PROCEEDINGS AND PAPERS

OF THE

TWENTIETH ANNUAL CONFERENCE

OF THE

California Mosquito Control Association

AT

FRESNO STATE COLLEGE · FRESNO, CALIFORNIA

FEBRUARY 13, 14, 15, 1952

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Group of delegates and guests at Fresno State College

The Registration Desk. Col. Carpenter, H. F. Gray and T. G. Raley

Group witnessing an equipment demonstration

Group at the Fresno Field Station of the Bureau of Vector Control

PROCEEDINGS AND PAPERS OF THE TWENTIETH ANNUAL CONFERENCE

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California Mosquito Control Association

FIRST SESSION, WEDNESDAY, FEBRUARY 5, 1952, 1:30 P.M.

STUDENT UNION HALL, FRESNO STATE COLLEGE

Dr. Lang: I'm sorry that President Joyal is unable to be present, but it gives me a great deal of pleasure to welcome you to Fresno State College. I have a very special interest in the type of work you are doing. From 1913 to 1922, I was Superintendent of the public schools for the Panama Canal Zone. I knew Dr. Gorgas very well, had many visits with him and remember many things that he had to relate regarding the work which he headed on the Canal Zone in respect to health and, of course, basically it was a question of mosquitoes. I can't help but remember Col. Gorgas pointing out that the French failed largely because of the lack of control of malaria and yellow fever. In the hospitals of the French days little tins of water were put under each bed leg so that the ants would not disturb the yellow fever and malaria patients, which was a very fine setup for the mosquitoes to breed in these little cups and bite the yellow fever patient and fly off and inoculate someone else. I visited the Canal Zone again just two years ago this Christmas, the first time since I left there in 1922. I suppose they have made improvements in mosquito control, but the thing that I noticed particularly was that the Canal Zone did not look as spick and span as it did when I lived there. The grass was not so well cut. I didn't see any old tin cans around, but when I was there the grass was kept well cut and there were no bottles, tin cans or trash around. Buildings were screened until the last few years before I left. I know methods of controlling mosquitoes have improved and they still do a good job on the Canal Zone. You can see why I have an interest in the type of work you are doing here in mosquito control.

If we at the college can be of any help to you, do not hesitate to let us know. If you find some of the accommodations are not as you want them, let us know and we'll try to give you what you would like, and I hope you have a very, very successful meeting with us on the campus.

President Smith: Thank you, Dr. Lang. I'm sure that already we greatly appreciate the facilities that you've made available to us. I don't think I've ever attended a conference where there were more comfortable seats.

Next I want to call on Gordon Dunn, the Mayor of the City of Fresno.

Mayor Dunn: Thank you, President Smith. Your program says I am to present the key to the city. Unfortunately the budget didn't take care of funds for keys to the city, so it's strictly a verbal deal this particular time, but rest assured, President Smith, you do have that verbal key. We in Fresno are particularly proud of our mosquito control district. In my own mind, and I think our citizens would bear me out, that is one of the few taxes for which we can see beneficial results, and believe me, that's something. People don't like to pay taxes, but you can see the results of this mosquito abatement program, and it's something you can point to with pride. The people in this area who love to live outside in the summer and have gone in madly for barbecues and back yard activities, particularly appreciate it. I happen to be one of them, so I know whereof I speak. It is one of the things in government you can point to and say, this is what it has accomplished, and this is what we are attempting to do. I urge you to keep up the good work and I know that in this conference each and every one of you is going to learn something new. The ideas that one fellow has may be just what you are looking for and have overlooked, because many, many times you are too close to the forest to see the trees and the other fellow's problem may be your solution. I appreciate your coming to Fresno, and as Dr. Lang has so graciously said, if there is anything the city can do, please don't hesitate to call.

Mr. Smith: Thank you, Mayor Dunn. I want to make one announcement for the benefit of all of those official representatives of member agencies of the CMCA. So far our Secretary has received authorizations from only 15 out of the 36 paid up members. If you have your authorization as designated representatives of your agency, please present that to Ed Washburn. I'm going to call on Harold Gray to introduce the next speaker.

Mr. Gray: This introduction might be perhaps entitled, "Local Boy Makes Good," because our next speaker is a local boy. He was born in the town of Benicia, California, which also has the distinction of being the birthplace of my mother and father. After going through school and obtaining his medical degree, he became very much interested in the problems of public health and for many years was with the International Health Division of the Rockefeller Foundation. While he was with them he wrote a book, but in this case, he wrote one of the great classics in public health literature. The book is called "Malaria in Europe"—everyone who has ever had anything to do with mosquito control should have read that book; if you have not read it, by all means do so upon your return to your home community. I would without question classify our next speaker as one of the three leading malariologists in the world, another being Sir Malcolm Watson of England, and the third very probably Joseph Augustine LaPrince. He is going to talk to us about the world wide importance of mosquito control. It gives me very great pleasure indeed to introduce to you my old friend, and present colleague, Dr. Lewis W. Hackett, visiting Professor of Public Health, University of California, and Editor of the Journal of Tropical Medicine and Hygiene.

Dr. Hackett: Thank you very much for your kind welcome. I left California in the year 1901 and have now returned to live here, but I feel as any good Californian does—absence only tightens the bonds that we have toward our State.

Hardly four years ago we were enjoying a period of enormous optimism, not only in the United States, but all over the world. After the war, the United States invited all the other countries to an International Congress on Tropical Diseases and Malaria in Washington, and we were made to feel that this perhaps was the beginning of the end of a great many insect-borne diseases, including malaria. Dr. Soper was legitimately confident of this, since he, as you know, was the eradicator of *Anopheles gambiae* in South America, and Egypt, and of

Aedes aegypti in the yellow fever areas. Dr. Soper was convinced that, given enough DDT, we could probably even eradicate the malariologists. Dr. Boyd's great book on malaria was just about to be published and everyone had the feeling that it would appear just in time to be the tombstone of malaria and that these great volumes would repose unconsulted in the future in our libraries. There was some talk of preserving a colony of each malaria vector somewhere so that, like Noah, we might preserve them from extinction.

Well, as you know, all this was somewhat premature. What a contrast it was to attend the meeting of the American Society of Tropical Medicine and the National Malaria Society in Chicago in November. There was a general feeling of gloom, except perhaps among the malariologists. In Washington the malariologists had been quite downcast. Many of them earned their living studying and combating malaria and it was insinuated that a malariologist in the future would find himself on the horns of a dilemma: if he continued to study malaria without eliminating it, he would be a criminal, and if he got rid of it, he became a fossil. Well, the malariologists began to look up a bit in Chicago last November. It turned out that we had been pathetically dependent upon these insecticides. DDT was a great weapon even in the hands of ignoramuses, but we all had begun to realize in Chicago that it was not the final answer, and that there is really no substitute for knowledge.

Now malaria in the United States, as well as in California, has practically disappeared. In California there were only five cases reported last year. One of these was a death and this is suspect because people don't die of malaria in California. The other four were confirmed by blood preparations, but in the whole United States, outside of California, there were also only five indigenous cases last year that could be confirmed, out of some four thousand reported. Most of these were repatriated service men or laborers from south of the Rio Grande, but as you know, many of the good old doctors down South are accustomed to diagnosing almost all obscure fevers and complaints as malaria. That has been customary for many years and used to have some basis in fact. Probably neither the doctors nor the patients are yet aware that transmission has practically ceased. Nevertheless, reporting malaria by guess has been partially eliminated by the antibiotics. While the antibiotics are not a cure for malaria, they have done a great deal to cut down malaria statistics by providing something besides quinine which the country physician can give for these obscure infections. If the antibiotic gets results, it isn't malaria, so that the reporting of malaria has been reduced since penicillin has taken the place of the chill tonics which everybody took in the old days when he didn't feel so well. But what has really brought the facts to light is the vigorous campaign of the Public Health Service to have a laboratory examination on every reported case. Some previously malarious states showed no positives at all when this practice became established.

The *quadrimaculatus* mosquito of the southeastern seaboard seems to be a more dangerous one than *freeborni*. I don't think that even Harold Gray would claim that we in California have actually eradicated malaria by controlling *freeborni* production in California. Eradication of malaria means a plan of campaign with that as its objective, and *freeborni* I am told is more numerous now than it ever was in the past. Mr. Gray has told me that it is even possible that "miner's fever" in the early days of California, which was undoubtedly malaria, might not have been transmitted by *freeborni*. It isn't impossible that one of the other*Anopheles, punctipennis* or even *pseudopunctipennis* might have been the vector of that old malaria. The fact is that when irrigation brought *freeborni* to the Central Valley, malaria, while it appeared in occasional, acute and limited outbreaks, did not keep pace with the increase in *Anopheles* produced by irrigation and rice culture, and Dr. Freeborn told me that he thought as early as 1920 malaria ceased to be a serious public health problem in California.

Malaria lingered much longer on our southeastern seaboard where *quadimaculatus* while not perhaps a very good vector either, still had a greater contact with man than *freeborni*. Now it is quite likely that it was necessary in our South to use insecticides to accelerate the general fading out of malaria which took place spontaneously in the rest of the United States. However that may be, malaria has now disappeared as an endemic infection. It is simply impossible to believe that these five cases which have been confirmed in our southeastern states, independent of each other as they are and scattered geographically here and there, constitute a chain of infection which could maintain malaria as an endemic disease. Mexican labor has now begun to invade the Southeast as well as the Southwest, and it is quite likely that these indigenous cases are secondary to imported strains of parasites, and that we have no endemic malaria anywhere in the United States.

This almost automatic disappearance of the infection here has been due to a large number of cooperating factors such as screening, agricultural and other drainage, the domestic use of insecticides and the increase of cattle. Cotton is being replaced by dairy farming and cattle raising in the South. There has been a general rise in the standard of living and all of these things have contributed toward the disappearance of malaria in the United States.

But the picture in the world at large is a very different one. If you look abroad, especially at the underdeveloped areas where great poverty reigns and great overcrowding, you will find that malaria has remained the enemy, the principal enemy, of the rural inhabitant almost everywhere in the world. Dr. Paul Russell, after a very careful examination of the statistics and after visits to the various countries, estimates that we still have three hundred and fifty million cases of malaria each year in the world today, and of these, probably three and a half million die. Now you see, that is really a problem of first importance.

A change has taken place, however, in our approach to the malaria problem. Hitherto we have had our specialists in malaria and we have considered malaria as a problem by itself. Epidemiologists were over-specialized. I myself became exceedingly and narrowly specialized in the study and control of malaria. I think that is going out, which in part is due to DDT also, which is not at all a specific for malaria mosquitoes alone. For instance, in Bolivia, where we operated a malaria service for about ten years, we discovered that we could not only get rid of malaria with DDT, we could get rid of the vectors of typhus, plague and yellow fever, too. These four diseases were the great obstacles to the development of Bolivia. Typhus occurs on the high plateau, where the Indians live at from ten thousand to sixteen thousand feet above sea level. Typhus is their great enemy, and DDT, after the work in the Mediterranean during the war, proved to be sufficient to control lice and to eliminate epidemic typhus from villages of the high plateau. This at least was one public health measure which we didn't have to force or cajole or bribe the people into adopting. Everybody liked DDT. Everybody all over the world has liked it. Our trouble with DDT is to keep the people in order, to keep them from repeating, and to keep them from stealing it, and this is of course an extraordinary thing, for a public health measure.

The malaria was controlled in Bolivia by spraying with DDT every accessible house in the malaria zone which covered the eastern slope of the Andes from 8,000 feet down to about 1,500 feet and overlapped the yellow fever and plague zones in the lowlands, which could also be controlled by DDT. Our DDT gangs could handle the vectors of all four diseases and we therefore abandoned the malaria, yellow fever, plague, and typhus services, which had been functioning independently, and organized a service of Rural Endemic Diseases, an integration which eliminated duplication, gave prestige to the Health Department and benefited the almost forgotten rural inhabitant in South America.

Now in the same way in many parts of the world malaria is entering as just one of the public health problems in the whole picture of public health. This is a great advance it seems to me. I remember on a visit to Mexico some years ago how depressed I was to find that the new director of health had hit upon a novel scheme of organization. His idea was to have a Department for each disease, complete with a Director General down to doorman, and that seemed to me to be a backward step. We have met the new situation in this country by dissolving the National Malaria Society and combining it with the American Society of Tropical Medicine. They become one society and their amalgamation will preserve and perpetuate the interest in malaria as one of the chief problems which still confront mankind in this world.

One of the things which made DDT so acceptable to the South Americans, to the people in the Near East and to the Orientals, was that it also did away with the house fly. Now, you know the sad history of that development.

The era of fly control with insecticides is over, it seems to me, for the time being, and we have now, in this country, not only flies but six culicines resistant to DDT and to all the other chlorinated hydrocarbons. The body louse in Korea is resistant, and seems to have been resistant from the start, because the head louse is not resistant to DDT. That's a curious thing, if the reports are correct. And then there are stories from all over the world of other arthropods gradually becoming resistant to the chlorinated hydrocarbons. I do not think we should fold our hands till someone comes up with a new discovery. We had better go back to sanitation.

The important and fortunate thing is that up to the present time, hardly any of the *Anopheles* has shown any resistance to DDT and *Aedes aegypti* is still a push-over for this drug. DDT is so important still in South America, that we would really be in despair if *aegypti* did not promptly succumb. There are many ways in which we have used it against *aegypti.* As you know, the peoples in South American rural villages store their water in porous earthenware jars, and in that way they maintain this domestic mosquito. We found that a little DDT powder sprinkled in the water jar will keep that jar free from *aegypti* larvae over three months even though the jar be emptied, rinsed and refilled every day. In other areas we dissolved the DDT in alcohol, to make a one or two per cent solution, if the people objected to having this poison thrown as a dust in their drinking water. They found the alcohol less objectionable when added to their drinking water.

The two campaigns then, against the *Anopheles* of the world and against *Aedes aegypti* are still going ahead on the basis of insecticides. Insecticides are not always neecssary in *Aedes aegypti* work provided water can be piped to the local community; but any of you who know South America realize how far off any such situation as that still is in the rural towns. The city of Lima, Peru, for instance, used to have a great deal of yellow fever. No one has ever made a campaign against *aegypti* in Lima, but in 1941, we examined three thousand houses in Lima, houses in the poorer quarters and along the docks and so forth, and we didn't find a single *Aedes aegypti.* A piped water supply in Lima apparently had eliminated *aegypti* automatically from that big city. That is what happened years ago in our great sea ports which had periodic epidemics of yellow fever. We used to have water buckets on all the wharves for fire protection and those of course were sought by the *aegypti* each spring when they came ashore from the ships, and maintained them all summer. It seems that we never had an epidemic of yellow fever in San Francisco. That is rather curious because there was a great deal of it in Panama, and the old sailing vessels certainly transported *aegypti* from Panama to San Francisco. *Aegypti* had no trouble at all in traveling from Africa around the Horn to the Pacific ports of South America. Those sailing vesels had open water tanks in which *aegypti* could develop, and many of them had a running epidemic of yellow fever on board. In 1952, my grandmother's sister came to California from New Hampshire via Panama, and she died of yellow fever on board ship and was buried at Acapulco. Why yellow fever never became epidemic in California we don't know.

The danger of yellow fever to cities which breed *Aedes aegypti* in our hemisphere is still a lively one. As you know, yellow fever broke out in Panamá in November, 1948, after a silent period of some twenty years. They have had several cases each year sinec then and it has been traveling northward through the jungle along the Atlantic coast. Dr. Herbert Clark has just shot some young monkeys in southern Mexico and found some of them immune to yellow fever which means that there has been yellow fever virus actively transmitted in southern Mexico probably within the last six years. How far north that goes we don't know. There is a little jungle around Tampico, but it is quite likely that there are not eonugh monkeys nowadays in that area to maintain yellow fever.

The important thing is that we are in the process now of trying to exterminate the *Aedes aegypti* mosquito in this hemisphere. That seems like a big propostion and some years ago we would have thought it absurd even to dream of such a thing. However, with such a potent larvicide as DDT, which is fatal to *aegypti* larvae in a solution of one to forty million and has a residual effect lasting several months, it is quite possible now to eradicate the mosquito from any town or village in South America in three to six weeks, a task which is 1941 would have taken at least six months, if not a year or two to accomplish. *Aedes aegypti* has already been completely eradicated from three South American countries. Bolivia was the first, then Brazil, now Chile. Vigilance will have to be maintained in Brazil for at least a year longer before we can say it is absolutely eradicated, but at any rate, they are not finding it anywhere. The eggs of *aegypti* can sometime survive in the dry state for over a year. We found larvae in a jar in Bolivia which had been on a shelf empty, according to the family, for more than two years; but it had recently been put to use again for water storage. *Aedes aegypti* is practically gone in Uruguay, Paraguay and Panamá. Only one focus has been found in each country in recent months. The campaigns began much later in Argentina, Colombia, Central America and the West Indies, but they are going on now at a very intensive rate and intensive work continues in Peru, Equador and Venezuela. That about covers everything below the Rio Grande, and the United States is apparently the only country in this hemisphere not yet interested in trying to control or eliminate this potentially dangerous mosquito. I suppose the danger doesn't seem particularly acute to Congress or to our Public Health Service. Wherever dengue can spread, yellow fever can become epidemic, and we used to have a good deal of dengue in Texas and in the South, but not very much in the last few years. You have to have some sense of imminent peril, I think, to obtain funds nowadays for mosquito reduction and eradication. If we should find an immune monkey somewhere near the Rio Grande, that would help a lot.

With regard to malaria, the world situation is very encouraging, and is not hopeless even in India and the Far East. Wherever the modern insecticides are being intensively applied, malaria is being done away with. Italy and Greece have practically none left. My colleague in Italy, Professor Missiroli, with whom I worked so many years and who has just died, sent me last fall an invitation to attend the celebration of the disappearance of malaria from Italy, a disease which kept even the area immediately surrounding Rome uninhabited for over two thousand years. Turkey is spraying all the houses in the malaria zones, having bought some seventy tons of DDT last year. The largest effort is probably that of Brazil, as it was with *Aedes aegypti,* because Brazil is half of South America, with a population of some forty-five to fifty million people. Half the population of Brazil is exposed to malaria. There are 8,000 employees in the Malaria Service, and it is spending nine and a half million dollars a year and spraying two and a half million houses with DDT, some of them twice a year. By 1935 it is expected that malaria in Brazil will be reduced to negligible proportions. There is a coordinated campaign going on in Central America, where all the countries have banded together under the direction of the Pan American Sanitary Bureau.

British Guiana is interesting because it shows the value of a little entomological knowledge even with such a non-specific poison as DDT. In British Guiana, all the population lives along the coast except for a few Indians in the jungle of the hinterland; probably 95% of the entire population is on the coast. Inland, paralleling the coast is a range of sand hills which drain into a very acid swamp which will not breed *Anopheles darlingi,* the only important vector. The only way *darlingi* could reach the coastal belt from the interior would be to breed its way down three or four rivers which cross the sandy country and the marshes. They have been able to exterminate *darlingi* on the coast entirely, and by establishing road blocks on the rivers, can now suspend all other work. They have used DDT so intensively that it occurred to Dr. Giglioli, who is their malariologist, to try the experiment of reintroducing *darlingi* and *Aedes aegypti* into an isolated sugar estate at the northern limit of the coast. This was not a very dangerous experiment because he felt that he could promptly eliminate it again if it started to develop into a problem of serious proportions. He liberated hundreds of thousands of adult *Anopheles darlingi* and *Aedes aegypti* on this sugar estate. He was never able to find a single one, and he supposes that five or six years of intensive use of insecticide has produced a residual situation there which makes it impossible for either species to survive.

It is clear that we have become very dependent on the chlorinated hydrocarbons, especially DDT. Our apprehension springs mainly from the example of the house fly, and every malariologist atttributes great importance to the fact that flies all over the world are now resistant to DDT. Six culicines are already resistant, and several other arthropods including fleas and bedbugs. It seems to us quite possible that the malaria mosquito may also become resistant, and possibly *Aedes aegypti.* Everyone is working hard to get rid of malaria and eliminate *aegypti* while DDT is still a poison.

There are signs that possibly such fearful vectors as *gambiae, sacharovi,* and *darlingi* are beginning to develop a behavior which protects them in certain ways from poisoning. In tropical Africa *gambiae* often does not light on a wall inside the house, but will fly in, bite the human being, and then fly out without having acquired a lethal dose of DDT, and it looks as though *darlingi* might be adopting the same behavior in South America. Dr. Livadas reports from Greece that *A. sacharovi* are being capturel in considerable numbers in houses less than a month after spraying. Dr. Derryberry of the TVA, while he is unwilling to say that *quadrimaculatus* has yet developed a resistance of importance, still finds indications of such a possibility. The dosage of DDT in use still kills them but it is disquieting to find that the margin of safety is shrinking.

The need then seems to me to be clear. In the first place, we had better go back to fundamental and preventive sanitation. I've been talking to Dr. Gotaas of the Engineering Department at the University of California at Berkeley. He is working now very intensively on economical ways of composting garbage and manure, and he feels that it would be of great advantage to California and other states, not only to prevent the production of flies but at the same time to utilize garbage and sewage for fertilizer, to restore a certain amount of humus and nitrogen which we are badly in need of. However, though we speak of "returning" to sanitation, we can't go backwards. The best solution may depend on further study and research in insect physiology and biology. We have to find out how toxicants actually poison the mosquito, what the mosquito does to become resistant to the poison, and what entirely new measures can be undertaken. Certainly it seems to me we must now abandon the hope, once so alluring, that we can depend entirely upon insecticides. Let us consider the insecticides as auxiliaries and not neglect either sanittaion or research, upon which our present happy situation in this country with respect to malaria and other insectborne diseases is firmly and, we believe, irreversibly founded.

Ed. Smith: Thank you, Dr. Hackett. Dr. Hackett's remark about the mosquitoes which have learned not to land on walls is very disturbing. We have enough trouble with mosquitoes now; deliver us from educated mosquitoes.

It's always a pleasure to welcome some of our neighbors from Utah to California. My only regret this time is that just one of them came. Dr. Don Rees, the President of the American Mosquito Control Association, is going to speak to us now on "More Effective Mosquito Control Through the American Association."

Dr. Rees: It is always a pleasure for me to meet with the members of the California Mosquito Control Association. I enjoy your welcome, it makes me feel at home. I was very much interested in the remarks of Dr. Hackett when he stated that the members of the National Malaria Association had worked themselves out of a job. We have need for that kind of workers in the American Mosquito Control Association. We invite them to join. I might say that Dr. Hackett has been made an honorary member of the American Association.

Last night when I registered at the hotel I stated I was here to attend the meetings of the California Mosquito Control Association. The clerk said, "That is a very fine work that is being done in California by the Mosquito Control Association. That is one tax in Fresno that the people do not mind paying because they feel they are getting their dollar's worth." That was quite a compliment. I thought it would be worth passing on to you.

MORE EFFECTIVE MOSQUITO CONTROL THROUGH THE AMERICAN ASSOCIATION

By Don M. Rees

President, American Mosquito Control Association, Inc. Salt Lake City, Utah

I am scheduled to talk on "More Effective Mosquito Control Through the American Association." I wonder, on second thought, if this is appropriate for this group as Californians have unquestionably demonstrated this fact during the past summer, when you so generously volunteered to help out our colleagues in the American Association who live in Florida. According to the newspaper accounts our brothers in Florida were having temporary mosquito troubles and the members of the American Association in California thoughtfully volunteered to send them some California "mosquito fish" to control these ferocious Florida mosquitoes. I also read how our friends in Florida told you Californians where you and your fish could go, without even thanking you for your magnanimous offer. This never could have happened without the friendly relationships you have established with each other as members of the American Mosquito Control Association.

There is one thing mosquito control workers have in common and that is the desire to obtain more effective mosquito control through improved methods and programs. The primary purpose of the American Association is to determine and promote the most effective mosquito control methods, among all mosquito abatement agencies and workers. This can only be attained through the coopertaive efforts of all mosquito control workers in an extended organization such as the American Association.

The California Mosquito Control Association admirably serves the purpose of promoting more effective mosquito control for mosquito control agencies and workers in California and a few neighboring states, who, by their nearness, are able to participate in this organization. I congratulate you on the progress you have made and the effectiveness of your organization and mosquito control programs throughout the state. This is also true for New Jersey and a few other state organizations but there are innumerable isolated agencies and mosquito abatement workers throughout the Americas without the benefit of assistance from other local control workers.

There is always a danger in regional organizations of a growing self-satisfaction in local achievements without sufficient stimulation from outside sources to strive for more effective control programs. There is also a greater danger of retaining within these state organizations effective control practices without immediately disseminating this informtaion to other more isolated and therefore less fortunate workers who are engaged in this relentless battle. The American Asociation is the only means by which we can counteract these dangers and insure more effective mosquito control for all who are engaged in this work.

It is needless for me to point out to this group the advantages of your state organization but as an out-of-state observer who has been periodically attending your meetings and watching your progress for nearly 20 years, I am convinced that your state organization has been the most important single factor cotnributing to the general state-wide effectiveness of the mosquito control program in California. I base this statement on the fact that the state organizaion has been the means whereby the latest and the best in mosquito control has eventually been, or will be, established in every district in the state and ineffectual practices, no matter how firmly established, will eventually be uprooted and replaced by more effective methods, not at times without considerable local opposition. This has been accomplished by the California Association through discussions in these annual and regional meetings, through the publication of the Association manual and "Mosquito Buzz," and through sponsoring proper legislation, which has made available trained personnel and research funds that are being used in the solution of specific control problems.

These benefits, resulting in more effective mosquito control in California, have been made possible only through your organized effort through a state association. The same benefits of more effective mosquito control on a national or continental basis, which will undoubtedly be reflected on a world-wide basis, can only be accomplished through the American Mosquito Control Association or some similar organization.

At the annual meetings of A.M.C.A. we have been able to obtain speakers and first-hand information on mosquito control from all parts of the Americas and from many other parts of the world. It is my sincere conviction that the expense of sending proper representation to these annual meetings is the most profitable expenditure a local mosquito abatement agency can make in developing more effective mosquito control in their district. The representative who attends the American Association meetings to obtain information that can be applicd to more effective mosquito control in his own District always obtains something of practical value. This is especially true of representatives from states where the programs are small and funds are limited. It is also true of representatives from larger programs such as California as it broadens their scope and jars them out of the smug complacency of their own superiority in control work. The mere fact that at the American Association meetings they converse with control workers from other parts of the world is stimulating and is expressed in an added zest and in an increased effort in their own district. It also establishes personal contacts that are frequently helpful in obtaining ready assistance in solving particular problems as they arise in a district.

The publication of "Mosquito News" which contributes so much to more effective mosquito control for those who actually use this publication for this purpose, is only possible through an extended organization like the American Association. To publish and distribute a periodical with the international scope and the quality of the articles contained in the "News" would be humanly and financially impossible on a local basis. The current bibliography alone makes the "News" indispensible to workers who are constantly striving for more effective mosquito control methods.

It is unnecessary for me to continue enumerating the contributions of the Amreican Mosquito Control Association to more effective mosquito control, as most of you are members, and Californians have always been loyal supporters of this organization.

I, therefore, would like to summarize and make a few observations concerning conclusions I have arrived at, concerning the American Association contributing to, and other factors influencing more effective mosquito control.

1. The effectiveness of a mosquito control program is directly proportional to the ability and knowledge of the man or men directing the program. Boards of Trustees should always keep this in mind when appointing a District Manager, remembering, ability is inherited, knowledge acquired. This does not mean that the same degree of effectiveness of control can be obtained in each district by selecting the proper manager, as control possibilities vary greatly in the different districts. It does not mean that the best results possible, under existing conditiions, are dependent on the personnel in charge expressed in the daily direction of the work to meet ever changing conditions.

2. Only through an Association can we expect to eventually establish universally high standards of requirements for the personnel directing these programs and compensation sufficient to attract men of these qualifications and then keep them informed on the most recent developments. The manager or supervisor of these control programs should be just what these names imply regardless of special training or experience. He should possess sufficient information and judgment to know that the services of trained engineers, entomologists and other specialists are essential for the most effective mosquito control work. The clearing house for the problems of the man directing these programs and the specialists engaged in their solution can only be provided for in the annual meetings and official publications of a strong cooperative organization such as the American Association.

3. There is no cure-all that will insure effective mosquito

control. I have come to the conclusion that we all too frequently become self-satisfied with our own method of operating our local mosquito control program and if not disturbed we continue year after year with little change. When representatives from local districts attend meetings such as this and those arranged by the American Associations they frequently learn that they are not obtaining the effective results which are possible through the adoption of improved methods which are being used in other districts.

4. In my humble opinion, mosquito control is a service that, through public demand, will not only remain but will be extended until all major centers of populations in the Americas, where a mosquito problem exists, will eventually have a mosquito control program.

5. I am also convinced that this public service of mosquito control can be most effectively, efficiently, and economically conducted on a local level through the guidance and unification of a non-profit, non-political strong parent organization such as the American Association. I am further of the opinion that without such a strong organization mosquito abatement work will gradually be taken over by other existing local or federal governmental agencies, at greater expense to the public and with less effective mosquito control results. The American Association invites all agencies and workers interested in the program to participate in this organization dedicated to more effective mosquito control. I am confident if we do not all cooperate, and assume the responsibility of directing and improving the mosquito control program through the American Association, we will unquestionably be taken over by some other agency and the program directed for us.

Mr. Smith: Thank you, Dr. Rees. I would like to add just one postscript to your presentation, and that is to call on the Secretary of the Association to stand up so that everyone will know where to get application blanks to became a member of the AMCA. Mr. Mulhern has application blanks.

Yesterday I had the pleasure of spending a good part of the day in demonstrating to Chris Hansen that California has a few water problems. Now I want to introduce Chris Hansen, the Exeecutive Officer of the Communicable Disease Center of the Public Health Service in Atlanta, Georgia, who is going to speak to us on CDC's Participation in California's Water Resources Development Program.

CDC PARTICIPATION IN CALIFORNIA'S WATER RESOURCES PROGRAM

By Chris. A. Hansen

It is a real pleasure to participate in the California Mosquito Control Association meeting. Despite the fact that this is only my second official visit to California and my first C.M.C.A. meeting, I have a feeling of being among old friends and colleagues. As most of you probably know, we claim Dr. "Stan" Freeborn as a CDC stalwart since he participated in the organization of MCWA, and in establishing early program plans and policies which we continued in CDC. Arve Dahl also was one of our MCWA men. Arve thoroughly understood our organization and the manner in which he integrated CDC projects into the program of the Bureau of Vector Control and other units of the State Department of Public Health has been a great source of satisfaction to us.

Today I would like to discuss our water resources program with you. In 1945 we started our program for the control and prevention of mosquito problems on impoundments being constructed by the Corps of Engineers. The purpose at that time was primarily malaria control. As additional information became available on encephalitis and the public health significance of pest mosquitoes, it became evident that we should broaden our activity in mosquito control to include the newly incriminated encephalitis transmitters. This in turn led to a more careful consideration of mosquito producing conditions created by the expanded national water development program. As you are all well aware, this idea was first put into action here in California by the Bureau of Vector Control. At our annual CDC meeting in 1946 a rough outline of State and Federal public health interests in mosquito control associated with water resources development was prepared by Mr. Wesley Gilbertson, CDC executive Officer; Mr. Arve Dahl, Chief of the Bureau of Vector Control, California State Department of Public Health; Dr. John Rowe, CDC Regional representative in Kansas City, and myself, representing the Engineering Branch of CDC. From this beginning the CDC investigations program was expanded in Kansas City and initial steps were taken to review water development plans of other Federal agencies for the purpose of recommending mosquito prevention mesaures.

The organizational structure for water resources work within CDC has now been set up. A Water Resources Section has been established in the Vector Control and Investigations Branch. Dr. Stanton J. Ware is the Chief of this Section and you will hear from him in your symposium scheduled for Friday. Headquarters for the Section have been established in Salt Lake City in order to be more centrally located with respect to the irrigation-mosquito problem.

CDC Policies on Water Resources Development

We in CDC believe that the basic responsibility for dealing with the health problems associated with water resources development lies in the State Health Department. Our program has been established (1) to assist State Health Departments in establishing their own organization for the prevention and control of insects of public health significance (not all States are in the enviable position of California in this regard), (2) to conduct and participate in investigations, research, and demonstrations essential to the development of a sound mosquito control program, and (3) to establish better working relationships with other water resources development agencies.

Nature of the Public Health Problem Associated with Water Resources Development

Before beginning to write up my notes on CDC participation in the California Water Resources Program, I paged through recent issues of the procedures and papers of the California Mosquito Control Association. I noted that technical aspects of mosquito control had been well covered in previous meetings. At your Sixteenth Annual Meeting in 1948, Dr. Hammon presented a paper on the "Advance in Knowledge of the Vectors and Arthropod Reservoirs and Certain of the Encephalitides." At your Eighteenth Annual Meeting you hear an interesting symposium on "Water Resources Development as Related to Mosquito Abatement" presented by Mr. Dahl, Dr. Rowe, Dr. Smith, and Mr. Buchanan. Professor John M. Henderson's presentation of "Irrigation and Mosquito Problems" at your Nineteenth Annual Conference provided additional detailed information on the problem at hand. There were many other good papers on this subject.

Since the technical phases have been well covered, I will present cooperative activities of CDC and the Bureau of Vector control and an outline of our future plans.

Cooperative Projects Now Underway

(1) Preparation of reports and recommendations on Federal water resources development project proposals. We will continue to assign personnel to the Bureau of Vector Con-

trol to participate in the field studies and preparation of required reports.

(2) Studies to solve the mosquito problem of irrigated pastures and wild hay lands. It is not necessary to tell this group about importance of these mosquito producers. A thorough study of the ecological factors and farming techniques involved has been underway for several years. CDC has participated in this work because it is a major problem in many irrigated areas of the United States and the answers are long overdue.

(3) Drainage in the irrigation and mosquito abatement picture. We have supported a study in the Merced District by the assignment of an engineer, Mr. Lloyd Myers, with whom you are all acquainted.

(4) Training of personnel for mosquito control work. In order to develop a major program, such as that now being undertaken by the CDC Water Resources Section, it is absolutely necessary to have trained, competent personnel. The work calls for men who know public health, mosquito abatement, and irrigation agriculture. Men with such training and experience are very scarce. We have decided therefore to select the best personnel available and give them additional training as necessary. The Bureau of Vector Control and Mosquito Abatement Districts of California have been most helpful in this activity. We expect our trainees to participate in useful projects where they will have an opportunity to observe and participate in the work of State and local health departments and mosquito abatement districts, and study the problems, needs, and interests of the water users.

(5) Program development. The Communicable Disease Center Mosquito Control Program for Water Resources Development is new. Its success will depend in a large measure on the progress made in the several States carrying on cooperative mosquito control programs. The research and investigations activity of the Bureau of Vector Control and the California Mosquito Control Association, supported by CDC, will greatly influence our policy on the national program. It will probably continue to furnish the lead for other States now developing their organization for handling mosquito problems of public health significance.

(6) Bakersfield Project. We have cooperated with the Hooper Foundation in the Bakerfield encephalitis study since 1945. As you know, they have been concerned with the establishment of the infection chain of encephalitis as it occurs in that endemic area. We have supported this work by the assignment of professional personnel, as well as some equipment and supplies.

Plans for the Future as They Affect the California Program

Within limits of funds and personnel available, our cooperative program in California will include the following:

(1) Assistance in field investigation and research. In this area we want to include:
  (a) Additional research and investigations are needed on the irrigated pasture and wild hay land mosquito problem.
  (b) Additional ecological studies are needed with reference to flight ranges, dispersal and distribution of mosquito species concerned.
  (c) The rice field mosquito breeding problem is unsolved. Studies to determine feasible control methods will be supported.
  (d) Expanded study of methods and procedures for coordinating the mosquito control interests of irrigation, abatement, and drainage districts and the State and local health departments. This information is vital in the development of effective mosquito prevention and control projects throughout the problem area.

(2) Training of personnel by assignment to active developing programs for "on the job" experience. As the CDC program develops, additional men will be needed who have specialized training and experience. We believe that it will be necessary to continue this training program for some time in the future to keep up with this expanding work. We want to continue our present arrangements for assigning professional personnel for field experience to the Bureau of Vector Control and Abatement Districts as the need arises.

(3) Establishment of better working relationships with constructing agencies or groups and water users to insure adequate provisions for mosquito prevention and control measures in the national water resources development program. To further this work, it will be necessary to prepare informational material such as films, film strips, brochures, etc. Demonstration projects will be helpful.

(4) Additional work is needed in establishing the standards and criteria for evaluating problems and preventive and corrective techniques. The experience of the Bureau of Vector Control and the Abatement Districts in California will be helpful in working out the best standards.

(5) As a member of the family of Federal agencies interested in water resources development, we are obligated to furnish guidance and advice to the other Federal agencies of public health problems created or affected by the over-all national program. The States also have an interest in this and we have therefore established a cooperative plan with the California State Department of Public Health for the review of water resources development plans of Federal, State, and local groups. Based on initial studies of the development agencies, mosquito control and prevention procedures will be formulated. While it is important to participate during the planning stages, it is intended to continue this participation into construction and operations. This responsibility will be jointly carried out.

(6) Epidemic Assistance. The Communicable Disease Center stands ready to assist the California State Department of Public Health in the control of arthropod-borne diseases whenever assistance is needed.

(7) We plan to continue our cooperative project with the Hooper Foundation at the Bakersfield station. This activity will be of considerable value in establishing the relationships of virus encephalitis to the expanding water resources development program.

Mr. Smith: The next speaker you all know very well. I won't waste any time introducing him. Richard F. Peters, Chief of the Bureau of Vector Control, State Department of Public Health.

THE SCOPE OF CALIFORNIA MOSQUITO CONTROL

By Richard F. Peters

Chief, Bureau of Vector Control

The year 1951 offered its full share of variety to the California mosquito control worker. If anything, as a result of the total effort during the year, his future became even more secure, not that anyone in this field has been particularly worried about unemployment. This might be reworded to mean that the mosquito probably made a slight gain in her bid for supremacy over us. In line with the rising cost of living, the cost to the public of obtaining an acceptable level of mosquito control also was observed to increase. This came as a result of a combination of factors including increased operating expense, expanding problem area, and as a result of the wily mosquito herself having even more obviously thumbed her nose— palpied her proboscis, if you will—at our once invincible weapons of control. In the climatological sense, that long-awaited wet cycle came into being last year. Based upon this year's saturation to date, prospects for elevated ground water and the opportunity thereby afforded for round the clock operation of pumps is again in the probable offing. The overall influence which this high rainfall, accompanied by unusually heavy snow packs, will bear to the total mosquito production is difficult to forecast and remains to be fully experienced. Last year, the mild spring accompanied by prolonged rains served to delay the usual March opening battle with the mosquitoes a month or two, necessitating only minor skirmishes until summer.

The population of California has continued to increase at a phenomenal rate. To the mosquito worker this simply means that more possibilities for creating new domestic mosquito sources, not to mention enhanced mosquito production from the already over-taxed municipal and industrial waste disposal facilities, in our California communities came about. Whether the increased population brings industry or industry brings the people, both continued to become more apparent during the past year. But most important of all, agriculture, irrigated agricultural land that is, continued to expand at a rate which defies our current mosquito control resources to keep abreast of it. The scene of new canal systems under construction, along with well-drilling rigs and land-leveling equipment in operation has been a familiar sight to those who travel even the main highways, not to mention to those who invade the jack rabbit country. Those of you who are witnessing this amazing transition in your own spheres of influence have had, I am sure, a reaction which is beyond mere marveling.

Rather than divulge any particulars relative to Mr. Gjullin's studies on mosquito resistance, I will merely mention that such is a proven reality in California. Perhaps I should have said a dilemma.

While these many interesting developments have been experienced by you who are committed to keeping your constituents free from, or at least relatively unannoyed by mosquito attack, the Bureau of Vector Control has been undergoing several evolutionary experiences as well. With Arve Dahl having been claimed by the State's Civil Defense program, and after a period of double duty by Frank Stead, Chief of our Division of Environmental Sanitation, in July of last year I was handed the reins of the Bureau of Vector Control, which responsibility, probably responsibilities is the better word, I have endeavored to maintain since then. To say that it has pleased me to have been placed in this position of higher trust and closer relationship to your Association and each of its agencies is an understatement. What absorbs me most is the opportunity to develop with you a synchronized pattern of cooperation between our Bureau, your Association, and the field of mosquito control in general. Our staff is earnestly committed toward this objective. I believe this relationship deserves dwelling upon a bit more. The keynote of our program centers upon the word "service" in its broadest possible sense. Our Bureau program has been decentralized to increase the opportunity for close working relationships between our personnel and local agencies. In fact, our Areas of operation coincide with those zones which comprise the Regions of your Association. This suggests the opportunity for developing direct action through each of our Area Representatives and your Regional Representatives. Our headquarters is equipped with both engineering and biological personnel who may be utilized to provide specialized technical services beyond the basic consultant program of our Area offices.

While mosquito control is a very important phase of the program of the Bureau of Vector Control, I do feel obligated to point out that our Bureau is charged with many additional responsibilities which must likewise be met. Our direct relationship to local health departments and other local agencies and the resulting necessity for developing vector control programs pertaining to flies, gnats, ticks and other arthropods, as well as domestic and field rodents, in addition to other miscellaneous activities, all beyond mosquitoes, are such that we are frequently extended beyond our staff's numerical capacity.

Worthy of particular mention at this point is the implication of Civil Defense planning upon vector control as it relates to your agencies in the event of diseaster, regardless of kind. In the event of flood which this year is certainly not a subject to be dismissed lightly, the potential significance of mosquitoes is obvious, and your role in their control would follow naturally. But in the event of more violent disaster where human and animal bodies assume the characteristic of organic matter in the rubble of demolition, the place that your agencies might well expect to bear will probably relate primarily to fly and event rodent and ectoparasite control. Based upon the expression we have heard from some of you, it would take nothing less than a disaster to get you involved in the likes of fly control. But needless to say, and I am sure Arve Dahl would bear me out, the Civil Defense implications are certainly of concern to you and deserve some hard thinking and careful planning.

Possibly of prime significance in the past year's events was the meeting of the Advisory Committee to the Bureau of Vector Control, held November 7, 1951. At that time this Committee went on record in conformance with a trend which has been noted in the World Health Orginzation and the U.S. Public Health Service, namely, that of recognizing the irritant effect of pest mosquitoes and other bothersome arthropods to be of public health significance. The motions passed by this group of concern to you are worthy of reading:

1. We appreciate and recognize the fact that pest mosquitoes and certain other arthropods are a part of the public health program although not necessarily related to disease transmission.
2. It is recommended: That subvention funds be restricted to areas where there is a history of vector-borne disease endemicity. In such areas where subventions have been granted, it is permissible to use such monies for general control.
   This recognizes the current *administrative* difficulty of separating vector and pest control but re-emphasizes the fact that vector control is still the primary objective of the subvention program.
3. That the Department of Public Health and various other interested groups should consider increasing the intensity of general mosquito control throughout the State. To make this possible the Legislature should be approached to obtain a larger appropriation as funds now available appear inadequate even for the Districts now in existence.
4. That the present system of using a certain amount of the subvention funds for Studies and Demonstrations be continued but that careful consideration be given to the possibility of requesting an additional sum of money for this specific purpose to be allocated to the Bureau of Vector Control.
5. Recommendations of the California Mosquito Control Association on re-allocation of funds (re-appraisal and re-evaluation). It was suggested that increased attention be given to tax rate and assessed valuation in problem areas in the allocation of subvention funds; that disease and en-

demicity be maintained as a factor; and that the principle of permanent control be emphasized in determining allocations. That these recommendations be taken under advisement by the Bureau of Vector Control for presentation to a future meeting of this Committee.

6. The Advisory Committee reaffirms its recommendation that great emphasis should be placed upon encouraging water management procedures and upon owner responsibility.

The tendency on the part of the public to demand a high level of freedom from arthropods whose detrimental impact upon full and normal living is preventable, has apparently come with improving civilization and all which that connotes. I believe, although it is not stated in the aforementioned motions, that the Advisory Committee was collectively of the opinion that if the public demands attention to the control of such as flies, gnats, fleas, rodents, etc., and is willing to pay for it. Rather than create new agencies for obtaining control of each undesirable element of the environment, it would be sounder economics, and a more realistic use of manpower, to utilize existing agencies of government. Of course, the determination of which responsibility falls to which agency has not yet been entered into. This will have to evolve with our expanding knowledge and experience.

Since the title of this paper is composed of a broad word, "The *SCOPE* of California Mosquito Control," I have thus far dealt with the subject in a general vein. Perhaps this latitude affords me an opportunity for the objective appraisal of California mosquito control as to its strengths and its weaknesses, which subject always puts the bold adventurer into a realm where angels fear to tread. I assure you that my interest in adventuring is that of inquiring into how the Bureau of Vector Control can assist mosquito control to maximum advantage.

Undoubtedly, the most pronounced attribute of California mosquito control is its rugged determination. I think it can be said unobstrusively that California's program is the equal of any other program in this country or for that matter, throughout the entire world. The flexibility which exemplifies our mosquito control statutes and the administrative organization of local mosquito abatement district programs certainly makes for maximum versatility in coping with the great variety of situations presented. The trend in recent years toward encouraging the maximum of varied operations by each mosquito control worker has undoubtedly broadened the services of mosquito control agencies to the maximum. Many other complimentary remarks might be made, particularly of the resourcefulness which has characterized most agencies in California.

But now we might take stock of the deficiencies which if acted upon could make our total program even more effective. The following considerations seem worthy of objective analysis:

1. Whether by convenience, or necessity, or both, in an effort to absent the individual agency of its mosquitoes to the maximum degree possible and thereby to establish a favorable public reaction, it must be recognized that both the letter and spirit of the mosquito abatement statutes in the State Health and Safety Code have been rather considerably ignored, particularly during the post-war years. The responsibility of the individual or agency upon whose property the production of mosquitoes occurs has been overlooked to a great degree for the more expedient course of direct treatment by mosquito control agencies. Undoubtedly such a course of action is justifiable under certain circumstances, but is there not a need for redefinition and rededication?

2. Considering agriculture with its various irrigated crops and irrigation malpractices as setting the stage for a large share of mosquito production in California, to what degree have we utilized agricultural, irrigation, conservation, and other interested agencies in solving the chronic mosquito source problems which confront us? Amazingly little, I believe we must admit.

3. On the basis of casual observations it seems appropriate to inquire: To what extent are records fundamental to normal operations being kept and applied as fundamental guides to mosquito source reduction, to program planning and to the critical evaluation of seasonal manpower use and timing within the program?

4. In agencies which have employed entomologists, engineers and other technical personnel in fulfillment of the subvention requirements, are these specialists being used to capacity in the fulfillment of tasks within their specialty? Without being specific I am obliged to express the opinion that all too many of these people have been relegated to responsibilities of administrative assistants, which of course precludes their rendering the technical value to the individual program which they are capable of providing.

5. Another matter deserving expression is in connection with the position held by a few that investigational activities concerning problems of general statewide interest in mosquito control might properly become the responsibility of individual local mosquito control agencies. It would seem the time consumed in this regard by personnel from Administrator on through all those concerned in the conduct of specialized investigations is such that, unless the matter under investigation represents a virtual impasse to the agency, the distraction from the basic responsibility of local control operations can hardly be justified. The viewpoint is submitted here that the assumption of this highly technical and specialized work is more logically a responsibility of state agencies which, in addition to the Bureau of Vector Control, might possibly also include the Department of Agriculture, the University of California and its Extension Services, as well as your own Associtaion, were it to be endowed for such pursuits. To be sure, justifiable investigational projects demand both replication and qualification to suit the conditions which are unique within the individual agency and that can only be done by qualified personnel within local programs. The Vector Control Field Station here in Fresno and our Bureau resources elsewhere in the State are so constituted as to permit our participation with you in the solution of your major problems. Our facilities and our program are at your service. It is our total desire and wish that those of you in local mosquito control programs realize that the Bureau of Vector Control has no other reason for being than to serve the people of this State and the component agencies of government which in turn represent the people. It is our wish that you accept our program in this complete sense. My touching upon this subject comes in the interest of seeking to assure you of our attitude and willingness.

Now to touch briefly upon the subvention program which subject could well have consumed all the time which has been allotted for my presentation. There probably has never been a subvention program in all of history which has had total agreement with its basis of allocation. Our position on this matter is simply one of attempting to distribute funds within our best judgment possible and in compliance with the intent of the legislature through whose action the funds have been derived. The position of the California Mosquito Control Association with respect to this matter and the guidance provided us by our Advisory Committee will weigh heavily in helping us to arrive at the most practical formula for allocation. It has to be borne in mind that whatever formula is used, it must be acceptable to the State Department of Finance, which is not overly inclined to accept factors which are characterized by inconsistencies in their total conception. Also, there are two other fundamental considerations, namely, the history of the subvention program to date, and perhaps more important, the future of the subvention program. The history, however dusty or tarnished, must be acknowledged. With regard to the future of subvention I can only say that the Bureau of Vector Control is the custodian and administrator of the fund. It can only be spent as is legally provided for through the State Legislature, which translated means what the people, your constituents, want. Concerning subvention operational plans, I think it worthy of mention that the aspect of long range water management practices will receive increased emphasis.

Since Chris Hansen has preceded me and covered the water resources activities so adequately, further comment on this subject is unnecessary at this time, other than to mention that beyond the construction aspects and constructing agency responsibilities we are dedicated toward devising ways and means of heading off preventable mosquito sources associated with water use practices as well, wherever this can be accomplished. Other than to mention that it is often extremely difficult, you are assured of our concern, careful planning and concerted action in this field of activity.

In concluding, these suggestions might be considered for getting the most out of the taxpayer's dollar in 1952:

1. Let us all examine carefully and use to the fullest advantage possible personnel of other existing agencies of government where mutual interest and coincidence of responsibilities and activities are the case.

2. Let us expand each contact made by our personnel to become one of public education and thereby increase acceptance by the public of its responsibility in lightening the burden upon government.

3. Let us critically examine our programs and the manner in which we meet our responsibilities for assurance that our emphasis and timing are sound and precise. It would seem that a questioning attitude by each mosquito control worker toward every mosquito source routinely treated would result in the progressive reduction of the total problem.

4. Let us select new personnel discreetly for the task before us and above all, let us use our present personnel in keeping with their individual capacities.

5. Let us all get behind our total investigations activities in California and give them an opportunity to provide us with answers to our difficulties and problems in mosquito control. A reasonable continuing investment in the study of our mosquitoes and their control cannot other than provide sound dividends to our future programs. This should certainly lead to efficiency and economy.

6. In speaking on behalf of the Bureau of Vector Control, we wish to express our total desire to work with you in a spirit of complete cooperation toward the realization of our mutual aims for the advancement of mosquito control in California.

Ed. Smith: Thank you very much, Dick Peters. You've certainly given us all plenty to think about.

The next speaker we have is a man I had the pleasure of first introducing to an audience 14 years ago. Since that time I've introduced him to at least three or four other groups and I don't know of any time when he has ever disappointed an audience. It is with a great deal of pleasure that I introduce now, Dr. Guy F. MacLeod, the Technical Director of Sunland Industries and also the Secretary of the Board of Trustees of the Fresno Mosquito Abatement District.

AGRICULTURE AND MOSQUITO CONTROL

By Guy F. MacLeod, Ph.D.

Merely scanning the titles of papers to be presented by real authorities at these sessions should provide warning for even the most intrepid amateur. It rquires very little imagination and less wit to realize that the relationship of agricutlure and mosquito control will be covered in complete detail by people who are much better informed than any layman.

Having thus adequately set forth in less than a minute why I should not continue I will now absorb twenty minutes doing what I have proved should not be done.

Rather than encompass all agriculture and all mosquito control it might perhaps afford some novelty if I confine myself to a discussion of the mosquito problem in Fresno county in relation to the growth of population and agriculture: the implied novelty being that a speaker would talk about something he might reasonably be expected to have heard of before starting to orate.

The Fresno Mosquito Abatement District was formed in 1942. The report for the second year of operation presented, among other figures, those shown in the table attached. The workers spent about $39,000.00, drove almost 50,000 miles, used up 51,000 gallons of material along with a lot of other chores which consumed about 23,000 man hours. The problems encountered in these first years of mosquito control were exactly the same as those we face today, at least qualitatively.

The mosquito problems in the 56 square miles of city area with a population of 60,685 people in the city limits and 97,504 in the metropolitan area were already well in evidence. Urban Fresno had been growing at the rate of a thousand people a year for two or three decades. Sewer facilities were overtaxed and sewage disposal created a major mosquito problem.

The endless artistry in designing cesspools which would cave in and become good mosquito sources within a minimum period seemed mephistophelian to the boys who were kept busy repairing them. Add to this the usual array of typical city problems and the picture is one which is well known.

However, there is very little resemblance between the growth of an urban agricultural center and an industrial metropolitan area as far as mosquito control problems are concerned. There are almost 250 square miles of rural farming areas adjoining our rapidly expanding perimeter. The transition from cotton, alfalfa or irrigated pasture is sudden, not gradual. To protect new sub-divisions from endlessly increasing reservoirs of mosquitoes seems like an impossibility, yet we are justly proud of the fact that in 1951 there were 595 service requests received as contrasted with 840 calls for help in 1943. The population of the area involved has grown from 97,000 to 147,000 in that same time.

Of equal if not greater importance is the picture of agricultural growth. The activities in and around an agricultural center such as Fresno provide ideal conditions for the build-up of enormous populations of mosquitoes. Our almost infallible air currents at sunrise and sunset of each day provide aid in movement from one region to another over considerable distances in the broad flat valley.

Obviously what goes on over a rather wide area will affect both our mosquito populations and their movements. During the past ten years the value of crops produced in Fresno County went from $40,000,000.00 to over $285,000,000.00. This means more than a seven fold increase in ten years.

As everyone knows, the increase in field crops (including but not limited to alfalfa, irrigated pasture and cotton) has been extraordinary. A threefold increase in acreage of field crops in the last ten years in Fresno County was accompanied by an increase of eight times in dollar values of these crops. It is not at all surprising under such a stimulus to see the acres under irrigation by electrically pumped water jump from 745,000 to 1,960,000 acres and an increase of over 13,000 pumping plants in the same ten year period.

These things are bound to affect not only our underground supply of water but our "on the ground" supply wherein mosquito populations can build up. A large part of the new acres being brought into production are alluvial, alkaline clay soils. Salinity, alkalinity, water penetration and drainage are the initial and most important problems. The use of excessive amounts of water is dictated both by past experience and the high prices for farm commodities.

It is the opinion of many well-informed people that we must have water present almost continually on many soils where cotton, potatoes, alfalfa and irrigated pasture are produced. That there are now many flagrant wasteful abuses of our limited water supplies is obvious to everyone. There will always be a certain percentage of accidents in which irrigation waters create potential mosquito hazards, but much of the farm mosquito problem could be solved by a little closer supervision of irrigation.

For the past three years the pest mosquito problem on farms has been steadily becoming more acute. Horses, cattle, poultry and even hogs have been anxiously watched by ranchers who are much concerned at the obvious annoyance and injury caused their more expensive animals. I had the pleasure of being very nearly carried off by swarms of adult mosquitoes as a rancher and I walked through his permanent pasture to see how annoying the mosquitoes were to a prize Hereford bull. Perhaps we shall see increased interest on the part of ranch groups in doing something to help themselves and their animals rather than waiting for a ditsrict to do the job. There is another of those educational jobs to be done here now.

It is a generally safe assumption that mosquito control like many other entomological problems is an area affair. One must treat a considerable acreage to get any effect, even in the center. Our experience here in a very small district surrounded by every possible potential has been of great interest in this connection.

It is my honest belief that you can stop the first ten people living in the area served by the Fresno Mosquito Abatement District and all but one or two of them at most will tell you that there are no or few mosquitoes in Fresno. If you run into folks from unserved rural areas you will know it immediately from their response. The contrast is evident and well known. So much is an accomplished fact.

Probably no single factor alone is responsible. We admit that the district is small, well equipped, most excellently managed by Mr. Davis, and well financed. By virtue of none of these things alone could we hope to have a mosquito free island surrounded by heavy breeding areas. We have enjoyed helpful cooperation from the adjoining districts, a maximum of interest in the job to be done and a minimum of interference in doing these jobs on the part of the trustees.

Without regard to how mosquito control was accomplished the fact is that it has been done and can be done. Now what of the costs?

While agriculture grew at the tremendous rate already noted and our population was almost doubling, the assessed value of property more than doubled in the county. The county tax rate increased from $2.53 to $3.88 and our income was thus enhanced. We promptly reduced our rate of income until we are now receiving ample funds from our rate of 5.75c per $100.00 of assessed valuation.

The increased activity of the district is reflected in the fact that, within the last ten years we have almost doubled the man hours, the gallons of materials used and tripled the miles driven as well as the total expenditures. This is what it took to do the job, but note that it can be done.

The costs of mosquito control grew along with but not at the same rate as our agriculture. This despite the fact that the agricultural growth of the region was mainly along lines which increased the mosquito potential. In the urban area served by the district, assessed values of property doubled and the population nearly doubled. The tax rate increased $1.35 per $100.00, which was less than doubled in the county, while federal income taxes increased over 800% in the same period.

As was mentioned at the outset, the selection of my own district for this discussion was forced upon me by a lack of information about many others whose operational history might well surpass that given here. In any event the purpose intended was one of illustration—not comparison.

Using Fresno as an urban center of an agricultural region I have tried to establish these facts:

1. There has been a tremendous growth of agriculture in this area.

2. Much of the growth involved more water for mosquitoes to breed in.

3. The city and suburbs grew as agriculture prospered, thus mosquito control increased in importance, extent and cost.

4. Increased property values with a slight increase in tax rate permitted decreasing the rate of "take" from the tax dollar for mosquito control.

5. We got adequate, satisfactory mosquito control in urban Fresno at a moderate increase in cost with efficient operation.

6. Mosquitoes can be controlled when people are willing to pay for it.

Farming

	1940	1943	1950
Fresno Co. Crop Values..	$ 39,698,000.00	$127,719,086.00	$285,170,212.00
Field Crops Acres ...	371,400	543,347	934,395
Value ...	18,398,800.00	32,676,708.00	143,424,034.00
Electric Irrig. Acres ...	745,000	778,000	1,960,000
No. pumps	16,873	18,229	29,875
Assessed Value ...	$256,275,000.00		$516,670,000.00
Tax rate	2.53		3.88

People

	1940	1943	1950
Fresno Co. ..	178,565	No census	276,515
Metropolitan Fresno	97,504	No census	147,094
Fresno City ..	60,685	No census	90,618

Skeeter Chasers

Total hrs. worked	22,598	39,827*
Total miles driven	49,355	149,729
Total gallons of material used	51,311	100,519
Total money spent	$38,879.00	$102,406.00

*1951 Figures

Mr. Smith: The next paper is by Col. Carpenter, of the Sixth Army in San Francisco. I first met Col. Caprenter during the war at the 4th Service Command Medical Laboratory in Atlanta, when I had the very great pleasure of taking a course in mosquito identification from him.

ECOLOGICAL OBSERVATIONS ON MOSQUITOES IN PANAMA

By Stanley J. Carpenter

Colonel, MSC, Chief Entomology Section, Sixth Army Area Medical Laboratory, Fort Baker, California

Panama, a small tropical country with an area of approximately 34,000 square miles, mostly covered with humid and steaming jungles, has often been referred to as a paradise for entomologists. After spending three years there from 1948 to 1951 and having had the opportunity of doing mosquito work throughout much of the country, I am of the opinion that this is not an overstatement of the facts. It is indeed a paradise for an entomologist who has an interest in the Culicidae, and I am sure that it applies equally as well to many other phases of entomology.

The country is made up of lowlands along both the Atlantic and the Pacific Oceans, with an intermediate chain of mountains running the entire length of the country, and reaching their greatest elevation in the Volcan, in western Panama, with an elevation of about 1,000 feet. However, much of this mountain country has 2,000 feet or more elevation.

The rainy season in Panama usually extends from May to December, providing sufficient moisture for the development of heavy rain forests throughout much of the country. The period from January to early May is generally dry except for occasional rains in the lower areas, with somewhat more rainfall occurring on the higher mountains.

The country supports a rather large and complex population of mosquitoes. During the first half of this century, entomologists were almost continuously engaged in mosquito work in this area; however, due to the lack of roads and trails prior to World War II, their activities had to be limited to the Canal Zone and nearby areas except for occasional trips into the more distant interior of the country. During and since the period of recent World War II, there has been a rapid expansion of roads and trails providing access to areas that previously could only be reached with the greatest of difficulty. Furthermore, most of the entomologists working on mosquitoes in this area were concerned with a better understanding of the mosquitoes involved in the transmission of malaria and this did not require frequent and extensive trips into the heavy jungle.

The writer was fortunate in being in Panama when an outbreak of jungle yellow fever was recognized during January 1949, in an area near Panama City in the Republic of Panama. A joint study of forest mosquitoes in the Republic of Panama and adjacent Costa Rica was immediately undertaken, in cooperation with Pedro Galindo, Entomologist with the Department of Public Health of the Republic of Panama, and Dr. Harold Trapido, Biologist assigned to the Gorgas Memorial Laboratory. The remaining two and one-half years of my tour of duty with the Army in Panama was devoted mostly to this study of the occurrence, distribution and bionomics of forest mosquitoes in this endemic jungle yellow fever area. During this period, tree stations were established in heavy rain forests in various localities throughout the country. Ladders and platforms were installed at each station and adult mosquito collections were made each week at ground level and from the platforms, using human bait.

Bamboo larval traps were hung on the station trees within reaching distance of the platforms, and on nearby trees within reaching distance of the ground. Larval collections were made each week from these bamboo traps and from tree holes and other natural breeding places located in the nearby forest.

There are more than 200 species of mosquitoes known to occur in Panama. During the first year of forest mosquito studies in Panama, approximately 65 species were collected as adults at the tree stations (Galindo *et al.,* 1950). Forty-one species were collected in the larval or pupal stage from the bamboo traps, rot cavities in trees, and other types of breeding places (Galindo *et al.,* 1951).

In this paper, I will summarize very briefly some of the interesting observations made on mosquitoes in Panama during these studies, and while working on mosquitoes in relation to the malaria problem in the Canal Zone.

Notes on Genera and Species

There are about 20 species of anophelines known to occur in Panama, belonging to 2 genera, *Chagasia* and *Anopheles. Chagasia* is represented by one species *C. bathanus* Dyar, a mosquito occurring throughout the year in Panama, but more common during the dry season. This species breeds mostly in small eddies along the margins of swift streams, particularly in the hill country. The adults rest parallel to the resting surface instead of the customary "head-on" position assumed by most anophelines. The females do not feed readily on man, but a considerable number were attracted to the collectors and captured during the forest mosquito studies. The species proved to be predominantly arboreal, 85 per cent of the adults captured being taken in the forest canopy, and 15 per cent were captured at ground level.

