PROCEEDINGS AND PAPERS

OF THE

EIGHTEENTH ANNUAL CONFERENCE

OF THE

California Mosquito Control Association

Held at Agriculture Hall
University of California
Berkeley, California
February 1, 2, 3, 1950

EDITED BY

HAROLD FARNSWORTH GRAY

RICHARD FRANKLIN PETERS

AND

GEORGE EDWIN WASHBURN

CALIFORNIA MOSQUITO CONTROL ASSOCIATION

POST OFFICE BOX 649

BERKELEY 1, CALIFORNIA

TABLE OF CONTENTS

THURSDAY, FEBRUARY 2

FRIDAY, FEBRUARY 3

PROCEEDINGS AND PAPERS OF THE EIGHTEENTH ANNUAL CONFERENCE

OF THE

California Mosquito Control Association

Mr. G. Edwin Washburn: Shall we convene this Conference and get under way? I especially urge you who have prepared papers to leave your papers at this desk with Mrs. Mayo, who is in charge of the recording machines. Papers that are not prepared we will take down on the recorder.

If you ask a question or make remarks from the audience, please state your name so that we can pick it up on the mike. It's rather essential when you transcribe back for the stenographer to know who the individual is who is talking.

This is the Eighteenth Annual Conference of the California Mosquito Control Association. It seems like we have been in this business a long time. Yet eighteen years is really not very long in reality. On behalf of the Association I extend a cordial greeting to our guests from other parts of the United States, who through course of circumstances are compelled to forego the privilege of living with us in sunny California. It's cold this morning but it is sunny at least.

The President's message that is sometimes given at this time I will defer until this evening's business meeting, the Annual Business Meeting of the California Association. I introduce Professor E. O. Essig, Chairman of the Division of Entomology and Parasitology of the College of Agriculture here at our University of California. Professor Essig.

Professor Essig: President Washburn and ladies and gentlemen, in a modest way I would like to think this morning that I am pinch-hitting for Professor Herms. This will be the first of these meetings that he will have missed.

It seems to me that we might call this age the generation of pest control. Since I graduated from college, which I think might be called in this generation, practically everything that's being done now in pest control has been initiated and organized. I remember that in 1910 the revised act creating a single Horticultural Commissioner in each county in California was passed and the old inactive boards of three Commissioners, none of whom had any authority, was done away with and a single Commissioner was put in. Shortly after that the Farm Advisor and a Farm Bureau was created in California. Later on or even earlier than that people were talking about organizing Mosquito Abatement Districts, and all of that work has come during this brief period. The activities of the State Board of Health too, in rural communities, has been augmented, as has that of the State Department of Agriculture. Other organizations that have had to do with pest control have arisen, including the horticultural pest control operators, if we may call them that; they simply call themselves pest control operators, and what we might call the City and Community pest control operators have been licensed to control insects. New laws and ordinances, including the National Horticultural Quarantine Law and innumerable city and county and federal and state laws have been enacted that affect pest control.

I need only to call attention also to the rulings of the Pure Food and Drug Administration, which has had a tremendous influence in connection with pest control in agriculture. I have called this period the entomological dilemma, in which the federal laws require that foods and vegetables and fruits be free from insect contamination and insect parts on the one hand, and that on the other hand they have passed rulings making it impossible to use certain of the more important insecticides which would have to be used if you're going to keep the food products free from insect contamination and insect pests. The entomologist today is faced with a dilemma; the insect pest must be controlled and your fresh fruits and vegetables must be free of insect pests, and on the other hand there must be no residues on these foods.

It is hardly necessary to welcome you to this place. I know many of you are at home here. You have sat in this auditorium and sweated out many a lecture, and some of you, quite a few examinations, and I think that you need no welcome to this place. Others of you have met here for a number of years and this has come to be a sort of a Convention home for you. I hope this will continue and as the years go by you will feel even more at home here and that this institution and especially our division may be able to contribute more and more to the welfare of your organization. If there is ever anything that we can do to assist in insect determinations and in any suggestions regarding the use of insecticides or anything else that may improve or help any of you individually or collectively, I hope that you will feel that it is available at your asking.

