of Vector Control are doing a very effective job of coordinating their research programs. I hope that these two groups will continue to increase their research activities, that they will work as closely as possible with this Association, and that they will concentrate their efforts on our most serious problems on a priority basis.

During this past season it was very gratifying to me to observe some of the work that is being undertaken in the field, as well as in the various laboratories, not only by the research people from the University, the Bureau of Vector Control, and the Department of Fish and Game, but also by certain of the better equipped mosquito abatement districts. Each year, during our annual conference, we are including papers on flies, gnats, and other insects which are apt to be of direct concern to many of us in the future.

Fiscal considerations.—During the past few years we have come to the realization that we have reached a limit in spending unless new sources of revenue are assured. There are those among us who see the advantages in having a full-time secretary. We have discussed ways and means of changing the method of financing our Association. Various possibilities for curtailing present expenses have also been considered. It is difficult to see where existing expenses can be reduced to any great extent. When we look at other professional or trade associations we find they are spending much more today than they were ten or fifteen years ago. I believe that this Association must be prepared to make a greater financial investment if we want to continue to give the services we have been giving in the past. Under present circumstances, however, it is essential that committees of the Association keep their expenditures at a minimum this year. I hope that additional means of support for the Association can be found in the future.

Membership.—At the present time there is a desire on the part of many of our corporate members to change the bylaws so that anyone interested in vector control could become an active member of the Association. The Bylaws Committee has been studying this and other related proposals and has made recommendations to the Board of Directors. I do not know at this point whether there will be changes in the structure of membership or not. In many ways it would give the Association added prestige, assure a much larger membership and possibly create more interest in this organization. Those who are opposed to any change feel that we are an association of mosquito abatement districts and should keep it as such; they also feel that we would lose much of the financial support we presently enjoy if we were to make these changes. I am certain that no hasty decisions will be made in this regard, and I am confident that any future changes will be made in a democratic way and in the interest of progress within the Association.

Don't overlook the fact that you have elected representatives to the Board of Directors from your respective areas. I hope that you will both influence and support the decisions that these people make. You may be assured that the Board of Directors will carefully evaluate the wisdom of past decisions in planning for the future of your organization. Within an organization such as ours there must be mutual trust. It is important that we listen to all who desire to be heard. Healthy differences of opinion and intelligent debate will lead to decisions which are understandable and genuinely in the interest of our Association.

In closing, I should just like to say that it has been a pleasure to have been a member of this organization for 17 years. I accept this opportunity to serve you as President of the California Mosquito Control Association during 1964, and in behalf of your Board of Directors I ask for the help of each of you in making this a year of progress.

Finally, I would like to extend thanks to all whose efforts have gone to make this Conference such a success, to Bill Rusconi and his technical consultant, Dick Peters, and all of the members of the Program Committee; to Mr. Gallagher, Les Brumbaugh, Marvin Kramer and others who worked on the Local Arrangements Committee; to the trustees of the Sacramento County-Yolo County Mosquito Abatement District; to Mr. Geisreiter who, in addition to being a trustee, is Manager of the Sacramento Convention Bureau; to George Umberger, who has proved to be a wonderful host; and to the State Health Department and the University of California for assisting in many ways. I would also like to thank all of the sustaining members who have attended the Conference and given their generous support. As always, we are honored by the attendance and active participation of our colleagues from other states who have made the trip to California for this Conference. We shall look forward to seeing all of you at our next conference in Riverside in 1965.

The 32nd Annual Conference of the California Mosquito Control Association is now declared adjourned.