Many of the *Anopheles* of this area are ground pool breeders and are widely distributed over the country. *Anopheles albimanus* Wiedemann is abundant in many areas, and is regarded as the principal vector of malaria. *Anopheles punctimacula* Dyar and Knab and *A. pseudopunctipennis* Theobald are considered to be potential vectors of malaria in some localities.

A few species of *Anopheles* in this area are of particular interest due to either their restricted distribution or specialized breeding habitats. *Anopheles oswaldi* Peryassu is generally regarded as a very rare species; however, it was abundant in one small, rather inaccessible freshwater swamp along the lower Chagres River, on the Atlantic side in the Canal Zone. Approximately 600 specimens of this species were captured during a single night of operation of a horse-baited trap in this swamp. During one visit to the swamp, the larvae of *A. oswaldi* were abundant, but were restricted to dense tufts of emerging vegetation.

Anopheles kompi Edwards breeds in intermittent pools with leaf covered bottoms in shaded hill streams, during the early weeks of the dry season. It is rarely found during the remainder of the year and apparently nothing is known of the habits of the adults. I was never able to find adults of this species in the jungle, even in areas where larvae were abundant in all the nearby streams.

Anopheles eiseni Coquillett is abundant throughout the year breeding in rot cavities in trees, in rock holes, and in small ground pools with leaf covered bottoms. The adults are rarely attracted to either humans or horse-baited traps; however, blooded females were often taken resting in tree buttresses in the jungle.

Anopheles neivai Howard, Dyar and Knab commonly breeds in water contained in the leaf bases of wild pineapple in the lowlands and in epiphytic bromeliads on the heavily forested slopes of the mountains, between 1000 and 4500 feet elevation. The females are readily attracted to man and to horse-baited traps.

Anopheles fausti Vargas, a species previously known to occur only in southern Mexico, was reported from Panama by Galindo *et al.,* (1949), based on a single male reared from a pupa, collected in a tree hole at 1000 feet elevation on Cerro La Victoria.

Anopheles squamifemur Antunes known to occur in several of the South American countries, always from a few females captured in the forest, has been taken only once in Panama. This collection consist of four females captured on a white sheet with the reflected light of a gasoline lantern, and reported by Galindo *et al.,* (1949).

Anopheles parapunctipennis Martini occurs only at very high elevations in western Panama, where it breeds in cold springs and pools. The adults were collected on one occasion by the writer from hollow trees in a dense rain forest, at 6500 feet elevation, on the slopes of the Volcan at Cerro Punta in Chiriqui Province.

The genus *Toxorhynchites* is represented by about three known species in Panama; however, *T. hypoptes* Knab appears to be the only abundant member of this genus. This species breeds in rot cavities in trees and in bamboo, and is generally common during the rainy season. Males, and to a lesser extent, the females like to congregate and rest on some particular tree in the forest, near a rot caviety containing water, and can be found there throughout most of the rainy season. At one of the stations, males of *T. hypoptes* were captured on several occasions by our collectors on a platform located in the forest canopy 50 feet above the ground. The larvae were encountered about equally as often in bamboo traps situated near ground level and in the forest canopy.

Six species of the genus*Trichoprosopon* were collected during the forest mosquito investigations in Panama. The larvae of this group occupy rather specific aquatic habitats such as tree holes, bamboo stems, fruit husks, and the leaf axils of plants. One species, *T. magnum* (Theobald), showed a definite preference for feeding in the forest canopy. It has been observed that the larvae of *T. digitatum* (Rondani) can survive as long as three days after the complete drying of its breeding habitat, thus enabling them to survive during short periods between rains.

One of our most interesting genera of mosquitoes in Panama is the *Sabethes* represented by three rather common metallic-colored species, *S. cyaneus* (Fabricius), *S. tarsopus* Dyar and Knab, and *S. chlorapterus* (Humboldt). *Sabethes cyaneus* and *S. tarsopus* have the mid tibia and first tarsal joint clothed with long, erect, but compact scales, which give the legs a paddle-like appearance. The females readily attack man, usually about the head, but are slow in their movements and appear to hover in flight. The male of *S. tarsopus* was recently described by Galindo *et al.,* (1951b) from specimens captured as they accompanied the females to the collectors on platforms in the forest canopy, between 40 and 75 feet from the ground. The larvae of *S. cyaneus* and *S. chloropterus* develop in water in deep tree holes having small openings. These two species readily took to bamboo traps having closed tops and a small opening in the side, simulating their natural breeding places. The females of *S. chloropterus* and *S. tarsopus* feed mostly in the forest canopy, while *S. cyaneus* feed in the forest canopy and at the ground level in about equal numbers. The *Sabethes* spp. persist in the forests in Panama throughout the dry season after no adults of *Haemagogus* and *Aedes* can be found. This may be due to the fact that the eggs are deposited on the surface of the water in deep tree holes situated where the evaporation rate is very slow. One species *S. tarsopus,* apparently increases the number of eggs produced with the onset of the dry season.

The genus *Wyeomyia* is a large and complex one in this area. Seventeen species belonging to this genus were collected at forest stations in 1949 (Galindo *et al.,* 1951). Two of these were new and have recently been described (Galindo *et al.,* 1951b). Most of the adults were captured with human bait. The majority of the *Wyeomyia* either breed in the leaf axils of terrestial plants or in epiphytic bromeliads; however, some breeding takes place in tree holes, bamboo sections, fruit husks and other similar aquatic habitats.

The genus *Limatus* is represented in this area by two species, *L. durhamii* Theobald and *L. asulleptus* Theobald. Both species breed in tree holes, bamboo sections, tin cans, fruit husks and fallen leaves. The larvae are common in the deep forest during the rainy season in small collections of water held by fallen leaves found on the forest floor. Both *asulleptus* and *durhamii* feed on man to some extent.

Except for a few of the more common species, little is known of the biology of the *Uranatoenia* of this area. Those species of which larvae have been collected, generally utilize ground pools for their breeding, and are more prevalent during the dry season. The New Jersey Mosquito trap is particularly effective for collecting *Uranatoenia.*

Two species of *Orthopodomyia, O. fascipes* Coquillett and *O. phyllozoa* Dyar and Knab, were collected at the forest stations. The normal breeding habitat of *O. fascipes* is tree holes situated in the forest, while *O. phyllozoa* is known to breed in water collections in the leaf bases of certain terrestrial plants and in epiphytic bromeliads. Nothing is known of the feeding habits of the females of either species. The males and females of *O. fascipes* have been collected by the writer on several occasions resting in tree buttresses in the forest.

Mansonia titillans (Walker) is probably the worst pest mosquito found in those areas in the Canal Zone and the Republic of Panama located within flight distance of marshes. *Mansonia nigricans* (Coquillett) and *M. fasciolatus* (Lynch Arribalzaga) are pests in some areas, while *M. indubitans* Dyar and Shannon and *M. pseudotitillans* (Theobald), recently recognized as occurring here, are apparently too rare to be of much importance.

The genus *Aedeomyia* is represented by one species, *A. squamipennis* (Lynch Arribalzaga) in Panama. The larvae are found during the dry season mostly in floating river vegettaion. The species is particularly abundant in the shallow areas of Gatun Lake where it is commonly associated with *Anopheles albimanus* and *Culex erraticus* (Dyar and Knab). The adults are readily attracted to light traps and the females are occasionally captured in animal-baited traps.

Several species of *Psorophora* occur in Panama; howeevr, *P. ferox* (Humboldt) and *P. lutzii* are the only species found in sufficient numbers to be of much importance. Both species occasionally bear the eggs of *Dermatobia hominis.* The larvae of *P. lutzii* develop in temporary pools formed by the first heavy rains in May and June. The adults are seldom encountered after July, in contrast to *P. ferox* which occurs throughout the rainy season.

The number of species of *Aedes* in Panama is relatively small in comparison with the temperate zone of North America. The members of the subgenus *Finlaya,* particularly *A. leucoteniatus* Komp, *A. terrens* (Walker), and a new species closely related to *A. leucocelaenus* Dyar and Shannon, are tree hole breeders, occurring throughout most of the rain forests. The mating habits of *A. leucotaeniatus* were observed by Galindo on two occasions on Cerro La Victoria. At the first indication of the mating activity, the males were observed hovering about knee height. As the females came to the collector to bite, copulation started during flight, but the couples soon dropped to the ground where the act was completed (Galindo *et al.,* 1951). One species of *Finlaya, A. fluviatilis* (Lutz) generally lays its eggs in rock holes along rivers and they hatch in large numbers following the first heavy rains in May. The eggs continue hatching in smaller numbers as the breeding places are reflooded during the remainder of the rainy season.

Of the subgenus *Ochlerotatus, A. taeniorhynchus* (Weidemann) is the worst pest species in the area. The species breeds in the extensive tidal marshes and adjacent freshwater pools on both sides of the Isthmus. Following the emergence of a large brood of this species, the adults may be encountered across the entire Isthmus in the Canal Zone. Even though these mosquitoes were almost unbearable at times at ground level, at one of the forest stations, they were rarely taken on a platform situated only 20 feet above the ground. Those few specimens which were captured on the platform were always collected soon after the beginning of the collecting period, indicating that they possibly followed the collectors up the ladder.

Aedes fulvus Wiedemann, a handsome bright yellow colored mosquito, is occasionally picked up in biting collections made in the dense jungle during May and June, shortly after the beginning of the rainy season. During a single night of operation of a horse-baited trap in Mojingo Swamp in the Canal Zone during 1949, approximately 150 females of this species were taken. During June, 1950, the writer made a trip into the swamp in an attempt to find larvae and males of this species. No larvae were found, but recently emerged males and females were seen in considerable numbers resting on the lower surface of leaves on the underbrush. The larvae have apparently never been taken in Panama. Although over 900 eggs were obtained from ovipositing females, we were never able to hatch them by flooding, even by lowering oxygen tension with yeast and hay infusion. The eggs of *A. fulvus* are short and broadly oblong or diamond-shaped, which is different from any other *Aedes* eggs with which I am familiar. They are not resistant to drying and immediately shrivel when dried completely.

The genus *Haemagogus*, a group of brilliant colored forest mosquitoes, with scales of blue and purple lustre, is represented in Panama by six known species: *H. argyromeris* Dyar and Ludlow, *H. cholcospilans* Dyar, *H. equinus* Theobald, *H. iridicolor* Dyar, *H. lucifer* Howard, Dyar and Knab and *H. spegazzinii falco* Kumm *et al. Haemagogus spegazzinii falco* is regarded as the most important known vector of jungle or sylvan yellow fever in South America. The occurrence of this species in Panama was previously unknown, except for a single unreported collection of larvae taken by Komp on Barro Colorado Island several years ago. Recent forest mosquito surveys proved this species to be widely distributed and abundant in many areas in the heavy rain forests of Panama and Costa Rica (Galindo *et al.*, 1949, 1950, 1951a, 1951c). The females of *H. spegazzinii falco* are predominantly arboreal and are avid feeders on man under these conditions. The larvae were found only on a few occasions, even in areas where adults were abundant. Examinations made of a large series of tree holes in the canopy of the forest each week over a period of several months, failed to yield larvae in numbers commensurate with numbers of adults present. *Haemagogus equinus* and *H. lucifer* are widely distributed in Panama and breed in water in rot cavities in trees, particularly in forests. *Haemogus iridicolor* has been found only along the Atlantic coast of Costa Rica and the adjacent northern area of Panama, where it breeds in tree holes and bamboo joints. *Haemagogus chalcospilans* breeds mostly in small collections of water in mangrove trees in the tidal marshes. The females are avid biters, always attacking man about the head and shoulders. *Haemagogus argyromeris* utilizes a much larger variety of breeding places than any of the other *Haemagogus* spp. found in Panama. It has been found breeding in tree holes, bamboo traps, tin cans, coconut hulls, old tires, rock holes, terrestrial bromeliads, and occasionally in ground pools.

The mating of the males and females of *H. equinus* and *H. lucifer* were observed by the writer on several occasions. The males were attracted to the collector in the forest and remained in flight a distanc of 3 or 4 feet away, until the females arrived to feed. As the females approached the collector, they were caught by the males, and copulation took place during flight.

The eggs of *Haemagogus* spp. do not all hatch following a single flooding, but uneven hatching occurs following several floodings, thus protecting the species against temporary adversity. Approximately 100 bamboo section larval traps, used in the forest during the rainy season, were carried to the laboratory and alternately dried and reflooded each week, over a period of several months. *Haemagogus* and tree-hole breeding *Aedes* continued to hatch after each flooding during this period. In this connection, it was also interesting to note that the eggs of *H. spegazzinii falco* apparently do not begin hatching until after at least two or more alternate floodings and drying of their breeding places. Eggs obtained from gravid females kept in oviposition vials also displayed these same characteristics. It was also observed that adults of *H. spegazzinii falco* appear much later in the forest after the beginning of the rainy season than do other *Haemagogus* spp.

Prior to this work in Panama (Galindo *et al.*, 1949, 1950, 1951a), no information was available on the feeding habits of the females of *H. argyromeris,* as no characters were known for separating them from *H. lucifer.* During these studies, characters were discovered by which they can be readily distinguished, and it is now known that *H. argyromeris* actively feeds on man and is generally found in or near second growth timber, and does not invade the deep virgin forest. On the other hand, *H. lucifer, H. equinus* and *H. spegazzinii falco* are generally mosquitoes of the deep forest.

The genus *Culex* comprises a large number of species in this area, many of which are little known and undoubtely many remain to be described. Members of this genus occupy about every known type of breeding habitat existing in the area. Most of the species are known chiefly from their larvae and from reared adults, and thus little is known of their mating, feeding and egg-laying habits.

The genus *Deinocerites* is represented by about four known species in Panama, *D. cancer* Theobald, *D. epitedeus* Knab, *D. pseudes* Dyar and Knab and *D. spanius* Dyar and Knab. The larvae develop in water in crab holes situated in or adjacent to the tidal marshes. The adults rest in the crab holes and mating has been observed by the writer among resting males and females in crab holes on several occasions. The females of *D. cancer* and *D. pseudes* are readily attracted to horse-baited traps operated near the tidal flats in which they breed.

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Mr. Smith: We will now adjourn until tomorrow morning at 9 a.m., in this same place. You are all invited to attend the "Hospitality Hour" at the Hotel Fresno at six this evening. No dinner arrangements have been made, and after the "Hospitality Hour" you are on your own.

Second Session

Thursday, February 14, 1952, 9:00 a.m.

President Smith: The California Mosquito Control Association brings its annual business session to order. Are there any preliminary announcements to be made at this time?

Mr. Gray: The Resolutions Committee will receive any resolutions that anyone wishes to offer. We have three or four resolutions before us.

PRESIDENT'S MESSAGE TO THE ASSOCIATION

It is customary at this time for the President to review the past year's activities of the California Mosquito Control Association. Rather than discuss at length the activities with which you are already thoroughly familiar or which will be reported on shortly by committee chairmen, I will confine myself to general remarks about the past and then discuss the future.

I have been very greatly pleased by the fact that we have had virtually 100% atetndance by the Board of Directors at all of the six Directors' meetings scheduled, and that each of the meetings attracted a large number of other district managers who took an active part in the discussions. I believe that this year has seen more widespread discussion of the business of the Association by managers and their boards of trustees than ever before, due in part to the fact that constant heckling from the southland (specifically Los Angeles and Orange County) resulted in your administration getting the agenda for each meeting out well in advance.

The membership as a whole has been consulted and kept informed, and in certain instances has been polled, so as to arrive at a concensus of opinion to guide the Directors in making decisions. This has resulted in carefully considered decisions arrived at in a democratic manner. In several instances decisions of the Board of Directors were handled by mail ballot resulting in a saving of time and expense all around. This method of transacting business might well be better utilized in the future.

1951 was a year of change in California Mosquito Control: The California Mosquito Control Association became incorporated, Norm Ehmann left Los Angeles for additional training in the East, Arve Dahl left the Bureau of Vector Control for an important post in Civilian Defense, Dick Peters became Chief of the Bureau of Vector Control and Art Geib left the ranks of "Skeeter-Chasers" to start producing them as a farmer. New mosquito districts were organized in Contra Costa County and Los Angeles County. However, the most important changes taking place during the year were not so readily discernible. They were changes in the nature of the pest with which we have to contend, the mosquito itself. The DDT resistant mosquitoes which first appeared at scattered points in the valley in early 1949, spread somewhat and increased their resistance in 1950, and then really came into their own in 1951. Resistance appeared in *Aedes,* then in *Culex;* first to DDT, then to other insecticides, and finally increased in intensity to a point where control at a reasonable cost was impossible.

These changes were generating other changes in the minds of that peculiar creature known as a mosquito district manager. By the end of the mosquito season he had seen prices on most of the materials and equipment he used rise 25 to 100%, and mosquitoes become uncontrollable by reasonable amounts of insecticide. At the same time his taxpayers began to demand more and better service than ever before. All of this affected the wealthy districts as well as the poor. It has resulted in many interesting remarks such as: what do we do now—go back to Diesel oil? — or get out the Flit Gun boys, here come the "skeeters." Speculation has been rife on such interesting questions as "Why isn't state subvention money restricted to permanent control work?" — or — "I wonder how many mosquito districts would fold up if state subvention was taken away?" Comments on this particular subject have been extremely prolific. I have heard the statement that subvention has outlived its usefulness. "We no longer need it. It may be true that there are some poor districts that do need the money, but if they can't support the program themselves, they just don't deserve to have a mosquito control program." That attitude has been expressed by wealthy districts of high assessed valuation and low tax rates, which do not have any particular need for the money. "If subvention money is no longer available for us then you shouldn't have it either." That attitude has been expressed by some districts which have accepted the money for five years. If these opinions had been expressed to begin with, together with a rejection of the money, they would at least have the merit of consistency. These comments sound as if some of the mosquito district managers are worrying about the future of mosquito abatement in California. We all should be doing plenty of worrying about just that. As a result of the wartime discoveries in the field of new insecticides, many mosquito districts in the post-war period changed themselves from mosquito abatement districts to mosquito control districts. Now that the honeymoon with DDT is over, it would seem imperative that some changes be made. Perhaps the change back to mosquito abatement will be necessary. However, some prefer to keep searching for the pot of gold at the foot of the rainbow, in the form of a newer and better insecticide to serve as a panacea. I would like to take a few minutes to state my own personal opinion as to what is going to be necessary in the future for mosquito districts to be able to justify their existence. These comments apply particularly to districts in agricultural areas.

Whether we like it or not, we are going to have to stop blaming the farmers for their carelessness and misuse of water and get busy and learn for ourselves just what their problems are in the handling of water. We can hope for no solution to our water problems until we thoroughly understand the principles of irrigation, crop needs, soil characteristics, rates of infiltration, drainage requirements, benefits of drainage, methods of drainage, and numerous other technical details concerned with proper irrigation practices and drainage. It is not enough to tell a farmer he is producing mosquitoes which is against the law and that he must stop it. We can expect no progress in reducing mosquito sources until we are in a position to go to the farmers and offer our help in solving their problems in regard to water use in such a way that it will also help us. In order to do this we will need the cooperation of every other organization and agency which is working in the field of water problems—this includes the local irrigation districts, drainage districts, soil conservation districts, road departments, health departments, and also state and federal organizations which have an interest in our own local problems. Again we can't expect to get help from them without being able to offer something in return. This then means that we must also be in a position to understand their problems and interests in water use.

I do not mean to imply that the use of insecticides is a thing of the past. Obviously we are always going to have to rely on insecticides for temporary control. But, it is becoming more obvious all of the time that we cannot rely completely on insecticides for several reasons: (1) Insecticidal control is never completely satisfactory and is becoming more costly all of the time. (2) It has to be done over again every year and every year there is an ever increasing amount of it to be done. (3) In many cases the cost of eliminating the source is actually cheaper than the cost of one season's spraying.

To maintain a well balanced program that can be justified in the future, we must take advantage of all of the information that is available from other sources and put it to use for our own purpose of reducing mosquito problems. We must further enlist the aid of every organization that might possibly help us with our plans for the future. At any number of the meetings that I have attended in the past year, and I have tried to attend all of the regional meetings that have been held, time and again I have heard expressions from people such as: "Just what are we going to do in the future? We are having troubles. We are having troubles with our rice fields. We are having troubles with our pastures, our insecticides don't hold up." I am afraid there are a lot of inconsistencies in human nature. Some of the people I have heard express those particular opinions have turned right around and said, "We shouldn't be spending any money on operational investigations as it is a waste of money. Give it to us for operations." In one breath they say they don't know what to do. The next breath they say they don't want to spend any money finding out. I don't quite know how to rationalize that particular inconsistency.

Our course is well charted for us. Harold Gray's now famous "Which Way Now" speech, given at our 18th Annual Conference, was an admirable appeal for a return to the tried and true basic principles of eliminating mosquito sources. Two addresses, given at the 17th Annual Conference, contain some very excellent suggestions which are well worth a re-reading at the present time. Those are Dr. Freeborn's talk on the relationship of mosquito abatement agencies to other agencies of government; and Dr. Nyswander's discussion of the place of education in a mosquito abatement program.

I do not intend in any way to belittle the many magnificent efforts that are being made throughout California to eliminate the mosquitoes, but I do feel that there is a new era about to dawn in the field of mosquito abatement and I do not feel that any of us can afford to be caught napping.

To get into the regular business of the session, the first item on our agenda is the report of the Secretary-Treasurer, Ed Washburn.

Mr. Washburn: As you know, I have been elected temporary Secretary-Treasurer of the organization in the interim from Art Geibs' resignation from the organization until election time when someone will be chosen. At the time that I received the books, about February 1st, the balance was $2775.42. Since then I have received two small amounts of money, one an associate membership, and a contractual membership which now leaves a balance of $2838.42. There are certain expenses involved as far as this conference is concerned. They are being taken care of from subscriptions gathered by the persons in charge of arrangements, particularly Ted Raley and Ed Davis. As of this date we have thirty-seven contractual agencies and for the first time we have been able to report any associate members as far as I know. That concludes my report at this time.

Mr. Smith: Are there any questions? Moved and seconded we accept the Secretary-Treasurer's report. Are you ready for the question? All those in favor say aye. Approved.

We appointed a Credentials Committee last night of Jack Kimball and Ed Washburn. A letter was sent out to all corporate members informing them that they should send in to the association the name of their designated representative. As of yesterday we had only 15 out of some 37 districts. However, this morning we can raise that figure to 21 who have definitely signified a designated representative. Ed, could you read off that list and if there is anyone here who is not on that list he can come up and clear with the credentials committee at this time. The approved list is Alameda, Anderson, Cottonwood, Butte County, Consolidated, Corcoran, Fresno, Hanford, Kern, Los Molinos, Madera, Marin, Matadero, Merced, No. San Joaquin, Orange, Redding, Three Cities, Tulare and Turlock. Are there any agencies here that should be on that list? That very definitely gives us a quorum. Next will be the report of the Publications Committee, by Harold F. Gray, chairman.

Mr. Gray: For the Publications Committee I report that the Proceedings of the conference at Riverside last year, after considerable delay, were finally printed and distributed to the membership, and were rather widely distributed throughout the world to a large number of agencies. Our proceedings are in demand from workers in the Orient, Europe, South America, Canada and wherever this work is going on, and this organization receives considerable prestige from the character of the papers and discussions that are presented at our meetings. I regret very much that due to certain failures on the part of the printer, page proofs returned with corrections frequently were not corrected, and it is the poorest job of printing I think that we have ever been guilty of. That is not the primary fault of the editor or assistant editor or the co-editors. It's just simply one of those slips, and I assure you that that printer will not have another chance with us.

Mr. Richard Peters, who has been responsible for getting out the "Buzz", has got it out in spite of difficulties. Dick has been up here at this rostrum upon a number of occasions and told you that you cannot build bricks without straw, you cannot get out a "Buzz" without some buzz behind it, and so I am going to repeat what he has said. If you want a "Mosquito Buzz" for heaven's sake buzz in your own locality and send the stuff into Dick so that he can have some news. You all are doing something. You all have something that's of some interest and of value. Send it into Dick. He's going to get discouraged one of these days trying to work in a vacuum. It might surprise you also to know that items that have been published in "Buzz", are being reported in the bibliography of technical papers which are published all over the world. Some rather important things that have been announced there have been picked up by entomologists working in other areas. So help Dick out with a little news.

Mr. Smith: We'll keep Harold busy here for just a minute. He's got a report to make for the committee on the William B. Herms award.

Mr. Gray: Mr. President, this is the report of the William B. Herms Award Committee, which consists of Richard F. Peters and Harold F. Gray. The William B. Herms Award from this Association for 1951 was made to Scout Melvin Ray, of Troup 15, Mt. Diablo Area Council, who was thus assisted to attend two weeks at the council's camp at Camp Wolfboro in Calaveras County. The committee recommends that the sum of $35.00 be made available to the Mt. Diablo Area Council, Boy Scouts of America, to continue the William B. Herms Award in assisting a deserving Boy Scout or Scouts to have the benefits of summer camping in 1952.

Mr. Smith: Shall we approve the foregoing reports? (A motion to that effect was duly made, seconded and carried by voice vote.) The next report is by the Committee on Irrigation and Development of Water Resources, by T. G. Raley, chairman.

Mr. Raley: My appointment to this committee as chairman came rather late in the year. I had little opportunity to call the committee together but I can report progress. The most important was a report by Bill Warner in the Bureau office to Dick Peters, the Chief, on the summary of progress made in 1951 with water resources development agencies in California. The major accomplishment in 1951 in connection with water resources development agencies in California was the reaching of a working agreement between the State Department of Public Health and the U.S. Bureau of Reclamation for the prevention or control of mosquitoes which result or might result from the construction and operation of major projects by that agency. This working agreement was developed as a result of the memorandum of understanding between the Public Health Service and the Bureau of Reclamation pertaining to public health aspects of reclamation projects. This was entered into by these two governmental agencies in 1950 and is applicable only to public health aspects covered in the memorandum of understanding which concerns the control of conditions favorable to mosquito-borne diseases. Actual agreements have been reached already to do particular work on certain features of the reclamation projects within California.

A form letter was offered for use by all districts, this form letter to be sent from the district to all agencies within their area who might be concerned with the management of water in any of its phases.

I would like to recommend that particular emphasis be given to this committee by the Association, with the thought of making it a permanent or standing committee so that the committee members can plan a long range project with these various agencies and individuals and parties concerned.

Mr. Smith: I call next on Ed Washburn to present the report of the Operational Investigations Committee for the year.

Mr. Washburn: This report will be somewhat different than we had in past years. There are five separate investigations that have been going on this past year. I have asked the personnel in charge of these projects to report on their individual projects so you would have a little closer contact and obtain more precise information from them than I can possibly give you, so the report will principally consist of the reports from these individuals. The first one to report is Dick Husbands who is in charge of the investigations with irrigated pasture mosquitoes.

A COOPERATIVE ECOLOGICAL STUDY OF MOSQUITOES OF IRRIGATED PASTURES

By Richard C. Husbands[1]
and
Bettina Rosay[2]

The Central Valley Mosquito Ecology Study on Irrigated Pastures, established by a cooperative agreement on the part of the California Mosquito Control Association and the Bureau of Vector Control, continued investigations during the 1951 season in three areas of the Central Valley. Investigations in the three areas were accomplished by the division of the Project into sub-projects in accordance with the recommendations of the Operational Investigations Committee (CMCA). A continuation of the embryological studies constituted a sub-project at the College of the Pacific. A cooperative sub-project was conducted in Kern County as a continuation of the studies of mosquito flight range. This was carried on by a cooperative agreement with the Kern Mosquito Abatement District, the district to supply operational direction and the Central Valley Mosquito Ecology Study to supply technical assistance and personnel qualified to meet the demands of the Atomic Energy Commission requirements. Finally, a project was established in the Fresno area to continue the studies on mosquito ecology in irrigated pastures. Working out of the State of California Vector Control Field Station the project was financially administered through the courtesy of the Fresno Mosquito Abatement District. Technical assistance was supplied by the Bureau of Vector Control, State Department of Public Health.

When the project in mosquito ecology was first established the problems were well defined. These problems have not diminished but instead have grown more apparent, more complex, and more in need of eventual solution. The problems are: the great increase in the amount of land being irrigated as a result of the development of the Central Valley Project, the increasing problems of maintaining the standards of mosquito control in California, the public health aspects of present control practices, and a complete lack of knowledge about the natural history of pasture mosquitoes.

With these problems in mind the project set up specific objectives. Fundamentals were to come first, followed by the investigations of the more complex aspects of mosquito ecology such as the interaction of various factors, the investigations of mosquito behavior, and the studies of mosquito ova. Objectives selected in the original program were outlined as follows:

1. The significance of *Aedes nigromaculis* (Ludlow) and *Aedes dorsalis* (Meigen) in regard to encephalitis.
2. The seasonal comparisons of the life cycles of species of pasture mosquitoes.
3. The influence of pasture fauna, soil, flora, and irrigation practices upon mosquito populations.
4. The influence of other environmental and biological factors upon the natural history of mosquitoes produced in pastures.
5. The evaluation of all biological material to assist in present and future mosquito control.

Much has been accomplished in terms of these objectives and much remains to be accomplished in future programs. The 1951 program was designed to investigate some of the more complex aspects of mosquito ecology and the progress herein reported will show the practicability of this type of study. Fundamentals are necessary but do not necessarily contain the answer to the problems mentioned. The complexity of the interaction of some of the ecological factors examined will show how dangerous it is to make any assumptions without proof of their validity. With this in mind the present investigations were directed at the accumulation of facts, not fancy.

EMBRYOLOGICAL INVESTIGATIONS

The sub-project conducted at the College of the Pacific has made rapid progress toward the accumulation of basic information on the embryology of pasture mosquito eggs. Much of this information has been useful to the Fresno branch of the investigations. The coordination of efforts has paved the way toward future progress.

An important phase of the embryological study on mosquito eggs has been its direct application on problems in field ecology. In determining the length of time that it takes for a complete cycle of development to take place, from egg to egg, the rate of embryonic development must be taken into consideration and, if there are indications of dormancy in eggs, the embryological approach will help us to understand the action and to analyze the methods of using this factor to set up possible improvements in control procedures.

FLIGHT STUDY

In order to facilitate the reporting of results, a summary of comparisons has been prepared to show the similarities and differences between the 1950 and 1951 flight range studies (Table 1).

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(1) Entomologist, Central Valley Mosquito Ecology Study, California Mosquito Control Association.

(2) Assistant Entomologist, Central Valley Mosquito Ecology Study, California Mosquito Control Association.

TABLE 1—*A List of Comparisons Between the 1950 and 1951 Flight Range Studies Conducted in Stanislaus and Kern Counties*

Comparative Data	*Stanislaus County 1951*	*Kern County 1951*
Time	August 9 to September 21	September 3 to 26
Release Point	8 miles west of Turlock	4 miles west of Wasco
Wind Direction	NW 0-10 mph	Variable but normally NW
Terrain	Abundant pasture areas	Cotton, desert and scattered pastures
Temperatures	Max. 100° F.—Min. 70° F.	Max. 100° F.—Min. 65° F.
Blood Meal	Readily available animal and human	Scattered sources animal and human
Larval Holding Tanks	Metal 79.2 gallons	Wood and Metal 400 gallons
Marking Agent	Phosphorus 32 Concentrate 0.1 mc. per ml.	Phosphorus 32 Concentrate 0.1 mc. per ml.
Number of Mosquitoes Tagged	Approximately 400,000	Approximately 2 to 5 million
Species and Stages Used for Tagging	Aedes nigromaculis Aedes dorsalis Culex tarsalis 3rd and 4th stages	Aedes nigromaculis Aedes dorsalis 3rd and 4th stages
Method of Collecting:		
Hand Collections	Radially about the Release Point up to one mile Collecting Stations	Collecting Stations
Positive Hand Collections Recovered	226	None
Light Traps: Numbers Used	70	80
Light Trap Arrangement	Radially about release point	Majority E and SE from release point
Positive Light Trap Collections Taken	86	22
Positive Light Trap Specimens Taken	249	45
Distance and Collections:		
Farthest Recovery (Female mosquito)	1⅞ miles	7 miles
Species Recovered at Maximum Distance	Aedes nigromaculis	Aedes nigromaculis Aedes dorsalis
Number of Negative Collections	1366	2662

The flight range study is an example of a continuing study on a complex ecological problem. The original objectives of the study were based upon observations and conclusions of many workers in the field of mosquito control. These reports seem to show a definite pattern, and a relationship to the build-up of mosquito populations in uncontrolled areas. The objectives were to obtain facts which would give more information about the movements of mosquitoes. The information obtained from the studies has been valuable in gaining an understanding of the "dispersal" of *Aedes nigromaculis* from an area of emergence. Dispersal may be the usual condition that could be expected of *A. nigromaculis,* while "flight" may be the exception and more dependent upon special conditions. Observations made in the special study pasture indicate that "dispersal" was the usual condition of mosquito movement during the 1951 season in the study area.

An examination of Table 1 shows several interesting features. It is apparent from the data that *A. nigromaculis,* and possibly *A. dorsalis,* was not moved or did not move great distances under the conditions of the study. Similar work on other species of migratory mosquitoes suggests that recoveries should have been expected with tagged specimens if actual migration had taken place. Further work along this line should be examined carefully before proceeding to general conclusions regarding the movements of *Aedes* species encountered in irrigated fields.

Dispersal movements of mosquitoes were examined in the Fresno-Madera area in connection with the special pasture mosquito ecology study that was initiated during the 1951 season. Limited movements were recorded that followed the pattern of a "dispersal" and was dependent upon the size of the population present at the special study area.

PASTURE STUDY

Studies conducted during the 1951 season were planned to conform with the original objectives of the pasture mosquito ecology study. Previous experience shaped the methods used, methods that were limited to some degree by a lack of refined equipment. Broad biological relationships were measured with a view of refining the measurements of previous studies. In addition to the usual adult, larval, pupal studies, a special emphasis was placed upon the investigations of mosquito ova, especially the ova of the *Aedes* species found in pastures.

Study Area

For the purpose of the study a special pasture was selected in Madera County, T 12S, R 20E, Sec. 16, that was located in an uncontrolled area and yet within practical working distance of the Fresno Field Station. This pasture is defined as Cobb's pasture. The special study pasture was approximately 12 acres in size and was bordered on the north by a cotton field, on the south by a corn field beyond which were many acres of dry pasture, on the east by an alfalfa field, and on the west by a bluff that bordered extensive areas of dry grazing land. As an observation point the bluff offered a means of making additional records of irrigation practices. The soil type was sandy loam deposited by the San Joaquin River. The pasture was two years old and had been planted on an area formerly occupied by a vineyard. The 12 acres was surrounded by a fence and roughly divided into two parts by a central east-west fence. Cattle occupied both sections of the pasture during various parts of the day and generally were able to leave the field at will. In at least two instances the presence of large numbers of mosquitoes held the cattle off the pasture for several days. Pasture grasses, alfalfa, and clover supplied cattle forage; ladino clover was not present until seeded at the end of the season.

Strip checks about 15 feet wide ran east and west. Water was pumped from the river and into the checks from a ditch on the east border. The south 6 acres was occasionally irrigated from another ditch running north and south and dividing it into two equal parts. Drainage of excess water from the field was accomplished by means of an overflow drainage ditch at the west end of the field. Overflow from the pasture occurred at times, but was carried into a low area containing *Gambusia* fish and therefore seldom produced mosquitoes. The drainage ditch at the end of the field was irregular in depth and occasionally retained water which produced mosquitoes.

Because of the isolated location of the field, district control practices had little influence upon the biology of mosquitoes produced. Furthermore, the migration of an outside mosquito source into the pasture was minimized to a great extent. Excellent owner cooperation was obtained.

Methods: Maps and photographs were used to measure and record the approximate amount and distribution of water on the field. Selected stations were located in the field, marked, and visited regularly to give a continuous record of pasture activities. A standard weather station containing a hygrothermograph was located at the center of the east border of the field. Cycles of irrigations were recorded, and records were made of water temperatures and depths. The volume of water remaining on the field each day was recorded photographically during the August 5th Cycle of Irrigation. Adult density measurements were obtained by taking daily light trap collections near the west central border of the field. Adult conditions of feeding and of egg production were obtained by the dissection of females collected daily. Field station studies guided and confirmed the field data. Studies of egg production, in addition to dissections, were conducted by utilizing daily collections of field adults that were held in special cages in the field station, fed on sugar water, and held at 80 degrees F. and 80 percent relative humidity throughout the period of egg production or until death. Studies on sites of oviposition and egg densities were obtained by collecting soil samples, using a generator driven vacuum cleaner, and examining these samples in the field station with equipment designed for this purpose. Eggs recovered by these methods were utilized for testing the effect of dissolved oxygen upon hatching, studies on the influence of conditioning temperatures upon hatching, and methods of rearing larvae in artificial containers.

Results: Fifteen irrigation cycles were recorded in Cobb's pasture during the 1951 season. The duration of cycles varied from 8 to 33 days with four short cycles of 8 day length and two long cycles of 32 and 33 days. The average cycle for the season was 15 days which was longer than the average of 13 days that was recorded for the 1950 study in Schaub's study (Stanislaus County). Cycles that occurred between June and late October were recorded in detail (Table 2).

TABLE 2—*Irrigation Dates (Hatching Date for "Aedes" Eggs), Dates Adults First Emerged, Length of Growth Cycles in Days, and the Mean of the Maximum, Minimum, and Mean Air Temperatures for the Two Stations in Cobb's Study Pasture—1951*

STATION #1			*Mean of Air Temp. in °F.*			
Date of Hatch	*Date of Emergence*	*Days of Aquatic Growth*		*Mean*	*Maximum*	*Minimum*
June 30	July 7	8	70.7	(74.2)†	90	54
July 11	July 17	7	77.4	(78.4)	94	60
July 18	July 24	7	80.2	(83)	96	60
Aug. 5	Aug. 11	7	73.7	(77)	93	53
Aug. 16*	Aug. 23	7	77.4	(80.7)	96	58
Aug. 26	Sept. 2	8	70.4	(72.5)	88	53
Sept. 14*	Sept. 20	6½	77.2	(78.4)	96	58
Sept. 22*	Oct. 1	9½	68.8	(69.8)	89	52
Oct. 24	(Nov. 6-7)‡	14-15	56.5	(56.1)	74	39
STATION #5						
	July 7		70.7	(74.2)†	90	54
July 11	July 17	7	77.4	(78.4)	94	60
July 19	July 25	7	80.2	(83)	96	60
Aug. 5	Aug. 11	7	73.7	(77)	93	53
Aug. 16	Aug. 23	7½	77.4	(80.7)	96	58
Aug. 26	Dried up	...	70.4	(72.5)	88	53
Sept. 14*	Sept. 20	6½	77.2	(78.4)	96	58
Sept. 22*	Oct. 30	8½	68.8	(69.8)	89	52
Oct. 24	Dried up	...	56.5	(56.1)	74	39

* Mid-day
‡ Theoretical emergence, dried up
† Fresno Weather Station, Hammer Field, Hourly Average Mean

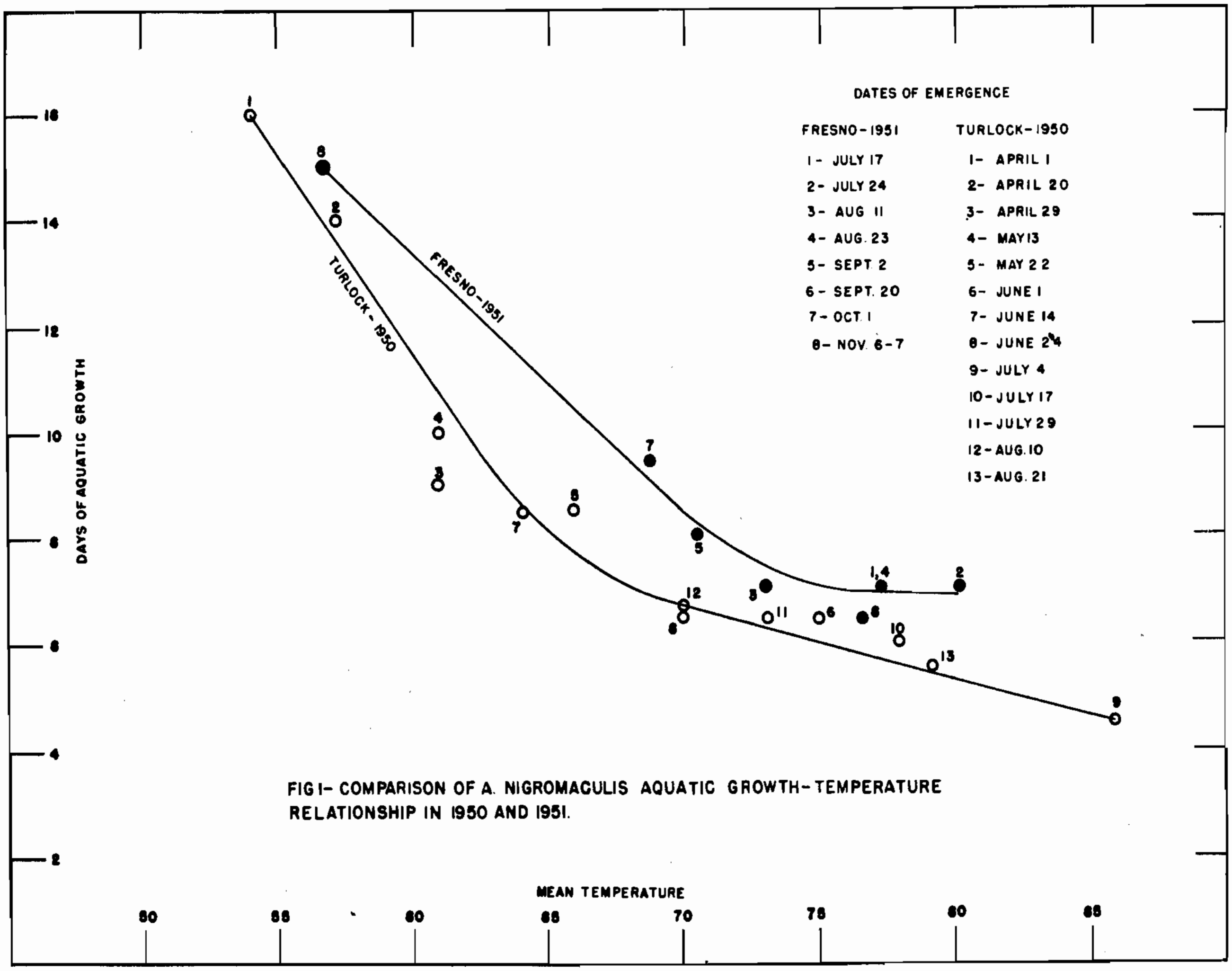

FIG I- COMPARISON OF A. NIGROMACULIS AQUATIC GROWTH-TEMPERATURE RELATIONSHIP IN 1950 AND 1951.

The results of the measurements taken during each cycle from June to October in Cobb's pasture indicated that for *A. nigromaculis* the rate of growth in the aquatic stages closely followed the temperature growth relationships shown in the 1950 study in Schaub's pasture. A difference was noticed in comparing these studies which indicated that at similar temperatures the rate of growth was slower in Cobb's pasture (1951) than in Schaub's pasture (Figure 1). This may indicate that the aquatic growth rates may vary from one area to another or from one pasture to another or from one season to another. The influence of many ecological factors can produce an over-all speeding up or slowing down of the aquatic growth rate but this rate can still be expected to closely parallel the curves indicated from the data obtained from the two seasons of study (Figure 1). Cobb's pasture produced its shortest aquatic cycle of 6½ days with a mean air temperature of 77.2 degrees F. Schaub's pasture would have completed this cycle during the 1950 season in about 5¾ days at the same mean temperature.

In both the 1950 and 1951 studies there were a few indications that the rate of aquatic growth of *A. nigromaculis* was not always a function of temperature alone. During one irrigation cycle in Cobb's pasture the overcrowding of larvae or inaccessibility of food or similar factors may have produced a longer period of growth (7 days) during the July 18th irrigation when the mean temperature was 80.2 degrees F. An overcrowding effect was demonstrated in the field station. Using pasture water and daily yeast feedings, numbers of *A. nigromaculis* larvae were allowed to grow from egg to adult in 100cc of water held at 80 degrees F. If one or two larvae were used per 100cc of water the growth period required 5-6 days. Crowding of 6-8 larvae per 100cc of water increased this period to 6½-8½ days.

Irrigation Cycles and Larval Densities.

During the 1950 pasture ecology study information was obtained which made it possible to estimate approximately the total time required for the completion of an "egg to egg cycle." This period (defined as the time required to complete a cycle from egg hatching, through aquatic stages to adult emergence, fertilization, egg deposition, and on through the period of time required for these eggs to develop to maturity so that they are available for hatching) was estimated to consume about 13 days (1). This coincided very closely with the 1950 irrigation cycle of 13 days average duration. Information was obtained during the 1951 study which refined this approximation to a more definite period. This was obtained by studies on egg laying and the rate of ovarian development based upon the data obtained from the study of the population as a unit; which, since the species emerged en masse, was called an "emergence brood." The maximum egg production periods (a period when the greatest number of eggs were deposited by a brood) was found to occur on the 3rd, 4th, and 5th day after the emergence of a brood of *A. nigromaculis*. Using this period it was possible to determine the approximate date that these eggs would mature and become available to hatch when flooded. When coupled with the information on the aquatic growth rates the length of the egg to egg cycle could be determined with a greater degree of accuracy. On the basis of this information it is possible to show that irregular irrigation cycles can result in the accumulation of eggs from two or possibly more emergence-broods so that the accumulated eggs hatch during a single period of irrigation. Furthermore, this same knowledge can be used to show that certain irrigation periods will produce low larval densities because eggs that were produced by adults of previous irrigations will not mature in time to hatch when flooded (Table 3).

TABLE 3—*Showing the relationship between the length of the egg to egg cycle and the duration of the irrigation cycles and the resultant increase or decrease in larval densities in pastures. Based upon the studies of Aedes nigromaculis stages.*

	Egg to Egg Cycle				Nearest
Irrigation Date (Hatch)	*Days of Aquatic Growth**	*Adults Emerge*	*First Eggs Produced Peak Days‡*	*Earliest Date Eggs Will Hatch†*	*Irrigation Period for Hatch*
June 11					
June 21	9	June 29	July 2-4	July 7-9	July 11
June 30	8	July 7	July 10-12	July 14-16	July 18
July 11	7	July 17	July 20-22	July 24-26	Aug. 5
July 18	7	July 24	July 27-29	July 31-Aug. 1-2	Aug. 5
Aug. 5	7	Aug. 11	Aug. 14-16	Aug. 18-20	Aug. 26
Aug. 16	7	Aug. 22	Aug. 25-27	Aug. 29-31	Sept. 14
Aug. 26	8	Sept. 2	Sept. 5-7	Sept. 9-11	Sept. 14
Sept. 14	6½	Sept. 20	Sept. 23-25	Sept. 27-29	Oct. 24
Sept. 22	9½	Oct. 1	Oct. 4-6	Oct. 8-10	Oct. 24
Oct. 24					

* Determined by the rate of growth as influenced by temperature.
‡ Peak of egg production which occurred between the 3rd and 5th day after adults emerge en masse from a pasture area.
† About 86 hours is required for eggs to mature after laying and before hatching will take place.

The high and low larval densities from the accumulated result of irregular irrigation cycles were measured in the special study pasture during the 1951 season. Using the egg to egg cycle to correctly measure the time period involved, an accurate prediction of expected larval densities was made (Tables 3 and 4). Three periods of high larval densities are indicated, one period on August 5th, one on September 14th and one on October 24th. On August 5th and September 14th the larval densities encountered in the field were above normal but these higher densities did not result in great numbers of emerging adults in both cases. The August 5th irrigation period produced large numbers of adults because irrigation water remained on the field in most producing areas until the adults emerged. Insufficient irrigation water failed to carry the September 14th group through to emergence. The October 24th irrigation period, the last in the season, failed to produce an above normal larval density as predicted (Table 4). This period was preceeded by a lowering of the mean temperature, and irrigation water was cooler than that used during any previous irrigation, both of which may have affected the hatch. Low larval densities

TABLE 4—*Showing the comparison between predictable densities of larvae and the actual densities of larvae as it is influenced by the number of batches of eggs available for hatch on a specific irrigation date.*

		Larval Densities in Terms of Irrigation Cycles		
Irrigation Date	*Number of Batches of Eggs Available for Hatch*	*Expected (Predicted)*	*Actual*	*Remarks*
June 21			Medium	
June 30			Medium	
July 11	1	Medium	Medium	
July 18	1	Medium	Medium	
August 5	2	High	High	Many adults emerged
August 16	0*	Low	Low	Few adults emerged
August 26	1	Medium	Medium	
Sept. 14	2	High	High	Few adults emerged
Sept. 22	0*	Low	Low	
Oct. 24	2	High	Very light due to low temperature	

* Eggs hatching on these dates would possibly originate from eggs that did not hatch during the previous irrigation or from eggs layed by the few mosquitoes migrating into or remaining on the pasture from previous broods or from more complex factors that could not be reported at this time.

occurred and were predicted on August 16th and September 22nd. These low periods were preceded by periods of high larval densities and a short irrigation cycle of less than 12 days.

Irregular spacing of irrigation cycles may result in the overlapping of broods of eggs available for hatching, presenting an added problem in control. Routine treatment practices can be complicated by the sudden increase or decrease in larval densities of fields that are treated on the expected or normal level of operation. For example, a sudden increase in the larval density of a particular field may be interpreted as insecticide failure by the uninitiated. Vice versa, a sudden decrease in the number of larvae can give a false impression of successful treatment in the routine of daily operations. This phenomenon should be considered carefully in the evaluation of any insecticide and could possibly indicate that accurate pretreatment sampling should be used in such studies.

Species Composition

Collections of adults taken by a New Jersey type light trap reflects the species composition of the pasture for the season. *A. nigromaculis* constituted 91 percent of the mosquitoes captured. *Culex tarsalis* (Coquillett) was 3.34 per cent of the total (Table 5). Collections examined by emergence periods (Table 6) show an interesting comparison of adult species that resulted

TABLE 5—*Species Composition of adult mosquitoes taken from Light Trap Collections for the period from July 26 to December 10, 1951, in Cobb's Pasture.*

*No. of times Collected**	*No. of Mosquitoes*	*Per cent of total Mosquitoes*	*Species*	*Per cent of each Genus*	*Species Compositions of Genera (%)*
17	23	0.02	Anopheles freeborni		19.30
41	119	0.09	Anoph. franciscanus	0.08	72.70
7	7	0	Anoph. sp.		7.89
8	9	0	Culex erythrothorax		0.19
9	12	0.01	C. quinquefasciatus		0.26
53	165	0.13	C. pip-quinq.	3.68	3.52
45	90	0.07	C. stigmatosoma		1.95
95	4123	3.34	C. tarsalis		89.9
18	196	0.19	Culex sp.		4.25
71	689	0.55	Aedes dorsalis		0.58
83	112,411	91.00	A. nigromaculis	95.65	95.3
62	420	0.34	A. vexans		0.35
25	4565	3.69	Aedes sp.		3.82
51	624	0.50	Culiseta inornata	0.50	100.00

* Number of collections taken during the season in which these species were found.

TABLE 6—*Distribution of three dominant species of mosquitoes taken from Light Trap Collections from July 26 to December 10, 1951, as related to Aedes nigromaculis emergence periods. (Cobb's Pasture)*

Active Period Following Emergence	*Species*	*Numbers of Mosquitoes*	*Per cent*	*Per cent of all Mosquitoes*
26 July—10 Aug.	Aedes dorsalis	108	1.48	1.3
	A. nigromaculis	7026	95.8	86.5
	Culex tarsalis	207	2.82	2.5
11 Aug.—22 Aug.	A. dorsalis	32	0.004	0.05
	A. nigromaculis	65497	99.98	99.2
	C. tarsalis	115	0.017	0.17
23 Aug.—1 Sept.	A. dorsalis	67	2.59	2.4
	A. nigromaculis	1967	76.0	73.3
	C. tarsalis	559	21.3	21.2
2 Sept.—20 Sept.	A. dorsalis	204	1.2	1.26
	A. nigromaculis	14021	88.5	87.0
	C. tarsalis	1676	10.5	10.4
21 Sept.—30 Sept.	A. dorsalis	126	0.87	0.69
	A. nigromaculis	13704	95.0	75.2
	C. tarsalis	596	4.14	3.27
1 Oct.—6 Nov.	A. dorsalis	150	1.71	1.63
	A. nigromaculis	7724	88.1	82.9
	C. tarsalis	910	10.3	9.1
7 Nov.—10 Dec.	A. dorsalis	2	5.71	0.45
	A. nigromaculis	0	0.0	0.0
	C. tarsalis	33	94.4	7.5

TABLE 7—*Showing the comparison between the larval species composition of the 1950 (Schaub's Pasture) and 1951 (Cobb's Pasture) studies for the inclusive period from June 28th to September 6th.*

Species of Larvae Pupae	*Schaub's (1950)*		*Cobb's (1951)*	
	Total Number	*Per Cent*	*Total Number*	*Per Cent*
Aedes sp.*	3922	29.7	1226	19.7
A. dorsalis	58	0.44	284	4.55
A. nigromaculis	7116	53.9	3111	49.9
A. vexans			425	6.81
Culex sp*	337	2.55	343	5.49
C. pip-quinq.	301	2.28	11	0.17
C. quinquefasciatus			10	0.16
C. stigmatosoma			244	3.91
C. tarsalis	1468	11.1	594	9.50

* Early stages not identifiable below generic level.

from each irrigation cycle. The August 11th to 12th emergence period that resulted in the greatest numbers of *A. nigromaculis* shows a decline in the numbers of *Culex tarsalis* which did not reflect the pasture conditions of more breeding areas containing *Culex* species.

A comparison of the species composition of larval collections taken from Cobb's pasture and from Schaub's pasture (1950 season) shows the similarities between the two pastures for the period from June 28th to September 6th (Table 7). Although a greater acreage was sampled in Schaub's pasture the selected sampling practiced in Cobb's pasture gave an estimate that was more reliable in terms of adults produced. This selective sampling was done to obtain information for the comparison of light trap collections with pasture potentials in terms of species. *A. nigromaculis* was the dominant species of larvae present and constituted 49.9 percent of identifiable species present in the pasture. However, 19.7 percent of the collected larvae were listed under *Aedes* species due to taxonomic difficulties, and a large proportion of these were probably *A. nigromaculis. A. dorsalis* constituted 4.55 percent of the total species, an increase over the 1950 study pasture total for this species. *Aedes vexans* (Meigen) and *Culex stigmatosoma* (Dyar) indicated the river bottom habitat of Cobb's pasture. These two species occurred only on the border sections of the field and in ditch areas that reflected the habitat preference of the species. The *Culex* potential is still high for the pasture and, since it follows the *Aedes* in succession, it is evident that additional treatment would be required for their control unless the first application for *Aedes* control would remain effective long enough to reach the *Culex.*

Larval collections (Table 8) show the relative percentages of species present in the two most productive stations in Cobb's pasture. These stations more nearly reflect true pasture conditions. Table 8 also shows the relative abundance of larval species for all nine stations in the pasture. From these nine stations, 78.99 percent of all the larvae were *Aedes* species, 20.98 percent were *Culex* species, and the remaining 0.02 percent were *Culiseta.* Of the *Aedes,* 63.9 percent were *nigromaculis.* However, 23.8 percent were listed as *Aedes* species because of obscured characters. Most of these were probably *nigromaculis.* Only 46 percent of the *Culex* were *tarsalis,* the rest of the *Culex* being *quinquefasciatus, pip-quinq.,* and *stigmatosoma.*

TABLE 8—*A comparison of species distribution by stations for the 1951 season* in Cobb's Pasture taken from daily samples of aquatic stages of mosquitoes.*

Species	*Station 1 Per Cent*	*Station 5 Per Cent*	*Stations 1-9 Per Cent*
Aedes sp.	20.8	27.5	18.75
A. dorsalis	4.6	2.56	4.38
A. nigromaculis	54.6	48.0	50.3
A. vexans	0.58		5.56
Culex sp.	1.9	4.94	6.33
C. quinquefasciatus	0.39		0.12
C. pip-quinq.			0.13
C. stigmatosoma	10.3		4.62
C. tarsalis	6.8	17.0	9.88
Culiseta sp.			0.01
C. incidens			0.01

* July through October.

OVA STUDIES

The objectives of the ova study were based upon the need to obtain information on the least known stage in the life cycle of pasture mosquitoes. Investigations conducted at the College of the Pacific has produced valuable information but little is known about the field phase of mosquito ova. The primary objectives were to obtain information on egg densities, environmental egg conditioning, egg hatch, and the distribution of ova in irrigated pastures. This work was to be supplemented by investigations into adult mosquito activities with reference to egg production.

Egg Densities and Distribution

The measurement of the distribution and densities of *Aedes* eggs was studied by developing improved techniques of sampling and examining samples of pasture soil. Field samples of soil were taken with the view of getting information on several types of habitat situations. Open areas as well as grass-covered

TABLE 9—*The distribution and density of Aedes eggs as determined by the microscopic examination of soil samples taken from selected areas in Cobb's irrigated pasture—1951.*

Number of Soil Samples	*Soil Condition*		*Parts of Eggs*			*Whole Eggs*		*Total*
	Moisture	*Covering*	*Broken*	*Hatched*		*Collapsed*	*Round*	*Whole Eggs*
5	Wet	Fescue	15	96		12	9	21
11	Moist	Bermuda	50	115		74	11	85
5	Moist	Fescue	11	65		13	1	14
3	Moist	Mixed	5	12		9	0	9
5	Light	Mixed	16	5		3	9	12
4	Dry	Open	0	1		0	0	0
2	Moist	None	1	7		1	0	1
2	Moist	None*	19	215		52	71	123
37 (29 with eggs)			117	516		164	101	265
					Minus	52*	71*	123*
Total eggs for *Area* samples (42 sq. in.)						112	30	142
Average number of eggs per area sample						3.8	1.0	4.8
Average number of eggs per square foot						12.9	3.4	16.32‡
Average number of eggs per *positive* area						5.3	1.4	6.7
Average eggs per sq. ft. per *positive* area						18.0	4.7	22.78

Positive samples were determined on the basis of whole eggs being present in the sample.
* Eggs taken from a hole 12 inches in diameter and 18 inches deep.
‡ All samples.

areas were selected for sampling. Samples were limited to a definite area by the use of a sleeve type biscuit cutter that encloses approximately 42 square inches. This area was close-clipped to remove grass and then sampled by the use of a vacuum cleaner to remove the top layer of soil to a depth of one quarter of an inch. The depth was determined by previous experiments. A record was made of all conditions of soil or flora that could influence the sample. Soil samples were accumulated in the field station and held at 80 degrees F. and 80 percent relative humidity until dry enough for screening. Samples were hand screened through 60-mesh and 80-mesh screens; the residue remaining behind on the 80-mesh screen contained the eggs, if eggs were present. Samples examined during the 1950 study indicated that the numbers of eggs to be expected per square foot of pasture area examined is relatively low. Out of 100 samples examined in the 1950 study, using a different technique, only 11 samples produced eggs. In comparison, the 1951 study, using the new techniques, produced some indications of the presence of eggs in about two-thirds of the samples examined.

Further improvements in the examination of the screened soil samples was accomplished by the development of a new process of examining soil under the microscope. A process of moving a continuous thin stream of soil under the microscope field was devised by the development of a mechanically-driven, rotary stage. This increased the accuracy of the egg counting technique and due to the elimination of excess soil and the increase in the speed of examination, allowed time for the examination of all the residue that contains the eggs instead of the aliquot sample that proved so unsuccessful in the 1950 study.

Results: The results of the examination of 37 out of a total of 60 soil samples taken for the 1951 season, show some useful ecological information (Table 9).

Samples producing the greatest numbers of eggs were not necessarily typical of the average pasture condition. The sample that produced the greatest numbers of eggs was a hole 12 inches deep, about 18 inches in diameter, and without vegetation on the sides or bottom. Eggs deposited on the sides were almost as numerous as those on the bottom, which may indicate that they were not carried into this hole by water movements. The hole was maintained in a moist condition by overhanging grasses.

Eggs were generally found in moist areas and in places covered with grass where moisture could be retained. Dense growths of grass seemed to contain lower egg densities but this is not fully established as a related condition. Areas with dry soil, short or dry grass contained fewer eggs. Studies conducted in the field station on the oviposition habits of *A. nigromaculis* showed that moisture was preferred in oviposition sites. The exact micro-environmental conditions that were preferred by *A. nigromaculis* in the field was not determined accurately although field station studies showed that eggs were readily placed in the soil near the stems of plants as well as in open areas.

Using whole eggs as an indicator of egg densities as shown in table 9, an average of 4.8 eggs per sample was obtained. This would give an average of 16 eggs per square foot of surface examined. If this average is used to compute the number of eggs per acre the information would be questionable since a complete analysis of the preferred oviposition sites would have to be taken into consideration as well as the areas that produced few or no eggs. Sampling techniques cannot be analysed until more facts are obtained. Disregarding samples that produced no eggs, the average number of eggs per positive sample is about 6.7 and the average per square foot is about 22.8. Using preferred oviposition site sampling, the field density could possibly be computed by determining the number and area of such sites per acre. Seasonal egg density variations are not evident in the samples but future work along this line may provide this useful information.

Oviposition

Methods: A supplemental study of the habits of *A. nigromaculis* in terms of egg production was carried out. Field collected *A. nigromaculis* females were held in small containers containing suitable moist laying media to determine the numbers, place, and time of oviposition as well as the influence of oviposition habits and mating upon the survival of females and the kinds of eggs produced. Most of these studies were conducted in a large incubator held at 80 degrees F. and 80 percent relative humidity. The laying media was 80-mesh moist white sand. Unless otherwise stated, the females were fed sugar water as a supplemental food.