We are happy that you continue to choose to meet in this building and I hope that it will become traditional.

The various members of our staff, many of whom are not able to attend the meeting because of other duties, will also welcome you to visit them at their respective offices and laboratories, and it may be that some of you may gain considerable information in visiting the laboratories in parasitology, or our entomological museum, or the members who are working in toxicology of insecticides, and the men who are engaged in field control of other insects may be able to give you some help.

It is especially gratifying to have so many representatives here from other States.

We are all engaged in the same general lines of investigation in pest control work. Our college has from time to time given short course work for pest control operators. Yesterday there convened at Davis such a short course, and I think there may be a second short course given to horticultural and agricultural pest control operators. Dr. Freeborn tells me that they set up for about 300 people and yesterday 600 showed up, so that gives you some idea of the interest in what we might call licensed agricultural pest control operations. We have for a number of years given a conference, a three-day conference, for pest control operators who are engaged in control of household pests and what we might call public health pest control, including not only insects, but rodents and even fungus diseases that attack woods. In all of these activities we are associated and concerned in the same general objectives. It is to our credit that we are able to work so harmoniously and so effectively toegther, and by that I mean all of these organizations.

May our chief concern be to continue these friendly and mutually helpful relationships. Like a hive of bees may we all work not for himself alone but for the good of all. I hope that you will have a very pleasant and profitable convention.

Mr. Washburn: Thank you very much, Professor Essig. Before we go on with our program I would like to introduce at least two people to you who will be responsible for certain parts of this program. Dick Maynard way in the back there is in charge of projection. Will you stand up, Dick, so they can see you. Any of you who may have motion pictures or slides for projection purposes please contact Dick as soon as possible, so that he will have proper equipment ready and available for your use. I want also to introduce Frances Mayo, our recorder operator here in front. Both of these people are associated with the Bureau of Vector Control program here in Berkeley.

We intended to start this program with a bit of remembrance to two of our past people, people who have always been with us in this meeting. Harold Lilley, as you know, passed away this last fall. He was a foreman of the Merced Mosquito Abatement District for at least the last three or four years and before that was the Superintendent of that District. He was the cornerstone in that District for some fifteen or sixteen years; and of course our good friend Professor Herms, we know of his passing last May.

Dr. Freeborn has a most fitting tribute. Dr. Freeborn, as you know, is the Assistant Dean of the College of Agriculture of the University and long a valued teacher and friend of ours in mosquito control work. Dr. Freeborn.

Dr. Freeborn: Mr. Chairman, ladies and gentlemen, it was thirty years ago next month, the 26th of March, that this organization was born in this room. I don't know whether to call Professor Herms the obstetrician or the father of the organization, but at least he was a cornerstone and continued to be that all through the years. I think he never missed a meeting except with the possibility of the time when he was actually in military service. I know that he would be the last person in the world to put up with any sort of a sanctimonious memorial of standing for a moment in remembrance, or prayer. or anything of that sort. He liked his fellow men but he didn't like to bore them with his own personal problems. I have here a memorial which has been prepared by members of the Academic Senate for inclusion in the files and records of that organization which I thought might be fitting to read to you today, and when I have finished, just in remembrance of Professor Herms, I suggest that irrespective of whether you like the memorial or not that we all applaud it as a remembrance of Professor Herms rather than doing the sanctimonious thing.

William Brodbeck Herms, Professor of Parasitology Emeritus, passed away suddenly on May 9, 1949, as a result of a heart attack. In reviewing his career of many facets it it difficult to decide where the emphasis should be placed, as he was a dynamic leader in every undertaking to which he directed his unbounded energies. As a scientist, his colleagues had elected him to the presidency of both of the national entomological societies, The Entomological Society of America and the American Association of Economic Entomologists, a distinction that is shared with only one other person in the last half century. His long service with the Boy Scouts of America had brought him the title of Counselor of Boy Scouts of the Western States and Hawaii. The citizens of Berkeley had awarded him the Benjamin Ide Wheeler medal for distinguished citizenship, for long service on the Berkeley Board of Ehucation and in other civic enterprises. He was President of the California State Automobile Association and of the Board of Directors of the Campus Masonic Club at the time of his death. Surpassing all these citations, however, are the memories in the minds of thousands of former students of an ideal college teacher, scholarly, friendly, approachable and infinitely wise.

He was born at Portsmouth, Ohio, on September 22, 1876. He graduated from the local high school in 1894, and although his heart was set on a career in medicine, his finances were such that he was forced to enter business for four years in order to accumulate sufficient funds to make possible a college career. He then entered Baldwin-Wallace College, from which he was graduated in 1902. From early boyhood he had seen the ravages of malaria that followed the annual spring flood of the Ohio river, and with the impetus of Sir Ronald Ross's discovery of the transmission of this disease by anopheline mosquitoes, his interest turned to medical entomology. He consistently emphasized the ecological aspects, for as he once phrased it himself, he had an overwhelming desire to know "what goes on in nature in the rough." He won Fellowships at Western Reserve, Ohio State, and Harvard. During this time he did pioneering work on the reactions of insects to light, which is still considered an authoritative, accurate, and effective starting point for all workers in this field. In 1908 he was selected from a relatively large field of applicants, several of whom became outstanding figures in entomology, to become Assistant Professor of Parasitology at the University of California. Incidentally he was the first person to hold an academic title in the field of Parasitology in the United States.

In the winter of 1909 and 1910 business men and fruit growers in the Placer foothill country near Penryn asked his aid in reducing the ravages of malaria in that area. He planned an educational campaign among adult groups and in the public schools, and in addition undertook with the help of his students to carry on an intensive mosquito control campaign over an area of 8 square miles. This was the first anti-malaria mosquito control campaign to be conducted in the United States. The district involved was one where a small amount of well-planned work was able to accomplish results that verged on the miraculous. As a result, Professor Herms was called to first one area and then to another to inaugurate mosquito abatement programs for the control of malaria. In many cases it was an uphill fight, for some local Chambers of Commerce bitterly resented the implication that their communities were centers of malarial infection. With true missionary zeal, however, he fought on, even in the face of personal violence in some cases, and lived to see malaria almost eradicated from his adopted State.

His record in the control of malaria is shared by few among other scientists in the world. For many years he was consulting parasitologist for the State Department of Public Health, and from 1930 until his death he was a Trustee of the Alameda County Mosquito Abatement District, being President of the Board of Trustees in 1949. It is obvious from his bibliography that he was primarily interested in applicable results, but a perusal of the contents of his papers indicates that he was never interested in what might be called "empirical" investigations. He used the tools of basic science and was never completely content until he had answered the ultimate "why" in every piece of research that he undertook.

When World War I was imminent, he volunteerd his services and was made a Captain and later a Major in the Sanitary Corps. After duty in Texas he became the Sanitary Inspector at the Port of Embarkation, Newport News, Virginia, where he supervised anti-malaria mosquito control over a wide-spread encampment area in tidewater Virginia with spectacularly successful results.

Although over-age at the outset of World War II, he was again called to active duty as Lieutenant Colonel, and supervised the training in environmental sanitation of the thousands of prospective Army physicians who were indoctrinated at Carlisle Barracks, Pennsylvania. Returning after World War I he was made head of the Division of Entomology and Parasitology in 1919, a position he held with distinction until shortly before his retirement on September 22, 1946. His text, *Medical Entomology,* is one of the most widely used references on the subject in the United States. It is characteristic of his sense of responsibility and his unquenching urge to keep abreast of his field that he completed the final typescript of the fourth edition of this work on the day preceding his death.

William Brodbeck Herms was a keen scientist of international repute, an inspiring teacher for many generations of college students, a conscientious citizen who gave of his services unstintingly to all worthy civic proposals, and lastly a kindly friend whose counsel was sought in times of trouble, doubt, or indecision by countless acquaintances. His wide range of friends in all walks of life sympathize with his widow and sons and mourn his passing, but glory in the fact that because of his living their lives were made richer and brighter by his presence and example.