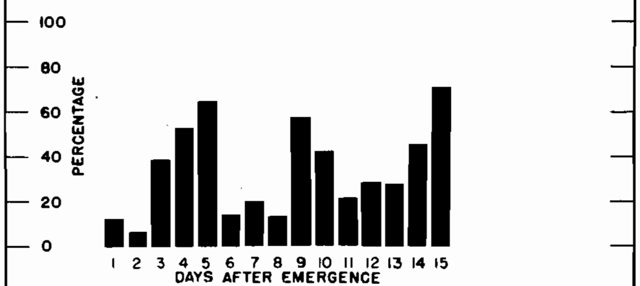

FIG. 2 - GRAVIDNESS BY AGE

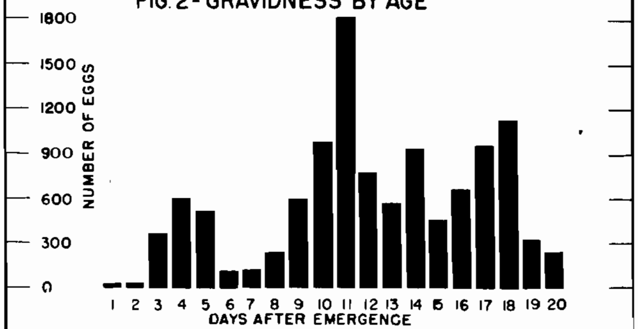

FIG.3-EGG PRODUCTION OF FIELD-COLLECTED A. NIGROMACULIS. BASED UPON DAILY COUNTS OF EGGS PRODUCED BY MOSQUITOES COLLECTED FOLLOWING EMERGENCE PERIODS OF AUG. 11, SEPT. 1, AND SEPT. 20.

Results: From these measurements it was determined that *A. nigromaculis* females would generally take a blood meal 24 hours after emergence but seldom sooner. Under the conditions of the study the number of eggs produced by *A. nigromaculis* females fed on human donors varied from none to about 110 eggs per female. Previous studies indicated that they could produce as many as 200 eggs per female. Field fed and collected females produced slightly more eggs per female than those fed on human blood.

Rees and Nielsen (2) reported that the eggs of *Aedes dorsalis* are deposited on the ground in groups of one to six in small depressions. Observations on *A. nigromaculis* shows a similar habit. Eggs were laid in groups that varied from one to ten eggs per group and usually were placed in small depressions, crevices, or in areas where the soil was loose enough to insert the egg below the surface. About one-third to one-half of the eggs were laid in groups of two, three, or four eggs, and it was found that such grouping is generally a response to laying the eggs below the surface in crevices or holes; otherwise, the eggs were placed singly just below the surface in a vertical position with the cap end protruding slightly. In several cases the depth of egg insertion into the loose soil was almost the complete length of the unextended abdomen. As mentioned before, eggs were also grouped about the stems of plants if the soil was loose enough to allow the eggs to be placed below the surface. Eggs were also laid upon the surface of the soil, but this situation was generally brought about by adverse conditions.

Unmated *A. nigromaculis* females will produce eggs if given a blood meal. Eggs produced by virgin females are non-viable. Virgin females are vicious biters and will take blood meals for many days in succession.

Field collected *A. nigromaculis* females have been held in the field station during these studies for periods up to three weeks. Males lived as long as 17 days under similar conditions. On the other hand it is possible that male and female *A. nigromaculis* do not live this long under field conditions. This is based upon observations and records from light trap collections made in Cobb's pasture.

Egg Production Cycles

The object of this study was to determine the relationship of egg development in broods of *A. nigromaculis* mosquitoes to the numbers of eggs laid over an extended period of time and following an emergence period.

Two methods were used to gain this information. One method utilized the daily dissection of field collected female mosquitoes, to determine their stage of gravidness, while the other method made use of the daily count of eggs produced by female mosquitoes collected daily and held in special cages in the field station. The condition of gravidness was determined by the stage of devolopment of eggs within the ovaries of the female. The field emergence period, or date on which a majority of the *A. nigromaculis* field population emerged as adults, was used as the base date or day from which these studies were made. This study was conducted during several consecutive emergence periods for a comparison of results. Although a large majority of the adults collected for this study originated with each emergence period being examined, there was some hold-over or migration of adults into the pasture which would show up in each sample as potential egg producers which would be out of step with the emergence group. This would account for eggs being found on the first day after emergence, etc. See Figures 2 and 3.

Results: Figures 2 and 3 represent a summary of these studies. Figure 2 represents the results of the dissections of 723 mosquitos taken following 3 emergence periods. The accumulated data shows a definite increase in the number of gravid females by the 3rd day after emergence, a condition that continues until the 5th day. A second peak of gravidness is encountered by the 9th day after emergence, a condition that continues at a decreasing rate until the 11th day. A third peak is indicated by the 15th day but this information is not reliable because of overlapping data. At least two peaks of egg production are indicated that can be relied upon; one is centered about the 4th day and the other is based upon the 9th day.

Since the dissections of adult female mosquitoes will not indicate actual eggs laid, the results of the second study gave complementary information on the basis of actual eggs laid. An examination of figure 3 shows that the first peak in the numbers of eggs deposited by field collected *A. nigromaculis* occurred on the 3rd day after emergence and continued on through the 5th day. A second peak of egg production began on the 8th day and continued through the 11th day. Two peaks of egg production are indicated; one on the 4th or 5th day and a second on the 10th or 11th day.

A comparative examination of figures 3 and 4 shows how dissections complement the egg laying study. The second peak of egg production, indicated in the dissections, occurs shortly before the actual peaks of eggs deposited. This is to be expected since a lag of about one day could occur between the late stages of gravidness and the condition of eggs actually deposited. This also indicates the close parallel between field data and laboratory studies if handled correctly.

DISCUSSION

The results obtained to date from pasture and field station studies indicate that the data obtained from the 1950 and 1951 sudies are comparable and supplement each other. Cobb's pasture was irrigated 15 times during the season and produced as many broods of mosquitos. The peak of adult production occurred during the months of July, August, and September. The species composition of Cobb's pasture was approximately the same as the species composition of Schaub's pasture (1950 study) where field conditions were somewhat different. *A. nigromaculis* is still the dominant species of mosquito present, while *C. tarsalis* is the major *Culex* present. Cobb's pasture produced more *A. vexans, A. dorsalis* and *C. stigmatosoma* than were found in the 1950 study. The *A. vexans* present in the pasture can be attributed to the river bottom location of Cobb's pasture. The aquatic growth rate in Cobb's pasture was slower than in Schaub's pasture and may reflect the true difference between the comparative study pastures; on the other hand, it could also reflect the differences in the two seasons of study. Mild weather prevailed during the 1951 summer, while the 1950 season was warmer. Larval growth periods, when used to compute the egg to egg cycle, gave evidence of the relationship between irrigation cycles and the sudden increase in the numbers of eggs made available for hatching. Using temperature relationships based upon larval growth rates and the duration of time between irrigations, it should be possible to predict in advance a major increase or decrease in the number of larvae that can be expected to occur in an irrigated pasture. This major increase or decrease can be used to help explain the phenomenon of questionable results with insecticides in specific pastures. In all cases of this type further consideration must be made of surrounding pastures and the dispersal of adults from those pastures. The flight range study has indicated that this dispersal is gradual and within the limits of short distances. From this it can be expected that an emergence area, if well stocked with food and oviposition sites, will influence its own egg density greater than it will influence the density of a field one mile away. Egg densities are in the process of being determined, and results to date could indicate a high potential for irrigated pastures. Flooding tests of soil samples show that the number of *Aedes* eggs per acre could go as high as 20,000,000, but actual counts show that it may be between 1,000,000 and 10,000,000 for any one irrigation cycle. A period of maximum egg production from broods of *A. nigromaculis* occurs on the 3rd, 4th, and 5th days after emergence. A second period of egg laying by the same broods can occur on the 9th, 10th, and 11th days after emergence. Further peaks of egg laying are indicated, but these results are questionable. There are some indications from adult counts that the first period of egg production is the most important in terms of total eggs deposited per brood. Adult control to prevent maximum re-seeding of a field should occur before the 3rd day after the emergence of *A. nigromaculis* broods. To prevent biting, adults should be controlled within 24 hours after emergence. Habitat studies show that *A. nigromaculis* eggs are deposited in moist places, generally in soil with clumps of grass, and can be placed in the soil in a vertical position, singly or in groups. This placement of the eggs indicates the complexity of trying to reach eggs with ovicides or fumigants.

SUMMARY

Two seasons' work are compared for two different pastures. Species composition, aquatic growth rates, and peaks in seasonal activities are discussed. Studies on the flight of dispersal of *Aedes nigromaculis* are compared. The use of embryological data is indicated, and progress in the measurement of egg densities is considered. Oviposition studies in terms of cycles of egg production and habitat preference is reported, and the relationship between irrigation cycles, egg to egg cycles, and temperature is discussed in terms of increases and decreases of larval densities in irrigated pastures.

ACKNOWLEDGMENTS

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Useful guidance was received from the California Mosquito Control Association Committee on Operational Investigations.

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Mr. Washburn: The next report will not be read, but will be printed in the Proceedings. It has been mimeographed and sent to all member Districts. On behalf of the Committee I want to thank the various Districts and the Bureau of Vector Control for the loan of personnel and equipment during the course of the flight range study. We had to put out several calls for help, and the Districts responded admirably.

AEDES FLIGHT STUDIES — 1951

Kern Mosquito Abatement District Gordon Francis Smith

The primary objectives of the Aedes flight studies this year were an attempt to prove the basic pattern, developed during 1950, thru the use of tagged adults and to further develop and investigate the ramifications of this pattern.

Since the Central Valley Mosquito Ecology Study Unit (C.V.M.E.S.) was experienced in the use of tagging agents and flight range is considered to be a basic ecological problem in mosquito control this unit was invited to participate with the district in the study. In their study at Turlock in 1950 they had been able to demonstrate an *Aedes* flight range of only 1½ miles which is extremely short in view of general field experience. It was felt that another study on a larger scale, with the field information on hand in this area, might give more satisfactory results.

Two methods of tagging were proposed. One the use of radio-active phosphorus and the other the use of Rhodamine "B" dye, both of these methods having been used previously by various workers. In the use of radio-active phosphorus a salt of this material is dissolved in tanks of water. Mosquito larvae in these tanks will metabolize the phosphorus and the adults developed from them may easily be detected by a geiger counter. The use of this material is however hedged in by regulations and requirements of the Atomic Energy Commission. It requires that the tanks be set up in an enclosed, protected area and not moved, and only a limited number of personnel may be allowed to enter the enclosure. This means that the larvae must be gathered and transported to the enclosure which may lower their vitality and limit the number of tagged specimens. Also it is not known what effect the radio activity may have if any, on the larvae even tho they appear in all respects to undergo normal development.

The other material, Rhodamine "B" is a harmless dye which flouresces under ultra violet light. In use, this dye is sprayed on concentrations of adults immediately after they emerge and before they disperse from the breeding area. This method allows for the tagging of great numbers of adults which were allowed to develop in their natural environment and without interference. However in checking for recovery each individual mosquito must receive careful microscopic examination under ultra violet light. A worker can only do this examining for a few hours each day without undue strain and the labor involved in comparison with screening radio-active material is almost prohibitive if there is much material to check.

It was decided that, all factors considered, radio-active tagging should be the primary method used and that a limited use of Rhodamine "B" should be made. Material from selected recovery sources in the Bakersfield area to be examined for recoveries of Rhodamine "B" tagged adults. It was also agreed that field direction of the project be the joint responsibility of Mr. R. C. Husbands of the C.V.M.E.S. and the district entomologist. As the project developed, it was apparent that Mr. Husbands would be available for only very limited periods of time and that the work of planning, field direction and carrying out of the project would fall almost entirely on the district with one field man to care for a part of the light traps and one laboratory helper being furnished by the State Bureau of Vector Control and the C.V.M.E.S. respectively.

As the mosquito season progressed it became evident that, due to some unknown factors, breeding was very low in the tagging area where larvae were previously available in great abundance, and that it would be necessary for the district entomologist to spend all of his time in locating larvae for the radio-active tagging and in field direction of the project. As a result the consideration of using Rhodamine "B" as a supplementary tagging agent was dropped and the further investigations on the extended flight pattern, which would have necessarily consumed a considerable amount of time, unfortunately came to a standstill.

In the radio-active tagging it was originally planned to use two flat tanks of 50 gallons capacity each, used in a similar project at Turlock in 1950 and specially prepared ground pools having 150 gallons capacity to contain the radio-active solutions. However permission for the use of ground pools was denied by the Atomic Energy Commission so 3 additional waterproof plywood tanks of 100 gallons capacity each were provided by the Bureau of Vector Control.

It was proposed that two releases be made from these tanks by introducing *Aedes* larvae into the water containing radio-active material. The larvae would then metabolize this radio-active material and the resulting adults could be sorted out with a geiger counter. 150 microcuries of radio-phosphoric acid to 400 gallons of water would be used for each release.

The radio-phosphorus for the first release was introduced into the tanks on the 16th of July. Previous to the introduction of the radio-phosphorus the district had been informed that only third instar larvae would be suitable and that at least two million larvae should be in the tanks before the addition of the radio-active material. When told that within the limits of time and personnel available it was very doubtful if this could be accomplished, it was agreed that 3rd and 4th instar larvae might be introduced and that this might be done on a continuing basis rather than attempt to introduce a full quota of larvae at one time.

On the Sunday evening before the introduction of the phosphorus the District Entomologist, Mr. Husbands of the C.V.M.E.S. and Dr. Scudder of the Bureau of Vector Control met in Bakersfield and set up rules for conducting the installation. At this time it was decided, on the recommendation of Mr. Husbands, that only the above three persons would be authorized to enter the enclosure. It was later decided that Miss Rosay, the entomologist technician assigned, would be so authorized in emergency cases should they arise.

During the morning and early afternoon of July 16th, a considerable number of 3rd and 4th instar larvae, which had been previously located, were put in the tanks. The car bringing the radio-active material arrived about 4:30 p.m. and this was introduced to the tanks by a chemist from the State Health Department.

The next morning it was quite apparent that at some time during the filling of the tanks or placing larvae in them, a toxic contamination of some kind had occurred. All of the third and most of the fourth instar larvae were dead. The adults emerging from those that lived were monitored with the geiger counter and it was determined that they were well marked and so 4th instar larvae would be satisfactory for introduction into the tanks. It was felt by all concerned that the contamination in the tanks was a transitory thing which would clear itself up in time and allow for another attempt at a later date. The district entomologist was made responsible for daily inspection and care of the tanks and for determining when the toxicity had been reduced to such an extent that they would again be usable.

On July 26 the District Manager and the Entomologist met with Mr. R. F. Peters, Chief of the Bureau of Vector Control, Mr. Husbands of the C.V.M.E.S. and Dr. Scudder and Mr. Mulhern to discuss further plans for the project.

At this meeting it was agreed that the district would assume over-all planning and operations responsibility, the Bureau of Vector Control and C.V.M.E.S. being responsible only for technical service and advice in connection with the handling of the radio-active material and that Dr. Scudder would be stationed in Bakersfield during the time that the tanks would be in active use. However, Dr. Scudder became ill shortly after the second introduction of radio-isotope so this phase also became the responsibility of the district entomologist. It was further agreed that other districts, through the California Mosquito Control Association, should be asked to loan personnel to aid in collecting of larvae for the tanks and of adults for recovery of tagged specimens. The B.V.C. also agreed to furnish what men they could and as were needed for this work.

During this period the district entomologist again revived the idea of direct tagging of adults but with the thought in mind of using an easily indentified water soluble material. Thus the recovered adults could be simply rinsed in water several at a time and the water rinsings checked. Dr. Metcalf of the Citrus Experiment Station suggested the use of flourasciene dye and ultra-violet light. Checks by the entomologist showed that this dye was detectable under ultra-violet light in strengths as low as one part per million in water. Field tests showed that 75% of adults in a sprayed field could be readily detected by the use of water rinsings. Even though this method was much simpler than the others discussed and would allow for possible tagging of many more adults, it was felt that considerable preliminary work should yet be done before it could be used with confidence and that it should be laid aside for the present.

On August 20th Mr. Husbands and the district entomologist cleaned out the tanks, transferred the remaining hot material to 10 gallon milk cans to be held until broken down, and prepared them for the second introduction of radio-active material.

The second charge of radio-active phosphorus was put in the tanks on Thursday, Aug. 23rd. For the three days preceding, with the aid of men loaned from other districts the district entomologist had completed preparation of the tanks and a large number of larvae had been put in them.

With the exception of the sudden serious illness of Dr. Scudder and transfer of his responsibilities to the entomologist, the program went smoothly until it was closed on the 29th of September. Personnel were on loan from other districts and the Bureau of Vector Control were on hand at all times to aid in all phases of the work.

Collections of adults in attempt to recover marked specimens were made both by hand and light trap. 49 light traps were operated in the release area (see map) by a vector control officer on loan. 29 light traps in urban Bakersfield and the hill area were operated by district personnel.

In addition, body collections were made by personnel on loan in 4 locations to the north and one on the Tehachapi Highway, by all members of the town crew and by the foreman of Area B to the west of the urban area.

Although thousands of mosquito adults were collected and probably at least 2 to 5 million released from the marking tanks, only 21 recoveries from a total of 45 marked mosquitoes were made. These were all made in light traps in the valley areas. The recoveries farthest distant from the release point were at distances of 7 miles northwest and 7 miles southwest. (See map and chart.)

Considering the very large numbers of mosquitoes taken in the traps in the valley area to recover these few mosquitoes it must be that tremendous numbers of mosquitoes are in the area under study. It is also not surprising that no recoveries were made in the Bakersfield area since the numbers taken were quite small relative to the normal population of the uncontrolled vally area and the numbers of recoveries there.

No information was turned up during the season to alter previous thoughts on the basic flight pattern or its origin area. Ideas as to size of the basic origin area were enlarged however as a result of the work done in searching for larvae to be used in the tanks. Very heavy breeding areas were found, some uncontrolled, in the Delano District and in the uncontrolled areas north into Kings County.

It would seem, in the light of this work, that to prove the flight pattern as it is now seen a simple method of tagging must be used which is applicable to the markings of the adults directly in emerging swarms—which would give a maximum number of marked specimens for the least effort—and that it should be done on an area basis in an uncontrolled or semi-controlled area where the population is high enough to be a potential source.

Body count stations were again set up this year to check on the presence and number of *Aedes* present in the flight area and to correlate their presence with other factors. The first flight in May was not of the typical pattern and appeared to come from flood waters in Poso Creek. There were 15 apparent flights following the established pattern during the season and the flights during August and September were considerably heavier than any encountered during 1951. This may be due to expanded agricultural acreage, especially in the area to the north and west of Wasco where it seems that every farmer has some desert to run his tail water on. Also in late August and September the breeding in this area, which had been quite slow for some reason, took an upswing to its normal volume.

During the second flight in June the entomôlogist checked outside of the already known areas of flight presence to further define or delimit the area affected by the movement. *Aedes* mosquitoes were found in fair numbers at Woody to the north-east and Keene to the east and in small numbers as far as Hobo Hot Springs in Kern Canyon. Light traps were operated through the months of July, August and September at Woody and Keene and the presence of *Aedes* adults at these points was definitely tied into the flight pattern. Further work along this line of investigation had to be dropped in favor of the tagging project.

The early flights this year were somewhat erratic in appearance in the Bakersfield area but became more definite later in the season. They continue to conform to the meteorological pattern as established last year.

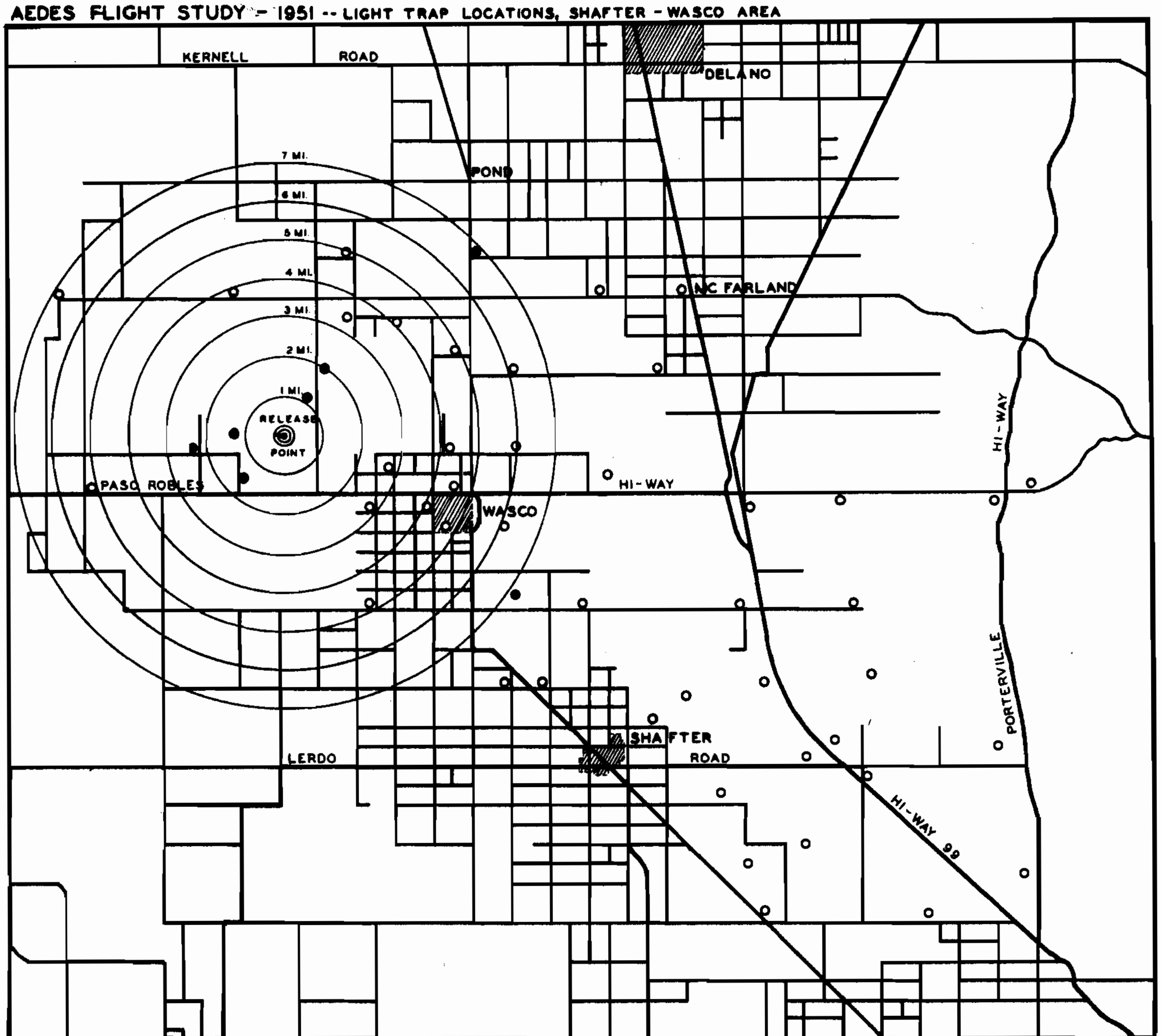
SUMMARY OF CAPTURED POSITIVE MOSQUITOES

1951 Flight Study—Kern County

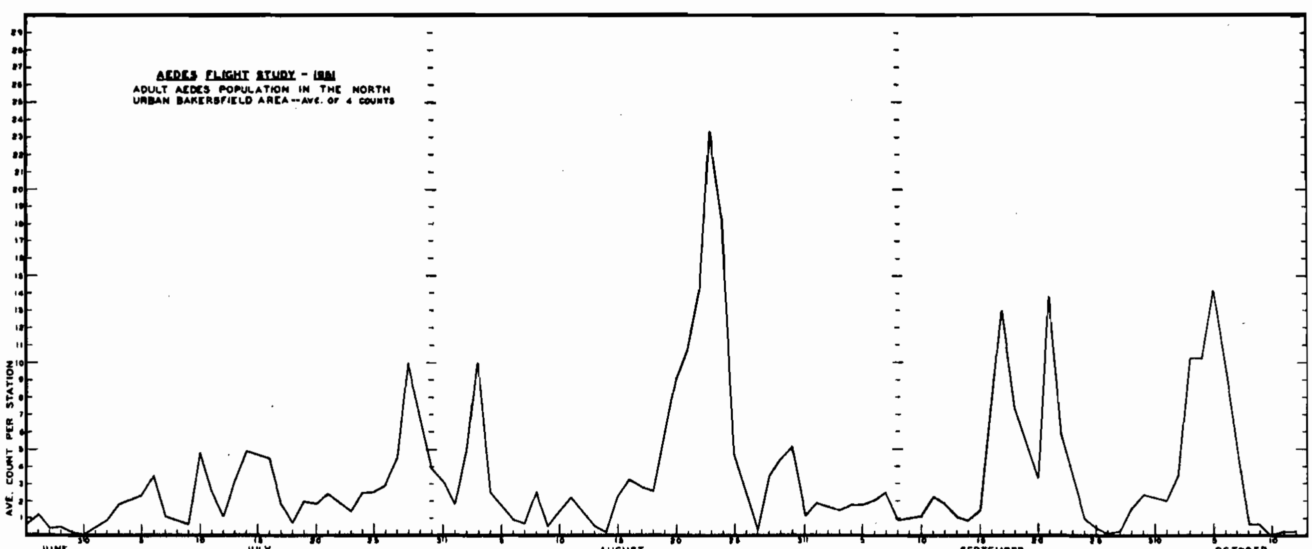
Trap No.	*Location*	*Distance from RP*	*Date of Capture*	*Species*	*Sex*	*Counts per min.*
117	Central Valley Highway and Elmo Highway	7 mi.	Sept. 12	Aedes nigromaculis	F	150
131	1 mi. E of Wasco Ave, ½ mi. N. of Kimberlina	7 mi.	Sept. 10	Aedes dorsalis	F	11,000
135	Wildwood Ave. ½ mi. N. of Highway 466	1½ mi.	Sept. 3	A. nigromaculis	F	600
				A. nigromaculis	F	3,000
			Sept. 5	A. dorsalis	F	5,500
			Sept. 10	A. nigromaculis	F	400
				A. nigromaculis	F	550
				A. dorsalis	M	750
				A. dorsalis	F	14,000
			Sept. 12	A. dorsalis	F	7,000
			Sept. 19	A. dorsalis	F	1,700
				A. dorsalis	F	5,000
			Sept. 26	A. dorsalis	M	1,350
136	Wildwood Ave. 1¼ miles N. of Highway 466	2 mi.	Sept. 15	A. dorsalis	F	10,000
			Sept. 26	A. dorsalis	M	3,500
				A. dorsalis	M	5,500
140	McKibben and McCombs Rds.	3 mi.	Sept. 17	A. nigromaculis	F	160
				A. nigromaculis	F	700
141	N. of RP on Schofield	1 mi.	Sept. 3	A. dorsalis	F	70
				A. nigromaculis	F	160
				A. nigromaculis	F	4,500
			Sept. 5	A. nigromaculis	F	1,100
				A. dorsalis	M	3,000
				A. dorsalis	F	9,000
			Sept. 7	A. nigromaculis	F	1,500
			Sept. 10	A. nigromaculis	F	250
				A. nigromaculis	F	600
				A. nigromaculis	F	2,000
			Sept. 11	A. dorsalis	F	12,000
			Sept. 17	A. nigromaculis	F	400
				A. nigromaculis	F	450
				A. nigromaculis	F	500
				A. nigromaculis	F	500
				A. nigromaculis	F	700
			Sept. 19	A. nigromaculis	F	200
				A. dorsalis	F	4,000
			Sept. 22	A. dorsalis	F	450
				A. dorsalis	F	1,100
			Sept. 25	A. dorsalis	F	7,000
142	Schofield, 3 mi. N. of RP	3 mi.	Sept. 21	A. nigromaculis	F	200
				A. nigromaculis	F	350
				A. dorsalis	F	1,700
				A. dorsalis	F	1,800
				A. dorsalis	F	2,000
				A. dorsalis	F	7,000

TOTAL 45 CAPTURES

AEDES FLIGHT STUDY - 1951 -- LIGHT TRAP LOCATIONS, SHAFTER - WASCO AREA



LIGHT TRAPS --- POSITIVE ● -- NEGATIVE ○



Mr. Washburn: The next report on Insecticide Investigations carried on in cooperation with the Kern Mosquito Abatement District also will not be presented orally, but will be presented in the Proceedings. It has been mimeographed and copies were sent to all member agencies.

PROGRESS REPORT
CMCA OPERATIONAL INVESTIGATIONS PROJECT
INSECTICIDE INVESTIGATIONS

By Lewis W. Isaak

Introduction

This report is a summation of the CMCA work done on the toxicological project which is being carried on under the supervision of the Kern MAD. You will notice that most of the work completed this summer has been done on *Culex* larvae rather than *Aedes.* The two reasons for this preference are: 1) Mr. Gjullin in his resistance studies in the San Joaquin Valley during the summer of 1951 concentrated on *Aedes.* 2) The seemingly sudden up-shot of extreme resistance encountered with *Culex* larvae at the various Duck Clubs in the Kern MAD. This resistance to the chlorinates has reached proportions far beyond all previous estimations. The project therefore has been primarily concerned with defending against this type of resistance since it poses a potential menace to all districts involved in chemical control of mosquitoes.

The report begins with work completed during the early months of 1951 and then chronologically follows through the season up to the present time.

Laboratory Screening Program Using Colonized Culex Quinquefasciatus

Larvicidal screening, utilizing the colonized *Culex quinquefasciatus,* was continued throughout the early summer months. Most of the insecticides on hand in the technical grade have now been screened. The total number is twelve. Of these, the most effective was EPN followed by parathion, aldrin, colloidal aldrin, heptachlor, dieldrin, chlordan, DDD, DDT, Q-137, lindane and toxaphene in that order. Results of the experiments are listed in Table #1. Except for colloidal aldrin, all larvicides were screened utilizing an acetone suspension. After the early trials were completed, it seemed advisable to reduce the range between dilutions for a more accurate estimation of the LD-50. These later experiments therefore, have a more complete range of dilutions.

Each larvicide screened was run in at least 6 replicates involving a total of 120 larvae per series.

No tests on field caught *Culex quinquifasciatus* from Kern have been completed. One test was run at Fresno from larvae taken at the Sanger Sewer Farm. Since only one duplication was compelted, there isn't sufficient evidence for an accurate estimation of the range of toxicity. Indications were however, that this group was approximately twice as resistant to the chlorinates as the laboraory reared larvae.

Field Applications of Colloidal Compounds

Work done in other parts of the country (Mosquito News, Sept. 1951) have rather conclusively proved that colloidal larvicides are superior as residuals to the emulsions in certain types of permanent water holes. Preliminary experiments have been completed in the Kern district which further substantiate the work already done. On June 7, three water holes were selected for applying colloidal aldrin at .075 lbs. per acre. Unfortunately, two of the holes were dry within two weeks, but the other held its water level throughout the summer months. Samples of the water from this pond were brought into the lab each week for a bio-assay using egg rafts to see if the first instars would survive. At the same time, fourth instar lab reared *Culex quinquefasciatus* were also introduced into the water. For 52 days all 1st instars were killed within 24 hrs. after hatching and about 50% of the fourths. Laboratory testing was discontinued after this time but field observations were made each week thereafter. In the 11th week (73 days) after application, 2nd instar larvae were seen by a field inspector who unfortunatly sprayed the water with toxaphene.

Oil Field Waste Water Applications—An oil field wastewater hole was treated with colloidal aldrin at .5 lb. an acre. Although the water was heavily polluted with residue from oil refinement, larval breeding was exceedingly heavy. The day after treatment, a few 4th stage and the pupae were still alive so the area had to be oiled. After this oil treatment, the sump was clear of larvae for a couple of weeks even though other sumps in the area continued to breed larvae a day or so after initial kill by oil.

Colloidal chlordan at 2 lbs. to the acre was applied to the same type of water (PH 8+) in another location. No larvae were observed for two weeks, even though egg rafts were constantly deposited under the foliage along the banks. After a two week period, active breeding was again observed and colloidal chlordan was applied once more at 2.0 lbs. per acre. Two weeks later, the water was still free of larvae except for one corner where the water was flowing into the sump. This small corner was treated with an adidtional 2½ ounces actual of chlordan. Two weeks later larvae were seen again in the sump so further investigations using larvicides on oil field waste water were discontinued.

The colloidal compounds, although more permanent than diesel oils on these waste sumps, still are not the answer to this particular problem. It may be theorized that the larvicidal particles are somehow bonded by minute droplets of crude oil dispersed throughout the waste water system and are held harmlessly with the droplets even though they may pass through the digestive system of the larvae. Or the particles may be dissolved by oil drops which are too large for the larvae to ingest. In either event, the larvae are seemingly well protected against the larvicide. Over a period of time, more and more of the larvicide is removed from the water suspension through this exchange and held harmlessly by the waste oil so that the probability of larvae making contact with the free toxicant particles becomes increasingly negative and the population soon builds up to its normal level. More effort should certainly be made to clear up this problem as well as to the winery wastes, sewer farms, cannery sumps, etc.

Field Applications of Emulsifiable Heptachlor and Colloidal Aldrin

Because certain permanent pastures in the Bakersfield area have definitely shown resistance to the larvicides now being usd, DDT and Toxaphene, two of the more promising larvicides tested in the laboratory were applied to determine at what rate they might be used in the field. Irrigation checks measured at 1½ acre plots were chosen. A Gage power pump was used to apply the spray. *Aedes* larvae, 3rd and 4th instar, were relatively heavy, 10-15 per dip over extended areas. Heptachlor was applied at .031 lbs. (½ ounce) per acre; .0625 lbs. (1 ounce) per acre and .124 lbs. (2 ounces) per acre. One plot was left unsprayed as a check. In all plots sprayed, mortality was 100% in open water, but by careful examination, covering every square yard of the sprayed area, several isolated pot holes in all plots were found in which no kill was apparent. These holes were pretty well protected with vegetation and it is likely that failure to kill was due to sub-lethal dosage resulting from incomplete coverage rather than failure of the larvicide itself. It is very likely that small holes like these are the birth places of developing resistance. Further tests should prove this point one way or the other. Another area with 3rd and 4th instar *Aedes* larvae at 30-40 per dip was sprayed using colloidal Aldrin and emulsifiable Heptachlor. This permanent pasture was located within 4 miles of urban Bakersfield so it seemed advisable to start at a maximum rate and work with more dilute solutions at greater distances from greater Bakersfield. Heptachlor was applied at .125 lbs. per acre using a spray gun. Colloidal Aldrin was sprayed on at .188 lbs. per acre using booms. At a 24 hour check, the Heptachlor plot indicated a 99% plus kill although it is doubtful if those few seen alive lived to pupate. The colloidal Aldrin using the booms gave an absolute 100% kill. Unfortunately the check plot dried up before the 24 hour reading. These tests indicate that both compounds have a potential usage in *Aedes* control. Further field trials will be administered at the onset of next year's breeding season for more exact information.

Aedes Screening at Fresno Field Station

The Fresno Field Station was quite ideally located for screening purposes since it lies within easy range of three abatement districts and is also relatively close to an "un-exposed" strain of *Aedes nigromaculis*. The value of this unsprayed area lies in its use in determining how far along resistance has developed within the borders of the various abatement districts. This method of analysis may not give us absolute proof of how far resistance has advanced since other variable factors must be taken into consideration, but since no records with this information from past years is available, it is the only way we are able to evaluate how far progressive resistance is established in a given locality.

For these Fresno experiments, 10 replicates involving a total of 200 larvae per dilution was used. Results are listed in Table #2.

Wootens Dairy is probably not too typical of the Consolidated area as a whole, but it was chosen because it is easily accessible from the Field Station and because breeding there was excessive. The breeding was most probably due to the fact that the district had some operator trouble in that particular area and control therefore was not as effective as it is in the district in general. It is believed that greater resistance could have been found in other parts of the district if the larvae had been available at that particular time. It is of interest to note that although neither of the chlorinates Q-137 nor Lindane has been used in that pasture, the larvae were as relatively resistant to them as to DDT and Toxaphene. The relatively small difference shown to Aldrin and Heptachlor between the two areas probably should not be considered as recognizible resistance.

Some resistance work was done on several other locations in the Consolidated district but because of insufficient replicates or copious pupation, the results do not warrant serious consideration.

The work done with the *Culex quinquefasciatus* will be of some use as a record but the work is incomplete as not enough larvae were found for sufficient replicates.

Earlier in the season, plans were made for further screening tests in other parts of the state but due to the extreme resistance of larvae at the Kern Duck Clubs, further trials in other districts were indefinitely postponed. It was the general feeling that further investigations of resistance developments was paramount and that more concrete evidence could be accumulated in one place rather than a smattering of incomplete trials from several localities.

Culex Resistance at Kern Duck Clubs

In July and early August of this season there was evidence of serious resistance in an area of un-improved pasture near the Greenfield region. A small percentage of all stages of *Culex tarsalis* seemed completely unaffected after the water had been sprayed on successive occasions with the three larvicides DDT, Toxaphene and Aldrin at standard rates of application. Larvae were comparatively scarce but enough were collected to prove, through laboratory analysis, that they were quite resistant as the LD-50 using DDT ran at approximately 1-2 million, whereas the LD-50 on non-exposed *Culex tarsalis* larvae runs in the neighborhood of 1-60 million. The area dried up a week later so no further work could be done with this strain. Tests will be made at the first flooding this next season however, which should give us a fairly definite answer as to what degree of resistance, if any, is carried over from season to season.

Another group of larvae proving resistance was from a duck club which was utilized for pasturing cattle during the summer months. Because of the un-level nature of the club and unusual irrigation practices, water had been standing over extended areas from one irrigation to the next. In some instances it stood all summer. This particular club had been sprayed with toxaphene and again with Aldrin. A large percentage of the *Culex tarsalis* larvae were killed by these applications but many remained unaffected. A collection of these few was brought back into the laboratory for testing with Aldrin, but because of their scarcity, a range of only four dilutions could be tested. At a strength of 1-25 million (.04 ppm) none of the larvae were killed, whereas 100% kill is generally realized using Aldrin at 1-250 million (.004 ppm) on an unexposed strain of *Culex tarsalis*. While the dilution range could not be extended far enough to give us the LD.50, it does prove that resistance is firmly established in that locality and that the foundation has been laid for a future highly resistant culture of mosquitoes. This particular testing was completed in the latter part of July.

As the season progressed, more operators became conscious of resistance in the Duck Clubs in their particular areas as the chlorinates in use, DDT and Toxaphene, continuingly failed to give results at the usual rates of application.

The screening program by the author was begun in Fresno at this time but Mr. Gjullin of USDA completed some very interesting experiments using this same group of larvae. After his departure from the Kern district, parallel investigations were continued to determine whether resistance continued to increase with the season.

At the time of his investigations in August, Mr. Gjullin found that in one Duck Club, "Wares," DDT resistance amounted to 10 times. This determination was made after the club had been treated with Toxaphene at .3 lbs. per acre on August 15 and on August 29 with 1.0 lb. per acre of DDT. The Toxaphene had been applied for *Aedes* larvae. Results were 100%. The DDT was used for *Culex tarsalis* larvae, results being 95% kill of all stages present. During the next week, DDT was again applied at 1.0 lbs. per acre. This time results were negative. The same area was then sprayed with 1½ lbs. per acre of Dieldrin, but no appreciable kill could be noted even at this excessive dosage. After these applications, the resistance, as determined by this laboratory, had jumped to 105 times for DDT and 100 times for Dieldrin on an LD-50 basis. TEPP was then tried in the laboratory starting at a dosage of 1-50 mil (.02 ppm) but it evidently hydrolizes too quickly in water to be effective as it failed to kill at any of the dilutions tried.

Subsequent floodings of this pond rendered collecting impracticable and all further screening of larvae from that club had to be discontinued. However, there were several other Duck Clubs in the vicinity which were also putting off resistant

Culex and so the same type of work was continued with larvae from some of these other ponds.

This next group of larvae were taken from a ranch area known as Klipsteins Duck Club. Results of an experiment using DDT are listed below.

4TH INSTAR CULEX TARSALIS LARVAE

1-100,000	or 10	ppm	90% mortality
1-250,000	4	ppm	80% "
1-500,000	2	ppm	95% "
1-666,000	1.5	ppm	80% "
1-1 mil	1.0	ppm	78% "
1-5 mil	.2	ppm	78% "
1-10 mil	.1	ppm	59% "
1-25 mil	.04	ppm	45% "
1-33 mil	.03	ppm	27% "
1-50 mil	.02	ppm	5% "

LD-50 1-17 million

The significance of this experiment is indicated by the fact that while there is not a great deal of difference in *mortality* between the dilutions 1-100,000 and 1-5 million, the difference in *dilution* is 50 times. Evidently this negative difference over a wide range of dilutions means that 10-20 per cent of the larvae are extremely resistant while the greater fraction of them are still moderately susceptible. In short, as your rate of application is increased for a higher lethal dosage, so proportunately does your rate of resistance increase. For example, the foregoing listing shows the LD-50 with DDT is 1-17 million; a resistance 3½ times to the Poso or non-exposed strain while the LD-90 in comparison to the Poso strain runs in the neighborhood of 100 times and the LD-100 would be even greater than that although the exact figures are not known. In an instance such as this, the LD-50 paradoxically covers up the small percentage of highly resistant larvae. In a strain showing this degree of resistance it appears nearly impossible to kill every last larvae with the chlorinates if one intends to operate within a feasible economic program. *And yet, killing off that last small percentage, that perhaps has been too often consciously overlooked, looms as a more important must all the time,* as this small percentage consciously overlooked may very probably be the birth place for development of a very highly resistant population.

LABORATORY SCREENING OF NEW INSECTICIDES ON RESISTANT LARVAE

To cope with the fore-mentioned resistance a number of new insecticides have been tested in the laboratory and field. Some show excellent promise while others show no improvement over the more common larvicides now in use.

Recent experiments have proved *Dilan* to be a superior compound in combating resistant house flies. A sample was obtained for screening on resistant mosquitoes, results are tabulated in table #4. The cost of this compound, $4.80 per pound, makes its use prohibitive for all practical purposes at the rate of application necessary for absolute control.

Metacide proved quite effective in the laboratory tests completed. However, *Culex tarsalis* larvae brought in from resistant ponds proved to be 3½ times more difficult to kill than non-resistant *Culex larvae* of the same species. This difference might be attributed to one of two things: merely a natural difference in susceptibility of the larvae or an actual carry over of chemical resistance.

Another new phosphate, 4049, was screened but proved to be relatively ineffective in comparison to other phosphates. The LD-50 is approximately ½ that of DDT on a non-exposed strain but the LD-100 shows it to be slightly superior. A comparison to DDT is given in Table #3.

One synergist, K-3926, was tried with DDT part for part by weight. The combination was not effective on highly resistant larvae in the laboratory. Field trails with this compound are given in a later paragraph.

Another phosphate, *EPN,* has been thoroughly screened and has proved itself to be the most effective compound yet investigated, even superior to parathion. It pretty well tells its own story by comparison with other larvicides as shown in table #4.

FIELD TESTING COMPLETED

While laboratory screening is the first step to realization of an effective larvicide, it is the field trails which actually give us the final answer as to how good an insecticide is. A very brief account of the more promising larvicides as tried in the field is given below.

All field testing completed was done on Culex tarsalis larvae at the various Duck Clubs where progressive resistance is most firmly established.

In laboratory screening, *Dilan* appeared to be in the category of DDT on non-resistant larvae, so it was applied in the field as an emulsion against resistant larvae at the same poundage per acre as DDT is generally used, .2 and .4 lbs. per acre. Water temperature was 64° F. At the 24 hour check, larvae were found in both plots. The .4 lb. per acre killed approximately 50% of the larvae but the .2 lb. per acre proved absolutely ineffective.

Metacide was applied to the grassy edges of another pond at .15 lbs. per acre. At a 48 hour check, none of the larvae appeared affected. One week later however, there were no larvae or pupae present. Water temperature was 64° F.

Parathion was applied at the same poundage per acre as Metacide, .15 lbs. per acre. Larval mortality was 100%. Howeveer, until the extreme operator hazard of this compound is eliminated, its use certainly cannot be recommended.

DDT plus K3926, a synergist was applied using a combination of one pound of each per acre. At the 24 hour check, approximately 10% were still alive and appeared healthy. Other synergists will eventually be tried but judging from work thus far completed, we do not anticipate them as being the answer to the problem of larval resistance.

EPN has proved to be the most effective compound yet screened both in laboratory experiments and field applications. The first trial was conducted in the same area as the *Parathion, Metacide* and *Dilan.* It was applied at .1 lb. per acre; results were 100%. After this initial trial by jeep, it was sprayed on by plane at .1, .05 and .025 lbs. per acre. In all trials, larval mortality was 100%. Water temperature was 56° F. The pilot repeated the .025 lb. per acre application several days later on another Duck Club, results were again 100%. After each application, many adults were seen dead on the water surface.

To test *EPN* further, it was applied by a jeep power pump on the Wasco sewer farm where *Culex quinquifasciatus* were extremely heavy, 500 plus per dip. Applied at .1 lb. per acre the compound again killed all the larvae and some pupae were seen dead on the bottom.

Toxicological research available indicates that EPN is moderately too highly toxic to warm blooded animals and should certainly be handled with the prescribed precautions. As a contact poison, it is much more toxic than DDT but about 1/3 as toxic as Parathion. Orally, 5-10 times more toxic than DDT but 3-8 times less toxic than Parathion, according to Metcalf. Preliminary findings by E. I. Du Pont De Nemours and Co. shows its danger relative to *chronic toxicity* to be rather favorable. As information becomes available, it appears that the use of *EPN* as a larvicide, at .05 to .1 lbs. per acre is a potentially promising larvicide. We have been advised that no trials using EPN should be undertaken until such time the testing project in cooperation with the manufacturer has been able to more completely evaluate this material.

Winter Screening Program

Preparations are being made for a continued screening program during the winter months. Many larvicides have yet to be screened as samples continue to come in. Stauffer Chemical Company alone has submitted 33 samples and other companies have promised to send their compounds, the accent being on materials other than the Chlorinates. For some districts, the idea of getting away from the chlorinates may seem to be a little premature as the operators still experience good results with DDT. However, for a number of the districts where intensive larviciding has been practiced for the past 5 or 6 years, the chlorinates appear to have run their distance as an effective means of control, especially on the *Culex* larvae.

Fortunately the colony of *Culex quinquefasciatus* is flourishing and we will continue to use it as the basis of comparison for all compounds screened.

Summary and Conclusions

1. Twelve larvicides have now been screened using colonized *Culex quinqiufasciatus.* Of these tested EPN was the most effective followed by Parathion, Aldrin, Colloidal Aldrin, Heptachlor, Dieldrin, DDD, DDT, Q-137, Chlordan, Lindane and Toxaphene, in that order.

2. Field testing of Collodial compounds have proved them to be superior to the emulsions as a residual larvicide in permanent ponds. One fresh water pond, treated at .075 lbs. per acre Colloidal Aldrin was kept free of larvae for 73 days during the warmest summer months, June-September. In highly polluted water however, these compounds appear to be of little value as a residual larvicide.

3. Screening completed at the Fresno Field Station consisted mostly of obtaining basic information on *Aedes nigromaculis* larvae from an un-sprayed area. Insecticides screened were DDT, Toxaphene, Q-137, Lindane, Aldrin and Heptachlor. In addition to the unsprayed area, larvae were collected from one field inside the Consolidated district. It was of interest to note that while neither Q-137 nor Lindane had ever been sprayed on that field, the larvae were as relatively resistant to these chlorinates as to the DDT and Toxaphene, the two larvicides which had been used in that area frequently.

4. Preliminary screening was completed with larvae collected from various Duck Clubs in the Kern area which had previously proved to be resistant to the chlorinates as applied by regular field applications. As indicated by Table #2, Wares Duck Club reveals, by far, the greatest degree of resistance. This extreme resistance as determined by laboratory analysis and field observation, might be explained by the fact that excessive amounts of various chlorinates were applied to an already resistant strain of larvae, thus killing off all the moderately resistant and non-resistant individuals leaving a residue of highly resistant mosquitoes. It was this remaining group which was brought back to the laboratory for screening, running the degree of resistance into staggering proportions. When it was evident that application of the chlorinates was of no avail, spraying of these resistant ponds was discontinued.

At the time that the Klipstein Club was screened for resistance, applications of larvicides had been discontinued for several weeks previously, giving the less resistant group a chance to build up. And while time continued, the resistance was quite moderate. As a result the LD-50 from Klipsteins paradoxically cover up the comparatively small percentage of highly resistant larvae which exists as part of the population. This can best be illustrated by glancing at the listing which shows that 10-20% of the larvae are extremely resistant while the remaining group shows only moderate resistance.

5. While EPN has proven to be the most effective insecticide so far used and tested, it should not be used in any manner without close cooperation of the manufacturer and regulatory officials.

6. Screening will be continued throughout the winter months utilizing the colonized *Culex.* Many larvicides have yet to be screened with emphasis on compounds other than the chlorinates.

TABLE 1—*Toxicity Range and LD-50 of Various Insecticides Against Colonized Culex quinquefasciatus Say Larvae (4th Instar)*

LARVICIDE															LD-50	
(1)	1	.2	.1	.04	.03	.02	.015	.01	.008	.005	.004	.003	.0025	.002	A	B
(2)	1-1 mil	1-5	1-10	1-25	1-33	1-50	1-66	1-100	1-125	1-200	1-250	1-333	1-400	1-500		
EPN										93	74	44	25	17	.0031	1-318 mil
PARATHION								100	99	63	52	15	6		.0039	1-255 mil
ALDRIN				100		92		72		39			4		.0060	1-165 mil
COLLOIDAL ALDRIN				100		90	80	73	44	36	31	16	0		.0062	1-160 mil
HEPTACHLOR				100		99		76		17			0		.0070	1-143 mil
DIELDRIN			100	95		79		49		22					.01	1-100 mil
DDD		100	95	82		40	28	10							.023	1-44 mil
DDT		100	84	79		16		0							.028	1-36 mil
Q-137			100	58		37	28		4						.029	1-35 mil
CHLORDAN		100	98	50		9	2								.040	1-25 mil
LINDANE		100	98	38		10									.0454	1-22 mil
TOXAPHENE	100	89	75	27		4									.055	1-18 mil

The first row of figures in Table #1 represents the number of parts of larvicide in one million parts of water; row 2, the number of million parts of water to one part larvicide. The numbers in the columns beneath these rows represent the percentage kill at these dosages. The gist of the entire sheet may be had by reading the two columns on the right hand side of the sheet opposite the corresponding larvicide. Column A lists the LD-50 in ppm as in row 1, while Column B lists the number of million parts of water to 1 part of insecticide for the LD-50. The smaller the number in Column A, the more effective the larvicide, while in Column B, the larger numbers represent the more effective compounds. The two columns actually tell the same story in a different set of figures. Column B being in whole figures is easier to comprehend but Column A seems to be more generally used. Technique involved in the screening program is essentially the same as that given in a previous report.

TABLE 2—*Toxicity ranges of various insecticides against 4th instar Aedes larvae.*

Aedes nigromaculis Larvae From Unsprayed Area, Jensen's Ranch, Madera County

Larvicide	(1) .04 (2) 1 25 mil	.03 1-33	.02 1-50	.0125 1-80	.01 1-100	.008 1-125	.0066 1-150	.005 1-200	.004 1-250	.0033 1-300	.003 1-333	.0025 1-400	.002 1-500	.0015 1-666	LD-50 B	A
Heptachlor											100	96	72	52	1-666 mil	.0015
Aldrin											93	74	65	30	1-554	.0018
Lindane							98	92		69		42	30		1-370	.0027
Q-137			100		82	63	44								1-141	.0071
Toxaphene			94		52	16	11								1-101	.0099
DDT	100	87	60		29										1-62	.0163
Aedes nigromaculis Larvae from Consolidated District, Wooten's Dairy																
Aldrin											82	70	62	41	1-590	.0017
Heptachlor												83	65	31	1-555	.0018
Lindane							96	75	39		20				1-230	.0043
Q-137			92	73	39	28									1-92	.0108
Toxaphene		90	72	30	10										1-66	.0150
DDT	79	37	25		9										1-34	.0294

Resistance in Wooten's Dairy vs. Jensen's Ranch

DDT ....1.7 times
Toxaphene 1.6
Q-137 ....1.5
Lindane 1.6
Heptachlor 1.2
Aldrin ....No signifiicant resistance

TABLE 3—*Comparison of DDT and 4049 on Resistant and Non-resistant Culex tarsalis Larvae (4th Instar).*

	4049 LD-50			*DDT LD-50*		
Poso Strain	1-29 mil	.035	1.5 times	1-61 mil	.0164	77 times
Resistant Strain	1-20 mil	.05		1-790,000	1.27	
	LD-75			LD-75		
Poso Strain	1-24 mil	.04	2.1 times	1.33 mil	.03	132 times
Resistant Strain	1-11 mil	.09		1-250,000	4.0	
Poso Strain	1-5 mil	.2		1-5 mil	.2	
Resistant Strain	1-5 mil	.2		?	?	

You will notice that the LD-100's are approximately the same with both materials on the Poso strain but while 4049 holds that level reasonably well on the resistant strain, DDT falls down rapidly.

TABLE 4—*Non-exposed strain of Culex tarsalis larvae compared with larvae collected from three locations within the Kern MAD*

LARVICIDE																	LD-50	
	4th Stage Culex tarsalis From Poso Creek																	
(1)	1	.2	.1	.04	.03	.02	.015	.01	.008	.005	.004	.003	.0025	.002	.0015	.001		
(2)	1-1 mil	1-10	1-5	1-25	1-33	1-50	1-66	1-100	1-125	1-200	1-250	1-333	1-400	1-500	1-666	1-1 bil	A	B
Aldrin											100	91	75	60	31		.0018	1-545 mil
Dieldrin											75	60	55	41			.0023	1-432
Metacide												80	41	30	22		.0026	1-383
DDT			82	70	75	53		41									.0164	1-61
4049		100	98	74	24	10	0										.035	1-29
	4th Stage Culex tarsalis larvae Wildwood Area																	
EPN											100	98		98	66	43	.0011	1-875
Metacide									100	93	82	20	0				.0034	1-290
DDT			100	64	60	28	5	3									.026	1-38
Toxaphene			100	59	42	35	21	1									.033	1-30
	4th Stage Culex tarsalis larvae Klipstein Duck Club																	
									.006									
EPN									1-166				100	93	80			
Parathion									100	90	80	69	40				.0022	1-460
Dilan			98		90	78	69	20									.0080	1-125
4049		100	80	40		1											.0435	1-23
DDT	78	78	58	45	29	5											.059	1-17
	Wares Duck Club. Extremely Resistant Strain																	
	10	4	2	1	.2	.1		.02	.01	.006	.005	.004						
EPN									100	64	53	20					.0049	1-205
Metacide								100	75	1							.0074	1-135
Dieldrin			100	94	44	1											.22	1-4.5
DDT	78	74	67	45	20	0											1.1	1-890,000

Mr. Washburn: The next project is a study of the embryological development of *Aedes,* which has been carried on at the College of the Pacific with Dr. John R. Arnold in charge.

Dr. Arnold: The subject is quite complicated, but we have been making a lot of progress recently. Mr. Jones will present the report.

REPORT OF THE STUDIES MADE AT THE COLLEGE OF THE PACIFIC ON EMBRYOLOGICAL DEVELOPMENT OF *Aedes nigromaculis* (Ludlow) AND OTHER FLOOD WATER MOSQUITOES

By Gilbert Jones and John R. Arnold
College of the Pacific, Stockton

With the drawing up of the "Project Proposal for the Study of *Aedes nigromaculis (Ludlow), Aedes dorsalis (Meigen),* and other Mosquitoes in Relation to Irrigation Water Use in the Central Valley of California" by D. C. Thurman, Jr. in November 1949, the San Joaquin Valley Mosquito Ecology Study began. At the College of the Pacific in Stockton, California, a sub-project was started under the direction of John R. Arnold, Associate Professor of Zoology, with the actual investigation to be done by students at the college; the particular orientation of this study being the effect of certain environmental factors on the embryonic development of those mosquitoes. Stockton, incidentally, was chosen in part because central and southern San Joaquin County, in which it lies, is the only large area in the Great Valley of California in which Abatement activities have not been undertaken and in which a population of mosquitoes exists with little or no influence by abatement measures, especially insecticidal measures. it is likely that the population of this area better represents the so-called "natural population" of the Central Valley.

The work has been under the joint direction of the Operational Research Committee of the California Mosquito Control Associtaion, the Bureau of Vector Control of the State of California, the Mosquito Abatement Districts of Fresno and Turlock, and the College of the Pacific.

During 1950-51 the work at Stockton was carried on by Mr. Marion Quessenberry and Mr. David Reed. During 1951-52, Mr. Gilbert Jones, aided by Mr. David Roberts, has continued the investigations.

The basic aims of this project as they were set down were to determine "the exact conditions, chemical, biological, and physical, governing the development of *Aedes nigormaculis* (Ludlow) and "to investigate certain factors causing the arrest or continued development of *Aedes nigromaculis.*" Basic investigations have been made on the embryology from the time of fertilization to the time of hatching. Special attention has been given to such things as rate of growth, the resistance of eggs, and the phenomena of over-wintering eggs. The first step toward the realization of these aims was an examination of published studies on species of the genus *Aedes* and other mosquitoes. Although the family, Culicidae, is probably one of the most widely investigated groups of economic insects, most of the compiled knowledge deals with natural history and general principles of mosquito biology. Literature on the embryology of these particular insects is practically non-existent. (Johannsen and Butts, 1943.) Other steps of procedure were 1) the collection of females in the field and inducing them to lay after a blood meal; 2) killing and fixing the eggs laid at different stages of development and their subsequent microscopical examination; 3) making slides, drawings, and photograps; 4) taking samples of "spring" and "winter" eggs and comparing these samples; 5) the establishment of a standard series of embryos that have developed under known conditions, as far as possible, with special regard for temperature. This series, made up of slides, drawings, and photographs, is to serve as a control for all tests involving induced changes in developmental environment. Embryos at the same age of development raised under a known degree of environmental variation can be thus compared to this standard and the amount of variation in growth observed. Each step in this investigation so far has demanded the development or acquisition of some specific technique or techniques. Techniques had to be developed for capturing females; identifying species; feeding; providing conditions similar to field conditions to insure survival of females and to induce them to lay; segregating eggs of various ages; killing; fixing, and preserving the eggs of different females at different serial ages of development; and flooding (hatching experiments) to determine the viability of eggs. The major technique problems centered around efforts to prepare the embryos both as whole mounts and as sectioned specimens for microscopical examination. Many variations of standard techniques have been tried, and the results have thus far indicated that removing the chorion with sodium hypochlorite (Mortenson's Purex Method) followed by mounting in either a liquid medium, e.g., glycerin, or a non-aqueous medium such as Canadian Balsam is most effective for whole mounts. Sectioning has been best achieved by using a modified paraffin method; the eggs are prepared for dehydration and infiltration by piercing the chorion and other membranes in order to equalize the pressure, permit rapid penetration, and prevent collapse of the egg. Sectioning with the chorion removed has been attempted and has been rather unsuccessful, but this method will be tested once again.

The results of this work thus far have been to a great extent the accumulation of isolated or random facts that are only part of the total picture which is being uncovered. It has been found that females usually lay their eggs about 36 hours after a blood meal, and in no case was it found that they laid sooner than 24 hours after feeding. Often before laying, the female eliminates excess or partially digested blood from the meal. Eggs are laid in hours of darkness, and they are for the most part hidden in the folds of the moist cotton (used to simulate the soil of the natural habitat) in groups; the number of eggs in a group vary.

Characteristics of the *Aedes nigromaculis* Egg

The egg of this mosquito is .546 mm. in length and fusiform in shape. Both the anterior and the posterior ends are somewhat pointed, but the anterior end can be distinguished from the posterior end by its slightly blunt appearance. The egg is black in color. On examination of the surface under a microscope it seems to have a rather pebbled or studded appearance if the egg is a freshly laid one; preserved eggs, however, seem to have a shiny or glossy surface. The egg, while in the process of being cleared, appears to have a covering of a hexagonal pattern; this probably the pattern of the exochorion. The egg shell of mosquitoes is built up of three distinct layers; an inner, thin vitellin membrane which surrounds the yolk and growing embryo; an intermediate endocorion, thick and opaque; and an outer exochorion, usually thin and transparent (Bates 1949). Studies here have indicated that the shell of the egg of *Aedes nigromaculis* is like that described by Bates. The action of sodium hypochlorite on the chorion is a dissolving action resulting in chemical destruction and breakdown of the successive layers. It has been noted that the amount of eggs laid per female decreased in the fall months compared to the mid-summer months, while the number of females that refused to lay increased.

Embryology

Work thus far has yielded the following exemplary stages of growth:

1. A modified germ-band stage in which the caudal and cephalic portions are well grown into the yolk.
2. An unsegmented stage having only a slight differentiation into head and trunk.
3. An embryo of incomplete segmentation having only six segments in the trunk region (thorax and abdomen), as well as distinct differentiation of the cephalic region.
4. A more advanced embryo, well segmented, but not complete as some yolk on the dorsal side is not enclosed. The cells of the serosa have been well stained in this specimen and it can be seen to completely encircle the embryo.
5. A number of nearly completed embryos, having completed segmentation with well distinguished head, thorax and abdominal regions. The thorax has 3 segments and the abdomen 9. These embryos have eye spots and well-developed cephalic differentiation.
6. A large number of embryos that are ready to hatch.

It was observed that not always were these different growth stages present at the same age of growth; sometimes similar development stages were found in ages that varied by several hours. This tendency seems to point a correlation between the temperature of development and also the season in which the egg is laid, and its rate of development.

It was noted that the bristles so common on the mosquito larva take a spiral pattern around the body of the embryo when it is within the shell or chorion, with their distal ends pointed anteriorly.

Hatching

A certain number of facts were gathered through flooding experiments, and some of the results follow:

1. The eggs of *Aedes nigromaculis* when flooded on the fifth day after laying hatched in some instances. These eggs did not dry out, but were moist or damp during the time of development.
2. The eggs of *Aedes nigromaculis* in certain cases hatched as soon as 13 minutes after they were flooded; however, the elapsing time was usually slightly longer.
3. In the case of *Aedes vexans* the earliest recorded hatching was ten days after laying; it was not necessary for these eggs to dry thoroughly prior to hatching, as some have held; these eggs were developed in a comparatively moist atmosphere.
4. It was noted that the "egg burster' so prominent on the dorsal part of the head of the first instar was lost as a part of the shed skin during ecdysis.

In several groups of eggs, abnormal hatching was observed. Normally the larva emerges from the egg shell by way of the "cap" or anterior end of the shell. Abnormal hatching has been observed when a longitudinal slit of the ventral portion of the shell has been produced; the embryo trying to get out of the shell by this slit gets completely free except for its had. These larvae died without freeing the head. In two other cases it was noted that apparently a weak formalin solution stimulated hatching; in one case the embryos that hatched were less than three days old (since laying) when hatching occurred.