Mr. Washburn: I'm sure that we all concur with Dr. Freeborn that that is a more fitting tribute than perhaps a moment of silence.

Now we come to an interesting topic—as far as I'm concerned it's interesting. I don't know what we have in store for us in this next title. Harold Gray, who is now President of the American Mosquito Control Association and is Engineer and Manager of the Alameda County Mosquito Abatement District. The title of his paper is"Which Way Now?"

WHICH WAY NOW?

By Harold F. Gray

President, American Mosquito Control Association

A year ago at our annual meeting held here at the University of California it was the privilege of the California Mosquito Control Association to present to the University the fine portrait of Billy Herms which now hangs in this lecture hall. None of us then even dreamed that within a few months he would no longer be with us, and even now it is difficult to realize that he is not here to help us with sound advice and with inspiration to try to do a better job.

For forty years he was the active leader in mosquito control work in California, and many of the workers in this field are his direct disciples. While many of us have followed closely his general philosophy as to basic principles in mosquito control, there have been a few who have followed false gods, and have attempted to substitute immediate, spectacular and ephemeral methods for time-proven, slower but ultimately more certain and effective control measures.

He was thoroughly convinced, through practical experience, economic analysis, and logic, that effective and economical mosquito control must be based on reduction, *to the lowest practicable extent,* of mosquito production water. This is the foundation, the very cornerstone, of successful mosquito control under temperate climate conditions. Larvicides and adulticides are merely supplementary measures, necessary indeed, but purely secondary in value and usefulness.

I wish to call particular attention to the use of the words *"lowest practicable extent,"* in the foregoing paragraph, lest they be misunderstood. Obviously there are some situations (e. g., rice fields) where water cannot be eliminated; but even here, external and lateral seepage can be reduced.

The importance of this statement of basic principle is pointed up by present indications that at least some species of mosquitoes are displaying an increasing tolerance to some of the newer insecticides. If the present rate of tolerance development continues, within a few years these materials may become relatively useless as mosquito toxicants. What then? Go back to Diesel oil? Possibly, but anyone who has used Diesel oil under the hot summer sun of our California valleys will soon decide to use a shovel to dig a ditch to drain off the mosquito production water, if possible.

I suspect that many of you are by now, out of sad experience, quite well convinced that in some areas of California mosquito control is impractical within reasonable costs if unrestricted misuse of irrigation water is to be allowed to continue and extend in area. On the face of it, the magnitude of the present problem, and its greater magnitude in the foreseeable future, is quite discouraging. But it is not an insoluble problem. We have several natural allies if we will work with them; water conservationists and agriculturists in particular.

California cannot afford to waste water, and it will be necessary to minimize water waste. We don't have to beat the tom-toms on this idea. They are being well drummed by others. The real interests of the irrigation people are identical with our intrerests, but we have not as yet got down to effective working agreements with them. This area of mutual problems is still ineffectively explored and implemented, both on a statewide basis and on a local basis. Could not the Bureau of Vector Control and this Association initiate meetings with the Division of Water Resources and other agencies concerned with water use to establish a general pattern of regulations for reduction in irrigation water waste? And thereafter, could not such a general pattern be implemented locally by conferences between irrigation districts and mosquito abatement districts?

Secondly, water wastage is bad agricultural practice. It reduces crop yield. It is detrimental to the farmer directly in his pocket book. He may need training in this concept, however. Our natural allies in this area are the farm advisors, the soil conservationists, and the county agricultural commissioners. To what extent have we attempted, effectively, to enlist their help in the battle? The Soil Conservation service of the federal government can be of material help. In Marin County, for example, Paul Jones has helped to work up reclamation projects in which, I am informed, 80% of the cost was defrayed by the Soil Conservation Service and 20% by the land owners.

Have we worked directly with farmers on their own property, giving them cooperation and getting their cooperation in joint projects for drainage of their own property? We can accomplish a lot by this procedure.