Acknowledgments

Advice and counsel has been received from so many sources that proper acknowledgment is impossible, but the names of Col. W. W. Komp, Dr. Alden Noble, Dr. Harvey Scudder, D. C. Thurman, Richard Husbands, Earl W. Mortensen, Edwin G. Washburn, and Edward Davis must be mentioned in any progress report.

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Mr. Washburn: The next report will be on the rice field studies. These have been carried on in the Marysville area for more than a year and a half, but recently the work has been accelerated and new personnel has come into the project. I will ask Dr. Robert Soroker to make a few remarks on the present status and future prospects of this study project.

Dr. Soroker: Since I am comparatively new on the Rice Field Ecology Project my remarks at this time will be brief. First I would like to announce that in March we will have an opening as project entomologist. This project has a particularly promising future for a qualified entomologist or biologist. Any interested individuals should contact either Dick Peters, Dick Sperbeck, Herb Herms or myself.

The basis for the existence of the Rice Field Project is the need for a more economical and effective method of controlling mosquitoes associated with rice fields.

Up to the present the studies were divided equally into two portions; control and ecology. A springtime control program was attempted during the last two years in a 25 square mile study area in the southern portion of Sutter County. While a considerable amount of biological information was gathered, the result of the control program was inconclusive. The area presented some extremely serious drainage problems and was too large for proper coverage and evaluation by the manpower available.

We have decided to move our project to nearby Placer County, primarily because it is not controlled by a mosquito abatement district and has some relatively isolated rice fields which would be satisfactory for comparative studies.

Seevral of the mosquito abatement districts in rice field areas do put on a springtime control program and would like to have some idea of its effectiveness particularly later in the summer and fall. We will attempt a control demonstration this spring if an isolated rice field can be located; one that in our belief can be completely controlled around a two mile area.

Possibly such a program will contribute some answers to the following questions:

1. Can such an operation, carried on under comparatively ideal conditions, effectively reduce the summer and fall mosquito population?
2. What are the operational costs and manpower hours expended to completely cover the area?
3. What is the time interval between treatment of breeding areas and reappearance of larvae?
4. Is it possible to establish a larvae-free border around a rice field and prevent infestation of the field during summer and fall?

The major portion of our studies will be on rice field cultural practices and their relation to mosquito production. In other words, we would like to know if any correlation can be made between "clean" rice field culture and successful mosquito control.

There are almost as many ways of growing rice as there are rice farmers. We will locate one or more combinations of rice fields, such as first year versus second, drilled versus broadcast, fall prepared checks versus spring prepared checks, and compare the larval population, adult activity and limnology of each.

Adult resting stations will be located within the study area for the measurement of adult densities in the stations during the year, the percentage of blooded females and the fat body and egg development.

The preceding measurements correlated with the egg, larval and adult densities and limnological studies in the immediate rice fields will give us a clearer picture of cylcical development of the mosquitoes and very possibly a clue as to how they may be more effectively and enocomically controlled.

We have had a very difficult time locating a field center which could be used as a meeting place and for necessary laboratory work. However, we were fortunate last week in finding a promising structure about 2 miles southwest of Lincoln which we hope will be suitable.

Several combined laboratory and field investigations might be initiated, depending upon our personnel and the extent of our involvement in the other studies.

1. Length of aquatic cycle at various times of the year; eggs, larvae andf pupae of *Anopheles freeborni* and *Culex tarsalis.*
2. Resistance to dessication of aquatic stages.
3. Resistance of aquatic and adult stages to variations in temperature.
4. The optimum conditions (physical, chemical, etc.) for ovipositor.

As you can realize our plans at this stage are not completely crystallized. We would certainly welcome any suggestions you might have and would be very glad to talk to any of you.

Mr. Washburn: In summing up, you can see that a great deal of work has taken place under these various projects. This Operational Investigations Committee has met four times during this past year to help guide the studies. We've had large attendance at some of these meetings. I'd like to report on one or two of the things that have happened, for your general knowledge because the minutes have not been generally distributed. During November the Board of Directors of your Association sent out a questionnaire to determine the status and feelings of the various agencies regarding investigations as well as subventions. At the moment I am not interested in the subvention phase of it, but only in the investigation phase. As I recall the results of that survey most of the districts favored the continuance of operational investigations. On January 11th, the Operational Investigations Committee met in Fresno at the Field Station with a large attendance. We went over the propostion of the continuance in the future of the operational investigations as a whole, that is all the projects individually and collectively. It was the opinion then of the members of the Committee that the operational investigations, as they are, should continue, and that we should try to seek additional funds to expand these projects if we want to obtain results more quickly than we are now able to. However, later in that same month on the 15th, the Board of Directors took no action regarding our recommendtation so this Committee now stands without any official backing. I would like, though, to report as far as the Committee is concerned that the Committee does favor the continuance of these projects and that $25,000.00 be set aside for this coming fiscal year for the continuance of these projects. We also recommend the continuance of this Committee.

Mr. Smith: Thank you, Ed Washburn. We will get into further discussion of some of these matters very shortly.

Next is a Committee report by Chet Robinson, Chairman of the Legislative Committee.

Mr. Robinson: I will make a very short report. Our legislative mission was accomplished. There were three bills asked to be presenetd to the legislature by the CMCA. They were presented and all of them passed and are now in effect. For your information, those three bills are the continuation of the exemption from the District Investigations Act for two years, the raising of the trustees' allowance from five to ten dollars, and the permission to put red flashing lights on the smoke generators and jeeps.

Mr. Smith: Is our auditing committee ready to report?

Mr. Kimball: The auditing committee is composed of Ernie Campbell, Contra Costa County, and William Bollerud from Durham. We got together and looked over the Treasurer's books and state that the books are set up excellently, that the recordings have been made on all expenditures and receipts and also have been broken down into various categories. We feel that the Treasurer is doing a good job of keeping track of the several thousand dollars that pass through the Association each year. The balance that the Treasurer has reported this morning was the balance that was struck off February 1st which we witnessed.

Mr. Smith: We come now to the Report of the Resolution Committee.

Mr. Gray: The Resolutions Committee consists of Ed Washburn, Chester Robinson and myself. I'll read first two non-controversial resolutions and then we will bring up the controversial ones. You may remember that last year we decided that resolutions were more or less the bunk anyway and we were going to produce a minimum of them. So the first resolution is in part a resolution to end resolutions.

"BE IT RESOLVED that the Secretary of this Association be directed to send letters of appreciation to the various officials, individuals and companies who have contributed facilities, services or funds to make this annual meeting successful, informative and enjoyable."

The second resolution is in recognition of the service of a very famous man who is perhaps somewhat unknown to many of you, but he was in appreciable part responsible for the original mosquito abatement district act being passed in 1915, and very strongly supported and made possible many of the mosquito surveys of California that were performed by Billy Herms.

"BE IT RESOLVED that the California Mosquito Control Association expresses its great regret at the death, on November 12, 1951, of Wilbur A. Sawyer, M.D., formerly Secretary of the California State Board of Health in 1915-18, and later Director of the International Health Division of the Rockefeler Foundation. While Secretary of the State Board of Health, he was helpful in the passage of the original mosquito abatement district act, and he encouraged and assisted with State funds the mosquito surveys and investigations carried on in California by William B. Herms and his students. We had hoped that, upon his retirement and return to California to live, he would have been spared for many years of valuable service to the people of this State."

I recommend that these resolutions be adopted.

Mr. Smith: A motion is in order for adoption of Resolutions 1 and 2 as prepared by the Resolutions Committee. Do I hear motion? Moved by Adolph Preuss. Is there a second? Seconded by Don Grant. Are you ready for the question? All those in favor of adoption of Resolutions number 1 and 2 as read by Harold Gray, say aye. Opposed? These resolutions are passed unanimously.

Mr. Gray: I will now present one recommendation and one resolution and request that no action be taken upon one without consideration of the other. The first is not prepared as a resolution. It is prepared as a recommendation of a special committee and was approved by the Board of Directors last night. "The California Mosquito Control Association offers the following suggestions for a more equitable distribution of subvention money to local mosquito agencies of California. As a result of a series of meetings a committee was appointed by the Board of Directors of the CMCA to prepare recommendations based upon the consensus of opinions of the control agencies. Allocation of the funds to mosquito control agencies should be based on two prime factors: Number 1, mosquito borne disease endemicity; Number 2, the need and willingness of a local agency to support its own mosquito control program. This seems to be best evidenced by the local tax rate. Methods for equitable allocation of funds considering the above factors are (1) a basic allotment to all agencies; (2) additional funds to those agencies showing a need and a willingness as evidenced by a tax rate of 15c or higher, this factor to be on a scale adjusted to the local tax rate; this scale amount to be applied to the total square miles of the control agency to determine the final allocation. It was felt that it would be simpler to use the total square miles in the agency in place of the problem area because it would avoid any disagreements as to the actual extent of the problem area of an agency. In all agencies except two the ratio of problem area to legal area is so close that little or no inequities would develop. In cases where there is a marked difference in problem area and legal area the Bureau of Vector Control could make the appropriate adjustments with those agencies. The total subvention fund allowed to a mosquito control agency should not exceed 10% of the total or $40,000.00."

"Applying the above principles, the following examples are given; and please note that these are given just as examples of what might be done. Number 1; the basic allotments to districts showing a high degree of endemicity as determined by the Bureau of Vector Control to be 50% of their local budget but not to exceed a maximum of $7,500. Number 2; a basic allotment to districts not showing a high degree of endemicity to be 30% of their budget but not to exceed $5,000.00. The scale of tax rate applied to the square miles of the agency would be, in the case of a tax rate of 15c or higher, to apply a $25.00 amount per square mile. It was recognized that that would have to be adjusted by the amount of money that was left after the basic allotment was made. These are not given as hard and fast rules but as suggestions."

We've also had submitted to us a resolution prepared by Gordon Smith of the Kern District and Paul Jones of the Marin district.

"WHEREAS, Subvention funds from the State of California, for mosquito abatement districts were originally allotted by a special act of legislature as an emergency funds, and

WHEREAS, such an emergency did not occur, and

WHEREAS, it is the majority opinion of the Cooperate Members of the California Mosquito Control Association that the disbursement of these funds is no longer in the best interests of mosquito control in California, now therefore

BE IT RESOLVED that the California Mosquito Control Association does recommend that these funds be withdrawn over a maximum period of three years, and

BE IT FURTHER RESOLVED that the Secretary of this Association is instructed to send copies of this Resolution at the earliest moment to Dr. Wilton L. Halverson, Director of the Department of Public Health of the State of California, and to the proper committees of the Legislature of the State of California, whose duties are to consider budgetary matters."

Gordon F. Smith
Kern Mosquito Abatement District

G. Paul Jones
Marin County Mosquito Abatment District

There is the dynamite, gentlemen.

Before it goes to discussion I would like to make one or two comments to help you with your consideration of these matters. The Advisory Committee on Vector Control of the State Health Department, whose opinion has a little weight with Dr. Halverson and I think even with some of you people, at its meeting last November took some of these matters under consideration. If you will notice the wording of some of the sttaements that we put forth at that time, we endeavored to recognize certain changes in operating conditions which have occurred since the original subvention program was launched. We certainly recognize that it was a difficult or at least an impracticable matter to segregate strictly vector control operations for which the original subvention was set up, from pest control and presumably non-vector operations. I think that was one of the principal ideas that the Advisory Committee produced and I think it will clarify the atmosphere to a certain extent. That did not mean that the Advisory Committee did not consider that endemicity of disease, nor that the presence of vectors was not a primary consideration in the granting of subvention. I think the Advisory Committee is still pretty much of a mind that vector endemicity is a very important thing and until such time as the intent of subvention is changed by new legislation we are obligated to give that the very greatest weight, even though you recognize as a practical operating procedure that you cannot segregate all this after you once give an agency the money. The other thing that I think perhaps was in the back of the mind of some members of the Advisory Committee was this very problem of the difficulty of reconciling a situation which was originally thought to be of importance as a postwar problem and yet that problem did not occur. We should not operate under false pretenses. How this will work out ultimately, as to whether we have continuance of subvention or whether we have a gradual discontinuance of subvention, is not a matter that I believe the Advisory Committee wishes to take any appreciable stand on. We feel that is a matter between the association and the legislature. I shall not inject my own personal opinions into it, except that I want to spike one idea which I think is completely mistaken and I think the other members of the vector advisory committee will entirely agree with me. It doesn't make any difference where this money comes from in relation to the taxpayers in the state of California. Let us admit that the bulk of the money comes from the San Francisco Bay area and the metropolitan Los Angeles area. Most of it is spent in the Sacramento and San Joaquin Valleys. But this is a statewide problem. If I leave the relatively mosquito-free Bay area and go to some other part of California that is relatively mosquito infested, I am entitled to protection, and if the local people are unable to give me that protection then I beleive it is a perfectly proper function of the state to take money from the wealthy counties and give it to the non-wealthy counties to protect myself, my family, the foreign visitor and the immigrants who come into areas which are less well supplied with money.

Mr. Smith: Thank you, Harold, you gave us a handful. It would appear that there are some differences of opinion as to what the majority opinion of the California Mosquito Control Association is. Personally, I welcome this opportunity to find out just what that majority opinion is, and it looks like maybe we are going to find out today. I would like to go back and review things to show why this subject is coming up for discussion here and now. I think most of you have taken part during the last six or eight months in one or more discussions of this particular subject of state subvention. Some of those discussions were in smoke filled rooms in a hotel, some of them were at banquet tables and some in conference rooms, but at any rate, the subject has been freely discussed by many people. Now it's an interesting point to me that in all of those discussions I have heard no criticism of the administration of that subvention money. I haven't heard people express themselves as being unhappy about that. The discussions instead have been on a different plane. They have been on the matter of the philosophy of state subvention as a whole, and on the intracacies of allocation of our particular mosquito control state subvention fund. These discussions have been carried on in the regional meetings and in directors' meetings. There was a questionnaire sent out to all the districts to try to arrive at some kind of a consensus of opinion. It showed that there were many opinions. In some instances they were clear cut. Jack Kimball and myself as representatives of the CMCA on the Advisory Committee wanted to get as much expression of opinion on the subject as we could before we attended the meeting last November, because we understood that the subject was going to come up for discussion. At that time, as a result of the meetings we had had and the correspondence, we as representatives of the CMCA told the Vector Control Advisory Committee that we endorsed two things. First, a change in the basis of allocation of subvention money, so as to take into account the need of districts. We also, however, said that we felt that endemicity as a factor should still be retained as a basic requirement for subvention. We did not request that any additional amount of subvention be made. We did say that we realized that a good many of the districts didn't need more subvention money, but at the same time we felt that if there was a change in allocation so as to give it to those that did need it most, that it wouldn't be necessary to ask for more. The reason that the same subject has been discussed at further meetings and is being brought up here is because we felt that it was necessary to clarify or endorse the recommendation we gave the Vector Control Advisory Committee in November. It is not for us to decide these matters of state subvention. However, we are the parties getting the money and are most concerned with it, since we are spending it. Certainly it is not at all out of order for us to express our opinion as to the way it should be allocated. It is then up to the Vector Control Advisory Committee to advise the State Department of Health and the Bureau of Vector Control. What we are going to be discussing here is a matter of recommendations and advice as the experts in the field, and that's what we are. Certainly our opinion should be worth something.

However, just one more point I want to make before I throw it open for general discussion. Personally, I am firmly convinced that democracy is a good form of government and I see no reason at all why it shouldn't work in any kind of organization. Regardless of what my own opinion is, I am perfectly willing to go along with the majority opinion, even if it's directly opposite to what I think myself. As long as a subject like this is brought out in the open for a full and free discussion, and as long as everyone is given an opportunity to express his opinion, and then there is a clear-cut issue on which to vote, then I should hope that we are all well enough sold on democracy to be willing to go along with the majority opinion.

Before we even try to get these matters to a vote, I shall call for a general discussion.

Mr. Gray: I would like to make a suggestion that may help clarify the entire discussion, by presenting one point that the Advisory Committee reported upon, but which I did not bring up at the time because I thought it was better to segregate it. The Advisory Committee recommended that the State Health Department give consideration to the establishment in the Bureau of Vector Control of a special fund for operational research which would be a part of the State Health Department funds and not be abstracted from the subvention funds. That would relieve you immediately of twenty-five thousand dollars which could then be used for district purposes. In all probability, it would be possible to get say a hundred thousand dollars from the legislature about as easily as twenty-five thousand dollars, and you could do a better job. I do not believe you need a resolution to do this; it could be put in the form of a simple motion that we recommend that the opinion of the Advisory Committee on the operational research fund be accepted. I think this is non-controversial so I will move that the Board of Directors be again requested to present this matter to the State Health Deparment for budgetary consideration.

Mr. Smith: Let's be clear on what this motion is, Harold. This is to eliminate the operational investigation funds from the subvention fund; to no longer take the money, twenty-five thousand dollars or whatever it is, out of the subvention funds, but have it in the future set up as a part of the funds of the Bureau of Vector Control of the State Health Department. There is one correction on the attitude of the CMCA on that: we stated that we wanted to approach that as an end result, as we realized that it might not be possible this year, and we were willing to support the operational investigations for one more year.

There's no use disturbing the present situation. But for the subsequent fiscal year, let's try and get it out as a separate item. I'll suggest that as the motion. I want to be sure that we're talking about the same thing. Your motion is to the effect that we as the Association endorse support of the operation investigations to the tune of that same tweny-five thousand for the fiscal year which is coming up? That's starting the first of July through the end of June, 1953, but at the same time we start the machinery in motion to make the change-over so that it will not be taken out of subvention funds for the fiscal year following that. Are there questions on that motion? Or is there a discussion? Let's have a discussion on it first.

Mr. Umberger: Mr. President, shouldn't this question and this motion be held over and voted on after we have considered the whole matter of whether we want subvention or not, because it's part and parcel of the same program? I think perhaps Harold's design in the matter was to protect it regardless. Well, we are not here for design, we are here for facts and determinations of what we want to do.

Mr. Smith: We have it as a motion by Harold Gray, seconded by Don Murray and perhaps the best way to decide it will be on that basis, so is there further discussion? We'll have a roll call vote on this. If you are ready for the question, we will read the name of the district and the designated representative's vote.

(On the motion, twenty-nine districts voted yes, no districts voted no, and three abstained from voting.)

Mr. Smith: The motion is passed. Now before we get further into this discussion, let's see if we can get it as a clear-cut issue. We can just ignore the resolution for the moment. It seems to me we have three points of view represented, even though there are just one resolution and an opinion. We have first the point of view that subvention should be increased. We've gone over the reasons for that at a number of our meetings in the past and I don't want to take much time on that. The reasons that have been advanced for increasing the subvention amount are simply that whereas four hundred thousand dollars was set in 1946 with only thirteen mosquito districts participating, at the present time that four hundred thousand dollars is really worth about half that in terms of the original dollar and is now spread over about twenty-eight mosquito districts, and even in those districts the mosquito problem has increased tremendously so that that amount of money is certainly not doing the same amount of good. We could go on for an hour on various other arguments on that particular point but it is one point of view that subvention should be increased. It is interesting to note that in spite of that fact we, the recipients of the money, voted by mail ballot and also at the Board of Directors meeting in Berkeley not to request any increase in subvention money. The very next day, at the Vector Control Advisory Committee meeting, Dr. Karl F. Meyer proposed a motion that all possibilities should be investigated for increasing the total amount of subvention money, principally on the basis of the vote that they had just taken to enlarge the scope of the program so as to take greater recognition of general mosquito control. The second point of view is that subvention should be continued as is. That is, the total amount to be the same, but with a shift in the emphasis of the basis of allocation. The third point of view is that subvention has outlived its usefulness and it should be done away with. We have three points of view. Now let's have discussion.

Dr. Ernest Tinkham: I would like to propose what seems to me a more equitable rate factor. I believe at present that tax rate is restricted to a maximum of fifteen cents, and of that fifteen cents you have certain categories; for instance anything below three cents is rated fifty per cent and I'm not exactly certain how they go up to ten but I believe everything from ten up to 14.99 cents is given seventy-five per cent or something like that; and fifteen cents or over is all put in one category. To me it seems that the tax rate factor, the actual tax rate over the fifteen cents without any regulating category would be more equitable. In other words, if the tax rate is one cent then the factor would be one over fifteen. If it's three, it would be three over fifteen and so on up to fifteen over fifteen. What about the district in which the tax rate is twenty-one cents or where in one case I believe it's thirty-six cnts? Is it fair that that district that is taxing its people thirty-six cents should get the same amount of money as one with fifteen cents? I would think that the more equitable factor would be the actual tax rate divided by fifteen; if the tax rate was thirty-six cents the tax rate factor would be thirty-six over fifteen times the amount of money available.

Mr. Gordon Smith: I believe that first, before we go into this business we should have discussion on the resolution. I'd like to clarify our position on this matter. Our Board of Trustees has been on record in the minutes for a considerable period of time against the basic philosophy of subvention. They feel that the whole economy would be on a better footing if subventions were not handled as they are now. It's our understanding that fifty per cent of the state budget now goes out in subvention moneys, and our Board has instructed me to present this resolution or to help present it at this meeting. I would like to make a motion now that the resolution be adopted.

President Smith: This is jumping to the resolution prepared by Gordon Smith and Paul Jones. There is a motion that this resolution be adopted, made by Smith and seconded by Jones. Is there further discussion?

Mr. Brawleys: In Kings County we have a lot of marginal land which produces considerable numbers of mosquitoes. It is not an unusual situation; I imagine that you'll find it in a great many counties, but in Kings County this area is so situated that the mosquitoes have a very detrimental effect on our program as well as the program in the adjoining counties. This area is not self-supporting and the chances are that it never will be. It seems imperative that somebody must take it and control it. We have taken some of it and we'll take more of it if it's necessary in the interest of better mosquito control in general. The only way that we can hope to do a satisfactory job is by getting some funds from some source other than taxation in the local district. We are already on a fifteen cent tax rate and have been since we started our expansion and will continue to do indefinitely. But even at that rate the funds will not be sufficient to carry on an adequate program.

A member: Has any consideration been given to having the tax limitation of fifteen cents increased?

Mr. E. A. Smith: I take it you mean raising the maximum of fifteen so that a district by consent of its own Board can tax higher than fifteen cents. Is that what you mean? That has been discussed but not at any great length. Are there any other comments or questions before we have this vote?

Mr. Coburn: May we have the resolution read again so that we may be more certain as to just what we are voting on?

(The resolution by Gordon Smith and Paul Jones was re-read.)

President Smith: The Secretary will call the roll on adoption of the resolution.

Mr. Gray: By direction of our Board of Trustees, the Alameda County District will abstain from voting, on the ground that two of our members are on the Advisory Committee, and we are not receiving subvention.

Mr. Washburn: Alameda, abstain; Anderson, no; Butte County, no; Coachella Valley, no; Contra Costa, abstain; Consolidated, abstain; Corcoran, no; Delano, no; Delta, no; Durham, no; East Side, no; Fresno, abstain; Hanford, no; Kern, yes; Los Angeles City, abstain; Los Molinos, no; Madera, no; Marin, yes; Matadero, abstain; Merced, no; Northern Salinas, no; Northern San Joaquin, no; Orange, no; Pine Grove, no; Pulgas, no; Redding, no; Sacramento-Yolo, abstain; Sutter-Yuba, no; Three Cities, no; Tulare, abstain; Turlock, no; West Side, abstain. Mr. President, the vote is two yes, twenty no, ten abstain, out of a total of thirty-two present.

President Smith: The resolution is defeated. We will now consider the recommendations of the Board of Directors concerning the basis of allocation of subvention funds. We will consider its presentation by the Resolutions Committee as having cast it in the form of a resolution. It is moved by John Brawley, seconded by Don Murray, that this resolution be adopted. Is there any discussion?

Mr. Umberger: We had a meeting of our northern group to discuss this subject. At that time it was the consensus of our northern districts that this was a problem fundamentally of the state health department. They were handling about eleven different subvention programs, doing a good job, and there was no assumption that they were not able to handle this one. Secondly, this is a matter that should be considered only by the Trustees of each mosquito abatement district. They are receiving the money, they are legal identity for the carrying on of the business of the mosquito abatement district. The decision of whether subvention should be discontinued, or increased or whether it should be modified is the responsibility of the Trustees themselves and it shouldn't be decided by this, an outside agency; what we are is a pseudo-official agency meeting here today. The statement has been made that whenever there's a meeting or a get together of the California Mosquito Control Association there is continually this discussion of subvention. Now that is rather strange because up the valley we have our meetings and we don't talk about the subvention program, except when an official communication is sent to us requesting some decision on the matter. Another matter that has been brought to my attention is the fact that unofficially the Bureau of Vecor Control is requesting this discussion or this opinion here to guide and influence them. I feel this way—that if the Bureau of Vector Control wishes to know the opinion of various mosquito abatement districts they are dealing with, why don't they go to the mosquito abatement district directly? Why don't they in person or by letter ask these questions brought up here today relative to subvention? Why shouldn't the Bureau ask the Boards of Trustees of districts carrying on subvention programs whether they want to continue it as it is, do they want it increased, or do they want it eliminated?

In our thinking, there are many intangible factors in allocating subvention money. I'll illustrate that in our own mosquito abatement district where we have a relatively low tax rate. We know we're being penalized by the fact that we have a low tax rate; we are presently penalized about 50%. However, we know that the answer in mosquito control, good control, is not more subvention, it is not insecticides, but is the basic eliminating or elimination program which we refer to as permanent control work. Our emphasis is along that line. We have gone to the Board of Supervisors in our two counties; in the last 60 days there have been formed four drainage districts. These drainage districts are controlled by the Board of Supervisors and they're not in terms of taking care of the Sacramento River or the American River, but they are small drainage problems located in populous areas. There is going to be a flat tax rate of 25c put on each of those drainage districts. In this discussion we are having today, are we going to consider that 25c tax rate with the mosquito tax added on top which is really a mosquito elimitative program? There are a number of other intangible factors in this subvention program. There is another matter, which is the basic allocation, so many thousand dollars to each mosquito district. When the State Health Department came into our area and asked the governing boards to form a mosquito abatement district, they said, now form a big mosquito abatement district. It is more efficient and you can do a better job. We did. Since that day we've been penalized under subvention because in some people's thinking every mosquito abatement district is the same size. Under this plan being voted on here, the basic allocation is the same for all districts whether they have an area of 25 square miles or 2,000. In a large district it costs more than the basic allocation to do the things the state requires. Now all those things are factors and a man can stand up here and talk for a day but I do believe that if we are going to have a successful Association which is going to advance and take care of the needs and the problems that come up, the sooner we discontinue the talking and trying to formulate a policy for the State Health Department, the better off we will be. Fundamentally this is not our job. Right now we're going out and minding somebody else's business. If you stir up the water, the Bureau of Vector Control may get a few ideas to help their thinking. That may be fine for them, but in doing so I feel they are weakening this organization.

We are a new member; our mosquito abatement district just joined this year. One of the reasons we have not belonged in the past is because of this very subvention problem. Our Board felt that this subvention matter had more or less resolved itself and is being handled satisfactorily so we joined this Association. Personally I would like to see a motion that we leave the subvention program as it is. I hope that this group here today does not vote either way on this question because it's none of our business. In the voting a few minutes ago I did not vote. Why? Because I feel that as an Association this is none of our business but it is the business of each respective Board of Trustees. In closing may I ask does anybody here of the northern group happen to have the letter that was sent out covering our opinion on this subvention matter? Fundamentally what we pointed out to this Committee was the fact that this was policy and this policy should be determined by each Board of Trustees exclusively and if the State Health Department is interested in knowing how the mosquito abatement districts feel, why don't they go to the people legally responsible and ask them? If they haven't got courage to do that don't slip around in the back door by using this Association.

Mr. T. G. Raley: I think you all know Consolidated's stand has been consistant over the years. I think I can express the feeling of my Board. We have taken definite Board action and basically they are not in favor of subvention. This mosquito subvention as such is a matter that is perhaps a little beyond a decision of my Board in saying that we should throw that out, because it has been functioning and will probably function for years to come because of need of the state. My Board has in the past passed up subvention in one year because they felt they had been nicely taken care of in the preceding years and felt that they could go along that year without asking for money.

I hope that you will consider this resolution very carefully, and in weighing it remember that recently we have had a couple of good years, when everything has gone along well. There has been no criticism of the handling of the subvention money in itself. We get our money on time. Some districts may not be getting as much money as they should, but there may be better ways to adjust this than to set up rules which may create friction and perhaps put us back where we were three years ago.

Mr. Smith: We will now call for a vote on roll call.

(The roll was called by Districts)

Mr. Washburn: The vote thereon is 25 yes, no noes, seven abstain.

Mr. Smith: The resolution is carried.

Are there any additional items of business to be brought up?

Mr. Washburn: There is one matter which should be taken care of. There should be a motion from the floor for the approval of the actions that the Board of Directors have taken in the past year. We have the minutes here of five meetings and those should be approved.

Mr. Smith: Moved by Harold Gray, seconded by Dick Sperbeck. Are you ready for the question? All those in favor say aye. Opposed? The Minutes and actions are approved.

We will have the report of the Nominating Committee now.

Mr. Gray: Mr. President, the Secretary asked me to report for the Nominating Committee. These nominations have been made by the Nominating Committee: for President, Rolland Henderson; for Vice-President, Robert Peters; for Secretary-Treasurer, Ed. Washburn; for Board of Trustee representative, Dr. Stanley B. Freeborn.

Mr. Smith: Since there were no other nominations posted on the door this morning, I take it that no additional nominations will be forthcoming. Therefore a motion is in order to instruct the Secretary to case a white ballot for this slate as presented by the Nominating Committee. Do we have such a motion? Jack Kimball so moves. Is there a second? Don Grant seconds. Are you ready for the question? All those in favor say aye. Opposed? The slate is carried.

I think we'll install Rolland at the beginning of the next session. We'll adjourn right now. Let's have these regional meetings and get the regional members elected during the noon hour.

THIRD SESSION

Thursday, February 14, 1952, 1:30 P. M.

President E. A. Smith: The first thing I want to do, and I'm going to enjoy it very much, is to introduce the new president of the CMCA, and I want to state here and now that I enjoyed my past year as president of the CMCA very much. I've had a wonderful time. I've enjoyed working with all of you and I look forward to participation in the future on many more of the meetings of the kind we've had in the past year. I thank all of you, each and every one, for your cooperation. Now I want to introduce Rolland Henderson, the new president of the CMCA. Take it away, Rolland.

Mr Henderson: I had quite a long acceptance speech all prepared but after talking to a few of my dear friends they advised me that I'd better not give it. However, I would like to say a word or two in regard to this job of president of this Association. I feel very highly honored to be president of an organization that stands for the things that this organization stands for. I was interested in the remarks that have been made, both this morning and yesterday to the effect that this is a democratic organization. We all have a very definite part, an individual part and a collective part in seeing that this Association continues to live up to the motto that it is dedicated to public health and comfort and the advancement of effective mosquito control. That's a word picture of the direction into which this Association is headed and I know with the help that Ed has had this past year as president, and with the help that each one of you individually is going to give to this Association this coming year, we can't go wrong.

I have one or two announcements that I would like to make. We have a telegram from Sacramento reading as follows: "Greetings from your Capitol City, and best wishes for a successful meeting. All Sacramento would be honored if chosen as host city to your next meeting. Our convention bureau would cooperate in every way to making a meeting held here a success, lending not only its moral but its material support, furnishing adequate halls or meeting places, badges, registration service and taking care of many details thereby relieving your committee of that which might ordinarily be a burden. Sacramento is noted for its convention service. We urge that sympathetic consideration be given this invitation in order that we have an opportunity to demonstrate that which would prove to be a meeting outstanding in the history of your organization." Signed, the Mayor, the City Manager, County Executive, the President of the Chamber of Commerce, President of the Convention Bureau and the Manager of the Convention Bureau. I give you this word from them although at this time we will not take any action on it and in the meantime you can be thinking about it. If you have had any offers, be sure they get into our hands by our first meeting so that we can begin taking some action on it. Ed Washburn, do you have the regional representative names yet? I wonder if we could have that in a hurry.

Mr Washburn: When I call your names I wish you'd stand so that the people can see you. For the Sacramento Valley region, Dick Sperbeck. Regional representative for the San Joaquin Valley region, Roy Holmes of Eastside district. For the southern California district, Norman Ehmann. He is away at school but I understand will return soon and will resume that job. For the Bay Region, Donald Grant.

Mr. Henderson: Thank you, Ed. I think we'll hurry on into our afternoon program we've been looking forward to. I would like to turn the remainder of the program of the afternoon over to Art Geib, the ex-manager of the Kern Mosquito Abatement District, now ranch king of the San Joaquin Valley.

Mr. Geib: As the Association President so ably pointed out this morning, for the past five years there has been a tendency on the part of control agencies to switch from the so-called permanent mosquito control to more emphasis on the use of insecticides. I think we all concur with his statements this morning, and we all plan on emphasizing permanent control. Nevertheless, we are still confronted with the necessity, particularly in the central valley of California, of using insecticides for mosquito control purposes. Probably all of us would like to see the day come when we might just about get along without them, but it doesn't seem that this condition will develop in the foreseeable future.

I'd like to ask the members of the panel to come forward and be seated at the table here. Mr. Gjullin, Lew Isaacs, Gordon Smith, Dr. Hoskins, Dr. March, Dr. Metcalf, Mr. Gardner, Mr. McDuffy, Mr. Alan Lemmon, also Mr. Embree Metzger. Most of you know that Mr. Gjullin, Bureau of Entomology and Plant Quarantine, Corvallis Laboratory, worked in cooperation with the Bureau of Vector Control, State Health Department and mosquito control agencies of California this year, studying in the central valley the development of resistance to chlorinated insecticides by local species of mosquitoes. Mr. Gjullin will now report on his findings this past summer.

(Note: Mr. Gjullin's paper is scheduled to be published in "Mosquito News," therefore an abstract of his paper follows.)

ABSTRACT OF RECENT STUDIES OF MOSQUITO RESISTANCE TO INSECTICIDES IN CALIFORNIA

By C. M. Gjullin

Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

and

Richard F. Peters

Bureau of Vector Control

California Department of Public Health

The resistance of several important species of mosquitoes in the San Joaquin Valley of California to DDT, toxaphene, lindane, and aldrin was determined in laboratory tests of larvae from treated and untreated areas. Tests were made in five counties in the Valley.

Aedes nigromaculis larvae from the treated areas were found to be from three to seven times as resistant to DDT as larvae from the untreated areas. Resistance to toxaphene was less than twice that of larvae from the untreated area except in two areas, in which resistance was from two to three times that of the larvae from the untreated area. Little or no resistance to lindane and aldrin was shown except in one area in the Kern District, where it was twice that of the larvae from the untreated area.

In a few tests with *A. dorsalis,* resistance to DDT was 3 to 12 times that of larvae from the untreated area, but no resistance to the other insecticides was indicated.

Culex tarsalis larvae from a duck club in the Kern District where applications of toxaphene and aldrin were failing were found to be 10, 33, 11, 215 and 1300 times as resistant, respectively, to DDT, toxaphene, lindane, aldrin, and heptachlor as larvae from an untreated area. Larvae from a nearby duck club had a lower range of resistance. Parathion was about equally effective on both treated and untreated larvae.

Culex quinquefasciatus larvae from sewer farms and dairy drains showed considerable resistance to several of the insecticides tested but untreated larvae were not available for comparisons.

Mr. Geib: Thank you, Mr. Gjullin. I think we were most fortunate to have had Mr. Gjullin in the valley this summer carrying on his investigations. His work shows and points out the problem with which we are confronted and makes one wonder what we are going to do about it. We'd all like to go to eliminative control but of necessity we do have to use insecticides. Therefore, I believe continued investigations are certainly in order.

Mr. Lewis W. Isaak, an entomologist, has been investigating these insecticides in the Kern Mosquito Abatement District under the sponsorship of this Association, and will report on some of his follow-up work on Mr. Gjullin's resistance investigations.

Mr. Isaak: I would like to talk with you this afternoon on a subject that many may consider as being dull. *Culex* resistance on a duck club in Kern County. Still, the subject is an extremely vital issue and should serve as a warning to all of you who are involved in the chemical control of mosquitoes. The subject matter will be kept as free from numerical figures as possible as I realize that talking about resistance in terms of parts per hundreds of millions or even billions, may seem quite abstract, and won't mean very much except by comparison. That is, we can fairly well estimate that a strain having an LD-50 at 1-100 million is twice as resistant as one having an LD-50 of 1-200 million. Thinking in terms of these astronomical figures is a little like trying to fathom our national debt. That is, none of us can comprehend just how much four hundred billion dollars really is except that unfortunately, it is four times as much as 100 billion. And it is with this same type of comparison that we determine our degree of resistance.

One reason why the investigations of resistance were continued at the KMAD after Mr. Gjullin's departure was to determine whether *Culex* resistance progressed proportionate with the season, and if so, why. At the time of his investigations in the early part of August, Mr. Gjullin found that resistance to DDT in Ware's Duck Club amounted to 10 times. Up to this time the club had been sprayed only at the normal rate of application, 0.4 pound per acre. The table following lists the sequence in which other insecticides were applied after he made his determinations from this club.

1951 FIELD APPLICATIONS TO WARE'S DUCK CLUB

Date	Spray	Lbs. Acre	Species	Results
Aug. 15	toxaphene	.3	Aedes	100%
Aug. 29	DDT	1.0	Culex	95%
Sept. 5	DDT	1.0	Culex	Negative
Sept. 8	Dieldrin	1.5	Culex	Negative

Results with one pound of DDT per acre were about 95% control on the *Culex* larvae. Six days later it was again sprayed with 1 pound DDT per acre. This time results were negative. So to rid the pond of this small extremely resistant population once and for all, Mr. Geib, the manager, had dieldrin sprayed on at 1½ pounds per acre. But even at this excessive dosage, there was no noticeable reduction in any of the stages of these larvae. Testing of these remaining larvae by laboratory analysis, indicated that DDT resistance on an LD-50 basis had jumped to 105 times and to dieldrin it varied over a couple of weeks from 400 down to 100 times as the influx of mosquitoes from surrounding areas in time diluted the extremely resistant population. All this work was based on a comparison with a strain of non-exposed *Culex tarsalis* larvae which were collected some distance away from any sprayed area. When it was evident that spraying with dieldrin at 1½ pounds per acre was of no avail, all applications to this pond were discontinued. The damage had already been done. Fortunately, continued flooding of this pond eliminated almost all of the desirable *Culex* breeding locations and with the onset of cold weather, the population gradually disappeared. Studies were then shifted to another area showing resistance, Klipstein's. Routine screening was begun from this place and though there were signs of resistance, it was not of great proportions. But it was noted that while the LD-50 wasn't indicating too much resistance, there was always a small percentage of the larvae which were not killed even at the strongest dilutions. Subsequently, the dosage rates were made at higher and higher concentrations to determine just how much insecticide would be necessary to kill all of the larvae.

This was all laboratory work. The following table will illustrate at what dilutions the series was run.

KLIPSTEIN'S DUCK CLUB

4th Stage *Culex tarsalis* larvae

1-100,000	or	10	ppm	90%	kill
1-250,000	or	4	ppm	80%	kill
1-500,000	or	2	ppm	95%	kill
1-666,000	or	1.5	ppm	80%	kill
1-1 million	or	1.0	ppm	78%	kill

1-5 million	or	.2	ppm	78%	kill
1-10 million		.1	ppm	59%	kill
1-25 million	or	.04	ppm	45%	kill
1-33 million	or	.03	ppm	27%	kill
1-50 million	or	.02	ppm	5%	kill

One part insecticide to 5-million parts water is the dilution which generally gives a 100% kill on a non-resistant strain. The increase in dosage as you see, was raised to 5 times, to 8 times, to 10 times, to 20 times and on up to 50 times and still no 100% kill. Now if you have been spraying 0.4 pound per acre for *Culex* control and you had to up your poundage 50 times, this would run the amount to 20 pounds per acre, and just for a 90% kill. And even though you kill 80-90% of the population, you still won't phase that 10-20% of highly resistant mosquitoes which survive and form the nucleus of what may be regarded as super-resistance.

It is a little frightening to us mosquito people when we consider that certain resistant strains of house fles have survived areas covered with 4000 milligrams of DDT a square foot, which amounts to 10,000 resistance. Speaking in our terms, 4000 milligrams amounts to 384 pounds per acre. So you see the 100 to 1000 times resistance that we encounter really isn't so bad yet. For if we ever develop 10,000 times resistance in the field, think of what that would mean in pounds per acre to be sprayed. It actually comes to 4000 pounds of DDT per acre.

We might take all of this philosophically and say, "Well, if we are going to apply DDT with a dump truck, why not also bring along a grader, fill in all the holes with it, level the land with it and thereby do eliminative control through chemical application."

To get serious again, I know that some of you may be saying talk, talk, talk, we don't have to be told that there is resistance, but what is being done about it and can something be done about it. The answer is yes, we can. In mosquito control, we do have one decided advantage in the fact that mosquito larvae are confined to water—we don't have to saturate the entire surface of the globe with insecticide to realize good control and that is our ace in the hole, as we have a much greater chance of surmounting this resistance than say, for instance, the fly people do.

During these past autumn months, we have been doing a great deal of work screening new insecticides. Some of them show excellent promise while other new ones show no improvement over the ones now more commonly used. A few of the new phosphates give every indication of being very fine larvicides. One, 4049, is a comparatively safe phosphate being less dangerous to handle than DDT, its over-all toxicity compares favorably with DDT, and it does kill larvae showing resistance to the chlorinates. However, the present cost of the material runs about four or five times that of DDT. Another new phosphate, EPN, looks especially fine, giving 100% control with as little as ½ ounce per acre on resistant larvae, but it cannot be recommended as yet until its hazard to warm blooded animals is eliminated, is better understood, or a technique of satisfactory application is developed.

Other methods of control are also a definite possibility. At least one chemical company is quite interested in drowning mosquitoes by lowering the surface tension of water to the extent that larvae cannot attach themselves to the water surface. And there are other possible means of control.

The important point is that we recognize resistance now as it's forming. Now it is a matter of adjusting to it and absorbing it before it gets out of hand. I'm quite confident that this can be taken in stride before we resort to applying DDT with a dump truck.

Mr. Geib: Thanks, Lew. I think it's worth a comment to point out that Lew has been doing his investigations for just twelve months as of tomorrow. It seems to me that he has covered considerable ground and I think it's been well worthwhile. Before we go any further, I wonder if there are any questions on his paper. By way of comment, perhaps we have reached another milestone in the operations level of mosquito control agencies. The Kern Board of Trustees wants to do as much eliminative control as possible. They however, have their feet on the ground and realize that eliminative control is not an immediate or complete answer to mosquito control in the valley. The Board members are sufficiently concerned with this insecticide problem that they are now going to put Lew Isaaks on a full time investigations basis paid by the Kern Mosquito Abatement District beginning the first of July.

The next paper will be by Dr. W. M. Hoskins of the University of California.

THE USE OF INSECTICIDES IN MOSQUITO CONTROL HISTORY OF INSECTICIDE USE

W. M. Hoskins
University of California

The present difficulties with chemical control of various insect pests, including mosquitoes, are causing some persons to take a despondent view regarding the future of insecticides. This 'back to the flyswatter' attitude is startling when contrasted with the boundless optimism so prevalent even among experienced entomologists shortly after the advent of DDT. It is worth remembering that these two situations are only extremes in the endless cycle that doubtless will continue as long as men and insects contend for mastery. There has always been keen competition between those on the one side who advocate sanitation, engineering procedures, cultural practices or natural control and those on the other side who chose to rely upon use of poisons. No doubt many a hot argument went on endlessly in the days of the cavemen between those who wanted to fill the cave with smoke from aromatice leaves and those who said that with a little teamwork all the biting bugs could be killed, and there was no need to strangle in the smoke.

The use of smudges of various kinds is, of course, an example of chemical control for the essential oils that distill from many kinds of plants are both repellent and toxic to many insects, especially to mosquitoes and other diptera. The widespread use of odoriferous oils and perfumes in olden times afforded considerable protection from both flying and crawling pests as well as covering up the natural odors of an unwashed age. One must come to relatively recent times, however, before the conscious use of chemicals for protection from biting insects was widely practiced.

L. O. Howard in his book "Mosquitoes" (1902) recalls earlier use of chemicals against mosquito larvae, e.g., oil of undefined nature in 1812 and kerosene in 1845, though this seems doubtful since kerosene did not become an article of trade until after Col. Drake's oil well was developed in the 1860's. Howard personally used kerosene on watering troughs in Ithaca in 1867 (he was only twelve years old then) and in 1892 his large scale test in the Catskills ushered in the modern era of mosquito control. He noted that both larvae and ovipositing females were effected. There was a good reason why kerosene should have been tried rather than some other of the multitude of petroleum products that we know now, for at that time kerosene was widely used for heating and lighting whereas castor oil, neatsfoot oil and other such products still served as lubricants. It may be recalled that kerosene emulsions were recommended by Cook and by Riley about 1880 for control of scale insects on citrus. From this limited beginning the whole vast subject of spray oils with their innumerable modifications of makeup and manner of application grew in the ensuing years.

Mosquitoes have always been looked upon as a nuisance but really serious efforts to suppress them awaited the discovery of their roles in transmission of malaria and yellow fever at the end of the last century. The sanitarians and drainage engineers justifiably took the leading role in all manner of campaigns from gathering old tin cans to draining vast marshes. The cleanup of Havana, of the Canal Zone and of the swamps of central Italy all depended chiefly upon sanitation and drainage though kerosene made a genuine contribution in preventing breeding in cisterns, rain barrels and other bodies of water that could not be eliminated.

It is interesting to remember that the Italian Celli prior to 1901 had tested a wide variety of chemicals against both larval and adult *Culex pipiens* and other species. His choice was wide and included the botanicals as infusions of tobacco, pyrethrum flowers, quassia root; heavy metal salts such as mercuric chloride, copper sulfate, ferrous sulfate, potassium permanganate, potassium dichromate, the alkalies potassium hydroxide, ammonia, lime water; sulfuric and sulfurous acids, formaldehyde, lysol and dinitrocresol. While some were fatal more rapidly than kerosene, the latter was chosen as most practical for larval control.

Celli also tested a wide variety of chemicals versus adult mosquitoes, including fumes of the botanicals pyrethrum flowers, tobacco leaves, eucalyptus leaves, valerian root and quassia root. A variety of plant oils and synthetic chemicals such as vapors from oil of turpentine, menthol, musk, camphor, onion oil, iodiform, naphthalene and asfoetidae were included along with the gases sulfur dioxide, hydrogen sulfide, ammonia, carbon disulfide, acetylene, illuminating gas and formaldehyde. Celli's recommendation for keeping mosquitoes out of sleeping quarters was to burn a couple of tablespoonsful of a mixture of dinotrocresol, pyrethrum flowers and valerian root.

It may be noted that no stomach insecticide was tested by Celli. This is surprising for Paris green had been in wide use in the US since the 1880's and lead arsenate had been introduced as a larvicide by Barber and Hayne in 1921. Perhaps the general dislike of Europeans for arsenic-containing chemicals stems from the professional poisoners of the Middle Ages.

These two substances—Paris green and light oil—comprised the chemicals available for destruction of mosquito larvae until quite recent times, though innumerable variations in methods of preparing and applying them were devised. For instance, to overcome the tendency of P. G. particles to sink and to dissolve, they were treated with oil which retards both processes and made P. G. effective against top-feeding larvae. The extensive work of Dearborn in the 1930's with so-called "greens," i.e. Paris green with other acid groups substituted for the acetate,, was intended to improve the properties of this class of arsenicals and only the increased expense of making them prevented use of these improved materials.

Fortification of oils with spreading agents gave much more durable films while on the other hand the addition of cresols which have a density exceeding that of water made possible the formulation of oils which sink instead of float. Addition of pyrethrum extracts both to larvicidal oils and to spray oil for use versus adults was possible after the toxic ingredients of pyrethrum had been found and methods devised for their quantitative measurement. Mention may be made also of the numerous chemicals used in repellent lotions or sprays but this development is not of much interest to those engaged in destruction of mosquitoes before they become adults.

The relatively simple procedures of using oil and paris green when combined with good engineering and sanitation gave fairly satisfactory results but it was inevitable that the new and more powerful chemicals that began a few years ago with DDT should be tried against mosquitoes. The subsequent story is familiar to all of you. As in so many other cases, DDT was almost too good to believe. The sanitarians and engineers took a back seat. Missiroli, the great Italian malariologist, related before the Fourth International Congress on Tropical Diseases and Malaria in 1948 how a five year program had been inaugurated in 1945 for elimination of malaria from Latina province in Italy. All prophylactic measures such as drainage, oiling and land reclamation and medication with quinine and other drugs were dropped and chief reliance was placed upon use of DDT against adults, and larvae to a lesser extent. For the first two years both mosquitoes and flies almost disappeared and the malaria index dropped dramatically.

Well, the flies became resistant within two years and while anophelines seem to still be susceptible, that is not true with other genera. Too many mosquito control workers who are not primarily concerned with malaria were guilty of putting all their eggs in one basket. There have been protests right along. Perhaps I may be forgiven for recalling that at the meeting of this Association in 1948 I stated that the most important subject in Mosquito control was to get away from complete dependence upon DDT, but few were listening then.

The situation that has developed in mosquito control is similar to that for several other important pests. It is to be expected that sanitarians and engineers will stress the value of their contributions after the temporary eclipse during the DDT honeymoon. On the other hand, some people remain unconcerned because they trust the "someone" will continue to find new toxicants as fast as the old ones become useless. It is by no means clear that resistance to the point of uselessness will develop with all toxicants and much work must be done on that point. The rate of decline in resistance after use of a given chemical is discontinued also must be determined. It is a good thing that the honeymoon was interrupted so soon for now we may return to the use of all available means of solving the innumerable problems of insect control in a somewhat sadder but wiser mood.

Mr. Geib: We've pointed out this problem of the use of insecticides in mosquito control and the developed resistance to the chlorinated hydrocarbons by mosquitoes. We now have a paper by Dr. Leo Gardner, California Spray Chemical Co., "The Industrial Outlook on the Use of Insecticides."

THE INSECTICIDE INDUSTRY OUTLOOK

By Leo R. Gardner
Manager, Research and Development
California Spray-Chemical Corporation
Richmond, California

In meeting with you I feel that I have the privilege of talking to the best qualified group in the United States in the control of mosquitoes. Throughout the history of your Association you have benefited by close contact with the national leaders in mosquito control and in addition you have had the benefit of meetings such as this, calling in the services of federal and other state experts throughout the nation. Your scientific leadership in this field is certainly evident in your accomplishments.

It is indeed a pleasure to be a participant in your meeting in 1952 and to represent industry here. I feel that the invitation to a member of industry to participate in this meeting is a true expression of your confidence in the service industry attempts to render you in the control of mosquitoes and allied problems.

Probably the most characteristic development in the control of pests has been the development of resistance to new organic insecticides. This development of resistance is not only a problem of mosquitoes here but is also a typical problem on mosquitoes in Europe, Africa and in other parts of this continent. Likewise flies, red spider mites, thrips, scale insects and certain other pests have shown a rapid development of resistance to the new organic pesticides.

I know that one of the questions you are most concerned with is the availability of pesticidal chemicals during 1952. Very briefly, sulfur is the shortest item on the chemical list and sulfur is used in the manufacture of most of the products we use. In general, the other chemicals are in satisfactory supply. Containers, lacquer lined drums and other such specialty materials may be short. Allethrin is available in ample supply now and especially so since military requirements for use of Allethrin in aerosol bombs have not been sufficient to limit availability for civilian use. The current anticipated production will bring the total U. S. production up to approximately 500,000 pounds a year by the beginning of 1953. Chlordan is in ample supply for 1952. DDT is currently in ample supply and the final availability of this chemical will probably depend on the development of cotton pests in the Cotton South. In general there will be ample DDT based on current expectations.

Lindane is currently in ample supply. Additional capacity will be in operation during part of 1952, which will better alleviate the tightness of this market due to the heavy demands for military use.

Although present stocks of pyrethrum are very low, imports probably will equal imports received in 1951. Increasing production in Brazil will probably add somewhat to the total availability of pyrethrum. Department of Agriculture requirements for 1952 are set at 5,000,000 pounds. Rotenone supply is reported to be high and imports will depend on demand.

In general it is highly important to anticipate the demand for all of these chemicals and wherever possible to order approximately one-quarter of the 1952 requirements well in advance and then maintain approximately this inventory throughout the season so as to insure the availability of the necessary chemicals for this use.

I know that one of the problems that is confronting all of you is where we are heading in the field of insect resistance and what may be expected. New synergists for use with the currently used compounds will probably be one of the most important developments for 1952. In addition, the extended usage of safened Parathion, other organic phosphates and in addition other chlorinated compounds will probably mark the highlights for 1952.

In the field of benzene hexachloride, probably the most important development for most of you will be the improved availability of higher gamma content technical BHC, which material is generally referred to as FBHC or Fortified BHC. In general, the trend in this field is to make available technical BHC with a gamma content of around 40% to 80% gamma, which materials are known as Fortified BHC.

The pesticide industry has very much the same problem as all other phases of industry; that is, it is confronted with a growing cost of manufacturing, packaging and distribution and to meet these costs; it is extremely difficult to hold to the old price line. Just as costs have gone up in mosquito abatement work, they have also gone up in the production and distribution of chemicals.

In bringing these few remarks to a close, I wish to encourage each of you to promote through daily work, though meetings and through resolutions the encouragement of fundamental research in the field of knowing more about insect resistance. Without such fundamental knowledge it is extremely difficult to forge ahead in this important field. Also to encourage more fundamental work in the field of synergists and in particular synergists that are tied in with a more fundamental knowledge of insect resistance so as to render the insect susceptible to the poison which it now may be able to resist.

I wish also to encourage you to adopt an attitude of flexibility in the use of new chemicals to meet the changing situation.

Insect resistance is undoubtedly the most important problem in front of us and I wish to emphasize the importance of extended fundamental research work aimed at a better understanding of this development.

Mr. Geib: Thank you, Dr. Gardner. Anyone have any questions? I believe his points were of sufficient interest and well enough taken; there's no point in making further comment on them.

We will next have a paper on "Aspects of Insecticide Resistance" by Dr. R. B. March, University of California at Riverside. We are fortunate indeed that both Dr. March and Dr. Metcalf have taken so much interest in this problem.

ASPECTS OF INSECTICIDE RESISTANCE

By R. B. March
University of California, Riverside

The acquired resistance of insects to insecticidal action is not a new phenomenon having first been demonstrated by Quayle (1916) for California red scale resistant to hydrogen cyanide fumigation. However, it has been the recent and spectacular development of resistance to the chlorinated hydrocarbon insecticides including DDT, methoxychlor, lindane, chlordan, toxaphene, and dieldrin, especially by the house fly and various species of mosquitoes, which has really focused attention on the seriousness of this problem.

Work on insect resistance at Riverside has been largely carried out on the house fly as this is, for many reasons, the most convenient species for study and significant findings with regard to resistant house flies are being applied to the study of related resistance problems. The work has developed around two phases; field control studies and more fundamental laboratory investigations. Additional studies are also in progress on resistant mosquitoes, thrips, and scale insects.

Initially, studies were made to measure the extent of resistance in wild house flies and it was shown in 1948 by the topical application of micro-doses that wild California house flies were resistant to more than 300 times the normal LD_{50} dose of DDT. A high degree of resistance was also shown to exist for analogues of DDT, but only a small degree of resistance for other chlorinated hydrocarbons such as benzene hexachloride, toxaphene, chlordan, and dieldrin, and no appreciable resistance was found for the pyrethrins, thiocyanates, and the organic phosphate insecticides (March and Metcalf, 1949a).

In 1949 marked resistance to the other chlorinated hydrocarbons including benzene hexachloride, lindane, toxaphene, chlordan, aldrin, and dieldrin in addition to increased resistance for DDT and its analogues, developed in the field. There was still no appreciable resistance to the pyrethrins, thiocyanates or organic phosphate insecticides, however (March and Metcalf, 1949b). With the spread of resistance of this type, it became increasingly difficult to achieve satisfactory fly control with the commercially available materials, normally used for this purpose, until at the present time in southern California, it is impracticable to use residual type insecticides in most situations (March and Metcalf, 1950).

Stability of Resistance: The stabilty of resistance of the Bellflower (DDT-resistant) strain to DDT and the Pollard (DDT-lindane-resistant) strain to DDT, lindane and dieldrin has been studied in the laboratory under conditions of non-exposure to insecticides since August, 1948 and August, 1949 respectively. In both strains there was an initial period of 15 to 20 months in which no appreciable change in resistance of the progeny occurred, followed by a period in which the number of more susceptible individuals has increased at the expense of the number of more resistant individuals. Five to 10 per cent of the individuals in the two strains, however, have remained at as high a level of resistance as initially and would be capable of forming a nucleus for rapid re-selection. (See Table 1)

In the field the situation is more complicated due to continued selection pressure from field control measures. In general, resistance has continued to increase in the field, especially for DDT even though this material has not been in widespread use since 1948. (See Table 2)

Development of Resistance: To study the development of resistance in house flies, a number of resistant strains have been developed by exposing successive generations of flies to dosages of insecticides so that only a few survivors remain to propagate the next generation. This has been done by exposing either adults or larvae, or both, and strains have been selected which are highly resistant to lindane, 1,1-bis-(p-chlorophenyl)-2-nitropropane, and to DDT plus a synergist, 1,1-bis-(*p*-chlorophenyl)-ethane. Similar studies with parathion have shown the development of only a low order of resistance (7 times) in 60 generations. (See Tables 3 and 4) From these studies it appears that resistance develops in two phases; (a) a preliminary period of gradually increasing vigor which may last over 20 to 30 generations resulting in a five to ten-fold increase in the LD_{50}, and (b) a more rapid increase in resistance over several generations which results in resistance of values of 100 to 5000 times, i.e., virtually complete immunity.

These studies indicate a certain co-relationship in resistance to DDT, lindane, prolan and DDT-synergist combinations, in fact they might be considered respective additional changes in the same basic resistance mechanism. For example, the fact that co-resistance to DDT developed along with resistance to lindane by selection of the laboratory strain with lindane, could indicate that resistance to lindane involves at least a portion of the DDT resistance mechanism. Similar relationships can be deduced from the development of resistance to prolan and the DDT-synergist combination.

The failure to develop resistance, except of a low order, with parathion in 60 generations of selection may be very significant. Although one certainly cannot draw any rigid conclusions, it may indicate that it will not be possible to develop the same order of resistance with the organic phosphates as with the chlorinated hydrocarbons. This initial resistance of seven times may be due to selection from the original and normal population variation and would be of the type which we have called phase (a) above and would not constitute the acquired resistance of phase (b).

Genetic studies involving paired matings of resistant and non-resistant flies have failed to produce any clear cut evidence of simple Mendalian inheritance ratios for the resistance factors. It should be pointed out that these studies are based on kill and not on knockdown which Harrison (1951) has shown is apparently inherited in a simple Mendalian pattern.

Studies of other flies co-inhabiting locations where resistant house flies have developed have recently been undertaken (Lewallen, 1952). In general, it can be concluded that the false stable fly, *Muscina stabulans* and two blowflies, *Callitroga macellaria* and *Phormia regina,* have not developed resistance as the house fly has. (See Table 5) Studies with these and other flies may be of importance in shedding light on the development of resistance and on the probability of the development of resistance in various other species.

Basis of Resistance: Studies of the biochemical mechanisms for the development of resistance have been made using the Schecter-Haller colorimetric technique and ultra-violet absorption spectra to identify metabolic breakdown products of DDT in resistant and non-resistant flies. It has been shown that DDT-resistant flies are able to metabolize DDT to incompletely identified degradation products in greater amounts and at a considerably more rapid rate than non-resistant flies. (See Table 6) Studies involving chromotographic separation of DDT degradation may involve more than dehydrohalogenation to form 2,2-bis-(*p*-chlorophenyl)-1,1-dichloroethylene (unpublished).

An additional significant factor in the degradation studies is the amount of intact DDT which remains in living resistant flies as long as 72 hours after injection. This amount is 25 or more times the topical LD_{50} of susceptible flies and indicates that changes in addition to the degradation mechanism may be involved in resistance. Such additional changes are also indicated by the development of resistance to prolan and DDT-synergist combinations. In this regard, studies have been in progress on fundamental enzyme systems which could be involved in house fly resistance. To date neither cholinesterase nor succinic dehydrogenase has shown any essential differences in resistant and non-resistant flies (unpublished).

Insecticide Investigationss On the basis of the above and similar experiences during the past few years in many parts of the world, it might appear that the residual application of insecticides for house fly control has little promise for the future. Nevertheless, since we know what can be accomplished with effective residual insecticides in comparison with other control measures, the most feasible solution to this critical problem appears to lie in the development of new residual insecticides against which resistance will not develop, the development of synergists for the present insecticides against which resistance has developed or the better utilization of such insecticides so as to prevent the build-up of resistance. The necessity for such a solution becomes even more apparent and critical when one considers other arthropods of both medical and agricultural importance which have been effectively controlled only through the use of insecticides, especially the new organic insecticides. The development of resistance is being reported in ever increasing numbers of species, but important as these cases may be, the potential development of resistance in the remaining numbers is of even greater importance. An unsolved problem of resistance is a most critical threat to our present theory and practice of chemical control.

New Insecticides: On the basis of the studies of the detoxification of DDT in resistant house flies by a dehydrohalogenation mechanism, it seemed that analogues of DDT which could not be dehydrohalogenated might be effective against resistant flies. The compounds Prolan[1] and Bulan[2], although structurally related to DDT, cannot be detoxified by such a dehydrohalogenation mechanism. Studies in the laboratory with these compounds have shown that although they are somewhat less toxic than DDT to non-resistant flies, they are about equally toxic to both non-resistant and resistant flies (See Table 7). Limited field trials with Dilan[3] over a period of two years have shown that satisfactory control of resistant flies for 1 to 2 months can be obtained with residual applications containing 40 pounds of a 50 per cent Dilan wettable powder per 100 gallons of finished spray (March and Metcalf, 1950). Laboratory studies have shown, however, that a field strain of house flies of the DDT-lindane resistance type is rapidly able to develop further resistance to Dilan to as high a level as to DDT (See Table 3). Thus resistance undoubtedly would develop in the field if its use were to become extensive.

On the basis of failures to develop high levels of resistance

[1] 1,1-bis-(*p*-chloroprenyl)-2-nitropropane
[2] 1,1-bis(*p*-chlorophenyl)-2-nitrobutane
[3] A proprietary mixture of 3 parts Bulan and 1 part Prolan.

to the parathion, we have been searching for suitable organic phosphates for use in residual applications for house fly control. Two materials, compound 3456[4] and malathon[5] have appeared promising in labortary tests (See Table 7). These two materials, and especially malathon, have considerably less acute toxicity to laboratory animals than parathion. Their respective acute oral LD_{50}'s to the rat are: Compound 3456, 115-120 mg./kg; malathon, 300 and parathion, 4-15. Preliminary field trials with these two materials have been accomplished, but when used at 0.5 to 4 gallons of a 25 per cent compound 3456 emulsifiable concentrate, or one gallon of a 47.7 per cent malathon emulsifiable concentrate per 100 gallons of finished spray, neither gave satisfactory residual control for more than two weeks. Further exploratory field trials are planned, however.

In addition, an intensive search is being made in tests with both house flies and mosquito larvae for other compounds of suitable characteristics from a collection of over 4000 organic compounds which have been screened against other pests in our laboratories.

Synergists: We have recently studied (March, Metcalf and Lewallen, 1952) more than 100 compounds as synergists for DDT against resistant house flies. Dosage mortality data for combinations of DDT and the fourteen most active synergists are given in Table 8. The toxicities of these combinations when used at a ratio of 5 parts of DDT and 1 part of synergist, were 20 to 140 times greater than that of DDT alone. Increasing the ratio of synergist to DDT increased the toxicity of the combination. However, even a 10 to 1 combination of the most active synergist, bis-(*p*-chlorophenyl)-chloromethane, and DDT was not as toxic to resistant flies as DDT alone to susceptible flies, although it approached within ten times this value.

Synergistic activity was not confined only to DDT, but was also effected with methoxychlor (See Table 9). The relative increase in effectiveness with methoxychlor-synergist combinations was not as great as with DDT-synergist combinations since methoxychlor alone was considerably more effective against the resistant strain than DDT. The synergists are peculiar in that they were ineffective in increasing the activity of DDT against susceptible flies, in fact they appeared to decrease its toxicity somewhat (See Table 10).

When resistant flies were exposed to residual deposits of DDT (200 mg./ft.^{2}) or DDT-synergist combinations (200 and 40 mg./ft.^{2} respectively) a number of interesting observations were made with respect to knockdown activity and time of exposure necessary to achieve 50 per cent mortality in 24 hours (See Table 11). In general, the addition of synergists increased the knockdown activity of DDT for resistant flies to about the same level as DDT alone for susceptible flies. The resistant flies, however, required more than 4 times the exposure to the residual deposits of the combinations for 50 per cent mortality in 24 hours than susceptible flies required for DDT alone. The relative effectiveness of the synergist combination is evident though, since no appreciable mortality in 24 hours was produced by a 3-hour exposure of the resistant strain to deposits of DDT alone although 50 per cent of the flies were knocked down in this time.

Limited field trials with the three best synergists were accomplished at two small hog ranches and two dairies near Riverside. The populations of house flies at these locations showed high levels of resistance of the DDT-lindane resistance type. In general the DDT-synergist combinations gave equal or superior control to any other materials which we have investigated since of the three best synergists (synergists 1, 2 and 3) were formulated as xylene emulsion concentrates and their applications the development of the combined DDT-lindane type of resistance in southern California. Combinations of DDT and each using 20 pounds of DDT and 4-8 pounds of synergist per 100 gallons of finished spray resulted in 5-8 weeks of satisfactory residual control under conditions of very heavy fly populations at the two hog ranches though somewhat less at the two dairies, 3-5 weeks.

A logical consideration in the study of synergists concerns the possible development of resistance to the combinations. Laboratory selection of a field strain of DDT-lindane resistant flies was thus undertaken with a combination of DDT and synergist 2. Rapid development of resistance to the combination to levels as high as to DDT alone before selection, was effected (See Table 3). Further tests with combinations of a number of the other synergists showed that resistance had developed to them as well (See Table 4). These laboratory results presage its eventual development in the field if the use of synergists were to become extensive.

[4] 0,0-diisopropyl-0-*p*-nitrophenyl thiophosphate.

[5] 0,0-dimethyl-S-(1,2-dicarbethoxyethyl)-dithiophosphate.

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TABLE 1—*Stability of resistance under conditions of non-exposure to insecticides. Topical dosage-mortality data in micrograms per female fly, 24-hour per cent mortalities.*

	24-hr. per cent mortalities determined on following dates						
Bellflower Strain Dosage DDT in microg./ female fly	8/48 ***Original Collection***	12/49	2/50	3/51	8/50	11/51	2/52
.01						55	35
.02						65	60
.05						75	65
1.0						70	65
2.0	10	35	55	70	95	70	95
5.0	22				90	95	100
10.0	49	45	50	75	95	100	100
20.0	58	40	70	75	90	95	90
50.0	55	65	60	50	90	100	100
Pollard Strain Dosage-lindane	8/49 ***Original Collection***	3/50	8/50	1/51	6/51	11/51	1152
0.1	18	35	0	0	40	30	20
0.2	45	75	15	25	35	35	30
0.4	61		60				
0.5				40	75	80	70
1.0	82	95	95	65	100	100	80
2.0	100						

TABLE 2—*Survey of field resistance of house flies in southern California 1948-1951. Figures represent average relative resistance (calculated from topical LD_{50}'s) in terms of non-resistant strain as unity, for 12 field strains collected at various localities.*

	1948	1949	1950	1951
DDT	96	440	1300	1800
Methoxychlor	7	21		20
Lindane	6	4	36	28

TABLE 3—*Development of resistance in laboratory. Topical dosage in micrograms per fly, permitting 20 to 40 per cent survival.*

Lindane		Parathion		Prolan [1]		DDT-5 pts. 1,1-bis-(p-chlorophenyl)-ethane 1 pt.	
Generation	*Dosage*	*Generation*	*Dosage*	*Generation*	*Dosage*	*Generation*	*Dosage* [3]
P=laboratory strain	0.01	P=laboratory strain	0.01	Super-P=Pollard strain[2]	0.15	Bellflower P=1951 strain[2] strain [2]	1-DDT
F_1	0.01	F_1	0.01	F_1	0.15	F_1	2.5
F_2	0.02	F_2	0.02	F_2	0.2	F_2	5
F_4	0.03	F_3	0.03	F_3	0.5	F_3	10
F_{10}	0.04	F_{15}	0.04	F_7	0.7	F_4	50
F_{14}	0.05	F_{28}	0.05	F_8	1.0	F_5	100
F_{15}	0.06	F_{34}	0.07	F_9	2.0		
F_{28}	0.08	F_{60}	0.07	F_{11}	50		
F_{29}	0.1			F_{12}	100		
F_{33}	0.2						
F_{34}	1.0						
F_{35}	10						
F_{36}	50						
F_{41}	100						

[1] 1,1-bis-(*p*-chlorophenyl)-2-nitropropane.
[2] larvae and adults both treated.
[3] Dosages shown are in terms of DDT and include, in addition, 1/5 as much synergist.

TABLE 4—*Dosage-mortality data characterizing strains in which resistance was developed in the laboratory as shown in Table 3.*

Compound	*LD_{50} in microg. per female fly* Pretreatment	Post-treatment
Lindane resistant strain rfom laboratory strain		
Lindane	0.010	>100
Dieldrin	0.031	7.5
DDT	0.033	1.0
Methoxychlor	0.068	0.9
Prolan resistant strain from Super-Pollard strain	*(approximate)*	
Prolan	0.1	50-100
Bulan[1]	0.1	6
DDT	>100	>100
Methoxychlor	>100	>100
Lindane	0.5-1.0	2.5
Pyrethrins	2	6
Parathion	0.02	0.032
Prolan + MR_{60}[2]		4.4 + 0.8
DDT + MR_{60}[2]	0.92 + 0.18	3.3 + 0.6

[1] 1,1-bis(*p*-chlorophenyl)-2-nitrobutane
[2] bis-(*p*-chlorophenyl)-chloromethane

DDT-1,1-bis-(p-chlorophenyl)-ethane resistant strain from Bellflower 1951 strain

Compound	*Approximate dose in microg. per female fly for 100% mortality pre-treatment*	*Dose in microg. per female fly post-treatment*	*Topical 24-hr. per cent mortality post-treatment*
DDT + 1,1-bis-(*p*-chlorophenyl)-ethane	5 + 1	100 + 20	50
DDT + bis-(*p*-chlorophenyl)-ethynyl carbinol	5 + 1	100 + 20	48
DDT + bis-(*p*-chlorophenyl)-chloromethane	5 + 1	100 + 20	89
Prolan	.1 — .2	100	41

TABLE 5—*Relative susceptibility of three species of flies co-inhabiting a dairy where house flies are resistant.*

	Topical 24-hr. LD_{50}'s in micrograms per female fly				
	Musca domestica				
Compound	*Laboratory strain*	*Resistant strain from same collection source*	*Muscina stabulans*	*Callitroga macellaria*	*Phormia regina*
DDT	.033	9.5	.027	.004	.024
Methoxychlor	.068	1.3	.014	.0082	.040
Lindane	.01	0.13	.0041	.029	.17

TABLE 6—*Degradation of DDT in a susceptible and resistant strain of house flies injected with 2 micrograms of DDT per female fly as measured by the Schecter-Haller colorimetric method.*

	Micrograms DDT of 2 micrograms injected dose degraded per female fly	
Time interval after injection in hrs.	*Laboratory*	*Super-Bellflower (living flies)*
4	.22	.85
24	.64	1.10
48	.46	1.25
72	.20	1.15

TABLE 7—*Topical micro-drop tests showing 24-hour LD_{50}'s in micrograms per female fly for laboratory, Bellflower and Pollard strains.*

	24-hr. LD_{50}'s in microg./female fly for following strains:		
Compound	*Laboratory*	*Bellflower*	*Pollard*
Prolan	0.095	0.15	0.11
Bulan	0.15	0.18	0.11
DDT	0.033	11	>100
3456	0.086		
Malathon	.56	1.2	1.4
Parathion	.015	.020	.023
Pyrethrins	1.0	.97	1.6

TABLE 9—*Topical application of graded combinations of methoxychlor and synergists in constant ratio of 5 parts to 1 part respectively.*

Synergist		*24-hr. per cent mortalities for following dosages of methoxychlor-synergist combinations in micrograms per female fly:*					
	Methoxychlor	10	5	2.5	1.25	.62	.31
	Synergist	2	1	.5	.25	.12	.06
1		100	100	100	100	82	82
2		100	98	82	90	42	20
3		100	100	100	100	100	62

Methoxychlor 0.3 microg./female fly 24 13% mortality
10 microg./female fly 76 4%
Synergist 10 microg./female fly >10%

TABLE 10—*Topical application of DDT and combinations of DDT and synergists against susceptible flies.*

		24-hr. per cent mortalities for following dosages of DDT and DDT-synergist combinations in micrograms per female fly:				
	DDT	.05	.04	.03	.02	.01
Compound	*Synergist*	.01	.008	.006	.004	.002
DDT alone		67	60	48	32	18
DDT + 1					25	10
DDT + 3		38	23	18	10	12

TABLE 11—*Residual tests with DDT and DDT-synergist combinations against susceptible (Laboratory) and resistant (Super-Pollard) flies.*

	Time in minutes for 50% knockdown		*Time in minutes of exposure causing 50% mortality in 24 hrs.*	
Compound[1]	*Laboratory*	*Super-Pollard*	*Laboratory*	*Super-Pollard*
DDT alone	120	173	20	>180 (5%)
DDT + 1		127		92
DDT + 2		135		94
DDT + 3		160		111

[1] Residues contained 200 mg./ft.[2] of DDT and 40 mg./ft.[2] of synergists.

TABLE 8—*Twenty-four hour per cent mortalities by the topical application of acetone solutions containing graded combinations of DDT and the fourteen most active synergists in constant ratio of 5 parts to 1 part respectively.*

		24-hr. per cent mortalities for following dosages of DDT-synergist combinations in micrograms per female fly					
		Synergist	50	10	5	2.5	1.25
No.	*Synergist*	*DDT*	10	2	1	.5	.25
1	Bis-(*p*-chlorophenyl)-chloromethane		100	100	100	87.5	67.5
2	1,1-bis-(*p*-chlorophenyl)-ethane		100	100	100	85	52
3	Bis-(*p*-chlorophenyl)-ethynyl carbinol		100	98	95	72	48
4	Di-/bis-(*p*-chlorophenyl)-methyl carbinol/ -ether		100	100	90	75	38
5	Bis-(*p*-chlorobenzyl)-sulfide		100	98	98	62	35
6	1,1-bis-(*p*-chlorophenyl)-1-chloroethane		98	100	80		
7	Bis-(*p*-chlorophenyl)-methyl carbinol methly ether		100	98	72	48	32
8	Bis-(*p*-chlorophenyl)-methyl carbinol		100	78	55	48	30
9	Bis-(*p*-chlorophenyl)-vinyl carbinol		100	90	62	22	18
10	1,1-bis-(*p*-chlorophenyl)-ethylene		100	92	48	38	8
11	Dibenzyl sulfide		98	80	50	30	35
12	Bis-(*p*-chlorophenylmercapto)-methane		100	65	50	30	10
13	Bis-(*p*-chlorophenyl)-methane		100	65	28	25	10
14	Bis-(*p*-chlorophenyl)-bromomethane		92	55	25	18	5

DDT—50 micrograms per female fly 20 12% mortality
Synergists 10 micrograms per female fly >10% mortality

Mr. Geib: Thank you, Ralph. Your presentation goes a long way towards giving us a picture of the amount of work that is required to get the basic information necessary to help us in the practical application of these materials. I can see we've run a bit overtime. We ought to get up and stir around a little and take a ten minute recess. I see we have a couple of visitors who came in a bit ago, Mr. Frank Stead, Chief of the Division of Environmental Sanitation in the State Health Department, and he is accompanied by Arvie Dahl, Chief of Sanitation Section, Division of Medical Health Service of the State Office of Civil Defense. We are glad to see you here, gentlemen.

RECESS

Mr. Geib: You've heard considerable about the development of resistance as related to mosquito control, also some on flies. We have with us Mr. Allen Lemmon, Chief of the Bureau of Chemistry, State Department of Agriculture, who will have to leave in just a few minutes, so we're going to change this schedule slightly and ask Mr. Lemmon if he won't present his paper at this time.

AGRICULTURAL PEST CONTROL LAW AMENDMENTS' EFFECT ON MOSQUITO CONTROL

By Allen B. Lemmon

Chief, Bureau of Chemistry, State Department of Agriculture

The present laws governing agricultural pest control are the result of a two-year study by a Joint Legislative Committee on Agriculture and Livestock Problems growing out of persistent demands for effective legislation to curb abuses in the application of pest control materials.

The 1949 session of the legislature passed three laws having to do with this subject. The first provided for licensing of agricultural pest control operators with specific attention given to examining and licensing pilots engaged in the business of pest control for hire. The second provided for issuance of rules and regulations governing the use of injurious herbicides in order to prevent damage to crops from use of these important materials. The third had to do with use of injurious materials.

At your meeting in 1950 I briefly discussed these laws and pointed out that the definition of pest control as used in licensing agricultural pest control operators, did not include control of mosquitoes. After two years operation under these laws the 1951 legislature revised the definition of pest control in the agricultural pest control statutes to make it more inclusive. It now includes the use or application of any pesticide or of any substance, method, or device for pesticidal purposes or for the purpose of preventing, destroying, repelling, mitigating or correcting any disorder of plants, or for the purpose of inhibiting, regulating, stimulating or otherwise altering plant growth by direct application to plants. It is obvious that this includes application of pest control materials for the control of mosquitoes.

The provisions of the chapter do not apply to any person while engaged in any activity defined as structural pest control and required to be licensed under the provisions of the Business and Professions Code, or to preservative treatment of fabrics or structural materials, or to household or industrial sanitation services. In other words, we do not license janitors as agricultural pest control operators. Also, there is no duplication between the operations under the agricultural pest control law and the operations under the structural pest control act, but neither is there any "No Man's Land."

These amendments made by the 1951 session should not in any way affect your mosquito control work but do give you added protection under the law which you may find quite helpful in some cases. If you hire an agricultural pest control firm to apply materials by aircraft as an independent contractor, it must use pilots who have passed an examination and secured a certificate of qualification. Furthermore, if either the pest control firm or the individual pilot are negligent, do unsatisfactory work, or in some other manner violate the law or the regulations, action can be taken against the guilty persons. Actually the action is against the licensee by filing an accusation. The Department holds a hearing on the accusation and renders decision as to whether the case is proved and what the penalty is for such infractions. This should tend to provide you with better qualified individuals with whom to do business.

Our operations in policing pest control operators should provide you with the same protection and aid that has been provided you in connection with enforcement of the economic poisons law to see that the materials provided you are properly labeled, of value for the purpose intended, and correspond to guarantee on the label.

In some of your operations, with particular reference to use of injurious materials such as EPN, you will need to secure a permit from the agricultural commissioner of each county in which work is done. The law with regard to injurious materials which was passed by the 1949 session of the legislature has not been changed and the rules and regulations that were issued under this law require permits to be secured for the following classes of economic poisons:

Pest control materials containing calcium arsenate, standard lead arsenate or copper acetoarsenite (Paris green), when applied in dust form by machine-powered equipment.

Pest control materials containing tetraethyl pyrophosphate (TEPP) when applied in unconfined space as a thermal aerosol. aerosol.

Pest control materials containing parathion.

Pest control materials containing ethyl-para-nitrophenyl thionobenzene-phosphonate (EPN).

The purpose of the regulations and of the requirement to secure a permit is to protect, not only the persons using the materials, but also those who may be affected by such use. It is presumed that you will be familiar with all the necessary precautions and warnings that appear on the labels of these injurious materials and will understand the importance of requiring your men to follow such precautions. You should have no difficulty in securing permit from the agricultural commissioner when you find it necessary to use these materials. Do not apply the materials without a permit as it serves as a protection to you to show full compliance with all the requirements of law.

I wish to bring to your attention a recent decision of the Attorney General, No. 51-11, dated November 15, 1951, concerning liability for damages resulting from the use of injurious materials for pest control. I will not read the whole opinion but only the conclusions which are in reply to two questions submitted by the Honorable Lloyd W. Lowry, Member of the Assembly. Mr. Lowry's questions were:

"1. Is one, who has first secured a permit in accordance with the provisions of Section 1080, Agricultural Code, liable for damages resulting from his use and application of injurious materials for pest control or other agricultural operations in accordance with said permit, irrespective of negligence on his part?

"2. Assume that a person applies herbicides in strict accordance with rules and regulations established by the Director of Agriculture under the provisions of Section 1066.7, Agricultural Code, and as a result of said application, damages or injuries arise to other persons' property:

(a) Is the person who so applied the herbicide freed from liability for damages resulting from his negligent acts?

or,

(b) Is such person liable for said damages, irrespective of negligence on his part?"

The Attorney General's conclusions were:

"The liability of a person for damages resulting from his having negligently applied injurious material for pest control or for other agricultural purposes or from his having negligently applied herbicides, is not affected because of his having secured a permit and having observed the rules and regulations established as provided by Section 1080, Agricultural Code, or his having applied herbicides in accordance with the rules established by the Director of Agriculture under the provisions of Section 1066.7, Agricultural Code. The law of negligence and the measure of damages as they relate to such operations were not changed by the adoption of Sections 1080 or 1066.7, Agricultural Code.

"However, if one applies such injurious materials in violation of the law or the adopted rules and regulations, his acts are evidence of negligence as a matter of law. This evidence of negligence will be deemed conclusive unless affirmatively rebutted by a showing that the act was justifiable or excusable under the circumstances."

In other words, as I understand the matter, if you have a permit to apply injurious herbicides or other injurious materials, liability for damages is not affected because of having secured the permit, but is the same as it would have been before the law was enacted. On the other hand, if a permit has not been secured and application of an injurious material or an injurious herbicide is made in violation of the law, this is evidence of negligence as a matter of law.

If we can be helpful to you at any time in providing you with technical information with regard to operations of any of the laws under our jurisdiction, please feel free to write us. We wish to cooperate.

Mr. Geib: Thank you, Mr. Lemmon. We certainly appreciate your coming down here and taking your time to keep us informed about legislative matters covering the use of insecticides. It's something that perhaps many of us don't give enough thought to and it's certainly something that we could get ourselves in trouble over.

I believe it's been four, five, six years or so since we have had the pleasure of having someone present at our annual conference from the Orlando laboratory of the Bureau of Entomology and Plant Quarantine at Orlando, Florida. I think we're most fortunate today in having Dr. William C. McDuffy, Director of that laboratory report on the present status of research and control of mosquitoes in Florida.

THE PRESENT STATUS OF RESEARCH AND CONTROL OF MOSQUITOES IN FLORIDA[1]

By William C. McDuffie and John C. Keller

U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine

Research on the control of pest mosquitoes in Florida, as well as practical control operations, has been limited almost entirely to the salt-marsh species *Aedes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.), the glades mosquito *Psorophora confinnis* (L.-Arr.), and *Mansonia* (mostly *perturbans* (Walk.). These species occur in far greater numbers than any others and are therefore the source of greatest annoyance over the state. Prior to World War II the principal attention was given to the elimination of breeding by means of ditching, diking, and filling of areas susceptible to periodical flooding by high tides and rains or, in the case of *Mansonia,* by means of swamp drainage or host-plant suppression. Research on larvicides was confined largely to oils, with and without emulsifiers, to pyrethrum-oil formulations, and the available agricultural insecticides. Oils were used extensively for the control of larvae in accessible, heavy breeding areas, but control measures for adults were virtually unknown.

For several years after the discovery of DDT research on the control of mosquitoes was largely restricted to ways and means of utilizing its miraculous effectiveness. As other chlorinated hydrocarbon insecticides appeared, they were evaluated as extensively as DDT. Meanwhile, practical control became almost entirely chemical control, which was so highly effective that both research and control organizations became complacent in the belief that control of mosquitoes was no longer a problem. This complacency was not disturbed by a few reports in 1947 and 1948 of failures of DDT to control mosquitoes. These failures were variously attributed to inferior insecticide, low dosages, improper applications, or unfavorable meteorological conditions, all of which were known to have a bearing on effectiveness. In 1949, however, failures against salt-marsh mosquitoes became frequent in several coastal counties where DDT had been used extensively for four or five years, and proper investigations promptly showed that the failures were due to acquired resistance to DDT. This discovery resulted in a renewed interest in research and control of mosquitoes. The developments to date are covered in this report.

Recent Research with Insecticides

During the seasons of 1950 and 1951 small and large-scale tests were carried out with most of the available insecticides against both larvae and adults, or as prehatching treatments. The tests were conducted in several coastal areas where salt-marsh mosquitoes showed a moderate to high degree of resistance to DDT.

Prehatching treatments. In 1950 applications of dieldrin and toxaphene at 0.5 and 1 pound per acre gave effective control of larval breeding through two to four floodings in areas where larvae were highly resistant, whereas DDT at 1 and 3 pounds per acre provided only fair to moderate control. In areas where the larvae showed slight to moderate resistance similar applications of dieldrin and toxaphene were more effective than in highly resistant areas, and even DDT at 2 pounds per acre provided satisfactory control.

In 1951 extensive tests were conducted to compare the effectiveness of the same three insecticides as wettable-powder and emulsion sprays at dosages ranging from 0.1 to 2 pounds of toxicant per acre. This wide range of dosages was included in an effort to measure more accurately than in the past the effectiveness of the higher dosages. It was not expected that the lower dosages would provide any appreciable control, and this proved to be the case. Irregular flooding of the marshes, however, made it rather difficult to evaluate fully the effectiveness of the various treatments.

Final analysis of available data indicated that as a prehatching insecticide dieldrin was slightly more effective than toxaphene and both were superior to DDT. Emulsion and wettable-powder sprays of dieldrin at 0.5 and 1 pound of toxicant and of 1 pound per acre were highly effective through three or four floodings. At lower dosages both materials were relatively ineffective or were effective for only one or two floodings, but dieldrin was definitely superior to toxaphene at comparable

[1]This work was conducted under funds allotted by the Department of the Army to the Bureau of Entomology and Plant Quarantine.

dosages. All applications of 2 pounds of DDT per acre were effective through two or three floodings, but results at lower dosages were either poor or so erratic as to be considered unreliable.

Results obtained so far indicate that prehatching treatments may be used advantageously on areas that are inaccessible during the active season, or are too extensive for proper coverage with limited equipment and personnel. However, such treatments are not recommended as a general control measure because they are certain to hasten the development of resistance.

Control of larvae. In 1950 comparative tests in areas of moderate and high mosquito resistance showed dieldrin to be slightly more effective than benzene hexachloride (40 per cent gamma isomer) and toxaphene. All these insecticides were markedly superior to DDT. Dieldrin appeared to be equally effective in each area tested, but DDT and benzene hexachloride were distinctly less effective in areas of high resistance. The reverse was indicated with toxaphene.

In large-scale tests aerial applications of 0.1 pound of lindane, dieldrin, and heptachlor per acre in oil solutions gave excellent control of moderately resistant salt-marsh larvae. Heptachlor and lindane at half this dosage and toxaphene at 0.2 pound per acre showed about 90 per cent control. Aldrin at 0.1 pound and DDT at 0.2 pound per acre provided fairly good control. In subsequent tests in a highly resistant area aldrin at 0.2 pound and DDT at 0.4 pound failed to give satisfactory control. The difference in the results with these insecticides in the two areas clearly reflected the influence of resistance on their effectiveness and suggested that similar developments may be expected in time with lindane, heptachlor, and dieldrin, although they are currently highly effective against resistant salt-marsh larvae.

Larvicide research in 1951 was limited to small-plot tests of emulsion sprays and wettable-powder pellets of dieldrin and chlordan and of emulsion sprays of DDT alone and combined with various materials that had shown promise as synergists for DDT in laboratory tests. One series of tests was also made with DDT-benzene hexachloride Tossits (gelatin capsules with 5 ml. of an emulsifiable concentrate containing 12 per cent of DDT and 4.5 per cent of gamma benzene hexachloride).

Emulsion sprays of dieldrin at 0.05 pound and of chlordan at 0.1 pound per acre gave complete control of resistant salt-marsh larvae and were considerably more effective than the same dosages applied as pellets. The pellets of these insecticides were about equal in effectiveness, both showing about 90 per cent control at 0.1 and 0.2 pound of insectcide per acre. These results offered some encouragement for the use of pellets in heavily vegetated areas where sprays do not penetrate in sufficient volume to insure effective control. The Tossits proved highly effective in open pools, but gave generally poor results in heavily vegetated areas, apparently because the vegetation prevented proper dispersal of the insecticide. These results emphasize the fact that thorough coverage of breeding areas is necessary to achieve effective control of larvae.

In tests of emulsions of DDT plus a synergist, only one compound, monoethyl phosphate, increased the effectiveness of DDT, and this increase was insignificant. The other materials either showed no effect or actually seemed to reduce the toxicity of DDT. The results with DDT alone varied from 0 to 100 per cent control at the highest test dosage of 0.05 pound per acre. Such erratic results cannot be fully explained, but have occurred frequently in resistant areas.

Control of adults. In aerial spray tests for control of adult mosquitoes in 1950 lindane and heptachlor proved to be the best insecticides, both giving excellent control of resistant salt-marsh adults at dosages of 0.05 and 0.1 pound per acre. Dieldrin at 0.1 and 0.15 pound per acre was highly effective but similar applications of aldrin gave poor results. DDT was ineffective at the standard dosage of 0.2 pound per acre but gave satisfactory control at 0.4 and 0.5 pound per acre, as did toxaphene at 0.2 pound.

During the past season a study was made of the effectiveness of lindane, dieldrin, and DDT dispersed with ground-fog and spray equipment under different meteorological conditions. Other studies were made to determine the effectiveness and practicability of these insecticides and also of chlordan as outdoor residual treatments for the control of adult mosquitoes around home sites. For the first time in many years no studies of aerial spraying against adults were conducted. However, observations were made on effectiveness of practical aerial spray operations in several districts.

In the tests with ground equipment lindane gave consistently better results than dieldrin, and both were superior to DDT regardless of the type of equipment used. The feature of these tests, however, was not the relative effectiveness of the insecticides but rather the relative effectiveness of the different machines under different weather conditions. The results indicated that the fog machine (Dyna-Fog) was best when the wind velocity was less than 5 m.p.h. and the poorest at wind speeds over 10 m.p.h., while the reverse was true with an experimental model of a light pneumatic spray unit operated on a jeep. A mist blower (Hessian Microsol) was most effective at intermediate wind speeds of 5 to 10 m.p.h. The possible limitations of each type of equipment, as indicated by this season's tests, had not been realized previously, and this may account for the inconsistent results in ground control operations in Florida as well as other states. The results obtained this season emphasize the need for further studies on the use of ground equipment, and an extensive program of this nature is planned in 1952.

The study of outdoor residue treatments was undertaken primarily to determine whether such treatments would effectively control mosquitoes around homes located outside regularly sprayed areas. The tests indicated that applications of 0.5 pound of lindane per acre would provide a high degree of control for two weeks or more. Dieldrin at 2 pounds per acre gave similar results, but DDT and chlordan at 1 and 2 pounds per acre were effective for only a few days to a week. Effectiveness was not apparent during the hours of darkness when adults were migrating from the surrounding untreated area. Under Florida conditions, therefore, outdoor residual treatments are of limited value and are not likely to come into extensive use.

Present Status of Practical Control Work

Most of the mosquito control work in Florida has been concentrated in coastal areas against the salt-marsh species *Aedes taeniorhynchus* and *A. sollicitans.* Up until the end of the war, as previously noted, control work was confined largely to ditching and filling of habitual breeding areas and to treatment with oil in emergencies, or in places where ditching and filling were not feasible. Since the war control work has been largely limited to the use of chemicals, at first DDT and more recently benzene hexachloride and other available materials.

The high point in efficient control of mosquitos, chiefly the salt-marsh species, with chemicals probably was reached in 1946 and 1947. During those years a single application of 0.2 pound of DDT per acre usually was sufficient to control larval breeding and to annihilate existing adult mosquito populations. Since 1947 there has been a gradual but marked decrease in the degree of control with DDT which appears to be proportional to the increase in the resistance of salt-marsh mosquitoes to this insecticide. The decreased effectiveness of DDT, coupled with an unusually favorable breeding season in 1951, resulted in the most acute mosquito problem that Florida had experienced in many years. At times the situation got completely out of hand in some areas despite the best efforts of control workers.

Research by the Orlando, Fla., laboratory of the Bureau of

Entomology and Plant Quarantine late in 1949 showed that benzene hexachloride or lindane would give far better control of resistant salt-marsh larvae and adults than DDT (Deonier *et al.* 1950). Recommendations were therefore made for the use of these materials in those areas where DDT was no longer giving satisfactory control. Districts in which resistance was not indicated were advised to continue to use DDT. Control was generally satisfactory during most of 1950, but DDT began failing in additional districts, resulting in a shift from this material to benzene hexachloride. Before the end of the season, however, a few failures with benzene hexachloride were reported.

During the severe mosquito season of 1951, DDT and benzene hexachloride or lindane were the only insecticides in general use. Most of the control districts used some of both, but on the whole more benzene hexachloride was used than DDT, at least against salt-marsh mosquitoes. Reports indicate that benzene hexachloride gave excellent control of resistant larvae except in a few instances. However, there were many partial failures and occasional complete failures against adults in several coastal districts where salt-marsh species are highly resistant. In one of these districts experimental applications of dieldrin gave effective control of larvae and adults where DDT and benzene hexachloride had failed. This material, however, was not available for use in large-scale control operations. Another district reported satisfactory results under less difficult conditions with chlordan, but this insecticide was not employed elsewhere the past season.

At the present time there is deep concern throughout Florida over the prospects for effective control of salt-marsh mosquitoes in 1952. A review of the results of last season's research and reports on practical control operations in 1951 justify this concern and make one ponder over the future outlook of mosquito control in Florida. Sober consideration of the situation in the light of our present inability to control house flies leads to the belief that in a few years the chlorinated hydrocarbon insecticides now being used may have to be abandoned in favor of more effective insecticides or of our almost-forgotten eliminative control measures. Inasmuch as research to date has not revealed any insecticide capable of restoring chemical control to the high level of effectiveness obtained with DDT, and since there is no assurance that any new insecticide would remain effective longer than DDT, mosquito-control workers are again turning to permanent control measures throughout the state.

In an address before a recent meeting of the mosquito control districts in Florida, John A. Mulrennan, Director, Division of Entomology, Florida State Board of Health, reviewed the present status of chemical control of mosquitoes in Florida and recommended that renewed emphasis be placed on ditching, filling, diking, and other eleminative measures for control. Mr. Mulrennan stressed the fact that such methods are expensive and require considerable time to accomplish results, but are the only means of insuring a permanent solution, whereas chemicals are of only temporary value and would have to be used repeatedly year after year. Recommendations were made that the districts utilize at least 25 per cent of future budgets for permanent control work and that chemical control be considered only as an emergency measure. In line with these recommendations the State Board of Health is sponsoring an addition to the present State Aid Law which proposes that funds be provided to the control districts for eliminative control in addition to the $15,000 now provided for insecticides, equipment, and personnel.

The State Board of Health is also advocating intensive research on the biology and control of mosquitoes. It is their feeling that a complete understanding of the biology and ecology of mosquitoes is necessary to achieve the maximum effectiveness from both eliminative and chemical control measures. The Board also feels that further research is needed to determine the most effective insecticide formulations and methods of application, as well as the optimum time and conditions for application. All these proposals are sound and, if put into effect, should lead to more effective control of mosquitoes and possibly in time to the satisfactory solution of the problem. Meanwhile, the methods and insecticides available must be relied upon to alleviate annoyance.

Literature Cited

Deonier, C. C., T. L. Cain, Jr., and W. C. McDuffie. 1950. Aerial spray tests on adult salt-marsh mosquitoes resistant to DDT. Jour. Econ. Ent. 43 (4): 506-10.

Mr. Geib: Any questions to Dr. McDuffy? Well, he certainly brought home to us that a lot of those things we've been arguing about here for the last two or three years, subvention, resistance and permanent control, are also problems elsewhere. Everything he said concerning problems in Florida seems to correlate pretty closely with our own problems.

Time is moving on so we'll try to hurry a little bit. I'd like to introduce this next paper by saying that since we have begun using DDT and related compounds in mosquito control we haven't paid much attention or given discussion to the technical applications concerning insecticide formulations. We have made a rather cursory study of that and some of us have tended to ignore completely the fact that it takes a properly compounded material to do a specific type of job. Why that's been overlooked and left until today I don't know but at any rate we thought perhaps it would be of interest to cover some of this subject matter. Mr. Gordon Smith, Entomologist, and the new Manager of the Kern Mosquito Abatement District.

Mr. Gordon Smith: In the past few years the subject of proper formulations for mosquito control have been discussed informally and recognized as having a considerable effect on the efficiency of larviciding operations. This is the first time, however, that it has found a place on the program of one of our annual meetings. We have with us today Dr. R. L. Metcalf of the University of California, Citrus Experiment Station and Mr. Wilde of the Griffin Chemical Company. These gentlemen are expertly qualified to discuss formulations from the standpoints of theory and practical application and also of the problems involved in developing and manufacturing the spreading, wetting and emulsifying agents used in these preparations and their incorporation into the required end product.

In the years before 1945 the technical difficulties faced in the use of larviciding materials were comparatively few considering the many ramifications encountered today in the use of the chlorinated hydrocarbons and other synthetic organic insecticidal agents. The word "resistance" was not yet a part of the mosquito control vocabulary. In the areas then under control diesel oil and crankcase drainings were satisfactory general purpose larvicides and Paris Green dust and the New Jersey pyrethrum emulsion were used for special purposes.

Since World War II and the advent of DDT, with the compounds which followed it, much has been possible that was neither practical nor economical before. In mosquito control the low cost of these materials and their low phyto toxicity has made it possible to extend mosquito abatement into areas and spray croplands which would not have been practical using diesel oil. However, as always, with the sunshine a little rain must fall. With the advent of DDT and the rapid growth of mosquito abatement in California after the war, the pendulum of control effort swung to almost total use of chemicals with little effort toward the end of source reduction. This was, in a large part, necessary because of the rapid increase in control area during the four years following the war and the demand for immediate relief by the residents of the areas brought into mosquito abatement. Because of the increasing stability of much of this newly controlled area and the difficulties encountered in the development of resistance toward the chlorinated insecticides, the effort is now swinging back toward a major emphasis on source reduction as an elementary principle of mosquito abatement. However, especially in the rich farming areas of the great central valley, the complete elimination of mosquito sources would be well nigh impossible, so we must look toward a balanced operation of source reduction through education and painstaking contacts, and the use of chemical control measures where this is not feasible.

Since it seems that we must, for good mosquito control, rely at least to some extent on chemical measures, we should re-evaluate our use of these materials to date. This must be done not only to better understand resistance and how we might delay or overcome it, but also to attempt to get the greatest possible effiiciency out of the materials which we are using. The proper formulation of these insecticidal materials is a great factor in this efficiency.

During 1946 and the first part of 1947 mosquito control in California hit a bonanza as far as DDT insecticides were concerned. An emulsion was available from the War Assets Administration at a very low cost, which was truly spontaneous and almost indefinitely stable. It almost seemed that you could put a can of it down beside an infested body of water and larvae would all drop dead.

After this source of supply was exhausted, technical difficulties began to appear. It was soon apparent that the regular commercial emulsions were not satisfactory for mosquito control. Some of them were formulated with emulsifiers which were sensitive to alkaline hardness and broke down in the field. All were formulated for uses which called for an unstable or quick breaking material and these were not satisfactory for application in water as a larvicide.

Much work was done during the winter of 1947-48 by various districts and formulators in an attempt to determine what type of emulsion would be most satisfactory and to develop the formulations. Opinions at this time were divided. Some workers felt that a creaming type which would stratify in the upper few inches of water offered the most promise. Others felt that a completely stable emulsion would be best. Although no laboratory work has been done to give supportive evidence, field experience indicates that a highly to completely stable material is best suited to mosquito larviciding operations. Little work has been with the colloids of various chemicals now being developed. However they are definitely of interest and show promise of possible increased efficiency of control.

Oil solutions of the organic insecticides also have a wide usage in California mosquito control. These have proven more efficient in some areas or for special purposes than emulsions. Little work has been done on critical testing of the inherent toxicities of the oils used and their spreading powers. It has been a practice in many cases to add small amounts of emulsifying agents to oil solutions to enhance their spreading powers. It is possible that especially designed spreading agents might serve this purpose much better either in straight oils or insecticidal solutions with oil solvents.

I will now turn the floor over to Dr. Metcalf and Mr. Wilde who will discuss the subject of formulations from the technical and manufacturers points of view.

SOME PRACTICAL ASPECTS OF EMULSIFIABLE INSECTICIDE FORMULATIONS

T. E. Wilde

Griffin Chemical Company

The purpose of this paper is to provide you with an insight into the problems of practical insecticide formulation from our own particular point of view. We will dwell mainly on emulsible concentrate formulation as it has been indicated that this type of formulation is your main interest and since our view of this field is at the level of formulation origin whereas your view is at the use or application level, it is hoped that this discussion will prove of interest and value.

At the outset, let us establish the fact that the formulation of organic insecticides is still a new and incompletely explored field. I am sure our memories will confirm that the problem of organic insecticide formulation began with DDT during 1942. Since this beginning, literally thousands of compounds have been screened for their insectcidal value, and out of this work has come the many accepted compounds which are at hand in commercial supply for your use and for use in other fields of insect control.

With each new compound has come a new problem of practical formulation. Despite the fact that this is a new field, the progress and conversion of organic insecticides from the publicity stories of 1942 to the everyday tools for insect control as we accept them today is at least a minor miracle and has come about through the perseverance, know-how, and cooperation of the insecticide industry at large. We are but one company working in the field in an attempt to build business and reputation by contributing to the practical solution of its problems. Many other companies are following the same process, and out of the efforts of all working both in competition and cooperation have we been able to show the progress which is in evidence throughout the field. So much for perspective and the broad base.

In the specific discussion of the practical aspects of emulsifiable organic insecticide formulations, it is necessary to recognize a number of separate points; namely, 1—we are dealing with a complex compatibility problem; 2—commercial formulation deals for the most part with the technical grade of materials which contain impurities and side reaction materials to complicate further the chemical compatibility; 3—formulations must be balanced to fit the conditions of mechanical application, storage conditions, and economic considerations.

Once an organic insecticide is established as being effective for a given control problem, literally hundreds of questions must be answered before the most effective formulation involving the insecticide can be made available for field use. It would be impossible to cover each point which is indicated, but we can give you an idea of the problem by covering some of the principal problems which are common to most organic insecticides.

We have already indicated that all formulations present a complex problem of compatibility.

The primary diluents in common commercial use are either aromatic or aliphatic depending upon the solubility requirements of the organic insecticide and these solvents will vary in boiling range, aromaticity, gravity, and other physical characteristics from one manufacturer to another.

Some organic insecticides require secondary solvents such as ketones used in combination with the more common primary diluents and in such cases the problem of formulation becomes even more complex.

Once the concentration limit of the organic insecticide is established by a study of the most suitable solvent or diluent balance, it is of course necessary to select a compatible emulsifier which will be stable in the organic insecticide-solvent combination since one of the most important requirements involved is that of storage stability of the concentrate.

Once this set of balances has been satisfactorily established, it is of course necessary to obtain an emulsion result which is consistent with field requirements.

This is easily said, but let us look at some of the numerous points which must be given consideration before this job is done.

Selection of solvents: In addition to the actual degree of solubility of the toxicant in a given type of solvent, the use of aliphatic versus aromatic solvents has a very definite bearing on the emulsifying characteristics of a given insecticide formulation. The margin of solubility with respect to temperatures encountered in storage as well as the viscosity effect on the concentrate as a whole are important factors. Employing alternate solvents in a given formulation must be accompanied by consideration of the effect the alternate diluents have on the emulsifier used as well as their suitability as solvents for the toxicant.

Reactivity of toxicant: Certain organic insecticides and particularly some of the chlorinated types are reactive and under conditions favoring this reactivity during and after formulation of the concentrate may yield salts which have a nullifying effect on the emulsifying properties of the concentrate. This is accentuated by metallic container surfaces in some instances acting as catalysts and therefore due regard for containers, storage conditions and the length of storage time involved before the emulsifiable concentrate is used must be taken into consideration. Freshly prepared concentrates will eliminate these problems to a very large extent.

Water: The hardness factor of water used to prepare the emulsion has a very definite bearing due mainly to the wide divergence in total hardness encountered in the water available at various locations or areas where a given concentrate is made into an emulsion prior to application. Emulsifiers with a high degree of so-called "calcium and magnesium tolerance" must be selected to offset hard water adversely affecting the emulsion. Calcium and magnesium salts can, in some instances, remove a substantial portion of the water soluble component of an emulsifying agent, thereby weakening the stability of the emulsion. This has the same effect as adding electrolytes to the emulsion. Furthermore, if the emulsifying agent is of such a nature that calcium and magnesium salts occurring in the hard water form water insoluble compounds with any portion or all of the emulsifier, formation of the opposite type of emulsion is promoted and this leads to breaking out of the emulsion. Hot water can act adversely since emulsions are temperature sensitive to some extent. As a rule they are formulated to possess optimum stability at room temperature or say between 40 and 80°F. Heat may cause changes in the emulsion stability by altering specific gravity and viscosity of the concentrate components thereby favoring a coalescence of the finely dispersed particles; by altering the solubility characteristics of the emulsifier constituents towards greater solubility in the water phase with consequent influence on the interfacial film; by creating a higher volatility factor with the solvents involved and in some instances with components of the emulsifier. The presence of excess quantities organic matter in the water can have a bearing in view of possible introduction of soluble components affecting the diluent-emulsifier balance.

Order of adding components: This can have a profound bearing on the degree of dispersion and also the resulting stability achieved in producing an emulsion. To avoid reversion of phases which is experienced occasionally during the process of making an emulsion, it is considered best practice to add the concentrate containing toxicant solvent and emulsifier to the water phase. Inasmuch as most emulsions applied in your type of control activities involve the water as an exterior phase, this is, in our opinion, the best way to achieve it.

Quick and slow breaking emulsions: Generally this characteristic is related directly to the emulsifier content of the concentrate once satisfactory dispersion has been achieved through selection of a suitable emulsifier. While quick breakout of the toxicant on the surface of the object being sprayed may be desired, thereby dictating use of a quick breaking emulsion, spreading and wetting effects may be seriously curtailed when insufficient emulsifier is employed. Furthermore, penetration of a given surface is decreased in many instances when quick breaking emulsions are used.

Creaming of emulsions: Creaming is related to uniformity of particle size and is often influenced by the amount of emulsifier used. It has no adverse influence on the emulsion provided agitation is resorted to in some minor degree, at least, to effect distribution of the components evenly throughout the emulsion before it is applied. Should some phase separation involving the solvent occur in addition to creaming, the emulsion has then broken and special consideration must be given to re-establishing dispersion comparable to the degree of dispersion that existed before phase separation took place.

In the final analysis after due consideration has been given to the numerous physical conditions which must be satisfied in producing efficient emulsifiable concentrates of the many insecticides employed in your control work, the matter of economics enters the picture. This factor if overly stressed can result in loss of real advantages otherwise gained from properly formulated concentrates.

In conclusion may we say these few points covered briefly here are in our opinion some of the most important considerations that should be taken into account in providing suitable emulsible insecticide concentrates for optimum control results in the field.

Mr. Geib: The last paper in this symposium will be presented by Dr. R. L. Metcalf.

(Note: Dr. Metcalf illustrated his talk with molecular models, and demonstrations of emulsifiers of several types.)

EMULSIFICATION AS APPLIED TO MOSQUITO CONTROL

R. L. Metcalf

Division of Entomology, University of California Riverside

Emulsions of water insoluble organic insecticides are commonly used in mosquito control both for larviciding and for the application of residual sprays for the control of adult mosquitoes. These emulsions are generally prepared from emulsion concentrates which are solutions of the toxicants in organic solvents formulated so that they can readily be dispersed as tiny droplets in water.

The formation of emulsions is facilitated by the presence of small amounts of surface active materials (emulsifiers) which lower the interfacial tension between the water and the oil droplets. Emulsifiers are molecules which contain both oil and water soluble groups so that they orient themselves at the interfaces between the oil and water and thus stabilize the dispersed oil. In general, the greater the dispersion, i.e. the finer the oil droplets, the more stable the emulsion. In some cases these oil droplets may reach colloidal dimensions and the emulsion produced may have many of the properties of a true solution. Many thousands of emulsifiers are known with vastly differing properties. Knowledge of these and their intelligent use will greatly improve the efficiency of mosquito control formulations.

Outline of Emulsification

I. Types of Emulsions
   A. Oil in water—where oil is dispersed phase. This is most common in insecticide formulations.
   B. Water in oil—where water is dispersed phase. Used in cosmetics, creams, etc.

II. Properties of Emulsions

A. Breaking Rate—controlled largely by choice of emulsifier

1. Quick breaking — needs strong agitation, breaks rapidly. When used in residual insecticide application leaves heavy deposit on wall, but needs power spray pump.
2. Stable emulsion — requires only slight agitation. Suited for larviciding as it remains in suspension well, needs only slight agitation and thus is suitable for hand sprayers, aircraft sprays, etc. However, this type when used for residual applications promotes excess runoff.

B. Creaming—this results from differences in specific gravity of dispersed and continuous phases. Usually slight agitation will restore homogenous state.

1. Dispersed phase lighter than water, usually kerosene, fuel oil, or xylene. Most suitable larvicide for anophelines.
2. Dispersed phase heavier than water, usually alkylated naphthalene solvent. Most suitable for bottom organisms, culicines or Mansonia.
3. Dispersed phase has specific gravity equal to that of water, 1.0, remains dispersed for longest period —see formulation E.

C. Spreading and Wetting—Emulsifiers improve the efficiency of the insecticide by causing it to spread evenly over the treatment area and to wet the insect cuticle.

III. Classes of Surface Active Agents Used in Emulsions

1. Alkaline soaps which are sodium (hard) and potassium (soft) salts of long chain fatty acids. These are water soluble and do not function in hard water.
   Example—sodium oleate $C_{17}H_{33}COONa$
2. Organic amines which form soaps with equal molecular quantities of long chain fatty acids.
   Example—triethanol amine $N(CH_2CH_2OH)_3$ with oleic acid
3. Sulfates of long chain alcohols. Includes Gardinol, Dreft, etc. These are water soluble but are stable in hard waters, acids and alkalies.
   Example—sodium lauryl sulfate $C_{12}H_{25}OSO_3Na$
4. Sulfonated aliphatic esters and amides. Includes Vatsol, Igepon, etc. Excellent wetting and spreading agents, often used in wettable powders.
   Examples—dioctyl sodium sulfosuccinate $NaSO_3CH(CH_2COOC_8H17)COOC_8H17$
   sodium sulfoethyl methyl oleylamide $CH_3(CH_2)_7CH{=}CH(CH_2)_7CON(CH_3)CH_2CH_2SO_3Na$
5. Mixed aliphatic aromatic sulfonates—includes Santomerse D and others.
   Example—sodium decyl benzene sulfonate $C_{10}H_{21} . C_6H_4SO_3Na$
6. Nonionic type-ethers, alcohols and esters of polyhydric alcohols and long chain fatty acids. Includes Tritons, Atlox, Spans, Tween, etc. These are of varying degrees of water and oil solubility, are effective under most conditions of hardness, and acidity or alkalinity and are most used in emulsifiable concentrates.
   Example—glycerol monoleate $C_{17}H_{33}COO\text{-}CH_2CHOH\text{-}CH_2OH$
7. Natural gums, proteins, carbohydrates, alginate, etc.
   Example—blood albumin
8. Finely divided solids such as bentonites, flour, etc.

IV. Formulation of Emulsions

A. Choice of Ingredients—these will depend on:

1. Nature and solubility of toxicant
   a. Oil soluble
   b. Water soluble
2. Type of formulation desired
   a. Tank mix—separate ingredients added to spray tank. Emulsifier water soluble
   b. Emulsion concentrate—ingredients combined by dissolving in organic solvent. Emulsifier oil soluble.
3. Type of application, considering such factors as:
   a. Degree of agitation in spray equipment
   b. Desired speed of breaking of emulsion
   c. Wettability of surfaces or vegetation necessary
   d. Hardness of water where used—many emulsifiers which work well in soft water fail completely in hard waters. Sea water presents an especial problem. Non-ionic emulsifiers are much less sensitive to salt effects than ionic emulsifiers.

B. Compatibility of components of emulsion concentrate—certain chlorinated hydrocarbon insecticides break down slowly to form hydrochloric acid which adversely affects the emulsifier performance and attacks metal containers. This decomposition is accelerated by alkali and by traces of iron and moisture. It may be retarded by the presence of a HCl acceptor.

1. Test by storage of finished concentrate, preferably in glass container at elevated temperature (130°F.)
2. Immerse strips of proposed container in emulsion concentrate to see if this will promote decomposition. Most emulsion concentrates of insecticides must be stored in plastic or lacquer-lined containers.
3. Low temperature tests (0° F. or lower depending on where stored)—the solubility of the toxicant in certain solvents decreases rapidly at low temperatures and formulations very satisfactory for summer use often crystallize out and become very difficult to restore.

V. Typical Emulsion Formulations which may be used in mosquito control[1]

1. Chlordan

A. Chlordan	45%
Kerosene	47.5%
Atlox 1045A	7.5%
B. Chlordan	50%
Trex 80	50%

This formulation produces a solvent free colloidal suspension of chlordan which is very stable.

2. Toxaphene

C. Toxaphene	60%
Kerosene	30%
Atlox 1256	10%

Toxaphene emulsion concentrates often decompose slowly and liberate HCl which prevents proper emulsification. Compounds which combine with HCl will retard this process. Pyridine for example will often restore proper emulsification to such a deteriorated concentrate.

3. DDT

D. DDT	25%
Xylene	73%
Triton X-100	2%

This formulation has low emulsifier content to prevent excess runoff in residual spraying.

E. DDT 25%
   Kerosene 10%
   Sovacide 544C 60%
   Atlox 1256 5%

This formulation has a balanced specific gravity of the concentrate at about 1.0 to produce very slow creaming with moderate emulsifier content.

F. DDT 25%
   Xylene 50%
   Triton X-100 25%

This formulation emulsifies in either fresh or sea water with a minimum of agitation and is excellent as an all-purpose mosquitocide especially for military purposes.

4. Benzene Hexachloride and Lindane

G. Lindane 20%
   Velsicol AR-60 72.5%
   Atlox 1045A 7.5%

This formulation has a lower flash point than the xylene formulations such as D and F.

5. Aldrin and Dieldrin

H. Aldrin or Dieldrin 25%
   Xylene 70%
   Atlox 1256 5%

6. Heptachlor

I. Heptachlor 25%
   Xylene 70%
   Atlox 1045 5%

7. Parathion

J. Parathion 50%
   Thiosolve 50%

This formulation produces a very stable, solvent-free, colloidal solution and also has reduced hazards of skin absorption over the solvent-type formulations.

[1] All percentages by weight.

TABLE 1—*Solvents Commonly Used for Preparation of Emulsion Concentrates for Mosquito Control.*

Solvent	*Specific gravity 20° C.*	*Boiling point ° F.*	*Flash point ° F.*	*Solubility in grams per 100 ml. solvent 25° C.* DDT	lin-dane	toxa-phene	al-drin	hepta-chlor
kerosene	0.82	147-261	100-165	8	2	280	28	19
xylene	0.880	135-145	80	60	25	450	235	102
methylated naphthalenes	0.98-	240-290	245	60				82

Mr. Geib: Thank you, Mr. Wilde, Gordon and Bob. As we've run overtime, Embree Mezger, who was going to talk about Diesel Oil-DDT Toxicity Studies on Salt Marshes has requested that his paper be not presented, but you will find it printed in the proceedings. I am indeed sorry that we've run overtime so much, and I appreciate your patience. On behalf of the Association, I wish to express appreciation to all of you gentlemen who participated on this symposium and traveled many miles to come here and present these papers. In a personal vein, I would like to add that it's with sincere regret that I have left mosquito control. I have become a farmer, and it is with real regret that I am leaving this field. I hope that I will not lose my many friends and associations acquired during recent years as a mosquito control worker. I am looking forward to seeing you again as frequently as possible.

SALT MARSH FIELD STUDY FOR TOXICITY COMPARISON OF DIESEL OIL, DIESEL OIL-DDT CONCENTRATE, AND DDT-WATER EMULSION ON AEDES DORSALIS (MEIG.) LARVAE

Mezger, Embree G.[1], *Aarons, Theodore*[2], *Gray, Harold F.*[3] *and Onishi, Koichi*[4]

Repeated failures of Diesel oil and Diesel oil-DDT solutions to obtain high mortality in routine operational practices prompted the development of a field test project on the uncontrolled marshes of Sonoma County. This cooperative study between the Alameda County and the Solano County Mosquito Abatement Districts was conducted during the summer of 1951.

The San Antonio Creek Marsh, located on the west side of Petaluma Creek approximately 4 miles south of Petaluma, was used as the test area. This characteristic salt marsh site covered fifteen acres. The conspicuous vegetation throughout the area was the common pickleweed, *Salicornia ambigua.*

Each monthly high tide through the summer flooded the test site, resulting in high density hatches of *Aedes dorsalis* (Meig) larvae. Using both the pint dipper and the sampling technique of Hess (1941) (4" diameter net sweeping 3' of water surface) the average larval density was 156 per square foot or approximately 6,500,000 per acre.

MATERIALS AND METHODS

Four standard Diesel oil brands were used in the oil testing phase: Shell, Signal, Union and Tide Water Associated. These consisted of the brands most commonly used by the mosquito control agencies in the San Francisco Bay area. (Table I).

A commercial sample of technical grade DDT was used in all formulations. A 25% DDT mixture, using xylene and no emulsifier, was added to Diesel oil to make up the different percentages. (Table II). A xylene-DDT-Triton x-100 water emulsion was used for a direct overall comparison with the Diesel oil, and Diesel oil-DDT solutions.

Individual test plots, consisting of 1/16 acre areas (17 yds. x 8.5 yds.), were marked off on the marsh. Twenty-six plots were used in a single test. One-sixteenth acre plot size proved to be a convenient test area. Many such plots can be marked off in a relatively small larval source area, thereby allowing for several replications of each test material.

Pre-and-post larval counts were made on each test plot. Counts made prior to larvicide application were taken throughout the entire plot while post-larval counts were made near the center. By restricting post-larval counts to the center of the plots, the possibility of larvicide materials transferring from on plot to another through wind action or general water diffusion was minimized.

One-and-one-half gallon hand pressure sprayers (B & G Mfg. Co.) were used in applying the toxicants. Harang Engineering Company No. 8002 fan type nozzles were employed. The spray rate was timed so that the surface of each plot received two passes of larvicide. After each plot was sprayed, the sprayers were rinsed with water.

Encouragement and technical assistance during the studies was supplied by Dr. R. M. Bohart, Assistant Professor of Entomology, University of California, Davis; by H. C. Pangburn,

[1] Entomologist, Solano County Mosquito Abatement District.
[2] Assistant Manager, Alameda County Mosquito Abatement District.
[3] Engineer-Manager, Alameda County Mosquito Abatement District.
[4] Assistant Entomologist, Alameda County Mosquito Abatement District.

Manager, Solano County Mosquito Abatement District; and G. Paul Jones, Manager, Marin County Mosquito Abatement District.

RESULTS

An evaluation of four brands of Diesel oil (Shell, Union, Signal and Tidewater Associated) gave indications that no single brand was decidedly more toxic to larvae than others. (Table I). Also 12 and 8 gallons of Diesel oil per acre gave about the same mortality while 4 gallons of Diesel oil per acre gave a slightly lower mortality.

Using the Diesel oil-DDT solutions (Table II), results obtained indicated that when materials containing ½% and 1% DDT were applied at 8 and 4 gallons per acre, the average comparative mortality was nearly the same. 8, 4 and 2 gallons per acre containing ½% and 1% DDT failed to give a 100% mortality. The highest mortality obtained was effected through the application of 8 gallons per acre at ½% (0.35 lbs./acre) and 1% (0.7 lbs./acre). Average mortalities obtained were 94.1% at ½% DDT and 96.5% at 1.. DDT. Shell Diesel oil was used in all tests of Table II.

Two and a half gallons of DDT water emulsion were used at the rate of 0.2 lbs./acre. Average mortality was 97.6%

TABLE 1—*Diesel oil toxicity field test. Aedes dorsalis larvae, 4th instar salicornia salt marsh, brackish water.*

Gallons Per Acre	*Average % Mortality*			
	Shell	*Union*	*Signal*	*Associated*
12	99.5	99.1	99.5	93.9
8	99.0	94.1	91.1	90.0
4	83.8	84.8	86.3	85.2

TABLE 2—*Diesel oil-DDT toxicity field test. Aedes dorsalis larvae, 4th instar salicornia salt marsh, brackish water.*

Gallons Per Acre (Shell)	*Pounds Per Acre-DDT*		*Average % Mortality*	
	1/2%	*1%*	*1/2%*	*1%*
8	.35	.70	94.1	96.5
4	.175	.35	91.3	96.4
2	.08	.175	75.4	88.1

TABLE 3—*DDT emulsion toxicity field test. Aedes dorsalis larvae, 4th instar salicornia salt marsh, brackish water.*

Pounds Per Acre	*Gallons Per Acre at 1%*	*Concentration % Mortality*	*% Mortality Average*
.20	2.50	99.5	
.20	2.50	100.0	
.20	2.50	100.0	
.20	2.50	98.6	
.20	2.50	100.0	97.6
.20	2.50	99.6	
.20	2.50	94.6	
.20	2.50	92.2	
.20	2.50	99.8	
.20	2.50	93.1	

SUMMARY AND CONCLUSIONS

Tests conducted to determine the toxicity of three larvicides, Diesel oil alone, Diesel oil-DDT solutions, and the DDT water emulsion, on fourth instar larvae of *Aedes dorsalis* indicate the following:

1. 12 gallons of Diesel oil failed to give 100% mortality (99.1%-99.5).
2. 12 and 8 gallons of Diesel oil per acre gave about the same mortality. The 4 gallons per acre applications resulted in a relatively low mortality.
3. No one brand of Diesel oil used was appreciably superior to other brands in toxicity to the larvae tested.
4. The Diesel oil-DDT solutions—8 gallons per acre at ½% DDT (0.35 lbs./acre) and 8 gallons per acre at 1% DDT (0.7 lbs/acre—failed to give a 100% mortality.
5. The Diesel oil-DDT solutions of 8 and 4 gallons per acre at ½% and 1% DDT gave similar average mortalities. Relatively low mortality was obtained from 2 gallons per acre with both ½% and 1% DDT.
6. The DDT water emulsion at 0.2 lbs. per acre gave consistently higher mortality than the other two types of materials used. This comparison was based on gallon volumes and pounds per acre.

Literature Cited

Hess, A. D., 1941. New Limnological Sampling Equipment, Limnological Soc. of Am., Spec. Pub. No. 6.

EVENING SESSION

OPEN HOUSE, FIELD STATION OF BUREAU OF VECTOR CONTROL, AGRICULTURAL CAMPUS FRESNO STATE COLLEGE

8:00 P.M.

The field station was thrown open to visitors, and the operations, projects and equipment of the station explained. Colonel Carpenter also projected a series of Kodachrome slides illustrating the problem of sylvan yellow fever in Panama and Costa Rica.

FOURTH SESSION

STUDENT UNION HALL, FRESNO STATE COLLEGE FRIDAY, FEBRUARY 15, 1952, 9:00 A.M.

President Henderson: I welcome you again this morning to our fourth session of our 20th Annual Conference. In the reports that were given yesterday, the report of the Membership Committee wasn't given. I thought it might be interesting to give you the number of members of our Association that we had as of January 21st. I believe there are a few more members of this Association now. As of August 18, 1951, we had 22 corporate members. As of January 21st, 1952, we had 38 corporate members. As of August 1951, we had 25 associate members; as of January 21st we had 45. We had as of January 21st one sustaining member. However, I believe it goes into probably half a dozen or more now.

I will now turn the first half of the morning program over to Bob Peters, the Vice President of the Association.

Mr. Peters: Will the members who are on this panel please come forward? Our purpose is to approach the subject of mosquito source reduction in an informal manner. I hope that either members on the panel or anyone in the audience who has anything to contribute will participate. In starting to discuss the subject today we should have consideration of the terms we are using. First of all, the terms "permanent control" and "semi-permanent control" have been used. They may be good but they don't exactly represent what is intended. "Eliminative approach" is another. I believe that the terms which come nearest are either "mosquito source reduction" or "mosquito source minimization.."