Another agency which can be of material help in permanent water control measures is the county road department. Excess water damages roads. Have we always, or even frequently, tried to work with the county surveyor or roadmaster to plan and carry out an effective program of roadside drainage? Would not such a program be of benefit to both?

Have we taken this story to the farmers' organizations, the farm bureaus, granges, etc.? Have we told it to the women's clubs, the chambers of commerce and other similar organizations? Have we done a decent job of public education, along the lines that Dr. Nyswander suggested at our last annual meeting?

It takes time and considerable effort to work out such programs, but it is eminently worth while to do so. These programs for reduction of water wastage are necessary not only for the economic welfare of large sections of California, but they are essential to effective and economical mosquito control. Until we have done all we can to obtain cooperation along these lines from every agency concerned, plus everything possible to get an informed public opinion back of our efforts, we have not done an essential part of our job. I suggest, therefore, that this be a principal order of business for the Association and its members for the next few years.

Billy Herms sincerely believed that men are generally reasonable and will act for the general welfare, if only they understand what is required. He also believed that most men need to be taught, especially in the field of public health. He did not expect men to come to him; he went to them. Up and down California he preached mosquito control. He taught it on a sound, practical basis—eliminate mosquito production water as far as practicable. He oriented us to procedure in the right direction. We should continue in that direction, but expanding our efforts to match the growth of the State and the increasing complexity of its problems.

Finally, in those residual cases where persuasion and appeals to the general interest fail to move those relatively few people who are opinionated, ignorant, careless, or completely uncooperative, we should not hesitate to invoke the legal remedies available to us. In such cases the cost of mosquito abatement should be charged to and collected from the offending parties under Sections 2271-2289 of the Health and Safety Code. It is unjust and unreasonable to charge such unnecessary costs of mosquito abatement upon the general taxpayer. A few successful applications of the procedure in these sections of the Code will have a most salutary effect upon the recalcitrants, and do much to make your problems simpler, your control measures more effective, and your operating costs lower.

Mr. Washburn: Thanks a lot, Harold.

Now we're going outside of California for our next discussion. We're going up into the North country, up into Alaska, where a great deal of work has been done the last two or three years on mosquito control, especially on investigational work along biological phases of it. Charles Wilson, Sanitarian with the Public Health Service, is with us today from that section of our country and will present some interesting information from way up north.

Mr. Charles S. Wilson: I think I would like to start with the slides. In our work we can never get away from a map. because the space there is so great. You may remember that if that map was set on the map of the U.S. it would just about spread out over nearly all of it. If you put Point Barrow up along the Canadian boundary, then the southeastern part of Alaska will come down about the Georgia and Carolina line and the tip of the Aleutian chain will come close to San Diego, so in our work we're up against terrific distances. Now fortunately the Aleutian chain which covers so much of the mileage doesn't have much that the control men have to worry about. The interior, though, is just full of mosquitoes and black flies, and in places there will be spots with lots of *Culicoides* and sand flies. The mosquitoes are almost universal except in spots in the mountains, and they occur in terrific numbers. The coastal areas are very spotty, and every little spot has its own individual problem.

Then another problem we're up against is the lack of population. I don't know what this new census is going to show, but I doubt very much that it will show more than 100,000 people in that whole area.

Many of these places that have names on them are just single buildings. That is, they are named because you can find someone there, but really it's a place, not a town.

Anchorage is the greatest center of population, and aside from Army personnel I doubt that they will be able to find more than 30,000 in the area in this coming census. Fairbanks will have somewhat less, and all along the coast they are just little settlements. Even where the people are they are living under primitive conditions, and many of them are without electricity and the usual facilities. Transportation is limited by the few highways and railroads.

A rather typical highway is the road between Anchorage and Palmer. Although we consider it relatively thickly settled, you can see really nothing in sight; there's fifty miles of that and then there really are some settlements and cabins. Then we go on from Palmer up to Big Delta. There's 500 miles that looks very much like that, and I don't think there would be more than 100 people or so living along it. Then from Big Delta to Fairbanks is seventy miles, approximately. That again is settled, so that there is a house every mile or so and in some places two or three a mile.