In selecting our topic, we decided that it was in order to present the panel in two parts. I prevailed on our immediate past president, Ed Smith, to take the second half of our panel discussion, and I think that I have perhaps the easiest part. The first part of the program is "What is now being done in California in the way of source reduction programs." But in order to have a basic understanding of what we are attempting to do today, it is in order that we have an historical review, and we prevailed on Harold Gray to present this. I introduce Harold F. Gray, the Engineer-Manager of the Alameda County Mosquito Abatement District, to present the "Historical Highlights of Mosquito Control in California."

HISTORICAL HIGHLIGHTS OF "PERMANENT" MOSQUITO CONTROL IN CALIFORNIA

By

Harold Farnsworth Gray

Engineer-Manager, Alameda County Mosquito Abatement District

The rather considerable preoccupation of mosquito abatement workers in California in recent years with the problems of mosquito control through the use of the new chlorinated hydrocarbon insecticides, of which DDT is a type, has possibly caused some in this audience to think that the rather sudden interest in so-called "permanent" control measures is a new or at least recent change in ideas. On the contrary, that type of control which seeks to reduce to the least practicable extent the water available for larval habitats is the earliest and still the most basic concept in mosquito control operations in California.

The first mosquito control operations in California were performed in the vicinity of San Rafael in 1903, and near San Mateo and Burlingame in 1904 and 1905. Ditching of the salt marshes to minimize the pools which were producing *Aedes dorsalis* and *Aedes squamiger* by the billions, was almost the only idea involved, though it was recognized that the use of oil as a supplementary larvicidal measure might be helpful to a limited extent. In the period from about 1909 to about 1935, N. M. Stover most successfully applied this basic idea to the salt marshes in San Mateo, Marin and Contra Costa counties, though it must be admitted that from about 1930 to the last few years, when Paul Jones took over, Marin County practically abandoned the ditching concept and substituted oil spraying, with such poor results as to give mosquito control a "black eye" in the opinion of many people.

In 1910 began the first anti-*Anopheles* malaria control work in California, first at Penryn in Placer County, followed by Oroville in Butte County and by Bakersfield in Kern County. These campaigns, supported by voluntary contributions from private citizens, and greatly limited by meagre funds, were directed almost strictly against *Anopheles freeborni,* and were among the earliest "species sanitation" campaigns—in fact, they began long before Swellengrebel coined that term. Although they were limited as demonstrations, and considerable oil spraying was done, nevertheless drainage was not lost sight of, and was recognized as the basic measure when combined with care in the use of irrigation water. In fact, as early as 1911 Herms was warning against the excessive application of irrigation water, not only because it helped to increase malaria, but also it destroyed agricultural land by alkali. The area around Traver became a fine "horrible example" of failure to heed such warnings, and to this day has not recovered.

If you will look at page 263 of the Fourth Edition of "Medical Entomology" by W. B. Herms, you will see a picture of a ditch put in to drain an *Anopheles* producing marsh near Penryn. That ditch was dug in 1910 by a young man named Gray, who also took the picture. He is still proud of his handiwork. Being naturally lazy and averse to unnecessary repetitive work, he put the ditch in at the cost of a lot of sweat so as to avoid frequent spraying of that swamp. He also did not see why the local farmers should make his job harder than necessary because they let their irrigation water run on and on, long after the ground had given obvious evidence that it was saturated. So he expostulated strongly with the farmers about this careless practice, just as some of you are beginning to do today—and with about the same effect. The next year he was at Oroville, still wedded to the idea that a round point shovel was mightier than the spray can, and still expostulating with irrigators. For the next two years he went up and down the state, alternating with W. B. Herms on the Agricultural and Horticultural Demonstration Train, preaching the necessity of conservation of irrigation water, and the imperative need for drainage, if malaria and mosquitoes were to be controlled in California.

In 1912 the Los Molinos Land Company in Tehama County was going bankrupt because an epidemic of malaria in this new irrigation project caused purchasers to throw their farms back on the company. The company appealed to Herms, who sent a young fellow named Gray up there to see what could be done. The problem was simple, and the cure obvious: too much irrigation with no provision for drainage. No wonder malaria and *Anopheles* flourished! Although oil as a larvicide was recommended as an immediate relief, stress was put on drainage and greater care in the use of water. As soon as the manager, T. H. Means, put these recommendations into effect, malaria faded away and the project became successful.

Also in 1912, San Diego asked for help with their affliction of *Aedes taeniorhyncus* and *Aedes squamiger*. The presence of swarms of these mosquitoes did not promote the tourist business. Again Herms sent Gray down there, and again the logic of the local situation called for emphasis on salt marsh ditching, with supplemental oiling. In this case, however, the advice was not followed; they sprayed rather futilly, and did little ditching, and it was many years before the mosquito nuisance was even passably reduced.

In the fall of 1917, the Anderson-Cottonwood Irrigation District went into operation in Shasta County, and in 1918 the area had a terrific epidemic of malaria. Leakage from the new canals and laterals provided hundreds of acres of shallow seepage water ideally suited to the production of*Anopheles freeborni.* Gray, who was then State District Health Officer, reported to the State Board of Health on the need for drainage to control the seepage water (also measures to reduce the seepage). But on a visit in 1937, with Dr. L. L. Williams, Jr., of the U. S. Public Health Service, Gray observed several of the original seepage areas still undrained and still producing a moderate amount of *Anopheles freeborni.*

It is interesting to examine the Proceedings of this Association since 1930, when they began to be recorded. In practically every year you will find articles and discussions on drainage as a means of eliminating larval habitats, and from the discussions it is apparent that drainage was considered to be a basic factor in mosquito control in California. A cursory examination of these proceedings also indicates that excessive application of irrigation water was also a primary headache to the "mosquito man" of those days. Two quotable quotes struck my eye—in 1930 Gray stated "The airplane cannot supplant drainage but can possibly be used economically as an adjunct to drainage"—and in 1932 C. G. Hyde said "Temporary measures result in permanent taxation."

After about 1943 our Proceedings appear to show a marked obsession with DDT and its analogues. This obsession with a new idea or gadget is not peculiar to "mosquito men," but we seemed to have acquired it in a particularly virulent form. But in spite of the disease, I find that there was one paper in 1948 by Campbell on "permanent control." In 1949, at our joint meeting with the American Mosquito Control Association, I took occasion in my Presidential address to enter a protest against the then current obsession with temporary and insecticidal methods of control. I thought this protest had passed almost unnoticed, but the next year (1950) I was asked to speak further on the subject, which became the paper given in those Proceedings and known to you as "Which Way Now?" That same year we began to have papers and discussions again on water management and control, and Mulhern conducted a symposium on eliminative control measures, which was participated in by Kimball, Jones, Sperbeck, Portman, Murray, Ed Smith, Russell, DeWitt, Rolland Henderson, Bob Peters and Gray.

Last year John Henderson presented an excellent study on irrigation as related to mosquito control problems, and again this year we have this symposium on "mosquito source reduction." Possibly we have at last come up with a better descriptive phrase for our basic necessity in mosquito control, and until a better term or phrase is coined, I am willing to go along with it. But I think it should be pointed out that the logic of events is inexorably forcing us to a re-acceptance of the fundamental idea that the "shovelologist" and his works are the foundation on which successful and economical mosquito control must be built. If mosquito tolerance to the chlorinated hydrocarbon insecticides has again compelled us to re-examine and re-use this old but perennially young concept, then it has been a valuable lesson. But above all, let us eschew unnecessary work. The constant repetitive application of insecticides is generally useless, unnecessary work, when the application of common sense and a little public education and the application of engineering ingenuity to our problems, through water conservation and drainage, can reduce unnecessary repetitive work to a minimum. This will in the long run redound to the benefit of the taxpayer, the farmer, the business man and the public generally, and we will receive better recognition for a job well done at minimum effort and worry on our part.

Mr. Peters: I don't know whether I gained this thought listening to Harold, or whether it's been something that's come as a consequence of thinking about this subject for awhile, but perhaps the slogan which a flour company uses may have a certain amount of practical application, "Eventually, why not now?" I think that history indicates that we are again facing the same issue. "Eventually, why not now?"

I would like to impress on the remaining participants that we have had quite a bit of information in the past on what individual programs are actually accomplishing in this state. In this presentation I prefer that the members of the panel approach the subject from this standpoint: What is your problem? Secondly, why have you proceeded as you have to overcome your problem? And third, what have been your methods and your tools to accomplish your end? The first topic that we are going to consider is "Drainage for Source Reduction," and I have asked Edgar Smith, Manager of the Merced County MAD to initiate the discussions.

DRAINAGE FOR MOSQUITO SOURCE REDUCTION

Edgar A. Smith
Manager, Merced County Mosquito Abatement District

It would appear to be obvious that any type of drainage which removes standing water from a field or roadside and carries it to a drainage channel or natural stream is of necessity performing a mosquito source reduction function. This simple fact is the basis of the policy and practice of the Merced County Mosquito Abatement District in regard to "permanent" or "eliminative" control which we prefer to call mosquito source reduction.

Our mosquito source reduction program in Merced County has many facets. First is actual performance of the drainage work (at cost or less) as an aid to the individual farmers concerned and as a demonstration for other farmers to see. Second is cooperation with other agencies also interested in drainage problems. Third is a public relations and education program designed to acquaint the farmers with the advantages of drainage and inform them as to the help obtainable in solving drainage problems through the mosquito district and other agencies.

The Merced County Mosquito Abatement District is in the drainage business, at present owning and operating a Fordson tractor and ditcher, an Allis Chalmers HD-7 tractor and dozer with two ditchers and a pull-type grader, and a Link-Belt Dragline with ½ yard bucket. All of this equipment is handled in the same way. Individual farmers or groups of farmers contract with the District to have drainage construction or maintenance work performed. The District enters into such agreements only when such work will eliminate or reduce an actual or potential mosquito hazard as shown by the District records; specifically the inspection-treatment record card and the section survey map sheet. These cooperative drainage projects may involve only one farmer or they may involve as many as twenty or more property owners. Most of the projects carried out by the District so far have involved installation of drainage systems in irrigated pastures. These are usually designed to carry off the excess irrigation water at the lower end of the checks to a drainage channel where the mosquito larvae can be eaten by mosquito fish or can be more easily sprayed if necessary. This type of drainage after successful completion of a project of this kind is exemplified by the statement made by Mr. Elmer Murchie, Manager of the Crocker-Huffman Land & Cattle Company of Merced. Mr. Murchie credited the Merced Mosquito Districts's drainage program with three positive benefits to them: 1) Relative absence of mosquitoes in the area with drainage systems making it possible for irrigators to work and for cattle to eat unmolested; 2) Increased yield of pasture grass; 3) Consequent increase in the weight of beef cattle.

In addition to contracting with the farmer to do the drainage work at cost, the Mosquito District helps the farmer in other ways. Some of the projects are promoted by the District on its own intiative while others are requested, but in both cases District personnel perform the "leg-work" necessary to get all the property owners involved interested. The District sponsors meetings of such groups and provides free legal and engineering advice. Any surveying necessary is done by the District with no charge. If hand work is needed the District provides a crew of rehabilitation center labor with no charge. If easements are needed, the District handles the negotiations. If concessions are needed from other governmental agencies the District makes the arrangements. All in all the Merced County Mosquito

Abatement District is making available to the farmers drainage at a very low cost.

This type of drainage program reduces the area requiring spraying in some individual pastures by as much as 95%. It means that operators instead of having to spray entire fields, spray only a few residual drains in the field. It also means increased yield to the farmer and consequently increased good will for the District.

We have no illusions as to the impact of our drainage program on the county as a whole. We regard our program as a long range approach and our individual projects as demonstrations of what can be done. We realize that there is more to be done by way of drainage in Merced County than any one organization without unlimited resources could ever hope to do. For that reason the second phase of our program is an important one—the matter of cooperation with other agencies. A year ago the Mosquito District took the initiative in organizing the Merced County Water Conservation Committee. Membership of the group includes about thirty-five organizations concerned with water problems in the county, such as the irrigation districts, canal companies, drainage districts, County Health Department, County Road Department, County Planning Commission, Bureau of Reclamation, State Department of Fish and Game, local sportsmens' associations, etc.

The working sub-committee on drainage has attempted to coordinate work on drainage being done by the various member organizations. This has greatly facilitated cooperation. The Merced County Mosquito Abatement District has received excellent cooperation on drainage projects from the Merced County Road Department, the Merced Irrigation District and the Soil Conservation Service of Los Banos.

Any reduction of mosquitoes through drainage so far is infinitesimal compared to what is left to be done, but it is at any rate a step in the right direction. Further accomplishment in any marked degree will depend in large part on the cooperation obtainable from other agencies as well as from the farmers themselves.

The public relations and education program starts with each and every employee of the District, as they are all required to be able to discuss the District's drainage program intelligently with anyone. However, it is the operators and the foremen who do the bulk of the contact work with individual farmers. The subject of mosquito control drainage is covered in the annual illustrated talks given to the grammar schools and high schools throughout the county. Special talks on the drainage program of the District are given to service clubs, farmers' organizations, etc. News releases and feature articles have amply covered the District's drainage program. Through the medium of public meetings, panel discussions, etc., the Merced County Water Conservation Committee has publicized the work being done in Merced County on drainage.

In summary: The Merced County Mosquito Abatement District is approaching the problem of reducing mosquito sources in irrigated fields by contracting with the farmers to do the necessary drainage construction and maintenance work at cost; by cooperating with and enlisting the aid of other agencies with mutual problems; and by conducting an educational program to promote the solution of drainage problems by the farmers themselves.

Question: Does your drainage program aim at eliminating the need for spraying pastures?

Mr. Smith: Only in extremely rare cases has our drainage in an individual irrigated pasture reduced the amount of spraying to zero and then only for one or two seasons. Ordinarily the drains have to be maintained the second or the third year. In most cases it isn't a matter of eliminating the amount of spraying completely, but of reducing the necessary spraying from a hundred acres of pasture down to two acres or in some cases only a couple of hundred feet of a drain ditch.

Mr. Peters: I'll next call on Dick DeWitt of the Kern County MAD.

SOURCE REDUCTION IN THE KERN MOSQUITO ABATEMENT DISTRICT WITH EMPHASIS ON PUBLIC RELATIONS

Richard H. DeWitt

A definite need for a program of source reduction was realized by the Kern District back in 1945, but due to the lack of sufficient personnel a workable program was not put into effect until in the fall of 1948.

At this time one man was employed the year around in a more or less trouble shooting capacity to make individual surveys of locations where source reduction might be possible. He would then follow through with contacts to the individuals concerned in an attempt to reduce the problem for the district and at the same time try to obtain his willing cooperation. This has not been easy and several things had to be learned the hard way.

Farmers are the majority of persons contacted, and most farmers by nature are a fairly independent group. It was found that the most successful means of gaining his cooperation was to work the problem out with him individually and to guard against any tendency toward standardizing recommendations. The primarily important things were found to be the economy of any proposed plan, and of course explaining the district's problem to him and generally educating him in mosquito control. Usually an individual who has been educated to the program will come up with some pretty good ideas of his own on source reduction, and he hasn't the feeling that his toes are being stepped on. All of this is of course time consuming, and results cannot always be expected right away.

All during the first year the program was in effect, the results were slow. During the second and third years, many of the larger "hard to control" sources were reduced to a minimum. We have now become quite well known to the rural parts of our district and it is not an uncommon thing for many farmers to consider mosquito control when laying out plans for new land. This was very definitely not the case during the early days of the program. No attempt has been made here to relate the types of recommendations made by the district, as they have been many and varied to suit the individual problem.

We feel that this type of program has been a definite benefit to the Kern District, especially in the light of insecticidal resistance and the large increase of additional farm acreage annually in Kern County.

Mr. Peters: The next on the program was to have been George Umberger, Manager of the Sacramento-Yolo Mosquito Abatement District, but he was unable to remain. The reason that he was included on this program is that from all indications he was the first to initiate the utilization of prison labor in order to accomplish source reduction programs. However, we have a representative on our panel familiar with this approach, and Ed Smith can perhaps tell you how he has utilized prison labor to perhaps the same end.

Mr. Smith: In the Merced District we are taking advantage of the County Rehabilitation Center which is right next door to our depot. The prison labor is put out for work to county agencies, but has to be paid for at the rate of so much per day for guard and so much per day for transportation. Since they are right next door to us, they have agreed to swear our men in as deputies to act as guards, and we provide the transportation. We are then able to provide this labor with absolutely no cost to the farmers. We make use of this labor in all of the hand work that is necessary after use of our dragline or after use of our tractors.

Mr. Peters: I think that there is not much difference in this approach from what I have seen of George's program in the Sacramento-Yolo area.

Mr. Smith: Let me point out one difference. We get about six or seven prisoners. George Umberger gets about a hundred.

Mr. Peters: Are there any further questions?

Mr. Dahl: Just who are the personnel and how are these source reduction programs conducted?

Mr. Peters: That's a good question. I think that we have somewhat overlooked who are the personnel that are involved in accomplishing this end. Would you like to answer that, Ed?

Mr. Smith: We try to get all of our men to be in a position to help out. Our operators do the initial contact work out in the field. When they get a project worked up to a point where it's beyond them, they turn it over to the foreman. If the foreman needs some additional help, he calls on the manager. One of our pilots is trained now as a surveyor, so when surveying is needed he goes out. But all of our men do contribute. When it gets to the point where some legal advice is needed, we call in our attorney, and for engineering advice, thanks to the Public Health Service, we've had Lloyd Meyers there for the last several months, but outside of that the irrigation districts furnish engineering advice and also the soil conservation service, so we are able to call for help when we need it.

Mr. Greenfield: I've attempted to establish that form of program using prison labor and it's failed because they are hesitant about starting a fuss with the neighbors. How many districts now have such programs?

Mr. Peters: Howard Greenfield, Manager of the Salinas Valley Mosquito Abatement District has initiated a program of prison labor and such has failed because of lack of public acceptance. He would like to know just how widespread the movement is, and who is participating and who not. Does anyone have anything to say in that respect?

Mr. Smith: In all of these rehabilitation centers it's an honor camp. The guards themselves don't carry guns. They make no attempt to stop any prisoners from walking off. They say if he wants to walk off, let him go. When they get him he goes to San Quentin instead of the county jail.

Mr. Peters: I don't know whether that idea would work if applied to district workers. We'll go on to the next topic—"Land Reclamation"—and I'll call on Mr. Ernest Campbell, Manager of Contra Costa County Mosquito Abatement District, who I believe has created quite a bit of history in mosquito control.

SAN FRANCISCO BAY MARSH LAND

By Ernest Campbell

It seems pretty well established that the San Francisco Bay was not discovered by white man until 1769. Even three years later the extent and importance of the Bay was not realized. In 1772 a party had set out from Monterey to look for a suitable location for a mission to be located in the harbor of San Francisco. They were attempting to reach the quiet waters off Point Reyes. It was later that the name San Francisco was switched to the present San Francisco Bay. In attempting to get around what was thought to be only an estuary which had been discovered in 1769, the party followed north along the East Bay and turned east up the Carquinez Straits to about where Antioch now stands before turning back.

It seems rather singular that this the first recorded journey to penetrate so far up the Bay had occasion to mention, on March 27, 1772, being much troubled by mosquitoes. These were referred to as being as bad or worse than at the Port of San Blas. The diary kept by Father Crespi also noted the absence of heathens on these days.

In 1850 the United States Congress passed "An act to enable the states of Arkansas and other states to reclaim swamp land . . . ," and California took over a million and three-quarter acres of swamp and overflowed land. In 1855 California passed a law allowing swamp land to be taken up in 32 acre tracts at $1.00 per acre. This was increased to 640 acres in 1859 and in 1868 all restrictions on acreage were removed and capitalists moved into the Delta.

Reclamation of the swamps was an obligation which in a large measure was not immediately fulfilled.

The first levees were put up by team and scraper but in greater part by Chinese coolies using shovels. Traces of so-called "Chinese Levees" still exist.

The soil types of the Bay can be generalized into three sections: The Delta with a relatively stable peat and other good agricultural soil types: the straits and Bays connecting the Delta to the Lower Bay where the marshes are composed of a darker peat muck that has little agricultural value; in the lower bay the salt marshes are a clay like material of intermediate agricultural value. Precipitate, from the interaction of sea water and sweet water has been a factor in formation of the latter marshes.

In reclaiming the Delta area it was a long process of building and rebuilding the levees until about 1889 when adequate floating dredges dropped steel clamshell buckets into the water and built levees at four cents per cubic yard.

On the lower Bay reclamation was more desultory and in general by 1915 had if anything aggravated mosquito propagation; sporadic periods of drying had shrunk and cracked many square miles of marsh without sustained adequate reclamation works. These open fissures of perhaps one to three miles per acre were the source of abundant mosquito propagation.

Levees in the Delta are built on relatively stable material and adequate levees are somewhat readily attainable. The fact that these levees in the most part surround islands which have high, relatively dense material on their borders contributed to the relatively stable condition of these levees. Below the junction of the two rivers this is not the case and the levees are simply cradled in a mat of material which becomes relatively compressed in time. It is necessary to go over a levee usually at least three times to get sufficient height. Overloading of the levee may result in a fracture of the accumulating mat under the levee followed by displacement and subsidence in the ooze and a new start must be made. Little engineering data applies to the technique of such levee construction and the work is a matter of experience and judgement.

For heavier construction and where the muck is not too deep the practice has been to simply fill to solid material. As an alternative, where deep muck exists the practice has been evolved of driving vertical weep drains to allow water to be forced to the surface as the lower material compresses under pressure from heavy surface fill.

An interesting phenomena is a deep and unstable strip approximately 3,000 feet wide extending westerly across the marshes from about Lower Sherman Island opposite Antioch to near Fairfield. In this strip levee construction is difficult due to the poor material and foundation. The Southern Pacific Railroad crosses this strip near its west end and were filling for years before finally getting a reasonably stable road bed. The waves of displaced marsh muck were a phenomenon and train conductors made a point of calling this to the attention of passengers.

While dredging a drain canal on Grizzly Island in this strip, the crew awoke one morning to find yesterday's ditch bottom high and dry and yesterday's spoil in a trough under water, as a result of displacement and subsidence.

There are three distinct phases of the Bay, i.e., submerged land, tide land and swamp and overflowed or the marsh proper. Even so eminent a person as the late Professor Herms does not make this clear. In his "Medical Entomology" Third Edition, he states "While salt marshes appear to be flat, there is a gradual slope between low tide level and the adjacent dry land. For practical purposes these marshes may be divided into two main areas, the area subjected to daily tidal action where mosquito breeding seldom occurs and the area between the elevation of mean high tidal water and the elevation of extreme high tides. It is in this latter area where practically all breeding of salt marsh mosquitoes occurs."

This is not entirely correct. It would present a more accurate picture to state that marsh areas are relatively high bordering the Bay and intersecting sloughs and that mosquito breeding occurs in the residual water trapped in the lower areas.

Marsh areas are distinctive and ordinarily well defined in contrast to tidal areas. The marsh areas, in general, coincide with what the law defines as Swamp and Overflowed land. The relatively high borders of these distinctive marshes are, in general, overtopped only by the higher high water. This segregation of marsh from tide land follows the English doctrine which declares that tide lands have their title in the sovereign and are not proprietory and subject to sale. This is based on the principle that certain elements cannot be lawfully in the possession of individuals. The marsh areas on the other hand serve no useful purpose to the soverign waters and are subject to private ownership.

Reclamation of the San Francisco Bay marsh lands originally was thought of principally for agricultural pursuits. Today there are all sorts of reasons for building levees and constructing drain ditches. The mosquito man of today may find himself cooperating with diverse interests in the pursuit of the strange combination of engineering and biology which is mosquito abatement on the bay area marsh lands.

Mr. Peters: Are there any comments or questions?

Question: How will the Reber plan affect mosquito control in the area?

Mr. Campbell: The feeling is that there won't be any Reber plan, except perhaps a modified version of it. One big sticker, which is very evident, is that even with the immense prism of water going in and out each day, dredges are still required to keep the channel open across the bar, and if you'd stop that off there wouldn't be dredges enough in the United States to keep it open. That's one big factor, in addition to others. But the Reber plan, except in a modified version, is probably not seriously considered by prominent engineers at this time.

Question: What is the effect of drainage on peat marsh fires?

Mr. Campbell: It's a long story. If the water is kept very low and our peat marshes catch fire we'd never in the world put them out. It would require a tremendous pump. The peat smoke might hover over a highway miles away and really be a serious traffic hazard.

Question: Would replacement of salt water by fresh water under the Reber plan affect mosquito control on the Bay marshes?

Mr. Campbell: You can't give a quick answer on what effect it would have on mosquito control. After the Bay were fresh for a good many years conditions would be quite different from what they are today, but I am not a prophet and have no answer to this question.

Mr. Peters: I know we're all interested in the Reber plan as it affects mosquito control, but in the interest of time we will have to keep to our program. The next speaker is Paul Jones, Manager of the Marin County Mosquito Abatement District.

MOSQUITO SOURCE REDUCTION IN THE MARIN COUNTY MOSQUITO ABATEMENT DISTRICT

G. Paul Jones, *Manager*

The Marin County Mosquito Abatement District has a reclaimed and unreclaimed marsh area of approximately 65 square miles. In the northern part of the District most of the reclaimed marsh land is being used for farming. In the southern part of the District only a small area has been reclaimed for farming, most of the open marsh land in this part of the District is being filled for home sites.

The unreclaimed marsh land is usually leveed by a floating dredger or by a large dragline. The first levee is built to a height of about four feet. The levees are built with marsh mud. This mud will not stand up higher than about four feet. After the new levee is a year old it is topped to an additional height of two or three feet. The slopes of the levee will vary from 1 on 1 to 1 on 2. On the outside of the levee a strip of land 15 to 20 feet in width is left untouched. This strip helps to support the levee and prevents cave-ins which will occur if the levee is placed too close to the shoreline of the bay.

Some farmers will dig small seepage ditches inside of the levee. These ditches are connected to tide gates or pumps. If the reclaimed marsh is near an upland area where there is a large amount of run-off water during the winter months, provision is made to keep this water off the reclaimed marsh land. By channelling the upland water into a separate ditch it can be brought into the tidal creeks under pressure. This increased pressure at the tide gates will give a better flow of water.

All levees on marsh ground have to be periodically raised. Where the levees face onto the bay they are protected from wave action by rock riprap or some other kind of facing.

When the open marsh area adjacent to a tidal creek is completely reclaimed the volume of water moving in the tidal creek is greatly reduced during the dry period of the year. This reduction in the amount of water flowing in the creek will cause increased silting and tule growth. This silt is brought in from the bay by tidal action. Some tidal creeks in the District which were formerly used by schooners and barges for moving farm products are not now wide enough to accommodate a row boat.

The settling of the reclaimed land and the silting of the tidal creeks is gradually making automatic tide gates inefficient for drainage purposes.

It has been the policy of the District to encourage the reclamation of open marsh land, especially that marsh land lying near the uplands. The open marsh land near the uplands is not usually easy to drain by simple ditching. If there is an upland pasture near the open marsh the cattle will tramp holes into the marsh ground and it will be nearly impossible to drain after extremely high tides.

The District has encouraged the reclamation of open marsh land by contributing to the cost of the culverts and the automatic tide gates. In all cases where the District has made financial contributions, agreements have been made calling for the ploughing and discing of cracked ground. In cases where the reclamation was done prior to the formation of the District outright contributions have been made for the ploughing and discing of cracked marsh ground.

As an example of source reduction, this year the District has approved an agreement with one rancher whereby the District will pay $170 of the cost of a culvert and tide gate in return for the reclaiming of 40 acres of open marsh and the ploughing and discing of 80 acres of cracked ground. Almost every year similar projects are completed.

Most of the open marsh land which is available for farming in the district has been reclaimed. The problem now facing the district is one of maintenance. Two years ago the district purchased a 3/8 yard dragline so that maintenance work could be done more economically. It is the policy of the district to do most of its maintenance work on land which is not very productive, and where payments from the Production and Marketing Administration, under the Soil Conservation Program, can not be justified. Wherever drainage work can be justified as a conservation practice, it is the policy of the district to encourage the farmers to apply for this financial help, and to encourage them to use private dragline operators. Miles of drainage ditches have been constructed in the district under the Soil Conservation Program in the past four years.

The problem now facing the district is the fresh water breeding. This problem has become more acute during the past few years because of the increased population in the district. The solving of this problem calls for more help and a more thorough inspection and mapping of the district.

Mr. Peters: When I acquired the program of the Northern San Joaquin County MAD I didn't wholly appreciate it in the beginning, but now I can say that I am proud to have been able to take over something which I believe was a well organized program which had merit beyond dispute. We should first of all hear from the man responsible for starting the program. I think we would be interested in the basic reasoning as to why Ernie Campbell, who was then manager of the No. San Joaquin Co. MAD, initiated the program of mosquito control and land reclamation on the Mokelumne river bottom in the Lodi district.

BASIC CONSIDERATIONS LEADING TO ELIMINATIVE WORK ON MOKELUMNE RIVER FLOOD PLANE

By Ernest Campbell

Former Manager of the Northern San Joaquin County Mosquito Abatement District

This work instituted in 1946 consists primarily of clearing and in some cases levee construction, in cooperation with the property owners. The Northern San Joaquin County Mosquito Abatement District owns two D-7 Caterpillar Tractors and two Le Tourneau scrapers. The property owners pay the cost of equipment operation on a fixed hourly basis.

As to the reasoning behind the decision to institute this program I could do no better than refer back to a discussion on Permanent Control by myself, at the Sixteenth Annual Conference of this association. The late Professor Herms evidently heartily endorsed that discussion for he voiced his approval on two different instances.

Any reasoning behind a decision to institute permanent mosquito control would embody factors obvious and familiar to us all and these would apply to the Mokelumne River. In this particular instance there was the need for as near 100% and positive control as possible on account of nearness to centers of population. Considering the breeding conditions no other approach could have satisfied this demand. An almost equal obstacle to a larviciding program would be the seasonal requirement of qualified personnel to perform such larviciding. Even inspectional requirements would be an item in conjunction with partial control through airplane spraying.

Along this river the predominating mosquito, *Aedes Vexans,* does not follow what might be called the classic pattern. This classic pattern calls for larval development following full flood when the dissolved oxygen content has been lowered in residual waters. On the Mokelumne River with the slow and gradual rise of water over a relative long period the eggs develop into larvae almost immediately. As the waters continue to rise and seep or flow into higher elevations other larvae develop until by full flood larvae in all stages and pupae are present. These are amply protected by the heavy vegetation and down-wood accumulation. Following subsidence from full flood, there is ordinarily only a relatively minor appearance of larvae which are following the classic pattern. This situation precludes an economically successful program of airplane adulticiding.

The Mokelumne River bottom, as is the case in such lands, is subject to the hazard of damage by high flood. However, according to qualified engineering advice, at least some of the larger of these areas presented sound reclamation possibilities. Our original thinking was to reclaim these larger areas and in the meantime gain a background of experience as to a continuation of the program.

Mosquito control is in essence a service to eliminate an evil. It is then, a program of negation rather than a program creating a positive good. However in a cooperative program of permanent control there are times when even a mosquito district can participate in the creation of a positive good through improved land usage.

Mr. Peters: I think that no summary of activities would be complete if we didn't hear from the other side of the Tehachapi Mountains, and will call on Jack Kimball, who is manager of the Orange County MAD.

MINIMIZATION OF INDUSTRIAL SOURCES OF MOSQUITOES IN ORANGE COUNTY

Jack H. Kimball

Bob Peters, Moderator for this panel discussion "Mosquito Source Minimization in California" has suggested that we briefly describe our particular problems, our approach to these problems and the "tools" we are using in our program to minimize industrial sources of mosquito breeding.

Mosquito workers north of the Tehachapies do not publically recognize mosquito problems in Orange County, and we agree with them. We who live in Orange County with its invigorating climate throughout every month of the year recognize these so-called problems as mosquito abatement challenges to be met with continuous energy and enthusiasm.

Industrial Waste Problems

The dairy farm industry and the oil industry in Orange County produce large quantities of waste water that are either discharged into the ocean through domestic and industrial sewage systems or spread on land. The procedure of spreading this waste water on land by means of evaporating basins, seepage sumps and/or agricultural irrigation has created numerous mosquito source problems that warrant our present program of prevention, minimization and elimination.

The dairy industry consists of some 135 farms producing an average of 100,000 gallons of milk per day with a total income of some $14,000,000 per year. Only two of these farms are connected to a public sewer, and almost 80% are located in a section of the county lacking surface drainage facilities and subject to storm water flooding as occurred in January of this year. The disposal of the dairy barn wash water is a difficult and expensive problem to each operator. General practice has been to spread this waste water uncontrolled on barren ground, although in recent years the larger operators have salvaged this water for supplemental pasture irrigation.

Oil in Orange County is a $100,000,000 per year industry with an assessed valuation totaling one quarter of the valuation of the entire county. Ninety per cent of the waste water separated from the oil pumped by the 2,600 operating wells is discharged into the ocean. The remaining 10% of this waste water, produced mainly by the small producing companies, is disposed of on land by various methods. Prolific breeding of *Culex tarsalis* and other pest mosquitoes occurs in the seepage sumps and evaporating basins in spite of the presence of heavy oils.

District's Approach to the Problem

Since the creation of this district in 1948 the solution to these industrial waste problems has been approached on an educational basis. Immediate control of mosquito breeding by larviciding methods has been carried out by the district. A study of the operating records for this temporary type abatement indicated the economic justification for preventing new industrial sources and for minimizing or eliminating existing sources. Cooperation with other public agencies having primary interest in the regulation of the industries involved has been the principle "tool" used for achieving the district's objective of permanent control of mosquito breeding sources. Procedures for incorporating mosquito abatement requirements within the required permit to dispose of any industrial waste or to operate a dairy farm are now in effect.

Dairy Farm Control Program

All new dairy farms locating within the county must obtain a land use permit from the County Board of Supervisors. All applications are processed by the County Planning Commission. Written recommendations setting forth minimum requirements for health and sanitation measures and for the prevention of mosquito breeding sources are made by the County Health Department to the Planning Commission, in cooperation with the Mosquito Abatement District. These written recommendations are incorporated within the land use permit when issued to the dairy farm owner. Compliance with these basic construction requirements is assured since detail plans must be submitted and final completion of the work approved by the Health Department before an operating permit is issued. A large area of the county's milk sheds is under inspection by the Los Angeles City Health Department, but working arrangements between the two health departments permit the same follow up of the minimum requirements set forth in the land use permit.

A joint program between the district and the Orange County Health Department for the minimization and/or elimination of mosquito breeding sources and other sanitation problems caused by the disposal of waste water, inadequate drainage of corrals and pastures, etc. is under way on all existing dairy farms. Joint inspection and recommendations are worked out with the dairy operator and then confirmed in writing by the Health Department. Careful operation of waste water disposal systems and management of pasture irrigation is our current objective. Each employee of the district is cooperating with the dairy operator by continually explaining the fundamentals of mosquito breeding and control and by larviciding the existing sources pending corrections.

Oil and Other Industrial Waste Control Program

Ordinance No. 601 of the County of Orange regulates the disposal of industrial wastes on a permit basis. Enforcement is by the County Health Officer who has set up an advisory committee to help set policy and review all applications. The manager of the Orange County Mosquito Abatement District is a member of this advisory committee along with representatives from the planning commission, Building Department, Agricultural Department, Joint Outfall Sewer Board and the State Water Pollution Control Board, Region No. 8.

Of particular interest to the Mosquito Abatement District has been the regulation of the disposal of oil well brines produced by the smaller oil companies. As mentioned previously the practice has been to discharge this waste water into sumps, cesspools or evaporating basins. Since the principle objective of the ordinance is to prevent the brines from entering the underground water strata, disposal by means of impervious evaporating basins has been the only solution in many cases. Tentative standards for evaporating basins including provisions for control of weeds and mosquito breeding have been recommended by the advisory committee for inclusion in all permit regulations.

Through this advisory committee the district has the opportunity to review all applications and to make specific recommendations for the prevention or elimination of mosquito breeding sources.

We believe that the interest of our Mosquito Abatement District in long range abatement and control of industrial sources of mosquito breeding is best served by our participation and cooperation with the various county agencies having primary interest in the regulation of industrial waste.

Mr. Peters: The last subject we have in this phase of our program is sewage disposal. We have divided that into two categories, what we might classify as public sewage disposal and private sewage disposal. Public sewage disposal as mosquito sources has been considered at meetings in the past, and I think every one of us has a problem of this kind, but at present I will call on Dr. Murray, Manager of the Delta Mosquito Abatement District, to give us a short presentation on private sewage disposal.

PRIVATE SEWAGE DISPOSAL CORRECTIONS IN DELTA MOSQUITO ABATEMENT DISTRICT

By W. Donald Murray, *Manager*

The Delta Mosquito Abatement District has been engaged in a continuing program of elimination of open cesspools for the past four years. Five years ago this district prepared maps of the district, most of these maps being based on the section concept, although in urban and suburban areas a different scale was sometimes desirable. These maps were essential in our survey and follow-up in cesspool corrections, therefore no particular stress could be placed on the corrections until the maps were available in 1948.

In the late Fall of 1948 our operators began a full-scale survey for cesspools and house drains which were open or improperly constructed and to which mosquitoes had access. Following the survey, we discussed the situation with the County Health Department and that agency was very willing to help because the corrections would be of mutual benefit. Ever since the beginning of this program the County Health Department and the Delta Mosquito Abatement District have pooled our resources and have worked hand in hand with each other. The following outline illustrates how the phases of the program were shared:

1. The Survey—Delta Mosquito Abatement District
2. Issuance of Written Notice—Health Department and Delta Mosquito Abatement District together
3. Return Inspecton--Usually Delta Mosquito Abatement District alone
4. Obstinate Cases—Health Department

This program follows closely the respective policies of these two agencies, the Health Department being to an appreciable extent a police agency while the Delta Mosquito Abatement District is largely a service agency. The Mosquito Abatement District laws in the Health and Safety code are strong enough, but much red tape is avoided when we make use of a local county ordinance which prohibits improperly constructed private sewage systems.

The written notice may seem unduly harsh to a first offender, buι a polite "please" is generally fruitless. We have issued notices to the highest type persons, including some of our friends. The notice acts more as a reminder than a threat to the better class person. Frequently the house-wife is eager to receive the notice—we can get her husband to fix something she had been nagging him about for months. Generally 15 to 30 days are allowed the owner and/or renter to make the necessary corrections.

When places are not corrected on schedule, we have had discouraging moments when we wanted to haul the offender into court and get it over with, but so far better judgement has prevailed. Most persons consider the notice to be a reminder and have no fear of it. A subsequent discussion must be done and he might as well get started on it. We then give a few additional days and usually obtain our desired goal. There have been only a couple of difficult cases, and we have approached the District Attorney about them. This agent has then called or written to the offender requesting him to appear at his office for an interview. At each interview it has turned out that the offender had not realized the position he was in, and subsequent to the interview full cooperation was obtained. To date we have not taken full legal action against any person. In almost all cases we have won the respect and confidence of the population, both the violators and the neighbors.

Summary records of a large part of our Mosquito Abatement District which has had consistently good progressive mosquito control and reasonably fixed personnel for the past four years show the following reduction in total open cesspools and house drains as found on our annual late fall survey:

Number of	1948	1949	1950	1951
open drains	1425	1205	658	456

Our present program has reached the place that we can issue corrective notices throughout the summer. We never spray a cesspool more than once, we never tie our operators down to routine spraying of cesspools at any time during the year.

While we have not made a check on species of mosquito in most of these cases, all checks to date on species occuring in true cesspools have shown 100% *Culex quinquefasciatus.*

Mr. Peters: Fresno County has had plenty of experience with industrial wastes, and I will ask Ted Raley, Manager of the Consolidated Mosquito Abatement District to tell us their experiences with this problem.

Mr. Raley: Fresno County has become synonymous with agriculture. When you say one, you say the other. In our first session, Dr. MacLeod gave you a good picture of what agriculture represents in Fresno County. But of course in handling these agricultural crops, the processing of them required industry, and our problem is the use of tremendous volumes of water to process these crops. With the discharge of water after it is used for processing, we get waste water with a high percentage of solid matter. In this area the only way to dispose of that is on top of the ground. So, as highly intensified as our agriculture is, we do along with it have an industrial mosquito problem. There are 21 wineries within the county. They vary in size from perhaps the largest in the world to just the smaller ones for more particular varieties or home use. Our Board of Trustees took the attitude and adopted the policy that whoever creates a mosquito problem within the area must be responsible for correcting it. With this policy, we approached the other agencies within the county and found that they were quite willing to accept that policy and move with us on a basis of correcting and neutralizing the problem not only as a mosquito source but as a health menace in other respects, and as a nuisance to the nose and to the general living conditions in that area. This cooperative effort produced a County ordinance, Fresno County Ordinance 381, regulating the disposal of industrial waste and requiring a permit therefor. I won't read the entire ordinance. The particular part of interest to you will be that we have left this ordinance on a very broad term of permit regulation. We only say that they must have a permit and that permit must be given by the Health Department, and in order to get this permit they must handle their industrial waste in such a manner that there will not be maintained or created a hazard to public health or a public nuisance, and we have gone along on this basis because there are no two industrial plants alike. Each has its own individual problems; each has a physical environment that makes it different. We have some wineries with land areas of as much as a hundred and twenty acres, and some with land areas of no more than an acre and a half. Our method of approach to that is, no deep ponds. All waste must be disposed of in shallow checks that will dispose of all the water either by percolation or evaporation in a short enough period of time whereby no mosquitoes or other insects will be produced. These shallow checks vary in size depending upon the volume of waste discharged daily by the winery. We ask them for daily rotation, sufficient checks in the area so that no water is returned to that check for at least seven days. Some wineries have gone so far as to put in graders and machinery to remove this waste as it dries before new water is brought in. That, of course, is the ideal and has been the most successful. We admit that there are still lots of problems but I feel that our approach has been as proper as we could hope for. We could have sprayed deep ponds forever but never would have had successful mosquito control in them. By this approach we are gradually reducing the industrial waste problem within our district to a point where it is just nominal inspection and casual spraying of small areas that for no particular reasons haven't drained out or haven't dried up as quickly as they should. Within the industrial plants themselves, we require the owners or operators of that plant to do all necessary mosquito control activity. Our only function is to inspect and to recommend what should be done to do away with mosquitoes.

Mr. Peters: I will just thank the members of my panel for participating, and will the members of the next round table discussion kindly come forward so that Ed Smith can make arrangements with them.

Recess

Mr. Smith: We're going to start this panel with a round robin discussion asking each of the representatives up here to state what the interest of his organization is in the use of water in California. First at the far end of the table, Mr. H. M. Posz, Engineer from the U. S. Bureau of Reclamation, Sacramento.

BUREAU OF RECLAMATION COOPERATION WITH THE STATE DEPARTMENT OF PUBLIC HEALTH IN MOSQUITO CONTROL

By Howard M. Posz

Bureau of Reclamation participation in mosquito control in the Central Valley Project area is based on a policy outlined in a Memorandum of Understanding with the U. S. Public Health Service, which states in part:

"Having mutual interests in the general welfare of the Nation and recognizing the public health aspects of the Reclamation program, the Bureau of Reclamation and the Public Health Service desire through cooperative action, including cooperation with state and local agencies, to avoid the creation of health hazards connected with water resources development projects and to insure that these projects provide maximum feasible health benefits consistent with other project functions. This understanding is therefore entered into in order that joint, concerted, and coordinated actions essential to the achievement of thes objectives may be taken and may be harmonized with those of other agencies (Federal, State, or local) whenever their actions are also desirable."

On March 8, 1951, following preliminary discussions, at a conference with representatives of the State Department of Public Health, Bureau of Vector Control, it was decided that cooperation between the Bureau of Reclamation and the State in mosquito control activities would require mutual agreement on four points of procedure, which are as follows:

1. Develop a procedure for bringing the services of the State Department of Public Health into new and existing projects.
2. Develop procedure for securing technical data necessary for project evaluation.
3. Develop an agreed upon program of regular reports on each project during planning and construction periods.
4. Develop procedure for continuing consultation service and reports during maintenance and operational phases of each operating project.

Although mutual agreement was reached on the foregoing program, it became evident later as the program was placed in effect, that the plan of action as outlined did not include sufficient detail on the cooperation between field personnel of the two agencies and on the division of costs of remedial measures on operating projects. In this regard, it was decided that Bureau of Reclamation fieldmen would work under the immediate direction of the Central Valley Project Operations Superintendent, or his representative. Also, it was decided that the State would conduct investigations of mosquito-breeding conditions at its own expense. The Bureau of Reclamation, in turn, would bear the entire cost of remedial measures, but such work would be limited to rectification of conditions on Government right-of-way and property.

The program of cooperation between the Bureau of Reclamation and the State is now functioning satisfactorily. The State conducts field investigations and submits reports of its findings and recommendations to the Regional Branch of Irrigation Operations of the Bureau of Reclamation. After approval of the report by the Regional office, it is transmitted to the Central Valley Project Operations Superintendent with instructions to carry out the remedial measures recommended by the State. Occasionally it becomes necessary for a State representative to cooperate with the Bureau's field superintendent in directing the actual work. Such cooperation is required for the reason that the report does not always provide the required detail for field action, and because certain recommendations need additional interpretation at the field level.

Thus far, the State has issued two reports on operating projects; the first concerns Friant Dam and the second concerns Madera Canal. Remedial work involving physical changes on Millerton Lake behind Friant Dam is just about complete, and routine maintenance work, such as keeping drains open, larvicidal spraying, and weed control, is being carried on as a part of the regular operating procedure. The State's investigation of Madera Canal disclosed that no specific control action is required because population density within flight range of the mosquitoes is not great enough to warrant such action. Nevertheless, the Bureau of Reclamation field personnel have been instructed to eliminate mosquito-breeding conditions insofar as it can be accomplished in routine maintenance procedure.

In accordance with Part 3 of the general agreement, the Bureau of Reclamation informs the State of projects in the planning and design stages. Project planning reports and designs of structures about to be built are made available to the State for study and recommendations for elimination of potential mosquito breeding conditions. Frequently such conditions can be eliminated at no additional cost by changing the initial design of project features. In other instances, where an alteration involves extra cost, the design is changed if the cost of the change is estimated to be offset by reduction in future maintenence expense.

When the Bureau of Reclamation first decided to cooperate with the State Department of Public Health in mosquito control, it did so with the realization that elimination of mosquito-breeding conditions on Government property would be but a small part of the abatement required in an area as large as the Central Valley Project. However, it was believed that a precedent should be established for inter-agency cooperation. The Bureau trusts that its action will pave the way for future collaborative action between the State and other agencies, to the end that the menace of mosquioes to life and health will be successfully eliminated.

Mr. Smith: Thank you Mr. Posz. We will come back to you very shortly with some questions. Next I want to introduce Dr. Stanton Ware of the U. S. Public Health Services, Water Resources Section, Vector Control and Investigations Branch, CDC, Salt Lake City.

FUTURE SCOPE OF AGENCY PARTICIPATION IN THE VECTOR CONTROL PROGRAM IN CALIFORNIA

By S. J. Ware

Chief, Water Projects Section, Vector Control and Investigations Branch, The Communicable Disease Center U. S. Public Health Service, Federal Security Agency Salt Lake City, Utah

It is understood that the objective of this panel, or round-table discussion, is to talk over and to point out the future scope of agency participation in the program of vector control in California. By agency, as the word is used here, is meant any organization, federal, state, or private, working toward a definite goal for the common good. In that regard, then, there is a sound basis for the interest of the United States Public Health Service in the work being carried on in vector control in the state of California. There is also a responsibility of California in the fulfillment of its part as a great state in the Union.

In order to be close to the problem of vector control as associated with the vast water resources development program, an important part of which is being carried on in California, an office has been established in Salt Lake City by the Vector Control and Investigations Branch of the Communicable Disease Center. The over-all program of water resources development is national in scope. Water is a national resource, both as a way of use and as to results of its use. A valuable share in the future of our country, I am sure you will agree, lies in the West and in its sound development. That being the case, there can be no doubt that the nation is deeply concerned with and dependent upon the successful use of water resources throughout the West.

Since the Communicable Disease Center's water resources vector control program has been ably discussed by Mr. Hansen, our Executive Officer, there is no need to take more time on that score. Rather, in keeping with the objective of this panel, it is intended briefly to point out the particular items of the cooperative State-other Federal agencies-Communicable Disease Center program as related to water resources development in California. As a part of the closely integrated Department of Public Health work, it has been possible to assign a limited number of Communicable Disease Center personnel here. They are being used to very good advantage and, in turn, are contributing measurably toward providing the sound foundation for good program work elsewhere. California is assuming a responsible part in the over-all program of water resources development.

The personnel here in California have been chosen carefully for their assignments. Mr. William P. Warner is with Mr. Richard F. Peters' organization, the Bureau of Vector Control. An important part of his work consists of fulfilling the very requirement that Mr. Howard M. Posz of the Bureau of Reclamation mentioned a few minutes ago. That is, he is working on all aspects of vector problems related to the water resources development programs being carried out by the Bureau of Reclamation, the Corps of Engineers, and other water resources development agencies. Dr. Bernard Brookman and Dr. R. Edward Bellamy are at the Bakersfield Station carrying on field investigations under the direction of Dr. William C. Reeves of the Hooper Foundation. Engineer Lloyd Myers, a member of this panel, is working with the Bureau of Vector Control and is stationed at the Merced Mosquito Abatement District. His goal is the development of practical principles, and their applications related to mosquito control-conservation, irrigation-drainage problems. The particular findings of this work, as well as those of the others, will be applicable and useful elsewhere in the water resources program as well as here in California. Dr. Harvey Scudder, assigned to the Bureau of Vector Control, is applying his particular abilities in connection with the water resources investigations program while serving as Technical Coordinator at the Fresno Field Station. It is very gratifying to note that Dr. Harvey I. Scudder is working closely with the Bureau of Vector Control, with Mr. Richard C. Husbands of the California Mosquito Control Association, and with others, toward common solutions to common problems in voctor contrl.

The Water Projects Section office in Salt Lake City will remain close to the work being carried on in California. In that way, we can be sure that, by working with California problems and able California personnel, we can apply the benefits and contributions of cooperative endeavor to the pertinent vector-public health matters relating to the entire United States.

Replies to Questions

Reply to question from the moderator, Mr. Edward Smith: It is understood, Mr. Smith, that you would like to know more of the basic working agreements under which the program work previously discussed is accomplished. Perhaps this can best be illustrated by referring to existing cooperative agreements whereby vector investigations are being carried out in relation to irrigation development and over-all water resources development programs elsewhere. It was my privilege to participate in the drafting of the original basic Memorandum of Understanding between the Public Health Service and the Bureau of Reclamation in the Missouri Basin. That agreement was prepared in September, 1947. It was followed by, and served, at least in part, as a guide for, the Memorandum of Understanding which Mr. Posz mentioned as existing between the Department of Interior and the Federal Security Agency. That has been followed by other memoranda of agreement between the Bureau of Reclamation and the Public Health Service. Similarly, the Bureau of Vector Control has gone ahead along the same lines and, to my best knowledge, is the first State public health organization to work so closely with the construction agencies. The means of accomplishment, by cooperative working agreement, is the important thing to take note of here.

Reply to question from Mr. Harold F. Gray: It is understood, Mr. Gray, that your question relates to the possible effectiveness of an over-all State group to assist in coordinating water resources work. I have observed the operation of such coordinating councils in various States in the Missouri Basin, and they have, without a doubt, been very effective. In the States of Montana, North Dakota, for example, it was called a Coordinating Committee of State and Federal Agencies. This approach has grown, and has become very important to the water resources development program. Participation by State, Federal, and private concerns such as irrigation districts, business firms, chambers of commerce, and a wide variety of interested organizations has been extremely effective. Work groups and offshoots of these committees have resulted in the formation of such cooperative undertakings as consrvation councils which arrange annual State tours and other such activities for the information of their members and of the public. This idea is working extremely well and with great success.

Mr. Smith: Thank you Dr. Ware. We're going to skip Lloyd Meyers for just a moment and come back to him. We'll ask next to hear from Mr. Fred W. Herbert, who is taking the place of John Barnes, and will present his paper. Mr. Herbert is the Assistant State Conservationist for the U. S. Soil Conservation.

Mr. Herbert: Many of you have heard this story but it will take ten seconds to tell about the fellow on the inside of the insane asylum and another fellow on the outside and the fellow on the outside said "why are you wheeling that wheelbarrow upside down all the time?" and the fellow on the inside said, "I turned it over once and they filled it up on me." The purpose of that story is that if I had brought all the information I could on this subject and had my wheelbarrow right side up it would have taken a long while, so I've condensed it into a statement which I can read in about three minutes.

MOSQUITO ABATEMENT AND SOIL AND WATER CONSERVATION

By John S. Barnes

California State Conservationist, U. S. Soil Conservation Service

The interest of the Soil Conservation Service in the use of land and water in such a manner as to assist in mosquito abatement can best be expressed by quoting your retiring President, Mr. Edgar A. Smith, when he said that, "we need to learn the farmers' problems in the handling of water and we cannot hope to solve these problems until we thoroughly understand the principles of irrigation, crop needs, soil characteristics, rates of infiltration and drainage."

In each instance where technical assistance is given to farmers in soil conservation districts by the Soil Conservation Service, that assistance is based on a very careful analysis of all factors affecting the land, including slope, previous and potential erosion, depth and texture of the soil, subsoil conditions, water, alkali and climate, as well as permeability and drainage. This complete physical inventory is taken in order that the farmer and the technician may, together, work out a practical program to use the land according to its capabilities and treat it according to its needs.

The way in which this program fits into mosquito abatement is well illustrated by the work of the Los Banos Soil Conservation District in Merced County. Based on these land factors, the Soil Conservation Service made a thorough investigation and an exhaustive report on the drainage of about 30,000 acres in that District. A drainage engineer of the U. S. Public Health Service whose services were loaned to Merced County Mosquito Abatement District used that report in studying a county-wide program of drainage. In the meantime, as a result of determining these basic land facts, operations in the Los Banos Soil Conservation District have materially assisted the mosquito abatement work. A typical example is one where nineteen farmers were concerned in a drainage project. The soils were heavy, the irrigation runs short, and water collected in borrow pits, providing mosquito breeding places. Through cooperation of the county road authorities, the mosquito abatement people and the farmers themselves, through their soil conservation district, rights of way were granted for the construction of a main drain to eliminate the possibility of standing water on the land drained by that project.

In another instance, in Tehama County in the Sacramento Valley, the Lassen View Soil Conservation District is assisting the Los Molinos Mosquito Abatement District in eliminating runoff water from irrigated fields into sloughs, creek channels and low spots which have become plugged with tules and debris. Where the cooperative work is now being planned there are about 455 farms and approximately 12,000 acres of land affected. The farmers are willing and able to do the necessary work but, as Mr. Smith inferred, they lack technical assistance for proper design and layout. This is where the soil conservation district is stepping in to assist them. It is natural that the forces of the soil conservation district be joined with those of the mosquito abatement district as the objectives of soil and water conservation and mosquito abatement are both served by the work.

In the two districts mentioned and in many of the other 72 soil conservation districts in California, a sound soil and water conservation program on individual farms includes many practices which aid mosquito abatement. Proper land leveling results in efficient irrigation that eliminates ponding or holding water in small pockets, and in reducing tail water to a minimum. Native swamp land pastures, which have been mosquito breeding places, have been eliminated by proper land leveling and the development of planted and irrigated pastures where water can be controlled.

As more and more of the valley floor lands are brought under irrigation, the following soil and water conservation practices become increasingly important: good land leviling, correct application of irrigation water, drainage, the development of good irrigated pastures, the reduction of alkali and, in short, every practice that will result in the most efficient use of water with little or no waste. These, also, are the practices which, as pointed out by Mr. Smith, will accomplish the objectives of mosquito abatement.

Mr. Smith: Thank you Mr. Herbert. We will come back to you shortly also. We'll next call on Mr. Lloyd Brown, the Extension Soil Specialist, from the University Extension Service, University of California.

COLLEGE OF AGRICULTURE AND MOSQUITO CONTROL

Lloyd Brown
Soil Specialist, University of California

The following quotation is from Bulletin No. V. C.-1—Mosquito Abatement in California: "In 1910, Professor William B. Herms, a distinguished scientiest and father of mosquito control in California, wrote 'what this state wants is the colonization of the great inland valleys and the productive foothills of the Sierra: and the control of malaria is one of the great problems to be solved."

If Dr. Herms could be with us today, I am sure that he would be gratified with the material progress now being made on mosquito control.

One of the functions of the College of Agriculture is to engage in research on agricultural problems and then to pass along to farmers the results of these studies. The latter phase of the work is done by the Agricultural Extension Service, which has farm advisors in 50 California counties.

With respect to the subject under discussion, a basic understanding of irrigation and soils is most important. We in California are very fortunate in that we have two very fine groups in the College of Agriculture working on these subjects—the Division of Irrigation and the Division of Soils. Both of these groups have been in operation for about forty years.

One of the long-time objectives of the Division of Irrigation has been to promote the efficient use of irrigation water. You do not use water efficiently if you drown out crops by ponding or have large amounts of waste water. The Divisions publication, "Essentials of Irrigation and Cultivation of Orchards" is a fine presentation of the when, where, and why of irrigation. More specifically, the recent publication on "Irrigated Pasture in California" and the "Contour Check Method of Orchard Irrigation" describe practices to minimize waste water. Two publications now being prepared will further efficient irrigation, "Border Checks" and "Land Leveling."

These publications are mentioned as specific examples, but other similar publications are available.

The Division of Soils has been making soil surveys, until at the present time much of the state has been surveyed. These surveys furnish a great deal of information on the suitability of the soil for various crops. In addition, information on the soil texture indicates the best methods of irrigation. This Division also has a circular "Land Drainage," which is a subject very important in mosquito control work.

County Farm Advisors work in cooperation with Mosquito Abatement Districts. As an example of this cooperation, the Farm Advisors in Sacramento and Yolo Counties and the Superintendent of the Yolo County Mosquito Abatement District prepared a publication, "Irrigated Pasture—Mosquito Control."

Thus it is obvious that the University of California has been and you may be sure, will continue to be interested in developing and disseminating irrigation and drainage information which will be good for the farmer and bad for the mosquito.

Mr. Smith: Thank you Mr. Brown. Next, Mr. Robert Durbrow, the Executive Secretary of the California Irrigation Districts Association.

Mr. Durbrow: I didn't bring either paper or wheelbarrow so maybe I can be brief too. The Irrigation Districts Association of California's interest in mosquito control is rather obvious when you consider that the association consists of 135 districts throughout the State, irrigating something over 3,500,000 acres of land. That's a big chunk of the irrigated acreage of the State represented by the one organization and I think that when Mr. Smith invited me to attend he had in mind that we would be a good forum for such practices as the control of mosquitoes, and the education of our people might have a salutory effect. The control of mosquitoes has never been an association problem. Our problems have mostly been legislative, and problems brought to us by the districts. They have been mostly legal problems.

You people, I think, have found most of our districts cooperative. Because mosquito control has not been an association problem, when Mr. Smith approached me I went to a number of our districts and asked them two questions. I said first, "do you cooperate in the control of mosquitoes in your area?" In almost every instance the answer was "Yes. We do whatever is asked of us. We volunteer some aid, and of course in all cases we try to control waste water." The second question I asked them was, "Have you been asked unreasonable things by the mosquito control people in your area?" That becomes of interest to us as an association problem. You are to be congratulated upon their answer on that question; in no instance did they feel that anything unreasonable had been asked by any of you mosquito abatement people. I feel that that's an indication of cooperation of an ideal kind, leading towards control of mosquitoes by the two groups.

We have been accused, and many irrigators have been accused of malpractices, misuse and waste of water because puddles stand sometimes. I think that anyone who thinks that a puddle can be either legislated out or ruled out in the irrigation business just doesn't understand irrigation. I have reference to a legislative item, a little gem of the last legislature, which would have made it a misdemeanor to allow a puddle to stand in the State of California. It was necessary for the irrigation interests to oppose that type of legislation. We don't think that it's the proper method of approach. I don't think that you would either if you think it over a little bit. A second thing which I would like to suggest that you think about; you shouldn't make broad accusations. Whenever you see water standing, it is often claimed that it is mismanagement, or waste, or lack of knowledge on the part of the man in charge. I've done some irrigating myself. I carried a shovel a good many years in an area which I noticed is not covered by a mosquito control district, and where I wish you'd get to work. I grew up in Glenn County up in the rice fields where we've got plenty of mosquitoes. I grew up taking quinine regularly. Glenn County is not covered by a mosquito control district. In that area we were anxious to save water as much as we could, but we had checks in alfalfa fields that sometimes ran a quarter of a mile long. You run water down those checks and you are anxious to get the water to the end of the check. It's important that you get it to the end of the check, and it's impossible to have it come out just exactly even every time. We tried to have drain ditches wherever we could, but once in a while either too much water came down to the drain ditches or the drain ditches weren't in good order, and there were puddles that stood. Anyone who knows irrigation practices knows that type of condition exists and you can't legislate them out of existance.

Our position should be one of encouraging both education and cooperation. Yours should be one of action. I pledge our support now as an association of irrigation districts to an attempt to educate our districts and their people in the control of water for mosquito control. To that end I will certainly try to see that one of you is invited to our next convention to help educate some of the directors of your irrigation districts. I pledge our cooperation and I think I am free in doing that because every district I have approached said that they have given their cooperation. That is the proper approach. I would hate to see you try to use a big club. I would rather see you use cooperation and education in the control of mosquitoes. All of the farmers and all the districts in the area would prefer that that be the method of approach to the problem. If we work on the three items, cooperation, education and action, we can all be very helpful in the control of mosquitoes and in the better use of water in the State.

Mr. Smith: Thank you Mr. Durbrow. The fact that this particular group is sitting around this table is an indication that we do like to start out with that first word, cooperation. You will be interested in knowing that I heard very recently that there was to be a general public meeting in Glenn County to organize a mosquito district. Next I want to ask Robert M. Paul, Sanitary Engineer of the Department of Fish and Game, to give us a statement as to the interest of the fish and game people in the use of water in California.

Mr. Paul: The use of water for fish and game in California is a subject that's too broad to be boiled down to five minutes, so I will try to confine my brief remarks to the areas where fish and game interests and the interests of the mosquito abatement districts tend to conflict.

We are one more agency which has been interested not in mosquitoes as such, but in the actions and plans of the mosquito abatement personnel. We have been concerned with two problems; one, fish mortalities because of excessive spraying of larvacides for mosquito control, particularly in the Central Valley; and two, the general problem of waterfowl areas and duck clubs as breeding places for mosquitoes and the subsequent need for intelligent water management.

The fish mortality question can be dismissed with a very few words. It has been our observation that abatement districts are generally not at fault, and the trouble has been caused by over-zealous pilots and other operating personnel who have the old idea that if one pound per acre helps then ten pounds per acre is ten times as effective. This is a philosophy that is hard to displace. I am sure that the mosquito abatement districts themselves have this problem because of the economics involved, as well as the possibility of building up resistance to chemical control in the mosquitoes. It has been our experience in California that carefully controlled use of larvacides does not jeopardize fish life to any extensive degree. This may not be true in the future with the increasing resistance pattern that is developing among California mosquitoes that requires larger and larger doses. It is certainly not true in the South where extensive quantities of toxaphene are used for weevil control, in some cases, hundreds of pounds per acre.

The other problem, which has become acute with the increasing emphasis on source reduction of mosquitoes, has been our attempt to establish a sound water management procedure for waterfowl areas. Duck clubs, both privately owned and those operated by the Federal and State agencies, have proven to be excellent breeding areas for mosquitoes. A committee from your organization has met with representatives of the Department of Fish and Game, and we have found to our gratification that the problem of sound water management for waterfowl is also sound practice for mosquito control. We now believe the best waterfowl management is not to have water standing for a long period of time during the summer. It has been found that it is possible not to flood these areas until late in the year after the active breeding season for mosquitoes.

The Department of Fish and Game has a field staff with which most of you are acquainted. Our fisheries biologists are quite familiar with some of your general problems and will be available for consultation on any of the problems which affect fish and game. It is our intention to cooperate to the fullest extent with the mosquito abatement districts. I keep referring to our mutual problems, but I don't think that the choice of words is too apt because our program is quite similar to yours. We both have a biological research program under way and your education programs and ours are very nearly similar. Let us hope that in the future we can have closer contact than we have had in the past, and that the cooperation that has been undertaken with your association can be continued.

Mr. Smith: Thank you Mr. Paul. Now I want to call on Vinton W. Bacon, the Executive officer for the California Water Pollution Control Board, to tell us something about his problems in regard to the use of water.

Mr. Bacon: The interest of the State and Regional Water Pollution Control Boards in the problem of water use is that we have the responsibility for the abatement, prevention, and control of nuisance or pollution of the surface or underground waters of the State caused by the discharge of sewage or industrial wastes.

In looking at the title of this roundtable discussion, "The Future Scope of Mosquito Source Reduction Through Agency Cooperation," I realize that from your point of view we could give you the best kind of "cooperation" by reviewing plans, specifications, and all of the details of existing and proposed waste treatment and disposal facilities. Naturally, you would like to see the pollution control authorities insist upon design features which would (1) prevent the breeding of mosquitoes or (2) provide means whereby mosquito control operations could be conducted conveniently and economically in those cases where mosquito breeding could not be eliminated. Unfortunately, from your point of view, the new legislation provides that orders of the pollution control boards cannot specify the design, plant location, type of construction, or particular manner in which an operation causing or threatening to cause a pollution is to be corrected. For instance, we cannot tell a discharger of wastes that the embankments around his oxidation ponds must be wide enough to permit use as access roads, and, as a further example, we cannot tell him that his ditches draining the wastes to a disposal area must be designed, constructed, and maintained in any particular manner. How, then, you logically ask, do the control boards operate to abate, prevent, and control nuisance and water pollution?

The water pollution control boards formulate sewage and industrial waste discharge requirements (1) by describing the quantity-strength characteristics of the discharge, (2) by describing the discharge in terms of the conditions to be maintained in the receiving waters or other disposal area, or (3) by a combination of the two methods. In simpler terms, the boards simply specify the end results to be maintained in the disposal area, without reference to the manner or equipment used to achieve these end results. Two examples will illustrate this procedure.

If it is proposed to discharge a waste into the Sacramento River, the pollution control board might specify the quantity-strength characteristics of the effluent or the board might simply state that the proposed discharge will at no time, beyond a definite distance from the outfall, (a) cause the coliform organism count to be greater than 25 per ml, (b) reduce the dissolved oxygen concentration below 5.0 parts per million, (c) raise the water temperature above 75°F., (d) cause the phenol concentration to exceed five parts per billion or the toxic metal concentration to exceed 0.05 parts per million, (e) produce noticeable or objectionable tastes, odors, or solid floating matter, and (f) cause other conditions not compatible with the uses of water in the river. But notice that nothing is said about the details of waste treatment plant design. The same approach must be used where oxidation ponds or lagoons are under consideration or are being used. The boards can specify the amount and strength of the wastes which can be discharged, or the conditions which must be maintained in the final disposal area, but they cannot order that specific designs or types of construction be utilized in accomplishing the end results which are required. The next question which you logically ask is what can be done to see to it that the waste discharger is aware of the necessity to make proper provision for control of mosquitoes? An explanation of the administrative procedure used by the control boards in setting discharge requirements will, I believe, satisfactorily answer this question.

At the time the discharge requirements for a particular waste are under consideration, the water pollution control board, in its capacity as overall coordinating agency, attempts to advise all other agencies having an interest in any problems which might be created by the proposed waste discharge. Depending upon surrounding circumstances, these agencies so advised might include the State Department of Public Health, the State Department of Fish and Game, the State Bureau of Vector Control, the local health department, the local mosquito abatement district, etc. This procedure serves to advise all interested parties that discharge requirements will be set by the pollution control board and it gives them an opportunity to recommend to the board any special stipulations that the agency believes should be incorporated into the discharge requirements. Very often, as a result of this procedure, the boards incorporate into their requirements statements to the effect that the discharge must conform to the requirements of the health authorities regarding disinfection or bacterial standards, that the discharge must conform to all rules and regulations of not only the Bureau of Vector Control but also of the local mosquito abatement district, or that requirements of other State and local agencies must be considered. Although the boards do not in any way assume official responsibility for your duties, nevertheless, they can help you a great deal by advising waste dischargers that all local agencies should be contacted to be certain that local ordinances, rules and regulations must be complied with in the waste treatment and disposal processes. Thus, as you can see, in many respects our work with the waste discharger is educational—that important aspect of the work of all of us which Mr. Durbrow mentioned.

In closing I want to make two suggestions which, if acted upon, should prove mutually beneficial to our two groups. First, it would be most helpful to us if we had specifications, documents, or designs that you mosquito abatement people have prepared which, if incorporated into plant design and construction, would aid you in your mosquito control and abatement work. Although we could not require that the waste discharger incorporate your suggestions into his designs, nevertheless, we could do much educational work for you by calling attention to your problem, your requirements, and your model specifications and designs. Secondly, if you have not already done so, I would like to respectfully request that you contact your regional water pollution control board and make your interests and wishes known. The accompanying map of the water pollution control regions and the list of the names and addresses of the regional offices should aid you in contacting them. I feel sure that if you follow this suggestion that they can be of significant help to you.

STATE OF CALIFORNIA
REGIONAL WATER POLLUTION CONTROL BOARDS

NORTH COASTAL REGIONAL WATER POLLUTION CONTROL BOARD (No. 1)
707 South State Street, Ukiah

SAN FRANCISCO BAY REGIONAL WATER POLLUTION CONTROL BOARD (No. 2)
364 Fourteenth Street, Oakland

CENTRAL COASTAL REGIONAL WATER POLLUTION CONTROL BOARD (No. 3)
Bank of America Building, San Luis Obispo

LOS ANGELES REGIONAL WATER POLLUTION CONTROL BOARD (No. 4)
Spring-Arcade Building, 541 South Spring St., Los Angeles 13

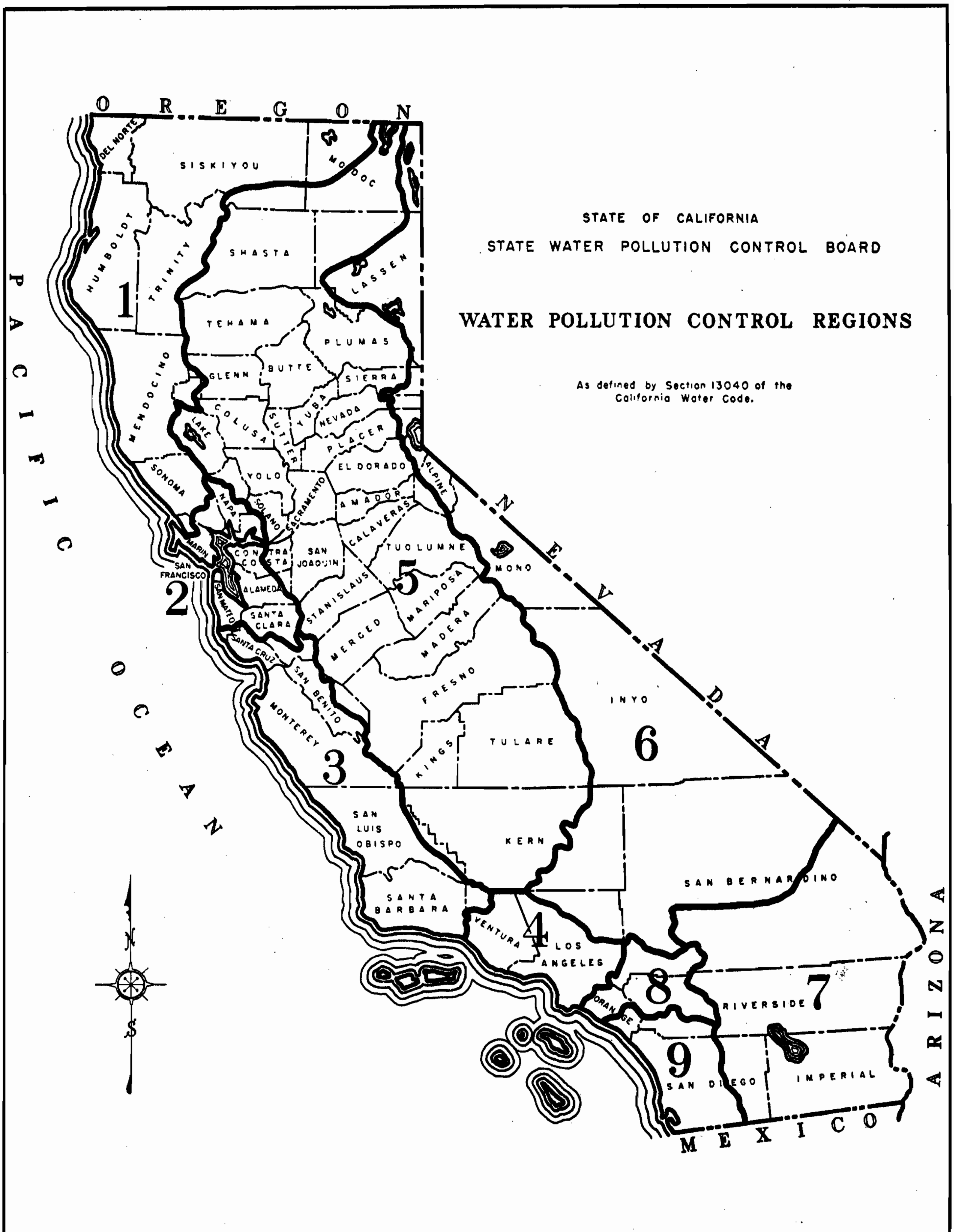
CENTRAL VALLEY REGIONAL WATER POLLUTION CONTROL BOARD (No. 5)
608 Thirteenth Street, Sacramento 14

LAHONTAN REGIONAL WATER POLLUTION CONTROL BOARD (No. 6)
310 North Main Street, Bishop

COLORADO RIVER BASIN REGIONAL WATER POLLUTION CONTROL BOARD (No. 7)
82-454 Miles Avenue, Indio

SANTA ANA REGIONAL WATER POLLUTION CONTROL BOARD (No. 8)
325 North Broadway, Santa Ana

SAN DIEGO REGIONAL WATER POLLUTION CONTROL BOARD (No. 9)
3441 University Avenue, San Diego 4


STATE OF CALIFORNIA
STATE WATER POLLUTION CONTROL BOARD
WATER POLLUTION CONTROL REGIONS
As defined by Section 13040 of the California Water Code.
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
1
2
3
4
5
6
7
8
9
N
S
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
LAKE
COLUSA
SUTTER
YUBA
NEVADA
PLACER
SONOMA
YOLO
EL DORADO
NAPA
SOLANO
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
SAN MATEO
STANISLAUS
MARIPOSA
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

Mr. Smith: Thank you, Mr. Bacon. In preparing this panel I had asked each of these gentlemen to have a brief prepared statement. I then planned on going into a question period, but I find that most of them have covered their subject so thoroughly they've answered the questions that I had prepared. However, I think we can dream up some new questions. Mr. Posz, can you give us some idea of the total impact of this central valley water development in terms of the increase in the irrigated acreage, and some idea what crops that is likely to involve?

Mr. Posz: First of all, the water distributed by the Central Valley Project is regarded as a supplemental supply. It is not correct to say that it irrigates a certain number of acres, because it is distributed over areas of deficient water supply and is regarded on the whole as a supplemental supply. Nevertheless, th Friant-Kern and Madera Canals will distribute an average of about one million four hundred thousand acre feet a year. Mr. Van Avery, the Central Valley Projects superintendent in this district, is in the audience, and also Mr. Baranek, our weed specialist. My remembrance is that means about the million four hundred thousand acre feet. Well, if you wanted to determine just how much land one million four hundred thousand acre feet would irrigate, you could figure about two and a half acre feet per acre and that would mean that this amount of water would irrigate approximately six hundred thousand acres. I don't mean that the water is put on a particular six hundred thousand acres; it supplies areas of deficiency over a much larger area than that. The fundamental objective of the water conveyed through the Central Valley Project conduits is to replenish groundwater storage, and, although the bulk of it is applied to the land, a great deal gets into the underground basin. Furthermore, it cuts down the extent of pumping in many areas and, as a consequence, the groundwater level rises. So, in effect, it is replenishing th groundwater supply in the Central Valley.

Mr. Smith: Regardless of whether we can get any exact figures, we all know that the increase is going to be tremendous. We have already seen evidence of increased mosquito problems. Dr. Ware, can you give us a little more specific idea of what the Communicable Disease Center has planned for the future to cope with this expanded water use in the Central Valley? I'm thinking more specifically of the use of the water out in the irrigated fields themselves.

Dr. Ware: I think this would scarcely be a very good time, Ed, to discuss that point purely because I'm liable to get wound up in it and take until dinner time tonight. But I would like to show you the means whereby we hope to cooperatively accomplish some of the work in regards to communicable disease and vector control in relation to the irrigation development or water resources development. I had the pleasure of participating in the drafting of the original Memorandum of Understanding between the Public Health Service and the Bureau of Reclamation in the Missouri Basin. That was in September of 1947. That I believe served at least in part as a guide for the Memorandum of Understanding which Mr. Posz is working under between the Department of the Interior and the Federal Security Agency. That has been followed by other memoranda of agreement between the Bureau of Reclamation and the Public Health Service, and the Bureau of Reclamation and the State. California to my knowledge is the first state which has gone ahead with initiative to work so closely with the various construction agencies.

Mr. Smith: I thank you Dr. Ware. Now I want to go over into the next group on Irrigation Practices and Agricultural Drainage in relation to mosquito control and call on Lloyd Meyers, Drainage Engineer of the Public Health Service, to give us a few remarks in regard to the relationship between agricultural drainage and mosquito control drainage.

THE RELATIONSHIP OF AGRICULTURAL DRAINAGE TO MOSQUITO CONTROL[1]

By Lloyd E. Myers, Jr.
J. A. Sanitary Engineer (R)

Agricultural drainage may be divided into two types—surface and sub-surface. The relationship and value of agricultural drainage to mosquito control is not always readily apparent and is often overlooked or minimized by mosquito control personnel.

I think almost everyone is aware of the relationship between mosquito control and agricultural drainage which is concerned with surface water. For example, residual or surplus irrigation water which stands in low places in a pasture for several days may injure grass covered by the water and at the same time may provide breeding places for mosquitoes. It is obvious that drainage for the removal of such ponded water serves both agricultural and mosquito control purposes. We may not all be aware, however, of the relationship between sub-surface drainage and mosquito control—that is the drainage which is designed to lower the water table. Some examples of this relationship may be in order.

First, we should define "water table." If a hole is dug down until water is struck, the level at which water stands in the hole is the elevation of the water table. Since this is true, it follows that the water level in a natural swamp or marsh represents the water table. Drainage which lowers the water table in a given area will dry up most of the swamps and marshes in that area and thus eliminate them as sources of mosquito production.

Mosquito control in many localities is seriously hindered because the natural drains have been filled in or dammed off and can not be used as outfalls for mosquito control drainage. In areas where deep open drains or tile are installed to provide agricultural drainage, these drains may be used as outfalls for mosquito control drains.

The relationship between soils, drainage, and mosquito control is another factor which has received little or no attention. We all know that water must ordinarily stand for at least four days to permit mosquito production. When ponded water or pools remain in a field long enough to permit mosquito production, there is usually something wrong with the soil from an agricultural point of view. In many cases, agricultural drainage will permit correction of the faulty soil condition, which in turn will allow the water to soak into the soil before mosquito production can occur.

Finally, the most important reason of all for the promotion of agricultural drainage by mosquito control personnel is that it increases land values, crop production, and the amount of money the farmer has in his pocket. The farmer who is having a hard time making ends meet isn't going to improve his land for mosquito control purposes alone, in spite of any good arguments that may be presented to him, and he will resent paying mosquito abatement taxes.

Some people believe that agricultural drainage construction would not be necessary if farmers were careful in applying irrigation water. We must be extremely cautious in accusing irrigators of being careless, particularly when we do not understand all of their problems. This will make enemies and destroy opportunities for cooperation. It is ordinarily impossible for farmers to apply to a field the exact amount of irrigation water required by the crop. Farmers apply water in excess of plant requirements for a number of reasons which cannot be considered carelessness. Some of these reasons are as follows: (1)

[1]From the Communicable Disease Center, Public Health Service, Federal Security Agency and the Bureau of Vector Control, California State Department of Public Health.

lack of information concerning the exact water requirements of various plants and the exact amount of water their soil will hold in the root zone; (2) poor field layout, often due to lack of money for proper preparation, which makes good irrigation practice impossible; (3) necessity for leaching salts from the soil; (4) mechanical difficulties with irrigation structures; (5) variations in flow of water in the supply canal, due to variations in use by other irrigators; (6) variations in the rate water soaks, due to variations in temperature, humidity, barometric pressure, soil moisture, or quality of water used for irrigation; (7) keeping plants cool in very hot weather; (8) accidents. The foregoing factors make it evident that irrigation water in excess of plant requirements will almost always be applied and that drainage to take care of this excess will always be necessary. A few localities are blessed with adequate natural drains, but in most areas it is necessary to construct a major portion of the required drainage system.

Good mosquito control is very difficult in any agricultural area where poor drainage conditions exist. This is true, first because there are too many sources for mosquito production, and second, because the people can't afford it. Accordingly, mosquito control interests have a very large stake in promoting agricultural drainage. Before we can promote agricultural drainage, however, we are going to have to learn something about it. There are other agencies already in the business of promoting agricultural drainage and we should learn from them and cooperate with them. When agricultural and mosquito control interests work together to solve mutual problems, crop production goes up and mosquito production goes down.

Mr. Smith: Thank you very much, Lloyd Meyers. The rest of the members of our panel have already answered all the questions I had. I can think of one more though that I might toss to Mr. Durbrow. Could you tell us something about the place of drainage in an irrigation district? What powers or responsibilities do irrigation districts have in regard to drainage?

Mr. Durbrow: I'm not sure that some of the districts would like me to give a legal opinion on that question. Let me point out however that I think that most of the districts that have a real drainage problem and a sanding water problem have taken some action to try to remedy it. In other words, they have formed themselves something of a drainage setup also. So far as I know, they are not required to, unless damage is done to property. However, the application of water on the ground entails drainage problems, and therefore good practice in any irrigation district entails a drainage program along with the furnishing of water in that district. I think you will find that most of our districts do have that sort of a program.

Mr. Smith: I thank you, Mr. Durbrow. I tossed that in to get into the next section here. Gordon Winton, the attorney for our Mosquito Abatement District in Merced, has prepared a brief statement on the various laws in regard to the formation of both drainage districts and improvement districts.

DRAINAGE AND IMPROVEMENT DISTRICTS

By Gordon H. Winton, Jr.

It is with some trepidation that I presume to speak to you today about the formation of drainage systems. I do not claim to be an authority upon the subject, and the law regarding the formation is complex.

There are at least four different legislative acts under which drainage districts may be set up. These are the Drainage Law of 1885, the Drainage District Act of 1903, the Drainage Improvement Act of 1919, and the Drainage District Act of 1923. In addition to these acts, there are certain other acts which set up districts which could perform drainage. Some of these are the various reclamation district acts, the Storm Drain Maintenance District Act of 1937, the Storm Drain Maintenance Districts Act of 1939 and the Storm Water Districts Act of 1909. In addition to these acts which have particular reference to the problem of excess water, either from irrigation or storms, many other water district acts incidentally have the purpose of drainage. For instance, the California Water District Act, which is set forth in Division 13 of the Water Code, has among its purposes to store and distribute water, to supply lands and district with water for irrigation and to drain and reclaim lands incident thereto or connected therewith. The same is true of the California Water Conservation District Act of 1923, the California Water Storage District Law of 1921 and the California Water Storage and Conservation Districts Act of 1941.

I know that a mere recital of these acts is confusing and, believe me, if we went into the particular provisions of the acts it would be even more confusing.

Perhaps the most important act which I have not mentioned so far is the Irrigation District Law, which is set forth in Division II of the Water Code, and states that the purposes for which the irrigation districts are formed are to furnish water for, and to put water to, any beneficial use, provide drainage, and so forth. You note that one of the purposes is to provide drainage. We who are interested in mosquito abatement work realize that adequate drainage is one of the important keys to our problem. While perhaps the most important phase of drainage is the drainage of excess irrigation water, still the drainage of storm waters is to some districts also important. In approaching this problem from the legal viewpoint, I cannot overlook the economic value of good drainage to the farmers. This is particularly important when we realize that, in order to institute proceedings to establish any of the districts we have mentioned, or those not mentioned which have to do with drainage, the land owners in the area to be drained must originate the action. Generally speaking, this is done by the circulation of a petition calling for the formation of a district with a certain specified number of signers in the district. Some drainage district acts provide for owners of two-thirds of the land, another provides for 50, or a majority, of the holders of title and another provides for 20 property owners or owners of a majority of the land, etc. The petitions go to the Board of Supervisors in most cases, although in some cases they go to the State Irrigation Board or the Department of Public Works.

I am not prepared, nor would I have the time today, to tell you the advantages and disadvantages of each of the many districts which can provide drainage. However, I would like to emphasize that, where there are already irrigation districts in existence, the irrigation districts can legally, and I believe should morally, engage actively in drainage work to take care of excess irrigation waters. Many irrigation districts have refused to deliver water to farmers who use poor irrigation practices, thus creating excess water which, of course, creates the mosquito problem. This is good common sense, inasmuch as water is a valuable commodity and should not be wasted.

In our own area we have gathered together groups of farmers having a common problem and, without the formality of a drainage district, have secured agreements between the farmers and the mosquito abatement district for the construction and maintenance of common drains. This is, of course, a simple way to do it and, if the area is not too large, a desirable method. The largest group which we have gotten together on an agreement involves approximately 21 different parcels of land.

Within the last few months there has been a new development in our county which may lead to very beneficial results insofar as our mosquito problem is concerned. As you are all aware, this last winter we had very heavy rains. Before cultivation in our county began, in wet periods such as we have just experienced, there had developed natural channels to carry off these rain waters. However, since the land has been put under cultivation, and particularly in the last ten or fifteen years, there has been much leveling and development of land within the county. In the process, many natural drains and water courses, which were necessary in the wet years, have been done away with. The contour of the land has been changed, and the natural flow of excess waters has been altered. As a result, we had some rather severe cases of flooding from surface waters which had no place to go. The County Planning Commission in Merced County has now before it a recommendation to adopt a drainage map for the entire county, together with an ordinance to be adopted by the Board of Supervisors that, before anyone can level or change the contour of his land, he must get a permit from the County Planning Commission. An inspection will then be made, and, if any natural drains are to be eliminated by the work or if the contour of the land is to be changed so as to create an additional hazard from excess waters in wet years, the owner desiring to do the work will have to provide adequate drainage facilities to take care of the situation. While this is merely in the "talking stage," it does seem to be going in the right direction.

In conclusion, let me advise all of you who may be interested in the formation of drainage districts to look first to your present irrigation districts to see if they will do the necessary work, as they certainly have the power to do it. Secondly, if a special district seems to be desirable, thoroughly study the various types of districts available and further study the various acts providing for these districts so that the one best suited to your particular needs and problems may be chosen. I rather fear that I have not given you any amount of new information today, but again I reiterate that the laws in the State of California regarding districts which have drainage as one of their purposes are complex, and cannot be covered in any brief statement.

Question: What is the advantage of an improvement district?

Ed Smith: Well, I don't know whether I'm really prepared to, but I can give my opinion. In the case of an improvement district within an irrigation district, they can take advantage of an organization that is already a going concern with permanent paid personnel who are experts in that field, whereas the formation of a drainage district requires the setting up of an entirely new political subdivision and would certainly be far more expensive. Are there questions from the floor now?

Mr. Gray: Much of this discussion has been on a statewide basis and involves cooperation of state agencies. I sometimes think that perhaps we can understand our problems a little better if we would reduce them down to small dimensions. How about this operation in your own county where you have a committee to consider water problems on a countywide basis? Would it be possible to expand this type of thing to a statewide basis?

Mr. Smith: I'll answer the first part of that question and toss the rest of it to our panel. The Merced County Water Conservation Committee was started about a year ago, stimulated largely by the mosquito district and also the irrigation district. That Committee includes about 35 organizations in the County, all of which are dealing with water problems. The first objective was to obtain better cooperation between those agencies; in other words, to let the left hand know what the right hand was doing in terms of county agencies. We felt that by so doing we might avoid duplication of effort in arriving at the solution of some problems, and that we might prevent ourselves from working at cross-purposes to each other. I think I can safely say that the achievement of that first objective has been highly successful in the past year. The second objective was to do long range planning in regard to water problems in the county. The third objective was to disseminate the information that we brought out through our discussions and meetings, to the farmers who are after all most concerned with water use. The second half of your question—as to whether some type of coordinating council on a statewide basis in regard to water problems might be possible, I'll just ask the opinion of these gentlemen up here on that. Would anybody on our panel care to comment? Dr. Ware.

Dr. Ware: In regard to that question by Mr. Gray, I have observed the operation of such coordinating councils in the Missouri Basin, and particularly in the States of Montana, North Dakota and South Dakota, under various names but all to the same purpose. In South Dakota they call it a coordinating committee of State and Federal agencies. In Montana they call it the Montana Natural Resources Committee of State and Federal Agencies; something like that. By these means they have obtained participation by State and Federal and also private concerns such as certain irrigation district personnel, where irrigation districts have been turned over by the Bureau of Reclamation to individual operation, or are in the process of it. There is a tremendous participation. The offshoots have led to such things as conservation councils. They take State tours for the information of their members and others interested, and it is working with great success.

Mr. Smith: Thank you, Dr. Ware. Do any of the others wish to comment? Mr. Herbert.

Mr. Herbert: I was greatly impressed by what you did down in Merced County. I learned about it recently from our men and since mosquitoes occur in the water on the land, and that land is operated by farmers and ranchers, it seems to me that any organization which brings farmers and ranchers together is the one which you should use. With regard to a statewide project enlarging the one you started down there, I just came from a state convention of soil conservation district directors at Calistoga; they represented seventy-two districts in the State, and it would appear to me that representation of the mosquito abatement people in that statewide organization of soil conservation district directors would be very appropriate. My suggestion toward getting this on a statwide basis would be that your organization communicate with the State Association of Soil Conservation Districts and thereby you will have a contact with seventy-two very democratically run organizations that would be interested in this subject because as all of my colleagues have agreed here soil conservation is really synonymous with mosquito abatement.

Mr. Smith: Thank you, Mr. Herbert. Do any of the others wish to comment? Mr. Bacon.

Mr. Bacon: Going back to Mr. Gray's question, "How can State cooperation and coordination be carried on down to the area or place where the job of mosquito abatement is really being done?"

I would like to recall your attention to the comments made by two speakers this morning. Jack Kimball and Ted Raley, respectively, told of the ordinance adopted in Orange County and Fresno County for the control of treatment and disposal of sewage and industrial wastes. Mr. Kimball told you that the Waste Disposal Advisory Committee, made up of representatives of all interested agencies, was set up in Orange County to aid the County Health Department in its administration of the waste disposal ordinance. Before any permit to discharge is granted in Orange County, everyone, including the Mosquito Abatement District which is represented on the Advisory Committee, has an opportunity to express his thoughts as to what design and construction features should be embodied in the proposed treatment and disposal facilities. The final decisions must be made by the Health Department, but in the process all other agencies have an opportunity to be heard. Mr. Raley described a similar procedure in Fresno County.

The water pollution boards, as well as other State agencies, are encouraging to the fullest extent the enactment of similar local waste disposal ordinances. Once these waste disposal ordinances are enacted and an advisory committee is set up, you can see what a very close contact you can maintain with waste disposal problems in your area. I would highly recommend that you contact Mr. Kimball and Mr. Raley for further details as to how the waste disposal programs are working out in their counties.

Mr. Smith: Thank you, Mr. Bacon. Are there any further questions from the floor?

Question: Do any of the Extension Service publications on irrigated pastures recognize the mosquito problem?

Mr. Brown: The bulletin wasn't written to prevent mosquitoes; it was to raise pastures, but in the bulletin there are many references on proper use of water and proper methods for preparing the field for irrigation. I think if you'll look for them you'll find them.

Mr. Smith: I think that is an excellent example of a place where more cooperation in the future might serve both ends at the same time with less expense, and I think we are getting closer to that aim all the time. Some of you may miss Dick Peters this afternoon. He is flying up to Davis to a conference of local farm advisors to discuss this particular matter of irrigated pastures. Dick Peters is going up there to tell them something about mosquitoes and permanent pastures. I think we will be getting more results through cooperation of that kind in the future. Are there any further questions from the floor? If not, I want to very sincerely thank the group of specialists whom we have had up here today. I feel that we have gone a long way towards increasing the amount of cooperation between these various interests concerned with the use of water. I hope we can go a lot farther in the next year. We will now have our noon recess.

FIFTH SESSION

STUDENT UNION HALL, 1:30 P.M.

Mr. Henderson: I really don't know what is liable to come next, as it is on the program as a "Model (?) Board of Trustees Meeting." Harold Gray is to direct it, and anything can happen.

Mr. Gray: Up to the present moment this has been a very good conference. From now on it goes to hell. The program chairmen have had the very bad habit of sticking various assorted jobs on to me, but the present one I never thought in my wildest flights of imagination would be given me: about a week ago they told me I had to be a playwright. There was wanted a representation of a meeting of a board of trustees, so I immediately thought how a meeting of a board of trustees should or should not be conducted (you know I wrote an article once about how to conduct a trustees' meeting, which is in your manual). You notice the program says "A Model (?) Board of Trustees Meeting." Well, that part was easy. The next thing was to get a cast. I picked out certain members that I though would make very good trustees. The man I wanted to act as president would have been a honey for the job, but the first lousing up of the program occurred in that Guy MacLeod isn't here although he faithfully promised to be present. So I'm going to take over that job, and I will now introduce my cast of characters and ask them to come up here. Two have to remain until a little bit later but I'll introduce them and they'll stand up. The secretary of the board of trustees will be Roy Holmes. Roy, will you come up and sit over here on my right. Trustee No. 1 will be Mr. Rowe. Trustee No. 2, a curmudgeon sort of a guy, one of those "pro bono publico" persons, is Mr. Dwyer. The other two trustees who will not appear for a few moments are Dick Maynard and Adolph Preuss. For manager I have picked a real life manager in Chet Robinson. Now then, the plot of utter confusion begins. Imagine that the time is approximately five in the afternoon or eight in the evening or or noon, whenever you happen to hold your board of trustees meetings. Here we go.

Five seated at beginning of action, 4 trustees and 1 manager. President has a pile of papers in front of him which he is signing. Each trustee has two sheets of paper. A screen and a small Kodachrome projector are set up to one side.

President: (Looks at his watch). "Well, it's after 5 o'clock and we had better get going. I hope none of you trustees are going to start any argument tonight, as my wife has a dinner party at 6 pronto and she'll scalp me if I don't get home on time. The Secretary will call the roll."

Secretary: "Rowe, Holmes, Gray, and Wyre are here, plus the Manager. That's only four Trustees, and we need five out of nine for a quorum."

Manager: "Mr. Preuss said he would be here, which will make a quorum. Mr. Brown is out of town. Dr. Maynard is tied up at the hospital with an accident case and probably won't be here. Mr. Evans and Mr. Whitman couldn't be reached by phone, though they had a written notice a week ago."

Secretary: "Suits me fine if Brown doesn't show up. All he does is pick on little details. That fuss he made last meeting about missing a 6 cent cash discount gave me a pain in the neck."

President: "Why don't these birds get here on time? All Preuss has to do is walk across the street for his ten bucks! Let's go ahead and to hell with the technicalities. What about the minutes of the previous meeting? You have all seen them, I presume."

Trustee No. 1: "I move we approve the minutes of the 67th meeting of the Board held Wednesday, January 31, 1952, as written."

Trustee No. 2: "Second the motion."

President: (Fast). "All in favor say "Aye," contrary "No"; carried and so ordered."

Trustee No. 1: "Hey, there, Hitler, give us a chance to vote."

President: "Any objections to the minutes? (Pause). "There being none, they stand approved as written. You have the agenda before you and we will proceed. The chair will entertain a motion to approve payment of warrants having numbers B-347 to B-375 both inclusive, dated February 15, 1952, in the total amount of $2,874.16. A list of these warrants is attached to your agenda."

Secretary: "I so move."

Trustee No. 1: "Second."

Trustee No. 2: "Hey, wait a minute! No quorum, so you can't pass bills."

President: "The heck we can't. We have done it."

Trustee No. 2: "Well, I was down at the California Mosquito Control Association meeting in Riverside last year, and that attorney from Merced was very definite that you can't transact business without a quorum."

President: "Well, so what? We've done it before."

Trustee No. 2: "O. K., maybe you get by, but any taxpayer could enter a suit and make us personally pay back to the District all money illegally voted."

President: "Oh, nuts!"

Just then Trustee Maynard (No. 3) walks in, says "Who's nuts?" and sits down.

President: "Where in hell have you been, Doc?"

Trustee No. 3: "Oh, a Mexican got his hand caught in the tail gate of a manure spreader and I had to saw him up a bit. Nice, clean job. Maybe he'll die of tetanus, so I gave him a shot, too."

President: "Well, better late than never. Anyhow, we have a quorum. How about the minutes of last meeting?"

Trustee No. 3: "Record me as voting for approval as written.

But do they have to be so long?"

Secretary: "If you fellows would argue less the minutes would be shorter."

President: "Let's not start that argument again. It has been moved and seconded that we approve the bills. All in favor say "Aye"; contrary "No." (All say "Aye" except Trustee No. 3).

Trustee No. 3: "Wait a minute! What's this item of $91 for a projector?"

Manager: "You were not at the January meeting, Doctor. The Board approved the purchase of this projector for slides, which we are going to use for talks to schools, service clubs and the like. After the meeting I am going to show the Board some pictures of our work"

Trustee No. 3: "O. K. I vote 'Aye'."

President: "Carried and so ordered. The President and Secretary will sign the warrants—in fact the President already has done so." (Passes pile over to Secretary, who starts to sign them.) "The next item on the agenda is an authorization for the purchase of a wide-tread tractor for about $2,200." (Turning to Manager)

Manager: "This will be a tractor with its treads 68 inches center to center. We propose to bolt wood cleats to the grouser plates to give a large bearing area to support the machine in soft wet ground, so that we can apply larvicides with it, and even convert it to do ditching construction and maintenance. Two districts in the Bay area have had excellent results with such a rig, and it will fit in fine both with our pasture spraying and in cooperative drainage work with our farmers."

Trustee No. 1: "How much money have we available?"

Manager: "After receipt of the first installment of taxes, and after paying the January bills, the Treasurer had about $65,000. From this we should deduct $40,000 for the Cash Basis Fund, and add about $35,000 for the second installment of taxes payable in April, so there is a net balance of about $60,000. Budgeted expenses from February through June are about $50,000, leaving a free balance of about $10,000."

Trustee No. 2: "Was this item in our 1951-52 budget under Capital Outlays?"

Secretary: "No, it was not specifically provided for, but there was a general item of $2,500 for miscellaneous capital outlays."

Trustee No. 2: "Has anything else been purchased against Capital Outlay?"

Manager: "Only this $91 you have just paid out for the projector, and $230 for a culvert."

Trustee No. 2: Do you really need this tractor?"

Manager: "We sure do. It will be a big help in two ways and it will greatly increase the amount of work we can get done, and cut our unit costs as compared with hand work."

Secretary: "I move we approve this purchase."

Trustee No. 2: "Wait a minute! Did you get competitive prices on this job?"

Manager: "There is only one firm which makes this wide tread type of tractor, so there is no competition. However, we get 10% off the list price."

Trustee No. 2: "O. K., I will second the motion, but I thought we had to take bids on such items."

Secretary: "Well, legally we don't have to take bids, as we are a little different from a city government, for example. But as a matter of good policy we usually take formal bids on larger expenditures, and the Manager certainly shops around to get the best prices on whatever we buy."

President: "It has been duly moved and seconded that we authorize the purchase of a wide tread tractor for not to exceed $2,200. All in favor say "Aye." (All say "Aye.") "Contrary, "No." It is carried and so ordered. The Chair will entertain a motion to adjourn."

Secretary: "Just a moment! There are two other items on the agenda. I have received a petition from the District employees addressed to the Board and requesting an increase in pay. What action do you wish to take on this petition?"

President: "Oh, Lord, do we have to go into that now? My wife will skin me if I don't get home by six."

Trustee No. 1: "This is a hell of a time to be asking for a rise, taxes being what they are."

Trustee No. 3: "You should squawk about taxes! You made so much money on cotton last year you are filthy with cash."

Trustee No. 1: "You ain't doing so bad yourself, Doc!"

Trustee No. 3: "Well, a few patients can pay their bills, and do. Certainly our men are not overpaid, and their take-home pay looks pretty small to me."

President: "This isn't anything that can be decided at one meeting. Suppose we just put it over for future consideration."

Secretary: "That is hardly fair to the employees. It is passing the buck and stalling. I suggest you appoint a special committee to investigate and report, with recommendations, at our next meeting, which will be held February 29."

President: "What do you know about that! Leap year! The Chair will entertain the motion."

Trustee No. 2: "I so move."

Secretary: "Second the motion."

President: "All in favor say 'Aye'." (Four say "Aye.") "Contrary, 'No'." (Trustee No. 1 votes "No.") "That is 4 ayes and 1 no. Carried and so ordered. The Chair will appoint the Secretary as Chairman of this Committee and as a punishment for their absence the other members of this Salary Committee will be our four members who are absent today. Mr. Secretary, will you please get them together as soon as possible?"

Secretary: "In the next few days. The last item on the agenda is a special invitation from the California Mosquito Control Association for our Trustees to attend the annual meeting at Fresno, February 13, 14 and 15. How many of you can attend? The cost of travel is a legitimate expense account."

Trustee No. 1: "Heck, I can't spare the time."

Secretary: "The heck you can't! All you have to do is to lame your wrist clipping bond coupons."

Trustee No. 2: "No use in my going. Those darn college professors use long Latin words and put a lot of cockeyed chemical formulas on the board. It's way over my head. All I want to do is kill mosquitoes."

Trustee No. 3: "Well, Bill, just because you can't understand it is just the reason you should go. Why not try stretching your brains once in a while?"

Trustee No. 2: "Seen your income tax form yet, Doc? There's a real brain stretcher!"

Secretary: "Well, who is going besides me?"

Trustee No. 3: "If Mrs. James has her baby before the meeting maybe I can go. I could sure use a day or two of rest."

President: "Rest, hell! That hospitality evening puts the crimp in rest. Oh, well, if my wife will let me I will run down for one night and get in a few snorts with the boys." (At this point Trustee Preuss enters and sits down.)

President: "Well, look at the late Trustee Preuss: he made it just in time to be sure to collect his ten bucks. You sure love a dollar like your right eye, Adolph!"

Trustee No. 4: "So what?"

President: "Good Lord, look at the time. I've got to get out of here. Any further business?"

Secretary: "None on the agenda."

Manager: "I have several items to discuss, including the January report, but rather than have the President skinned alive they can be postponed."

President: "If there is no objection, then, the meeting is adjourned. Next meeting at 5 p.m. on Friday, February 29. The Secretary will send out notices to the Board members. Feet, take me hence." (Trustees get up and leave.)

Manager: (Plaintively) "Doesn't anybody want to look at my pretty pictures?"

Mr. Gray: Well, what's wrong with that particular board of trustees meeting? Have you ever seen any at all like it? How many of you ever proceed without a quorum? I have never seen one board meeting that had everything in it like that, but over the past twenty-one years I have seen most of those things happen.

One of the things that is quite important is the item of the agenda. How many trustees have your manager or the secretary of the board prepare an agenda for your board meeting? Maynard of Three Cities. Who else? Delta is another. Pulgas also? Orange County; Northern San Joaquin has it; Madera does; West Side; Consolidated. Well, it seems to be fairly general. I suggest that it is a matter of expediting the public business, and tends toward better conduct of the board of trustees meeting if a track is already prepared for the trustees to run on. It does organize the business of the meeting so that all necessary items are brought up, nothing of importance is omitted, and at the same time there is sufficient flexibility so that anything new or unforeseen can be introduced if it comes up.

The question of quorum I don't think needs to be elaborated on. We had that discussed last year at Riverside, but there is one thing that I think should be kept in mind. If you notice in this little meeting, there was a certain amount of personalities injected. As far as possible, although you never can get away from personalities, those should be minimized and kept in the background. We all find sooner or later that the trustees somewhat group themselves into different types. There is the man on the board of trustees (and fortunately this type is not numerous) who has to look into every possible detail and who tends to get away from his proper function as a trustee and intrudes upon the function of the manager. I'm not saying that in regard to my own board because we've had almost no difficulty that way. But I have seen it. We need to keep in mind that there is a separation of functions here. The primary job of the trustees is to determine policy and see that the policy they determine is carried out; it is the job of the manager to see that that policy as established by the board is carried out. The manager should not attempt to encroach on the policy function of the board of trustees, and the obverse of that picture is that the trustees should not encroach on the managerial function of the manager. If you're not satisfied with the way he's running his job, don't try to do it yourself for him; fire him and get another manager that you can rely on and have confidence in. You can fire your managers tomorrow.

What I want to do is to draw out some of you trustees. I'd like to ask for questions from the trustees in getting discussions going as to some of their particular problems. Dick Maynard, you have two boards of trustees with one manager and one administrative and operative staff. How does that work out with you? Do you meet together, or do you meet separately, or at the same time and same place but separately, or what do you do?

Mr. Maynard: One month our two boards meet separately, and in alternate months they meet jointly.

Mr. Gray: What is the general practice among the districts as to meeting time? Some meet at noon for lunch, and some meet in the evening; some meet at other hours. How many districts represented here meet in the evenings? Apparently about eight districts meet in the evenings. How many meet at noon? Six. Anybody meet at 5 in the afternoon? I guess Alameda is the only one that meets at 5 o'clock. The time of meeting is more or less a matter of the convenience of the majority of the trustees. They are the ones who set the time of meeting. It so happens that the hour of five pretty generally meets best the convenience of our Trustees, and we usually are able to conclude our business in 35 or 40 minutes except when the budget is up, or a very involved proposition like the establishment of the retirement system, or occasionally when the report of the salary committee is being discussed.

How many districts have a special committee to investigate salaries? Apparently four districts do. We have our salary committee meet either late in March or early in April, in order to establish salary scales so that the Manager may estimate the money requirements for the next year's budget, which is prepared in March or April.

Do you have any set system of salary schedules or scales? Do you have a five step system for five years or do you just simply set a flat sum? (Several districts indicated the use of either three, four or five steps.) There seems to be a certain amount of advantage in schedules and steps; that is five steps in each schedule, and a series of schedules determined more or less mathematically so that each schedule is about 5% above the preceding lower one, and each step in the schedule is an increase in pay of about 5% over the preceding step. You can get those from almost any civil service commission. We have adopted the same schedule and step system as the County of Alameda and it seems to be working well.

What is the practice in the districts in regard to budget adoption? Does anybody adopt a budget as early in the year as we do? Paul Jones, you get yours in April? How does that happen that you're so early?

Mr. Jones: Well, we haven't a salary committee, and sometimes maybe the first time I propose a budget it's not accepted, so I just get it in early and if there's any argument it is set over one week, and we still get it in in time.

Mr. Gray: Gordon Smith, when does yours come in?

Mr. Smith: About the first and no later than the 15th of March.

Mr. Gray: Who else gets in early? Mr. Coburn does at West Side. Does anybody wait until as late as August to get their budget in? Apparently no one. What happens to your budget after you have made it? Who do you file the budget with?

A Member: You file with the Board of Supervisors.

Mr. Gray: Anybody else?

A Member: The County Auditor.

Mr. Gray: Precisely. That's what the law says. The estimate of the amount of money you're going to require has to be filed with the Board of Supervisors and with the County Auditor. Do you give them a segregated budget showing the various items you're going to spend the money for, or do you just say you're going to need so much money? Does anybody just turn in so much money? (Apparently all districts file a segregated budget.) We're very careful to see that our taxpayers' association not only gets the budget but I talk to them on the telephone and tell them whether it's going up or down and why. The public is entitled to know what you are doing, how much you're spending, and so on.

Mr. Washburn: I was wondering how these districts in two counties or maybe overlapping counties work out their budgets.

Mr. Gray: That's a very interesting question. Do we have any districts here that operate in two counties? Ted Raley, you explain what you do and how you do it.

Mr. Raley: We report to the county with the largest land area. They in turn make their request to the other county, for its pro rata of the total.

Mr. Gray: Let's see, you have Fresno, part of Tulare, and part of Kings. The money is apportioned between the counties according to the ratio of assessed valuation and not of land area.

Does anybody know who actually sets your tax rate?

A Member: The Board of Supervisors.

Mr. Gray: That's what you think. They adopt the ordinance or resolution establishing your particular tax rate, but there are few boards of supervisors who actually decide how much it's going to be. It's usually some one of the minor officials, perhaps in the County Auditor's office, who actually works out the assessed valuations that are applicable and divides the amount of money you ask for into the assessed valuation of your district; he comes up with a figure which is a tax rate and he reports that. How many of you know in your county just who that John Q. Jones is that does that? That's a very important man. In my county it's a chap by the name of Ralph Ruckert. After I've got the amount of my budget, and after I've found out the unexpended balance left after the first of July, I've got the net that I need to have produced by taxation. Then I go and sit down with Ralph (in fact I sit down with him every once in a while anyway) and we figure what the tax rate should be to produce the net amount required. He has been very fair and reasonable in setting our rate. Then this goes up to the board of supervisors for adoption as the district tax rate.

It is part of the job of the manager to know who does what in his county, and it's part of the job of the board of trustees to know that the manager knows these men and is on good terms with them. Don't think that because the law says a certain thing is done by a certain body, that that body doesn't cast the burden of the complex figuring upon some one individual with a calculating machine to work it out.

A Member: Can the board of supervisors raise more money than you have asked for?

Mr. Gray: I'm not an attorney, and I wish an attorney were here who does know something about this, but I assume that if the tax rate that they adopt raises at least the amount of money required, you have no further control over it. You can ask for money that could be raised by a 10 cent tax rate, and if the board of supervisors wants to raise it to make it 15 cents, you have nothing to say about it; but if it takes 10 cents and they give you 8 cents, that is illegal.

A Member: What can you do in that case?

Mr. Gray: Get a taxpayer to sue the supervisors who voted for the insufficient tax rate. They'll have to dig up the deficiency out of their pocket or out of their bond. Possibly, if time permitted, a mandamus suit might be possible. But, remember, that is not a legal opinion.

A Member: Suppose your budget requires a 20 cent tax rate, but they cut you to 10 cents. What can you do about that?

Mr. Gray: I don't know how the court would rule on this question. Suppose you have a budget that required 20 cents, and you bring it up before the board of supervisors and ask them to approve the extra 5 cents above the normal 15 cents: there's a possibility, owing to the peculiar construction of the language of the act, that the board of supervisors might say, "No, you can only have 10 cents." Once you ask for something above 15 cents there is a possibility that the board of supervisors could cut you down to one cent. The language of the law is ambiguous in this situation.

A Member: What can we do when there is mosquito breeding on our Indian reservation and they migrate into our territory?

Mr. Gray: It would probably be best to take the matter up with the Federal Bureau of Indian Affairs and try to work out some cooperative program for control. Since the Indian reservations pay no local taxes, the local people should not be expected to bear the costs, even for their own protection. But through negotiation you should be able to get substantial control work done. Dr. Rees, you still have some Utes in Utah. Do you have this type of problem?

Dr Rees: So far as I know our mosquitoes bite the Indians as freely as they do the whites. (Laughter)

Mr. Gray: While you are on your feet, are your Board of Trustees' meetings markedly different from ours in California? Your law is similar to ours.

Dr. Rees: I don't think I ever saw them conducted in any other way. (Laughter)

A Member: What about the rat control problem? Can mosquito control districts also control rats?

Mr. Gray: If your district was organized after August, 1931 you may do so, but if your district was organized before August, 1931, you would have to have an election to authorize you to control rats.

A Member: Isn't it possible to have an election to compel the board of supervisors to levy a tax beyond the 15 cents, if the supervisors decide not to allow it?

Mr. Gray: The board of supervisors could set an advisory election to determine whether public opinion wanted the larger tax, but I believe it would be purely in the discretion of the board of supervisors whether they call such an election or not, and the result of the election would be merely advisory, and the board of supervisors could disregard the result. I understand that an advisory election is to be held in November as to whether a certain city is to petition to be annexed to a mosquito abatement district. Some people want it, but the city council does not. The election will be purely advisory, but city councils and boards of supervisors seldom go contrary to a definite public opinion.

As we have run somewhat beyond our scheduled time, I will conclude this discussion and turn the meeting back to the President. (Applause)

Mr. Henderson: Thank you very much, Harold. I didn't see any talent scouts in the audience but I think they should have been here to see this show of the board meeting. We're very happy to have with us this afternoon Charles L. Senn, Engineer Director of the Bureau of Sanitation, Los Angeles City Health Department. Mr. Senn is going to talk to us on Mosquito Control and Environmental Sanitation.

Mr. Senn: Mr. President, the way has been well paved for a discussion on environmental sanitation's place in mosquito control. All of the discussion at this meeting, on permanent control and cooperation of mosquito abatement officials with other agencies and individuals, emphasizes that elimination of many sources of mosquitoes can be accomplished by application of the principles of environmental sanitation.

We realize that the average person likes to participate in the activities of government; that he likes to take part in things, not always to have things done for him. This principle was quite apparent at a meeting with the Inter-American Association of Sanitary Engineering last year where we heard of the fine acceptance of programs of the Institute of Inter-American Affairs, an agency of our government which is contributing technical knowledge and a little money to help our Latin-American neighbors help themselves. Those people don't get 'a hand-out' from Uncle Sam, they get help, advice, and guidance, but they have to pitch in and do their own job. I think that's why that program is so popular.

In mosquito control, in the past, there has perhaps been too much tendency to think of ditching, draining, larviciding, and other activities by employees of the mosquito abatement districts. A few years ago when we were arranging a series of meetings for dairy operators to be held in various parts of the state, our dairy sanitarians asked various local health department officials about what cooperation existed between the dairy sanitarian and the mosquito abatement officials in controlling mosquito breeding in dairy drainage. It was rather surprising that some of the health departments apparently have not developed close cooperation with their mosquito abatement officials; that some dairy sanitarians thought their job ended when the drainage from hosing down floors was conveyed a hundred feet away from the dairy barn. If there were mosquitoes breeding in the water, the abatement district would come in and apply larvicides. Some even thought the abatement districts would be offended by a program whereby the dairy sanitarian and the mosquito abatement district employees would jointly have the dairymen practice alternate furrowing or other means of getting rid of the water without creating mosquito-breeding conditions. In some cases, to my amazement, the answer was: "We don't want to offend the dairyman. He is a big taxpayer. We feel we should give him the service; we shouldn't make him do that work." The dairyman would think more of us if we showed him how he could do a better job instead of doing the mosquito control work for him.

There is a close relationship between certain sanitation programs and those we may develop in mosquito control. Some years ago, in the Los Angeles Harbor area, there was concern that plague rats would be imported from India or some other foreign ports. The rat population in the harbor area was high; there was fear that plague would spread from rat to rat; that the port would be closed by Federal quarantine. The Harbor Department asked us "Will you people undertake the job of exterminating rats in the harbor area? We'll provide the trucks, materials, poison baits, and funds for other necessary expenses. You provide the manpower and the technical guidance." We said, "No, we do not wish to engage in a program of extermination, but we will be happy to work out a program under which we will be your technical advisors on eliminating the breeding and feeding places for rats. As an adjunct to the program, we will do some poisoning." There resulted a program whereby the sanitation and rat-control specialist, whose role could be likened to that of mosquito control and drainage specialist, goes directly to the design engineer of the new structure, wharf, fish market, or cannery and shows him how to plan and build to avoid creating rat harbors. He works directly with the maintenance supervisor to show where he should patch up an opening to keep rats from getting into the building; where a pile of rubbish should be removed to eliminate rat-harboring. Through that program, rats have been practically wiped out.

How does that tie in with mosquito control? Mr. Arthur Shogrin, who supervises Harbor Sanitation, was approached by Harbor Department Officials, shipyard operators, Army and Navy officials, and others, who said: "Is there any way we can work together on a mosquito-control program?" Up to that time Mr. W. E. Duclus, our field supervisor of mosquito control, was having one of his crews spend several days a week in the Harbor area treating the then-existing many acres of mosquito-breeding water. Occasionally there'd be a miss on the treatment and a swarm of mosquitoes would emerge, so joint, cooperative action was organized toward permanent control. The Harbor Department did ditching and filling; the Navy decided to make sanitary fills at certain swamp areas that were problems; Ft. MacArthur Army officials said "We'll do our part." The Union Ice Company had some drainage problem. They said, "We can conserve that water and not waste it where it forms a mosquito-breeding pond." Throughout Wilmington there are hundreds of oil wells. At each well there is a unit where water is separated from the oil. That water was drained onto the ground, so each well was a potential mosquito breeder. The city Sewer Department said "That isn't much water, we'll accept it in our sewers." A sewer connection was then provided to run salt water drainage from each well into the sewer.

Now it is no longer necessary to reguarly treat this area. The entire San Pedro-Wilmington area is visited by our control crews only upon a request from our Harbor Health Department office. This treatment is confined to a few days a year. There is no routine treatment because breeding places are eliminated. The people who did their part feel much better toward us than if we had kept on spraying. The whole area looks better because eliminating breeding waters generally improved the environment.

At this meeting we have heard much of the tendency of mosquitoes to become more and more resistant to larvicides and insecticides. I hope they never become as resistant as the flies have become in some areas.

This brings up another parallel between mosquito and fly-breeding problems. Early last summer a meeting of our Board of Health Commissioners was interrupted by a group of about 50 women. They were as upset as any group of women could be They said that whenever they tried to feed their babies, flies would get in the children's mouths; that they would shoo the flies away from the screen doors but still a hundred would come in every time they entered. They had tried swatting and spraying and everything else without results. They feared the flies would cause an epidemic of polio. Our Board said, "This is an emergency. We want you to use all the men you can spare, and all the equipment you have, to spray the area and get rid of those flies." When I had a chance to comment I said I was afraid that these flies were so resistant to insecticides that spraying was not the answer; that we should get after the source. I couldn't complete my statement. I was booed down by the women who had loudly applauded our commissioners when they said we should get busy and spray.

Well, Mr. Duclus and his men worked many hours of overtime. They applied DDT, BHC, chlordane, and everything else to soak the walls of porches and garages; they used their venturi devices for fogging. It seemed that if one fly was killed, ten came from a nearby manure pile to take its place.

Finally, after about a week, the women agreed there was no point in continuing the spraying operations. The ring-leader said "You can quit. The spraying isn't doing any good."

What was the answer? Well, we don't have the complete answer as yet, but this morning we heard quite a bit about the need for cooperation. That's what we tried next. From the various feed companies we secured the names of all the poultry and animal raisers in the San Fernando Valley. We sent them invitations to educational meetings so we could show them what they might do to help eliminate fly-breeding. At the first of three separate meetings there were about eight hundred people; at the next meeting, six hundred; and at the next, about four hundred. The Farm Bureau Federation took up the project. They worked with the farm advisors, agricultural extension people and others. They arranged their own meeting, at which there were about a thousand people. They prepared pamphlets, made studies, and found, as you probably know, that by allowing the manure to 'cone' in a certain way, or by otherwise keeping the manure dry, they could eliminate fly breeding. Many of their members have cooperated in a program of scientific management whereby fly breeding is eliminated.

There are many people who do not attend educational meetings; many people who are not very considerate of their neighbors. Our recent checks continue to show that those people who had no interest in these meetings continue to breed flies. What should we do about them? We can try our best to get cooperation but I feel that all we can do, in justice to the neighbors, is to give the offenders notices and, as we have done in a few cases, cite them to the City Attorney or the District Attorney on a public nuisance charge, or whatever other violation we can prove. Education is certainly important. Cooperation is important. In some cases enforcement is a necessary part of our overall program.

Last year we began to have a problem of mosquitoes breeding in permanent pastures. Irrigation water was often applied at the upper end of a field in the hope it would flow across half a mile of pasture and somehow disappear into the ground. There were places where the water ponded long enough to cause large swarms of mosquitoes to fly into the nearby, thickly populated areas. We got together with th Farm Advisors and the Farm Bureau Federation. They were not ready to settle down to the problem because it involved considerable study and was of limited interest. However, on a statewide basis, there is the possibility of the Farm Bureau Federation, the Mosquito Control Association, the farm agents and all the others getting together to work out a solution to a common problem.

We have heard Harold Gray remark about mosquito breeding at cemeteries. What is the answer? We, in Los Angeles, got together with our local cemetery association and they said "If we have to tip over those vases every time they're full of water, we'll go broke trying to provide the man-power." Perhaps on a statwide basis we can find an answer. It seems unreasonable to expect public employees to treat every vase in a big cemetery as often as it would be necessary in order to control mosquito breeding.

We have such problems as surface drainage from new subdivisions. What gutter sections should be acceptable? Very crude asphalt paving that has depressions, so all the people that irrigate lawns create mosquito-breeding pockets? Maybe we can get together with the designers and point out the need for some minimum grades, minimum gutter sections, minimum type of construction that will reduce mosquito breeding! Then we have cases where they have well-designed gutters and good slopes for the subdivision, but the water doesn't go any place. It doesn't connect up with another street or with a storm drain. Here again it seems that we should be able to work out some kind of program so that, in considering subdivisions, as health departments do to check on private sewage disposal, we can consider the mosquito-breeding problems that might be created.

All in all, there is much need for continuing the trend toward giving other people an opportunity to work with us in helping to control mosquitoes. For instance, our water department maintains a number of reservoirs, spreading basins, and other potential mosquito-breeding water accumulations. They are reluctant to have us treat the water because we may add something that impairs the taste. They're happy to work with us by doing their own treating.

Our Public Works Department has a Sewer Maintenance Division. They have their own crews for cleaning out sewers and maintaining open ditches and storm drains. They have asked us to give demonstrations, talks, lectures, and instructions to their crews. They prefer to do their own adulticide-spraying wherever it might help control adult mosquitoes in culverts and similar resting places. They do their own work on improving channels when this helps control mosquito breeding. They would resent our doing their work for them.

In considering environmental sanitation we need to consider mosquito control, and in considering mosquito control we need to think about environmental sanitation. We, who are working mostly in environmental sanitation, are not operating agencies. We think in terms of getting someone else to do a better job of maintenance. Most people in mosquito control have had the viewpoint of operating agencies. They think in terms of ditching, draining, spraying, and so on, by themselves. I think they should develop a little bit of the concept of the Health Department people. By each getting a bit of the ideas of the other, both can do a better job. There is need for continuing the trend of the mosquito abatement district representatives getting together with the Health Department people.

One last point. We do know that if we don't have enough personnel to do our regular job we're never going to have enough time to get together with all of these groups; to do the necessary coordinating, teaching, and handling of public relations. That takes time. Each district could well consider the desirability of having someone on the staff who would be a public relations man. In health work we call such a person a health educator. He is trained in leading community groups, preparing educational pamphlets, and similar public relations programs. The viewpoint should be to help the people help themselves, and in doing so, help do a better job for the districts and the communities.

Mr. Henderson: Thank you very much Mr. Senn, for that thought provoking message following through on the themes that we have been discussing, not only this year but in years past. Our next speaker will be Dr. E. R. Tinkham, Manager of the Coachella Valley MAD.

THE EYE GNATS OF COACHELLA VALLEY WITH NOTES ON THE 1951 LARVACIDING PROGRAM

Dr. Tinkham: To those of you who may not know, Coachella Valley lies in that part of California that Jack Kimball has already told you was the "wonderful South." Coachella Valley is, I would say "wonderful" during the cooler winter months but in our very hot summer when temperatures soar daily to 108 or more and swarms of eye gnats plague our lives, it is marvelous if you can maintain that "wonderful feeling."

There are five species of eye gnats of the genus *Hippelates* representing four pest species and one non-pest species in Coachella Valley. *Hippelates collusor* is the year round pest. *H. robertsoni,* a large black species, is a late winter and early spring species. *H. dorsalis* is a large distinctive species found in summer and fall. *H. pusio,* closely resembling *H. collusor* except for the blackish infuscations of all femora, was formerly abundant until canal irrigation came into the valley in 1949. The non-pest species *H. hermsi* prefers the damper orchards and may in time replace *collusor.*

This chart on Trapped Gnat Comparisons will show some interesting factors concerning the gnat populations in former years and at present. I have compared the records given for the period October, 1931-May, 1933 (see Burgess, March, 1951, American Journal of Hygiene) with Tinkham records for the period December, 1948 - December, 1950. You will note the very high peak of spring gnat emergence back in Burgess days, especially for April, 1933, when 14 Burgess status traps collected 480,000 gnats. In May, 1932, the total was almost 200,000 and in May, 1949, 140,000 for 14 modified Burgess traps (on footlong legs). You will note the very low numbers trapped during the summers of 1932 and 1949 and the high peak fall collections. Although perhaps not true for 1932, I can say that the 1949 summer low was not due to the lack of gnats, but the failure of the meat bait, and to some extent a failure of the Burgess trap to index the gnat population. This is demonstrated by the 1950 figures for August when 10 Tinkham traps with a new bait (fresh or rotten egg in water) caught in three weeks over 300,000 gnats. This indicates that the gnat population, at least in recent years, is very high in August (as all valley residents will testify) and not low as indicated by previous trapping records. You will observe that in the spring of 1950, when using the 14 superior Tinkham traps, there was a great depression of trapped gnats. This is believed to be due to the introduction of cold canal water into the valley for the first time in the summer and fall of 1949. One of our objectives in 1952 will endeavor to index the gnats by trapping in proportion to their field abundance and thus demonstrate that gnat breeding follows the population curve typical for insects.