Almost on the outskirts of Anchorage is a new road, but there again there is lots of road and very little settlement. What they really depend on is airplanes, and they do have a splendid system of landing fields, airplane beacons, and then some of the finest bush pilots in the world.

In a lot of the north the real freight is moved by cat-train. This is one of their big shipping centers, Point Barrow, and each summer the ships sneak in here and they have one grand rush to unload and then they cat-train it out. Some of it is flown out. They've got the freighting down to about two bits a ton-mile and they are very proud of it. That's running the cat-trains over the ice early in the spring. You see that means everything is bought and lined up a year ahead. Not only that but everything is subjected to the winter's freezing, which is a bit rough on some of our solutions. If you don't like that of course you can take dog teams and occasionally river-boats.

In the entomological work, the mosquitoes, we have the big *Culiseta.* They furnish the big mosquito stories of Alaska, and they are big stories. The mosquitoes are just like the Culiseta you have down here except that they do come in numbers that will make you uncomfortable lots of times, and they don't even wait for the snow to go off. The anophelines, as I think you are all aware, are of no importance, but we have a nice collection of *Aedes* species and they all bite. I think you can say all species have just one brood, but there may be a succession of broods of species which spreads the season out. Over the good mosquito years, the wet ones, you'll get survival clear up until frost in many places, so one brood seems to be quite adequate.

In the mountains there are lots of barriers, and there we can use local control with larvicide. We can do some elimination of mosquito breeding water. Generally you can dig ditches all you want to, but it is in frozen ground and not of much help. South of Anchorage, not on perma-frost, it may be possible to get some drainage done in years to come. I don't think we can do it yet.

A fairly typical situation in the interior, on perma-frost ground, is hummock condition. A moose or a caribou can navigate the hummock country very well, but not a jeep; a weasel does fairly well, but a "cat" goes right down in. The best thing for larviciding hummock areas is an airplane.

In the lower Yukon area there are old ox-bows or dead channels of the river. Much of the area adjacent is mosquito-breeding tundra. As the rivers are the water highways, every one living and working along the Yukon is likely to get mosquitoes. Some of the lakes and ponds may disappear late in the season, but there's breeding all over the area. About all you can do is try to protect some little spot.

We have black flies too, and that's one of our problems. We find the most black flies breeding in the warmer water streams, but there are some in the cold streams also. One of the big difficulties of the black fly streams is that they are almost invariably important fish streams. Of course we have the sport fisherman playing around there, which is of importance in Alaska, but there are also salmon-spawning streams, and if in any of our treatments we mess up a spawning stream we'll be in bad shape.

We have several species of Culicoides. At Valdes we have an exceptionally large and hot variety. That's some of the roughest duty I've ever had and they are just in clouds, and in many places just little spots in which there will be immense numbers. So far it appears that each spot is going to require an individual prescription as a means of handling it, but also it is something we don't know very much about. In control measures you will find the flit gun, the head nets, and repellents, but screens, as a rule, are rather little used, because when they button up a house there they just seal the windows shut and let them stay that way, although in the interior it gets hot, but it's rather a short season. Usually they just sweat it out.

There are not very many places where we can use drainage, as we have both the frost problem and the problem of just how many acres one family can afford to drain. Airplane spraying, of course, is the stand-by. The Air Force is the only outfit that has a real program going. For example, up on the Arctic slope there is a small oil well outfit with infinite breeding all around. They used a C-47 spraying about one-half pint to an acre of 20% DDT solution in 800-foot swaths. They sprayed about 25 to 36 square miles to a treatment, which is pretty expensive for a little outfit like that, but the results were fairly good.