Hippelates, in Coachella Valley, is very much a vector insect. From this graph prepared from the Coachella Grammar School by the school nurse, Mrs. Snow, in the fall of 1951, you will note that the incidence of pink eye in grades Kindergarten through Grade IV ranges from 50 to 60% in September and October, dropping to about 10% in November after the onset of cooler weather. Nurse Snow found in her home rounds, that the incidence of pink eye in children of pre-school age was even greater and averaged at least 75%. In Grades V to VIII you will observe that pink eye averages about 20% in September and October and about 15% in November, disappearing in December. In High School, pink eye is negligible.

At this point time was taken to show a series of colored slides, the purpose of which was to give the listener a better "eye-dea" on what these traps and other items looks like. Shown at this time were colored slides of: Tinkham trap, modified Burgess trap, Emergence trap three feet square to evaluate the larvaciding program, chemical irrigation methods, and various shots of the 1951 Larviciding Program portraying various types of equipment to spray the cultivated soils of the date and citrus orchards. Also shown were various types of date orchards in cultivation and one (Williams) in non-cultivation. Since gnats breed almost entirely in the cultivated soils of date and citrus orchards, also in cotton (that surged to the fore in 1951) the lack of cultivation or the development of a Bermuda or grass cover or of a forage crop will also eliminate the breeding of *H. collusor,* the pest species. (Also shown were several photos of pink eye in school children.)

From non-cultivation many benefits are derived: (1) no gnats, (2) saving the costs of cultivation which with a man's salary, tractor, disk, gas and oil are considerable and (3) the production of a beef crop by pasturing. Many other benefits are also evident, and if I had time I could go into these more fully, including evidence that non-cultivation also increases date and citrus production. I wish that Dick Peters were here for I have now demonstrated two very important factors for Subvention Fund allocations:

1. The long time prevalence of the vector insect and the vector disease (pink eye) going back to the year 1924. Our District was formed March 17, 1928, to fight gnats.
2. The permanent control of eye gnats by natural means, i.e.: non-cultivation, which will not only eradicate gnat breeding in areas of non-cultivation, but will also save the grower and the taxpayer money, the latter by saving the cost of larviciding treatment which averages $10 per acre.

This is our battle-cry—"*Non-cultivation eliminates gnats and saves money. Cultivation propagates gnats and costs money.*"

1951 Gnat Larviciding Program

The Gnat Larviciding Program commenced June 4 and ended August 10. You have already seen the colored slides showing the type of spray equipment used, which consists chiefly of a 21 to 24 foot spray boom, wide enough to spray the soil surface of the cultivated space between two rows of date palms. The chemicals used were: Aldrin, BHC, DDT, Dieldrin, Chlordan and Heptachlor. All but DDT were applied at approximately two pounds of the actual chemical per acre. DDT applications ranged from 6 to 22 pounds actual DDT per acre.

In cooperation with the State Bureau of Vector Control with $5,000 in Subvention Funds to assist us, we have treated six orchards with three chemicals each. Thus the first row treated was Aldrin, the second BHC, the third DDT while the fourth row was the check or untreated row. This treatment repeats through each orchard until there may be 8 to 10 rows each of the three chemicals and the checks. Each row has a 3 foot square emergence trap to evaluate the larviciding program. This trap must be reset according to the disking program of the grower. In the summer one setting is usually of one month duration and long enough to record the gnat generation ranging 14-21 days. In the spring and fall the traps set usually two months for each setting and for the winter the traps set from December to February or March to collect the overwintering forms.

Four orchards of this special treatment were sprayed with Aldrin, BHC, DDT and check in series throughout the orchard. Two other orchards were treated with Dieldrin, Chlordan, Heptachlor and check in seried rows. Time has been too short to evaluate the latter series. In the former series we have found that Aldrin is superior to BHC and DDT. The emulsifiable concentrate also appears more effective than the wettable powders. Wettable powders are also most difficult to work with since they constantly clog the nozzles, and although cheaper in cost than concentrates the cost in lost time sometimes is very high. I recall one occasion where we applied a 200 gallon tank of emulsifiable BHC concentrate in 10 minutes and at 11:00 A. M. started with a 200 gallon tank of BHC wettable powder. At 3:00 P. M. we were just finishing up after sweating four hours repeatedly cleaning nozzles and parts of the spraying equipment. Computing the salaries of three men for four hours —this made the use of wettable powders most expensive.

This chart will illustrate the effectiveness of our larviciding control using emulsifiable concentrates. On 4 of the special ranches our information to date is:

87 trap settings on Aldrin treated soil produced only 8 gnats.
91 trap settings on BHC treated soil produced 32 gnats.
83 trap settings on DDT treated soil produced 20 gnats.
79 trap settings on the untreated soil produced 464 gnats.

Due to the farmers' variable discing program, it is not possible to maintain the same number of trap settings in the treated and untreated soil.

We also have a large number of trap settings in our general series. Many orchards are sprayed with one of the six chemicals with one or two rows of checks. In the general series we have one trap on chemical and one trap on check for each of the various chemically treated orchards. In all, we have 271 emergence traps set down to evaluate the 1951 Larviciding Program. Two hundred and seventy-one traps can in one season make over 1,000 different trap settings.

From our studies we have pretty good evidence that Aldrin, at least, at 2 pounds actual Aldrin per acre in the emulsifiable concentrate form will control gnats for a period of months. The big question that we hope to answer soon is for how long? We have hopes that Aldrin will give at least one season's control. Perhaps, in time we may find that some of these other chemicals will give almost as good control as Aldrin and perhaps for a longer period of time. These facts we hope to discover in 1952.

Mr. Henderson: Dr. Bryant Rees of the Fresno State College and entomologist for the Fresno MAD will give us a paper on "The Hippelates Fly or Eye Gnat in Fresno and the Feasibility of its Control by Present Mosquito Abatement Methods."

THE HIPPELATES FLY OR EYE GNAT IN FRESNO, CALIFORNIA, AND THE FEASIBILITY OF ITS CONTROL BY PRESENT MOSQUITO ABATEMENT METHODS

By Bryant E. Rees

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With the increased annoyance caused by the *Hippelates* fly or eye gnat to the population of Fresno, California, the Board of Trustees of the Fresno Mosquito Abatement District deemed it advisable to accumulate certain facts regarding the biology of the fly in local residential areas and to determine if control methods now being employed in the abatement of mosquitoes would be effective against the gnat. Work on the problem began on July 2, 1951 and terminated for the year on October 15, 1951 when the last field observations were made.

A review of the literature demonstrates that most of the studies dealing with the biology and control of the *Hippelates* fly are concerned with elaborate and extensive field tests and observations. The reports, therefore, cover the biology of the gnat as found in areas of many acres and even square miles. Studies of cultivated lands such as vineyards, date palm gardens, and citrus groves as potential and actual breeding places for the fly are included in various papers, and in one (Jones and Magy, 1951) uncultivated isolated desert areas are brought under consideration.

In these studies, it was shown that adult flies could be collected by means of emergence traps, each trap being constructed of a box three feet square and approximately ten inches high. A hole two and one-half inches in diameter was made near the top in two sides of the box. A standard size fruit jar was inserted into each opening and thus served as collecting chambers. The flies, after passing through the pupal stage in the ground, emerged and flew to the immediate source of light, thus entering and remaining within the fruit jars until collected. The successful employment of the emergence traps demonstrated that the gnat larvae were contained in recently cultivated and well fertilized fields, and Jones and Magy (1951) obtained adults from such traps located in several uncultivated desert areas. However, although adult gnats have been readily taken in the field by this method of collecting, in no instance, according to the papers reviewed, were larvae of *Hippelates* flies taken in California from their natural habitat.

Much has been revealed from these studies about the biology of the flies, their preferred breeding places, and even the opinion expressed that the flies will travel for a distance of "several miles," yet the studies do not answer questions centralizing on the propagation and control of the gnat within residential areas. Due to the lack of this desired information, the study at Fresno was concentrated within the limits of the city and the immediate outlying areas.

General collecting of adult gnats was made by means of bait traps. The traps consisted of one-half quart fruit jars into which baits of various types were introduced. A fine mesh screen funnel with an apical opening just large enough to allow the passage of a gnat was inserted into the mouth of each jar. The whole was then capped with standard window screening, the screen and funnel being held in place by the open fruit jar lid. The arrangement permitted small flies, such as *Hippelates* spp., to enter, while at the same time preventing larger flies from reaching the bait. After entering, the funnel prevented the gnats from escaping. Two dozen traps were prepared in this manner, baited and placed in various localities throughout the selected residential sites. Traps were placed in direct sunlight, in open shade, and in deep shaded areas. Use was made of various sites in which were growing such plants as ferns, oleanders, bamboo, myrtle, and bermuda grass. Traps were also placed beneath trees of various species. Several types of bait materials were used with the principal baits consisting of egg albumen, egg albumen and yolk, egg yolk, fish meal, blood meal, and finely chopped and putrifying liver. Specimens were collected daily from the traps and preserved in 70% alcohol for identification purposes. In some instances, young children were used as an attractant for the gnat. Specimens were collected by means of an aspirator as they attempted to reach the head orifices of the children, such as the ears, nostrils, and particularly the eyes.

Representative samples of the adults taken, both by the aspirator method and by means of traps, were identified by Dr. C. W. Sabrosky, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, as consisting of two, possibly three, species as follows: *Hippelates collusor* Coq., *H. microcentrus* (Tus.), and *Hippelates* sp. (*pusio* Lw.?).

It is well to note at this time that *H. collusor,* a species with light yellow to slightly orange legs, was the only one taken about the faces of children. In no instance was there any evidence that *H. microcentrus* caused annoyance to humans through their flight or feeding habits. In regards to feeding habits, *H. collusor* was readily attracted to the liver bait and egg albumen but only after putrification had set in and a perceptible odor emitted. On the other hand, *H. microcentrus* was attracted to the egg albumen bait within a few hours and continued to be attracted for about 48 hours thereafter. The latter species was also taken from traps containing egg albumen and yolk and from those containing blood meal. Preference was shown toward the egg albumen. Fish meal bait traps gave no results, but this might have resulted from the fact that the fish meal did not reach the stage of putrification before its use was discontinued. Most of the specimens of all species collected by means of bait traps were taken from traps located in open shade, very few were collected from traps placed in deep shade, and none were taken from traps located in open sunlight.

Emergence traps were employed in an attempt to locate propagating areas. In the present study, the emergence trap consisted of a wooden box 13½ inches long by 12½ inches wide and 10½ inches high, open on one side. All cracks and possible points of escape for the gnat were sealed with several layers of masking tape. A small hole, into which was inserted the mouth of a narrow-necked 12 ounce bottle, was drilled through the side of the box near the top. A prepared trap was then placed in an area suspected of being a suitable breeding place for the gnat, and for the purposes of this study, the trap was generally located near a house. It was firmly set into position and sealed by packing and tamping mud and wet paper about its edges. This precaution was followed in order to prevent the escape of the flies from around the box. Gnats emerging within the covered area were attracted to the opening near the top of th box and thus into the collecting bottle. Some of the bottles were used dry; ohers contained about 20 cubic centimeters of very dilute alcohol in which the flies eventually drowned. Fourteen such traps were prepared and employed, periodically being moved from place to place, usually after a period of one week in a given locality. In some instances traps were left in the same place for over a period of one month. Additional traps were prepared and left in position throughout the summer months. Although small flies of several genera and families were collected, along with spiders, pill bugs, caterpillars, and centipeds, no *Hippelates* gnats were taken.

Simultaneously with the work on the adults, efforts were made to obtain *Hippelates* larvae from their natural habitat. Soil samples were taken from many localities and types of terrain. Samples were obtained by pressing a soup can, open at both ends, into the soil for a distance of two and one-half inches.

Since the can had a diameter of two and one-half inches, the sample taken contained approximately ten cubic inches of soil. The samples were removed from the can and placed in cardboard cartons. Particular emphasis and care in recording the data were placed on the exact locality from which the sample came, that is, whether taken from a rose bush bed, fern garden, and the like, since such ornamental plots are to be found in various numbers within residential yards.

Examination of the soil for the presence of larvae consisted of washing the material through a series of fine mesh screens or seives. Although finer seives were used, it was found that small wormlike animals, thus the *Hippelates* larvae, were removed from the soil before or by the time the seive possessing 1,400 squares to the square inch was employed. Three larval specimens of *Hippelates* sp. were obtained by this method from approximately 840 cubic inches of soil. The first larva was taken from the peripheral soil of a fern bed that had not been cultivated or fertilized for over a two year period, the second was obtained from soil beneath an ornamental orange tree, and the third larva was taken from a rose bush garden. The significance of these findings lie in the fact that the eye gnat breeds in ornamental garden plots within residential areas. Since this is so, an infestation of *Hippelates* flies need not come necessarily from nearby or distant rural areas.

The scarcity of larvae per given unit of soil indicates that the larvae may be widespread and yet be in sufficient numbers as to produce a noticeable and annoying population of adults within the confines of a residential yard. This assumption is plausible since the adults arising from the dispersed larvae would naturally concentrate about any attractant, whether it be bait, dog or human being. It would also be plausible to assume, from the point of view of the mosquito abatement districts, that control measures against the larvae under these conditions would be economically impractical; too many large and scattered areas would have to be treated in an urban district in order to reach one to a few of the larvae. However, in the Coachella Valley of California where the gnat population is or has been extremely large, Jones and Magy (1951) report that ground application of 0.5% DDT at the rate of one pound per acre, both as a spray and a dust, indicated a small degree of control in one locality for at least 27 days, and 10% dust applied at the rate of one pound per acre gave similar results in a second test area for a period of one week.

In view of the above report and others by various authors, no efforts were made to control larvae during the present study, but work was directed toward the control of the adult gnat. Experiments in the control of the adult have been presented by several workers, and the following summarizes the data obtained by Jones and Magy (1951): 1. Mosquito control techniques were used in attempts to control *Hippelates* spp. in the Coachella Valley in the spring of 1948. 2. Two airplane applications of DDT in oil in the form of a thermal aerosol and one application in the form of a water emulsion spray failed to control the gnats. The spray was applied at the rate of 0.4 pound of DDT per acre. Since DDT appeared to be ineffective against the adult gnat, control of the adult in the present study was attempted by a thermal aerosol application of 0.3% lindane.

Four cardboard cylinders, capped at each end with fine mesh screening, were used as containers. Ten speciments of *Hippelates collusor* were introduced into each carton for experimental purposes, and the specimens were then taken into the field in order to subject them to control measures by use of aerosol as normally employed in the abatement of mosquitoes. Tube No. 1 was placed one foot above the ground on a flower plant, tube No. 2 was located on bare soil approximately ten feet from a house, and tube No. 3 was placed on a retaining wall surrounding a flower bed. Tube No. 4 was kept in the laboratory as a control. Tubes Nos. 1, 2, and 3 were in position well in advance of the approach of the aerosol generator, and they were kept there until after the machine had passed and the aerosol completely dispersed. Although the aerosol freely passed through the cylinders, in no instance were any of the gnats knocked down or killed by the insecticide. Tube No. 1 was then covered and otherwise protected from further exposure to the aerosol. Tube No. 2, still containing the same specimens, was taken to a new location and placed near the street curbing, while tube No. 3 with its contained specimens was placed about two feet above the ground in the fork of a small bush located three feet from a corner of a house. With the passing of the aerosol generator, tube No. 2, lying on the curb and about ten feet from the course of the machine, received a concentrated discharge of the aerosol in addition to the initial exposure of a short time ago. Tube No. 3, also previously exposed and now located about 20 feet from the passing aerosol unit, did not receive a concentrated treatment, but the tube was in a location where the aerosol lingered for a period of seven minutes. Again, there was no knock down or kill of the gnats. The specimens were then returned to the laboratory for observation. All remained alive and attempted to escape their containers for a period of over four hours. One to two hours later the gnats, including the control specimens, began to die, apparently from lack of water and food. Additional similar experiments were conducted at various times during the summer with the same negative results.

This report may be summarized and concluded as follows:

1. There are two, possibly three, species of *Hippelates* flies in Fresno, California: *Hippelates collusor* Coq., *H. microcentrus* (Tus.), and *Hippelates* sp. *(pusio* Lw.?).
2. Adult *Hippelates* spp. were collected by means of bait traps, while the use of emergence traps proved unsuccessful during th present study although successfully employed elsewhere. Egg albumen, egg albumen and yolk, egg yolk, blood meal, and putrifying liver were attractive baits for the gnats. Of those tested, the egg albumen bait and the liver bait were the most effective. Adult *H. collusor* were readily attracted to the liver bait but less so or not at all to the other baits tested.
3. Specimens of *H. collusor* were collected by means of an aspirator as they attempted to reach the eyes, nose, and ears of children. Only *H. collusor* was taken under these conditions; at no time were specimens of *H. microcentrus* collected about the faces of the children.
4. Larvae of *Hippelates* sp. were obtained from soil samples taken beneath a citrus tree, from a fern garden, and from a rose bush bed. The preferred soils appeared to be those that had been well fertilized and recently cultivated, but the larvae were found in ground that had not been fertilized or cultivated for more than two years.
5. The number of larvae taken per given unit of soil, as shown in the present study, indicates that they might be widely spread throughout a residential area although the adults may appear in concentrated numbers.
6. An aerosol treatment of 0.3% lindane did not affect the adult eye gnat, *H. collusor*.

From this and other studies it may be concluded that the *Hippelates* fly is not to be controlled by ground applications of DDT in low concentrations, either as a spray or as a dust, or by means of aerosoling with DDT or lindane when applied in concentrations normally used in mosquito abatement methods. Control of the gnat, therefore, remains a problem. Its solution may be found when the use of other, and perhaps new, insecticides, or higher concentrations of presently known insecticides, have been tested and proven ecenomically feasible.

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Mr. Henderson: Thank you, Dr. Rees. At the request of the gentlemen who were to have presented papers on the remainder of the program, they will be deleted. However, they will appear in the proceedings as will other papers that are not listed here. One man that we can always depend on to get us started in the right direction and keep us on an even keel wherever and whenever necessary, and button us up and send us home in the right direction is Harold Gray.

Mr. Gray: Some day I hope that we'll get somebody who will take part of these burdens off my shoulders and give more variety to the meeting. I could dismiss this with a very few words. However, before praising, let's have a little criticism. It seems to me that at this particular meeting the discussion was rather less than is normally characteristic of our California meetings. We have had some beautiful arguments at times and a wide variation of opinion has appeared and has been expressed vociferously with great edification of the audience. I hope that we are not getting around to the point where we are taking the "ipse dixits" of the college professors without putting them to the test of practical examination, and then expressing our individual ideas if they happen to be contrary. I commend to the program chairman for next year more time for discussion.

A few of our speakers have not been too distinct in their diction. That is partly due to the speaker, and sometimes the apparatus was not working well. On the whole, the presentation of papers has been pretty good. I was a bit disappointed that on at least one symposium the time limits either were not understood by the speakers or they were not observed; as a result some of them had to hurry along toward the end. That is partly the fault of the symposium chairman, but sometimes it is a lack of thoughtfulness on the part of an individaul speaker for those who come after.

Now for the good points. There were many. It was a very enjoyable meeting in a great many ways and extremely informative. We can express a very definite vote of thanks to the college authorities here for the excellent accommodations. Of course some of you that sat in the back of the room were less comfortable, but we men sitting up here in front in the soft seats have been very comfortable, so comfortable indeed that a few of the boys went to sleep. That's a little too comfortable. Also, being out here at the college has done wonders for the eyesight for some of the older men. The coeds here look younger and more pulchritudinus than around the Berkeley campus.

In the selection of papers and speakers I think the program committee did well in giving us a fairly good geographical representation. I would hate to see the day come when the California meeting should degenerate to merely a consideration of California conditions. We should always keep in mind that it is desirable to bring in speakers from other areas who can tell us what's going on in other parts of the orld. Don't get ingrowing in your ideas. Other people are doing things. We can learn from them. Bring them here. Let's see what they have to say, what they're doing. Sometimes we have something we can tell the other fellow that he can use, but always remember that a wide geographical representation is a very good thing for this kind of meeting. I was particularly impressed with the papers by Dr. Hackett and Coloner Carpenter which gave us a different geographical viewpoint. Symposia are always excellent. Dr. Stewart once said they are indispensible in a meeting of this kind. We had a fine insecticide symposium, and in spite of a few limitations the mosquito source reduction symposium also was valuable. This interchange of ideas and divergence of opinion is very helpful.

I'm extremely pleased to see a larger participation of trustees. I think we have more trustees at this meeting than we have ever had. It is one of the weaknesses of the California Association that we fail to get a majority of our boards of trustees present at these meetings. We should explore a little further the problem of trustee participation. It isn't that they don't know that they're welcome, and that we want them, but we haven't gotten the idea of participation over to them adequately. Admitted that they're busy men, but still I think that perhaps we could do a better job of selling these association meetings to the trustees. Another thing that I think is quite encouraging is that we had a very definite division of opinion upon certain matters of policy. We had a vote on it. Some people lost and some people won. Apparently the decision of the majority has been accepted in good grace and good humor by everybody. I now make a plea that all of us accept that decision as the present decision, and if it comes up in the legislature we present a united front. Once in a while we may scrap among ourselves but to the outside let's present a united front.

Our open house was excellent. It breaks the ice. People get acquainted. We have a group of officers who give promise of excellent management of the association this coming year. I see nothing on the horizon except further success. I want to congratulate everybody who has had charge of the arrangements. We're going to have a good time this evening, and I hope we can get home all in one piece and go back to the job, and use in our operations what we have learned here. Good luck.

Mr. Henderson: Thank you, Harold. Are there any announcements? Well, this is the end of the 20th Annual Conference. We have a big year ahead of us. It isn't up to me. It isn't up to the executive committee or the board of directors as far as this association is concerned, because you are the association. We are going to work together and to cooperate and we're going to go ahead in the future as we have grown and expanded in the past. Discussion is good, different ideas are good, and out of it can come a greater association than we have ever had before. I would like to extend my appreciation to the committees who have worked so hard on this meeting, and have made such a success of it. I'd like to have those men stand up. You'll agree with me that we owe a vote of thanks to the committees, to the men who are listed in the front of your program for the work they have done for this conference. Let's stand and give them a hand. We'll see you at 6 o'clock at the Rainbow Ballroom.

ADJOURNMENT

Following are five papers prepared for the meeting but not presented for lack of time.

THE CONTROL OF AEDES DORSALIS AND OTHER AQUATIC PESTS IN RICE FIELDS

By ROBERT F. PORTMAN[1]
and
ARTHUR H. WILLIAMS[2]

The rice fields of the Sacramento Valley are the source of a major portion of the mosquitoes which infest the area. Of the mosquitoes which infest the rice fields three species predominate:—*Anopheles freeborni, Culex tarsalis,* and *Aedes dorsalis.*

As this paper deals only with those pests which infest the rice fields shortly after they are flooded, the only mosquito involved is *Aedes dorsalis.*

This mosquito has been established in many of the California rice fields for a number of years and today is a serious pest in the rice areas during the spring. The eggs of these mosquitoes over-winter in the soil and will remain viable in fallow fields for several years. A large portion of the eggs survive the plowing, discing, harrowing, levelling and other cultural methods used in the preparation of the rice fields.

Soon after the flooding of the rice fields the larvae may be found and though the number obtained per dip in many instances is small when compared to irrigated pastures the large acreages involved result in great numbers of adults. When infested pastures and other irrigated lands are converted to rice fields heavy broods of *Aedes dorsalis* are often produced.

The barren rice fields provide little shelter or food for these mosquitoes so they are extremely vicious. And as they disseminate throughout the surrounding area they constitute a serious pest problem as well as infesting other rice fields and suitable breeding sites.

During September and October wild pastures, fallow fields and duck club lands are frequently flooded with drainage water from the rice fields. The resulting myriads of *Aedes dorsalis* disseminate for miles throughout the adjacent rice area, and in the past have caused harvest crews to walk off of the job. Mosquitoes from these sources have undoubtedly served to infest many of the rice fields.

The Fairy or Tadpole Shrimps, *Apus oryzaphagus n. sp,* and *Apus biggsi n. sp,* commonly called shrimp by the rice growers, are indigneous to the Sacramento Valley. Like mosquitoes they have infested the rice fields and often occur in great numbers. The shrimp eggs remain in soil over winter and hatch under favorable conditions when the rice fields are flooded the following spring. Shrimp eggs have been hatched from dried mud after two years storage, and it is common knowledge that phyllopod eggs are resistant for a number of years.

The first report that these shrimps were of economic importance was by Rosenberg in 1946. Since that time these crustaceans, primarily *Apus oryzaphagus n. sp* have been causing damage throughout the rice area of the northern Sacramento Valley.

They chew off the tender leaves and dislodge the soil around the roots of the rice seedlings. The uprooted seedlings then float to the surface. The muddy water resulting from their digging activities inhibits the growth of the rice by reducing the amount of sunlight which reaches the submerged seedlings. Often the shrimps appear in such large numbers and destroy so many of the seedlings that it is necessary to re-seed.

In recent years the larvae of the giant scavenger water beetle, *Hydrous triangularis* (Say) has become a pest of considerable importance in some of the California rice-growing areas. The beetle larvae do not chew off the leaves of the seedlings as do the tadpole shrimps, but uproot the entire plant. Their digging activity on the bottom of the flooded rice fields stirs up the soil causing the water in the check to become muddy, similar to tadpole shrimp infested waters. The beetle larvae are active during the first few weeks after the checks are flooded and are therefore a pest at the same time as are the tadpole shrimps.

The larvae of *Aedes dorsalis* which occur in the newly flooded rice fields may be controlled by spray larviciding but this would require the treating of thousands of acres in a short period of time either by hand or by plane, because the checks are inaccessible to power sprayers. Spray larviciding by plane is not feasible because this would entail a large number of personnel to determine when larvae are present in the fields and to coordinate the plane spraying at a time when the personnel are needed for larviciding in other areas of the district, and at a time when all available planes are being used for seeding and fertilizing and are not equipped for spraying. Also the district would have to pay the total cost of the operation. As the mosquito larvae and tadpole shrimps occur in the rice fields at the same time, a method of control and toxicant were sought which would control both pests. In this way the overall cost of control would be less and the rice growers would control the mosquito larvae when controlling the shrimps.

Herms and Sperbeck in 1948 found that wettable powder DDT would stick to the hulls of the damp seed rice as it was dumped into the plane loading-hoppers. They found that when the wettable powder was introduced into the flooded fields by this method that the*Aedes dorsalis* larvae were controlled effectively. They also found through laboratory tests that amounts of wettable powder at rates as high as four pounds per acre had no effect on the germination of the seed rice nor upon the growth of the seedlings.

Rosenberg in 1946 found that the shrimps could be controlled in the rice fields by applying one pound of copper sulfate per acre inch of water, or by applying one-half pound of DDT as a water emulsion per acre inch of water. Prior to 1950 the accepted method of shrimp control was to plane sow about ten pounds of granular copper sulfate per acre. Usually this is done when floating rice seedlings are observed, adult shrimps are seen, or when the water appears muddy. Often excessive damage occurs before it is realized that the fields are heavily infested with shrimps.

It is common knowledge that the adult giant water scavenger beetles are easily killed by many of larvicidal sprays used by mosquito abatement district, but the effect of these sprays on the beetle larvae is usually not observed. Davis (1950) stated that copper sulfate as used for shrimp control has no effect on the beetle larvae, and also states that no effective means of control has been found except draining the rice fields. As this is a hazardous procedure it is seldom used. Recently rice growers have tried some of the newer toxicants and achieved varying degrees of control.

Inasmuch as the Sutter-Yuba Mosquito Abatement District had been achieving control of *Aedes dorsalis* larvae by applying wettable powder DDT with the seed rice, and Rosenberg

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had shown that DDT was toxic to the shrimps, it was felt that this toxicant and method of application might control both pests at the same time in a single application. Therefore a cooperative field test was arranged with thirty-three rice growers in Butte County, representing about 4,000 acres of rice. The 50% DDT wettable powder was added to the seed rice in varying amounts so as to give treatment rates of from one to four pounds per acre.

After the fields were treated they were inspected at weekly intervals for *Aedes* larvae and tadpole shrimps. Thse inspections confirmed the reports of the rice growers that no shrimps or mosquito larvae were produced in any of the treated fields within a period of about a month after treatment. Subsequent random reports and inspections for a period of about three months showed that there was no infestation of these rice fields by shrimps, but the larvae of *Culex tarsalis* and *Anopheles freeborni* appeared in some of the fields in small numbers.

It was also found that the larvae of the giant water scavenger beetle were effectively controlled.

Field plot tests in 1950 showed that the three pests, *Aedes dorsalis, Apus oryzaphagus,* and *Hydrous triangularis* could be controlled by treating the dry soil of the rice paddies within nine days prior to flooding with DDT-xylene type water emulsion at the rate of one to four pounds of DDT per acre and with a DDT wettable powder suspension at the rate of four pounds of DDT per acre. The flooded fields remained lethally toxic for at least two weeks.

Random field tests showed that the three pests could also be controlled by spraying the infested fields with DDT-xylene

In the spring of 1951 wettable powder DDT was applied with the seed rice to some 20,000 acres of rice in Butte County on a cooperative basis. The Butte County Mosquito Abatement District furnished the insecticide to the rice growers on the basis of one-half pound per acre of rice planted, and many of the growers added varying additional amounts of insecticide to make in some cases a total up to two pounds per acre. Five thousand acres under the Glenn County Rice Growers Cooperative were treated with one and one-half to two pounds of 50% DDT wettable powder to their seed rice. On the whole excellent control was obtained; the few failures were due to improper methods of application. In some instances the hull of the seed rice was too dry, the wettable powder was blown away by the back-wash of the plane and not carried by the kernels to the bottom of the rice checks. Some growers tried to plane-dust one and one-half to two pounds of 50% DDT wettable powder per acre but the distribution was very poor and the toxicant did not penetrate the water of the paddies in sufficient quantity to give control.

The application of wettable powder DDT to recently flooded rice paddies with the seed rice has proven to be a successful and economical method of control of the three pests. This method of control provides the rice growers with an insurance against damage by tadpole shrimps and beetle larvae at a total cost which is less than the cost of copper sulfate alone, and reduces the cost of mosquito control to a minimum.

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SOME OBSERVATIONS ON MOSQUITOES FROM IRRIGATED COTTON FIELDS IN MADERA COUNTY, CALIFORNIA

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There is little doubt that wherever crops are surface irrigated mosquito problems will arise. Cotton as such a crop is no exception, particularly the way it is grown and irrigated in the San Joaquin Valley of Central California. Our point of interest here is not whether the cotton fields are sources of mosquitoes, but rather what are the predominant species involved. During the summer season of 1951 a survey was made by collecting and rearing larval samples from irrigated cotton fields by personnel of the Madera County MAD to attempt to establish some definite information. Some interesting, although not necessary new, facts were disclosed.

Our collecting and handling methods were kept simple and inexpensive. Getting mosquito larvae into the laboratory with daily temperatures well over a hundred, and transporting them distances of ten to twenty miles, is very difficult. There are many expensive thermos bottles on the market, but we felt a large volume of water with each sample could be of some help. We therefore used ordinary one quart milk bottles in a regular milkman's wire carrier rack, one dozen to a rack. These were kept in the shade as much as possible, but mortalities were still high. Contaminated dippers also contributed heavily to our mortalities—a condition almost impossible to avoid during normal control seasons. In rearing larvae we used one pint mason jars with screened lantern chimneys over each. A stick or a float in each enabled most emerging adults to fly up into the screened chimney, which was removed separately and chloroform applied easily.

During the summer of 1950 there were approximately 43,000 acres of cotton in Madera County. In 1951 there were over 95,000 acres. The increase was largely from fields formerly in alfalfa or permanent pasture, the plowing and discing being completed during the winter. As is customary between crop changes, most of the new fields were dyked and pre-irrigated early in the spring. In spite of the heavy mechanical tilling of the soil some fields had hatches of *Aedes nigromaculis* as early as April. This was particularly true with those having a known history as a source of this species in the previous crop. It was interesting to observe, however, that in these barren, pre-irrigated fields no adults could be proven to have emerged. Rearing attempts in the laboratory were also unsuccessful beyond the 4th stage larvae, from which identification was made. Perhaps the lack of vegetation of any kind in these fields accounted for this incomplete maturation, as at the same time *Aedes nigromaculis* adults were normally showing up in alfalfa and permanent pasture.

Very young cotton is not irrigated, except probably in very loose soil. We were not able to collect mosquito larvae of any species again from cotton until the 19th of June. This late date was ample time for oviposition by spring broods, and seems to indicate that overwintering eggs of *Aedes nigromaculis,* for instance, from a previous field of alfalfa or permanent pasture are not of importance in newly planted cotton. After this date mosquito larvae were collected at irregular intervals from cotton furrows near the tail ends or in low spots. Early samples proved to be mixed, as adults of both *Aedes nigromaculis* and *Aedes dorsalis* were reared. As daytime temperatures increased there was a decline in larvae of *Aedes dorsalis* but a continuance of *Aedes nigromaculis* for some time.

One very important factor must be kept in mind regarding the early and mid-summer cotton growing period; the plants are low and tractor cultivation is carried on regularly, which means excessive irrigation is seldom practiced. In poorly leveled fields water will stand in spots, and if these are too wet for the tractor and do not involve too large an area they are frequently abandoned to the weeds. These naturally are our main early sources of mosquitoes in cotton. From such a source our first larval sample of *Culex tarsalis* was taken on the 5th of July, along with larvae of *Aedes nigromaculis*. This combination persisted together in all our samples until about the 7th of August. By the close of the first week of August most cotton fields in Madera County are no longer machine cultivated, but will be hand chopped at irregular intervals depending on need and labor costs. It is from this time on until the end of all irrigation the picture changes complexion entirely. Gone are the breaks making up the so-called regular irrigation cycle. This wonderful practice is replaced by a system of continuous flooding of each field, a method condoned by all technical advisors of good cotton production. What happens is the water in the furrows is not allowed to disappear, but more added when it is low.

One can readily understand, then, why after approximately the first week of August *Aedes nigromaculis* begins to be absent from larval samples entirely, and is replaced by *Culex tarsalis* as the predominant species. Of nineteen successfully reared larval samples in August, four proved to be *Aedes nigromaculis,* while fifteen proved to be *Culex tarsalis*. Also during the last month of heavy irrigation in September, out of a similar number of successfully reared larval samples sixteen were *Culex tarsalis,* one *Aedes nigromaculis,* and two *Culex quinquefasciatus.*

The positive rearing of specimens of *Culex quinquefasciatus* from two samples was most interesting, but also proved to be of grave concern even into late October. When one observes how long water does stand in some cotton fields polluted with dead leaves, bolls, and many other unknown ingredients, it is easier to wonder why this species isn't the most common rather than uncommon.

As to control methods best suited for cotton fields, one must first walk through almost any field in the San Joaquin Valley during August and September to appreciate how difficult is good control. In order to even begin to get through some fields one would need at least hip boots considering the depth of water plus sinking in the wet, soggy soil. Then in the middle of some fields you may even get lost due to the dense foliage and extreme heights of the cotton plants. This may sound facetious, but those of us confronted with this situation every year know from experience. Airplane use early has been successful in some areas. In small fields, forty to sixty acres for instance, siphoning DDT, DDD, or toxaphene concentrate at approximately one gallon per acre has given very good results. A routine practice has been to power spray tail water as far as possible into each furrow. The reason this does work in some instances is because although the egg hatch may be well up in the furrow subsequent releasing of water at the head end floats the larvae to the tail end in great numbers. Another method used in Madera County was the planting of great numbers of mosquito fish, *Gambusia*. A peculiar situation arose in which our natural stock pond of some thirty acres began to dry up in August. The *Gambusia* were to be lost anyway, so we started planting them in those cotton fields that were most over-irrigated, being sure, of course, that an insecticide had not been used too soon previously. Results were fair, depending on how dense the grasses had grown in the cotton furrows. Thermal aerosoling of populated areas we found to be a necessary adjunct to the control program. There are approximately sixty acres of cotton within the city limits of Madera, and many hundreds more immediately bordering the city. Routine aerosoling during the last two months of the cotton growing season greatly reduced adult mosquito counts and complaints from this area. It may be well to say one should evaluate mosquito control in cotton production areas not to the exact one hundred per cent but how close to that goal you can work on an economical and worthwhile results basis.

Our observations during the entire past season of operations in Madera County indicates that *Culex tarsalis* was our predominate problem species from cotton. The fact that it is present during the two longest and hottest months of August and September, which requires heavy irrigation best suited for its propagation, leaves little doubt that conditions are ideal for this mosquito in any cotton production section of the San Joaquin Valley.

TOSSITS

L. S. Haile

Manager, Corcoran Mosquito Abatement District

In the Corcoran District where we always have a shortage of man power, I have been looking for something that we could use in our larviciding operations that would be a time and labor saver. We feel that we found it the past year, in the form of Tossits.

While the past year was very dry, we had some flooded areas caused by the snow melting in the mountains rapidly, which caused the creeks to overflow a number of times. We found that by using Tossits that we could work the overflows and creeks with a minimum amount of time and labor.

They proved very effective, always able to get good kills. A Tossit will cover seven hundred or seven hundred fifty square feet, as advertised by the makers. The only thing wrong with their usage, and that is no fault of the Tossit itself; it seems that the average operator cannot realize that they will cover as much surface as they do, and will use more than is really necessary.

As a whole, I consider Tossits a valuable insecticide and a real time and labor saver. We used about four thousand of them in our district of ninety square miles last year, and will continue to use them this year.

METHODS USED TO ERADICATE VEGETATION ALONG CREEKS, DRAINS AND SLOUGHS IN THE SHASTA AREA

By J. D. Willis

Manager, Redding Mosquito Abatement District

Access to all the areas within the districts for proper inspection and treatment has been one of the major problems confronting the mosquito abatement districts in this section of the Sacramento Valley. Controlling vegetation along water courses has resulted in a lowering of operational costs. Clearing out brush and trees makes it easier for operators to make inspections and do larviciding when necessary. In addition, eliminating vegetation that chokes drainage ditches increases the rate of water flow and promotes better drainage. The brush and grass not only make access to these areas difficult, but make treatment costly due to the amount of material necessary to make sure the proper amount of larvicide reaches the surface of the water.

In our winter maintenance work at the present time, we use two completely different means of removing growth from the drains. We have what we call the old methods and the chemical. First we will discuss those which we call the old methods.

These methods of clearing brush and grass have been used since mosquito control was started in this area in 1918. They include pasturing, mowing, dragging, brushing, and burning. In certain cases we still use these means of clearing along our drainage system.

Brushing and Burning

In certain cases, when new areas are annexed to our District, the first attempts at clearing are by hand brushing followed by burning, followed up the coming year by chemicals.

One of the faults of brushing, especially in willows, is that the following year there is a great deal of trouble due to suckering. Burning also leaves an area very undesireable for the operator to get into and do inspection and treatment work.

In this area a man is able to brush from five to six hundred square feet per day where there is a fairly heavy growth of brush. We use a 24 inch machette for this work. Care must be taken when brushing in areas where poison oak is mixed with the brush, because some of the operators are very susceptible to it.

For our burning we use a power sprayer with 200 pounds pressure. For material, we use drain oil which we pick up at several of the large mills around our area. This oil is given us by the mills, and by the time we haul and store it in our storage tanks it costs us about 4c per gallon. This is a very heavy oil, and during the cold weather we mix ten to twenty gallons of diesel oil to 100 gallons of drain oil. This has proved very good in our area for burning, and is very economical.

Mowing

About the only place where mowing is beneficial is where the drains are straight and level, and where we can mow along the bank and then drop the blade from each side of the bank into the drain and cut the cattails below the surface of the water. If we are able to cut the cattails under the water they seem to die back and do not create a serious problem in the future. Mowing seems to be of no great benefit along our natural waterways, drains, and gullies as we are not able to get into the areas due to the uneven ground and rocks.

Pasturing

Probably the cheapest method of keeping down brush and grasses along the drainage system is by the use of cattle and sheep in areas where there are ranchers who will cooperate. In this area sheep are preferred as they do not tramp down the banks and leave deep hoofprints along the water edge such as the cattle sometimes do.

We have carried on some experiments with the ranchers in our District and it has proved very valuable where we have large swampy areas along the river. In most cases it has only been necessary to do a little brushing to give us free access to all of these areas after a period of pasturing. In one case a few sheep were able to clean an acre to such an extent that it could be properly inspected and treated within ten days.

Dragging

In some cases where we have large areas of tules and cattails that are periodically dry, we use a tractor with a drag made of ties behind it, and drag them down in August and September. Later on we usually burn off these areas. This does not help in any way to kill them, and has been discontinued since we started using the 2-4-D.

In 1948 we decided to do some work with the new 2-4-D and ground sterilizers that were on the market at that time. During the past three years we have tried many materials; some of them have been very promising, while others have been of little benefit to us.

By use of these materials on our drains we have cut our maintenance costs 70% to 80% per year on some drains. For this reason, the use of weed killers has, in the last few years, become a major part of the mosquito control program. We are not only able to save the taxpayers money, but are able to give better mosquito control during the summer.

We have decided that for our own use we would use Dow Esteron 44-2-4D with the Esteron 245-T for all of our spraying. We do our own mixing of these materials, mixing 1½ quarts of Esteron 245-T, 1½ quarts of Esteron 44-2-4D, 5 gallons diesel oil, and 95 gallons of water. We have used this same mixture this past year for all of our brush killing with good results. By mixing the two materials ourselves the material is cheaper than buying the prepared mixture commonly known as brush killer. One hundred gallons of this spray mixture costs us $5.60.

In using this spray material we do not have it figured on any certain amount per acre. All of the brush and vegetation sprayed must be thoroughly covered before good results are obtained.

There are many areas in our District where we can use the 2-4-D with no danger to crops or pasture land. In other areas it is necessary to be very careful because of the spray drift or vapor injury that can be caused by the use of these materials to other vegetation in the vicinity. It is also necessary when using these materials to have a permit from the County Agricultural Commissioner. At the present time there are many new regulations in regard to the use of 2-4-D.

In using 2-4-D our best results in most cases are obtained during the spring months, just when our larviciding program is getting into full activity. Although it is very hard for us to carry on both a larviciding and a brush control program, we still are able to do some of this work in the most serious areas, even if it is necessary for us to put in a good deal of overtime.

In using 2-4-D we try to spray upstream, so that there will be less danger of a concentration of material in any one area downstream. For spraying the 2-4-D we have used the Essick Power Sprayer No. 400 with 75 to 85 pounds pressure. In much of our follow up spraying we have been able to use hand sprayers. These are the Dobbins Bighead No. 44-G. After using these sprayers it is essential that they are thoroughly cleaned so that no trace of chemicals are left in them. Most of the work has been on willows, blackberries, poison oak, wild grape, elderberries, and cattails.

Willows

We have had very good control on willows by spraying in the fall as well as in the spring, when we have not sprayed later than the 10th of October. In most cases where 2-4-D has been used on willows it has only been necessary to go back and respray once. We have probably saved enough in larviciding material and labor to repay us for the cost of spraying the 2-4-D on the brush. During winter months we have sprayed this material on the stumps of willows after having cut them off. There has been very little suckering on the sprayed stumps.

Blackberries

The most serious of our problems are the wild blackberries, which become so thick that it is impossible for us to get through them without cutting and burning or the use of 2-4-D.

The best results in spraying have been during the month of May, although we are able to get good control during all of the hot summer months. By one thorough treatment with two follow up treatments at thirty day intervals, we have been able to completely eliminate blackberries from many of our drains.

Wild Grape

The 2-4-D is very good for use on wild grape. It gives us a very good kill in one application. The results are very good either in the spring or summer months.

Poison Oak

In some sections of our District poison oak is very thick and causes a good deal of trouble with some of the operators, who are very susceptible to it. The 2-4-D results have been both good and fair. Where we have been able to spray just when the leaves are coming out in the spring, we have received about a 70% kill in one application. If we allow a two week interval and spray again after the leaves are fully formed and seem to become tough, the kill is only 30% to 40%, with follow up treatments being of very little value.

Elderberry

We are able to get at least an 80% kill on all the elderberries. The best results seem to be during the month of May.

Cascara Bush

The Cascara bush, which grows very heavily in some areas along our drains, especially in the hilly areas, is very hard to control by the use of 2-4-D. We do get some kill, but we are not sure at the present time if there is any value to the spraying.

Cattails

The use of this material on cattails has proved to be a great help to us. The results are not always the same in different areas. In all areas it will greatly cut down on the size and number of cattails we have to contend with. Some of the areas in our district where they were sprayed when about eighteen inches high, we seemed to get a very good kill, probably running as high as 75%. By respraying every thirty days with three follow up sprays we have had no trouble with them during the year but the following spring there has been some new growth.

This year we plan to use Dow 2-4-D Weed Killer Formula 40 combined with the Sodium T.C.A. 90%, which is supposed to be very good for the removal of cattails.

Basal Bark Method

A new method of killing trees and brush is the Basal Bark Method. This consists of spraying a strong solution in oil of a mixture of the Esthers of 245-T and 2-4-D on the basal bark twelve to eighteen inches high on the trunk. An oil solution is necessary for proper penetration through the outer bark into the cambium tissues, where the actual killing takes place. It is necessary to treat the entire circumference of the trunk of the tree.

This is a very good method of killing the larger trees along our drainage system. This can be done at any time of the year; it can be applied by hand sprayers and is economical to use. It is very good for killing live oaks. A suggested solution is to use one pint of the material to three gallons of fuel or diesel oil.

FUEL AND DIESEL OILS

Along some of our drains in areas where there are crops and other vegetation that we must be very careful of, and there is a very heavy growth of Johnson grass, wire grass, or Dallas grass, we have sprayed about every thirty days using diesel oil. This has kept the tops killed down to where we have had no trouble from grass along the banks. We have also used Lethane for this purpose, as we are able to larvicide and kill the tops of the grass at the same time.

GROUND STERILIZERS

Since the 2-4-D does not kill most of the water grasses which grow along the edges of our water system, in 1948 we attempted to sterilize the ground along many of our drains. Along some of the drains treated there is still very little plant growth.

Borax

Our first work of this kind was with powdered borax. It was sprinkled along the edge of the drains to a width of about four feet. The material was hand broadcasted on the ground, using a water bucket and rubber gloves. It was put on the ground at a rate of 10 pounds to 100 square feet, and where the vegetation was very dense, 15 pounds to 100 square feet. A great deal depends on the amount of rainfall after application. After some of the applications we did not receive as much rainfall as was needed to give proper penetration. Results were generally good.

Sodium Chlorate

Sodium Chlorate was used in 1948; it was broadcast on the ground about thirty days before the regular Borax was used. It was hand broadcast using fifteen pounds per one hundred square feet. It was put on one side of a drain in an area six feet wide and one thousand feet long. It gave us a very good kill on all the grasses along the drain, and was effective for two years. There was good penetration into the soil, which aided in getting good results. It is bought in 100 pound containers.

This material is very dangerous to use, as it is very inflammable.

Borascu

The following year we tried more ground sterilizing by using Borascu, a borax type material which seems to be a very good ground sterilizer when properly used. It is non-toxic, non-selective, non-inflammable, and economical to use. We applied it at the rate of 10 to 15 pounds per 100 square feet. It is purchased in 100 pound bags.

Sodium TCA 90%

Sodium TCA 90% has been used the past year for the first time in our district. We have used it at the rate of 50 to 60 pounds per acre by the hand broadcasting method. With this method it should be applied early so that the rains will give it plenty of penetration into the ground. It can also be sprayed during the spring and summer months at the rate of ½ pound to the gallon, using 150 gallons per acre. Two to three sprayings are sometimes necessary. This material can be bought in 50 or 100 pound drums. It has a very low toxicity.

MOSQUITO ABATEMENT TECHNIQUES EMPLOYED IN URBAN AREAS

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and

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Mosquito abatement work, if it is to be effective, must be flexible enough to render service to both rural and urban areas. Many mosquito abatement districts are composed mainly of farm, orchard, and pasture lands with from one to several small villages or towns interspersed throughout the defined areas. In these districts rural mosquito control techniques are generally applied. Other districts, similar to the above, may contain, in addition, a city with a population of many thousands. In this case, urban control techniques must be developed in order to meet the added problems, and men especially trained for the type of work assigned to them. The need for both rural and urban mosquito control literally results, although not always readily admitted, in the seasonal division of a district into two component parts, namely, the rural division and the urban division. The men of each division become responsible for the solution of the problems specific to their particular area. Since the Fresno Mosquito Abatement District contains the City of Fresno, California and several square miles of surrounding farm land, the district employes the two divisional organization. Consequently, selecting this district as an example of such an organization, attention can be directed to the work of either component part and thus specifically to the mosquito control techniques employed in urban areas.

Greater Fresno, with an estimated population of approximately 150,000, covers 38 square miles. Its boundaries enclose not only the business and residential districts but also many small adjacent farms, pastures, and vegetable gardens. For mosquito control purposes, the area is divided into eight zones varying in size from three and three-fourths to six and one-fourth square miles. The size of the zone is dependent upon the type of mosquito problems to be found in the respective areas. Of the 24 permanent and seasonal men employed by the district, nine are assigned to city or urban operations. Eight of the nine are seasonal employees since the training for city work is quickly accomplished and does not require a knowledge of land management. They serve as operators conducting routine inspections. The ninth man is a permanent employee serving as city inspector. One operator, responsible for controlling mosquitoes within his area, is assigned to each zone. The overall efficiency of urban operations, checked through continual inspections, remains the responsibility of the city inspector. The zones are so established that the operator can cover his assigned area at least once during every consecutive two-weeks period of time. Records are maintained of permanent and semi-permanent sources of potentially high mosquito propagation. These selected waters are inspected at least once a week and, when necessary, appropriate control measures are taken. Sufficient time remains after the routine inspections for the operator to search for the occurrence of new, and perhaps, overlooked mosquito breeding sources. Continued search is necessary since mosquito producing waters in the city are numerous and of many types. Mosquitoes will be found propagating in such places as gutters, sumps, cesspools, fishponds, swimming pools and their overflow water, pools of water from leaking garden faucets, and water beneath houses resulting from poor and leaking plumbing or carelessness on the part of the owner in the disposal of waste water. Mosquitoes are to be found propagating in waters contained in buckets, pots and pans, chicken and horse troughs, wine barrels, fire barrels, wine vats and winery sumps, treeholes, and other similar places and containers. Treating these sources for the control of the mosquito varies with the type of source and, equally important, the use of the container. As a result, different equipment and insecticides are employed by the operators.

The city inspector, whose job it is to carry on inspection throughout the entire urban area, operates a jeep supplied with a power sprayer. Among the operators are distributed, according to the needs, two jeeps, one with a pump and one with an air-pressure sprayer, one pickup truck, and five three-wheeled scooters. However, the scooters have not held up under constant daily use, and, therefore, they are being replaced with jeeps as rapidly as possible. At present, operators of the scooters and the pickup truck are each furnished with a pressure hand sprayer of three gallon capacity. The operators of the jeeps, since they often encounter fields and pastures within their zones, are each furnished with a four gallon capacity knapsack sprayer. The final equipment used in the city consists of two aerosol generators for combating adult mosquitoes. A third generator, normally assigned to rural operations, is available under emergency conditions.

Materials used in the control of the mosquito are of various kinds and are employed as conditions warrant. Under control materials most commonly used may be listed diesel oil No. 2, DDT, lindane, toxaphene, lethane, kerosene, and borax. Not to be overlooked in the control of mosquitoes is the Top Minnow or Mosquito Fish, *Gambusia affinis,* commercially manufactured tossits, and the homemade briquettes, the last two being different methods of applying some of the above mentioned insecticides. Insecticides may be used by themselves in solution or in combination with others. They are not to be used promiscuously or without due consideration given to the mosquito source and the conditions immediately concerned with the source. Often, unless care is exercised in the selection of the proper material, damage may result or control may not be realized. Some control materials may be used, however, in a general way; others are limited in their use and must be employed only under specific circumstances.

The key man in the urban operations is the city inspector. It is his responsibility to handle the major portion of the service requests and to check on the efficiency of the city operators. It is further his responsibility to see that the new men are properly trained for the jobs assigned to them. In the case of severe problems, or mosquito outbreaks that are beyond the control capacity of the zone operators, it is the job of the inspector to solve these problems and to bring any mosquito flight under practical control in the shortest possible period of time. Evasive mosquito sources are to be located by him through intensive inspection of the area. He may at times be assisted by men transferred into the area but without inhibiting control operations elsewhere within the district. It is further his duty to periodically inspect the zones of each of his men to see that they are obtaining and maintaining adequate control within their respective zones.

Each zone operator applies mosquito control measures to all types of propagating waters encountered, and he applies the control in a specific manner according to the problems involved. Gutter waters are sprayed with 3% DDT water emulsion mixture at least once every ten days and irregularly spot-sprays with No. 2 diesel when needed. If gutters constitute a large and difficult problem in zones in which scooters are normally operating, the operator overcomes his difficulties by exchanging his scooter and hand-spray equipment for a jeep supplied with a power sprayer. It is then possible for him to cover a large number of streets and curbs more efficiently than with his standard equipment. He retains the jeep until such time that he has brought the situation under control, then reverts to the use of his scooter.

Cesspools constitute an important source of mosquito propagation within urban areas. When a cesspool is found to be infested with mosquito larvae, the location of the pool is recorded on a slip of paper along with the name of the owner and the condition of the pool. The owner is informed of the improvements necessary to make the disposal system mosquito proof. The information obtained in the field by the zone operator regarding the pool is turned over to the city inspector. The inspector returns to the source in a few days for additional inspection to see if the recommended corrective measures have been taken and to keep the pool under temporary control. If the owner of the cesspool is not cooperative in correcting the situation, the inspector contacts the City and County Health Department sanitarian, and with the sanitarian he again calls on the property owner. At this time the sanitarian may further discuss the problem with the owner or serve him with a written notice to close the cesspool. If the pool is not repaired in the time specified by the sanitarian, the Health Department takes appropriate action as prescribed by law. The system has worked well in the Fresno District, and a large number of cesspools have been eliminated as mosquito sources. In the meantime, temporary control measures are continued by the zone operator and city inspector by spraying the pool with No. 2 diesel oil and in some rare instances with the introduction of homemade briquettes containing DDT, lindane, or both. The briquettes are used since the procedure reduces the number of times the operator must return until the source is permanently eliminated.

Household disposals and miscellaneous containers found in yards about the homes, with the exception of fishponds, are emptied or treated with a mixture of No. 2 diesel oil and 4% lethane solution, and as soon as convenient the ponds are planted with mosquito fish. If the infestation is heavy and the pond contains fish life, the owners are contacted and asked to remove the fish prior to spraying operations. Heavier applications of lethane may then be used without loss to the owner or to the abatement district. The planting of mosquito fish is made easy and almost routine by having the fish available at all times in the stock pond within the district property.

Another interesting and odd source of mosquito propagating waters that constitute a problem is to be found in wine barrels possessed by commercial firms and private individuals. The barrels present a rather severe problem since they are filled with water to prevent drying out when wines are not being made, and in this condition they are soon forgotten until the next season. Those of the commercial firms are easily found, but those owned by the private individual are difficult to locate, often being hidden in hard to find or inaccessible places such as backyard sheds, locked garages, beneath overhanging branches of trees, behind bushes, and similar places. In all events, whenever the barrels are found, the owners are asked to empty them once every week and refill them with fresh water, or to cover them with fine mesh screening. Little or no cooperation is experienced in these requests. Since the procedure of emptying and refilling the barrels is too time consuming for the operators, they are instructed to spray such waters with a 4% lethane mixture and to emphasize to the owners that they are creating a potential mosquito propagating source on their property.

Fire barrels, like wine barrels, are also potential sources of mosquito production. They are to be found principally in lumber yards and around cotton processing plants. However, they are easily located and treated with borax usually about twice during the year, each time at the rate of two pounds of borax per 50 gallon barrel. The first and most important treatment is applied during the early spring months. This gives good control for the summer season or until such time that the barrels are emptied and the borax lost. The second treatment follows whenever needed.

The Treehole Mosquito, *Aedes varipalpus* (Coq.) presents a problem not consistent with those encountered with other species. Since this species of mosquito primarily, but not of necessity, propagates in treeholes, treehole fiillng operations are necessary in their control. The search for propagating sources is conducted not only during the summer but also during the winter when the known holes are being filled. Treeholes found during the summer months are not filled at that time but their locations are recorded for later operations. At the end of the summer season and consistently during the winter months a crew of men supplied with ladders, sand, asphalt emulsion, buckets and ropes, perform treehole filling operations. The holes are filled first with sand and then capped with the asphalt emulsion. The capping is sloped, when possible, in order to allow rain or sprinkler water to flow off. The completed work is then marked with metal tags of different colors, the various colors denoting the year the work was performed. The program has given good results to date with indications that the number of treehole mosquitoes are being reduced, not only in local areas but throughout the general extent of the urban district.

Sumps and catch basins found throughout the city are treated with briquettes containing DDT, lindane, or both. In instances of catch basins not requiring a briquette, or streams too overgrown with grass or brush for effective use of spray equipment, commercially manufactured Tossits are introduced into the water. Fields and pasture lands are sprayed by power and hand equipment with 2% toxaphene mixture at the rate of approximately 2.5 gallons per acre. Toxaphene is used during the hot summer months, but during the cooler months of the season 0.125% lindane may be used in spraying the fields. Vegetable gardens, particularly large tomato fields of which many may be found within a city's boundaries, are treated with toxaphene. This is introduced into the irrigating waters by means of the so-called barrel-siphon method. The "siphon," which does not constitute or operate as a siphon, is composed of a 25 or 50 gallon reservoir barrel to which is attached a rubber hose. The hose originates at the base of the barrel and terminates in a discharge valve or nozzle. The amount of insecticidal mixture to be released is varied by adjusting the discharge valve or the size of the nozzle, as the case may be. The equipment is placed in operation where the main irrigation ditch enters into the land to be watered, and the nozzle of the "siphon" is placed beneath the surface of the water. By so placing the nozzle, in preference to having it above the surface, it is kept clean by the flowing action of the water and thus remains functional at all times with little or no care. The amount of toxaphene to be used is dependent upon prevailing conditions of the field under treatment. Experience in the use of the "siphon" and its application under different field conditions are necessary for approximating the proper amount of insecticide to be used in any given circumstance. This principle of dispersing the insecticide has proven very effective in many instances, and a large number of the "siphons" are now in use.

The application of aerosol is the final and last resort operation conducted within an urban area, and it is directed against the adult mosquito. A 0.3% lindane-diesel oil mixture is used, but at times, however, the mixture is fortified with DDT. Aerosol operations are performed generally during the early morning hours, often beginning as early as 3:00 A.M. and continuing until an hour or so after sunrise. The use of the aerosol generators during this time is adopted in order to escape the dangers encountered with the heavy daylight and evening traffic. Cool quiet mornings or mornings with little or no wind is the ideal time for releasing the aerosol. Warm mornings or mornings when the air is moving are considered unfavorable since the aerosol is dispersed or rises too rapidly to be effective. Since time is an important element in these operations only certain defined areas can be covered during a particular morning, consequently aerosol operations are carefully planned the previous day in order to efficiently and effectively cover the selected area. The use of the aerosol is not a "cure-all" but one of the contributing aids in the overall control of the mosquito.

Not to be overlooked in city mosquito control operations are service requests, source slips, and light traps. The service requests are generally handled by the city inspector, but the requests may be turned over to the zone operators for checking. As the requests are received they are recorded in duplicate on a dispatch and record book. The original slip is given to the city inspector for proper disposition. The person handling the request records on the back of the slip the type of problem encountered and the action taken towards its solution. The slip is then returned to the office at the end of the day, and the data obtained is recorded on the duplicate slip in the record book. By following this procedure, a permanent record is kept of the number and types of requests and the action taken.

Through answering service requests and routine inspections various mosquito propagating waters are located. In such instances a source slip is completed by the operator concerned. The location of the source, type of source, dates of discovery and inspections, number of times found infested, and the action taken are recorded on a card. The card or source slip is then signed by the operator. The source slips are turned in daily to the office and the data recorded on a large wall map by means of colored pins. The color of the pin indicates the type of source, and each pin denotes a new mosquito source or re-infestation. Sources indicated on the map are classified as: 1. Treeholes, 2. household disposals, 3. fishponds, 4. gutters and sumps 5. artificial containers, and 6. miscellaneous sources. A quick glance at the map immediately shows areas of prolific mosquito production and the types of sources to be found within those areas.

Light traps, from which daily collections are made, are employed as indicators of the comparative numbers of mosquitoes present, the occurrence of sudden outbreaks, and as an aid in determining the effectiveness of general overall abatement. Four traps are located in selected sites widely spaced throughout the urban area, and they are maintained permanently in the same locations year after year. A fifth trap is used in temporary sites. It is employed as an aid in indicating the effectiveness of control measures applied in localized areas and as a check on the validity of persistent service requests from the same location. In no sense are the interpretations of light trap collections to be considered infallible as many environmental factors effect their operations. The use to which light traps may serve and the interpretations placed on the collections taken from them must be made with due consideration of additional and supplementary observations.

In view of the above, it is not difficult to generalize that effective mosquito abatement in urban areas requires several techniques in order to meet the various problems that arise. The solution of the problems are facilitated by dividing the district into zones each with an operator under the supervision of a city inspector. The use of several types of equipment, both automotive and hand operated, are necessary, and since the applied insecticides vary with the type of problem, the method of their dispersal also varies. For effective and efficient control, inspection of the area is repeated as often and as thoroughly as time and man power will allow. Records are kept of known mosquito sources as well as the prevalence of adult mosquitoes in an area. The latter is an indicator of the effectiveness of control measures, and its status is obtained through the use of light traps and collecting stations. Permanent control is exercised whenever possible, and the emergency control of adult mosquitoes is accomplished by the use of an aerosol dispersed over the affected area. The above techniques, constant planning, and a continual search for new and better methods of abatement are necessary for improved and effective mosquito control.