This was a successful treatment because even several hours later you could still see the tower. In other cases, even though they put on a treatment on 35 square miles, the mosquitoes just came in so fast that they ran the plane off the field. We had one fairly good case, where we could watch pretty well, right alongside a little weather station, where the mosquitoes would come in clouds that you could watch. In a 15-mile wind you could see them come all right, but they couldn't quite make the turn and come back against the wind and bite. In a ten-mile wind they did pretty well, they would come back and hook on. Many of the mosquitoes would be flying cross-wind, as they fly in all directions, but they drift with the wind; those that are going with the wind will still be making their fifteen miles an hour. So they are not very happy about the large area spraying except as an emergency measure for military operations.

We decided maybe it would be better to treat 100 square miles once than it would be to treat 25 square miles four or even five times. So a 100-square-mile plot was sprayed and we got a fairly good larvae control, but within a very short time after that the mosquitoes came in from the outside. So they put on an adulticide spray, and it worked well but didn't hold up for the season. They sprayed that 100-square-mile plot three times. I think it's just a matter of making your plot big enough so that you don't have to keep eternally at it, but you can't figure on any seasonal control there. Some of the contractors have tried very small plot spraying, say along the railroad right-of-way, but they've pretty well given that up. But there is one small cooperative group at McGrath, which took up their collection, rigged up a plane with a very weird set of spray equipment, sprayed their little area four or five times doing less than a square mile and they are very happy about it, and they have enough money left over to do it again next year. I'm pretty sure that if I did it they wouldn't be satisfied, but since they are doing it and they do it just when they need it, maybe they are all right.

We did some work with the heavy ground aerosol generators in 1947. At Valdez, where they have *Culicoides,* it was almost practical, but our difficulty is that re-invasion is so rapid that by the time we can get back, if it was put on in the evening, the next morning there wasn't coverage enough even though we used one-half-mile fronts. In a town where you can take each block, it may work pretty well, but the roads in Alaska are just never where you want them.

One of the things that has been done recently has been to try to develop a gadget so that we can just surround an area with a spray that they can just turn on when the mosquitoes get chewing them up too much, then turn it off and start it up again by and by. The experimental model is essentially a compressor to supply air through hoses laid around an area we want to protect, with little reservoirs of 20% DDT placed at intervals. The nozzle acts on the flit gun principle and it can operate at quite low pressure, putting out just about what an aerosol bomb would put out, about one quart per hour of actual operation. These have worked out very well in getting results in limited areas, such as on construction jobs, where you just hang a series of these things around.

In Alaska we want to get the young fellows in, young men and their families; we've got to compete with the rather prosperous United States, and that's not too easy. The women and kids get it rough, and they are the ones that we want to try and take care of, and that is what is really the problem to handle.

Mr. Washburn: Thanks a lot. We have a little time for a few announcements that we would like to make. I would especially wish all of you to register outside, so we have your name. Dick Peters would like to make reference to our banquet tomorrow night.

Mr. Peters: I wish to remind you that we are having a banquet tomorrow evening, to be held at the Town and Gown Club. It may not have the type of program that we furnished last night but we will have an interesting program, because we are getting the Boards of Trustees to put it on. They are on the spot and they've got to produce.

The tariff is three dollars per person, which includes the smörgåsbord, a very tasty array of this and that, and dancing to the music of Gary Nottingham, a name band in this area, between the hours of nine o'clock until one in the morning. Only three dollars per person for everything. The deadline for it is three p.m. this afternoon, and we must know how many are going to come so we can order accordingly, so please purchase your tickets preferably in the morning, but at the very latest by three p.m.

Mr. Washburn: Thank you, Dick. We don't want any of you to forget the business meeting this evening, which is our Annual Business Meeting of the California Mosquito Control Association. We urge you all to be in attendance. It will be here, in this room at eight o'clock, I believe it is.

Mr. Peters: It says seven thirty.

Mr. Washburn: Well, we'll say seven thirty and hope we can get started by eight o'clock. According to the Constitution a nominating committee was to have met and posted at the beginning of this session the nominees for officers of this Association for the coming year. They have met and the names are posted. There is one on each door, and election of officers will be tonight here in this place.

Let's take a break for recess, and right after recess, say about five or ten minutes, we will hear from our good friend from Utah, Bob Wilkins.

(RECESS)

Mr. Washburn: I'd like to have one particular introduction at this time. I've asked Harold Gray to make that introduction.

Mr. Gray: President Ed. and members, we have with us a very honored guest and visitor, a gentleman whom I was very proud to call "Boss" at one time. He was State Health Officer in California about the time just preceding the first World War and during the early part of it. At that time, I was, unfortunately for the State of California, State District Health Officer in the Northern part of California. From there he went to the Rockefeller Foundation and became the Director of the International Health Division. He was with them for a great many years. A few years ago he retired and for three years he was a Medical Director of the United Nations Relief and Rehabilitation organization. He has for a great many years had a keen interest in and a great understanding of the problems of the control of the diseases transmitted by arthropods. I would like very much to have Dr. Wilbur A. Sawyer stand and say how-do-you-do to you so that you will know him.

Dr. Wilbur A. Sawyer: Mr. Chairman, I want to say that I met many of you last evening individually, and it's a real pleasure to meet you in a graup today. I wanted first to thank you and particularly Dr. Gray and your President, for the invitation to attend this meeting and see some of my old friends from the early days when there weren't any mosquito control districts, when they were just being started. In fact, that happened at about the time I became State Health Officer, and we were greatly encouraged by it in our health work, and afterwards somewhat disappointed that most of them were placed where there was no malaria. I again thank you all for this invitation.

Mr. Washburn: Again we go out of California, but to a very close and neighboring State. Some of us last year had the enjoyable pleasure of visiting them in Salt Lake City, and now we have the pleasure of having Mr. Wilkins give us a little report on the use of new insecticides in Utah. Mr. Wilkins, the floor is yours.

Mr. Robert Wilkins: Fellow members of the California Mosquito Control Association, it's a pleasure to be with you another year and get up to date on your practices. I didn't come down here to tell you something new, because we learn from you people when we come to these Conferences. We have a few little interesting problems that I think we might report on.

LARVICIDES, INSECTICIDES, AND ADULTICIDES USED IN THE CONTROL OF MOSQUITOES IN UTAH DURING THE SEASON OF 1949

By Robert A. Wilkins

Manager, Salt Lake City Mosquito Abatement District

Box Elder County

DDT emulsion as a larvicide was used throughout the year. A 5% solution was applied from 150 h.p. Iron Age sprayer pump, having a tank capacity of 200 gallons, operated at 10 gallons per minute, mounted on ¾-ton Ford truck. The pump was also used to fill the tank, and 150 feet of high-pressure neoprene hose was mounted on a reel and used to spray under 500 pounds pressure. Taking advantage of wind drift this fine mist could be sprayed long distances from the edges of ponds and lakes. 141,200 gallons of larvicide was used on field pools and the kill was reported as nearly 100%. The pre-spraying of areas before public gatherings in parks and in church yards required 40,000 gallons.

Fly and Earwig Control

A group of interested citizens petitioned the County Commissioners and the Mosquito Board of Trustees for fly control. The County furnished a power sprayer of 100-gallon capacity, capable of 400 pounds pressure, together with 115 feet of high-pressure hose; another truck and sprayer was purchased, and 28 cities were sprayed in a period of six weeks. In Brigham 1000 residences, stores, barns, and chicken coops were sprayed. The very heavy infestation of earwigs was found in the cemetery. A 90% kill was made with 2½% DDT. 10,000 gallons was used in the County. 1757 farm buildings were sprayed with 9,352 pounds of 50% DDT Wettable, at a cost to the owners of $5887.40. The results to us seem to be just short of phenomenal. Screens were not needed, and the yards could be used in perfect comfort. The bee owners and experts in the vicinity came to the conclusion that the DDT residual spray is not harmful to honey bees.

Larviciding Gnat Larvae

This work was undertaken by Dr. Don M. Rees and James V. Smith, the District assisting with jeep, equipment, and labor.

The biting gnat (*Holoconops kerteszi* var. *americanus* Carter) for six weeks beginning in the latter part of April, is far more annoying than the *Aedes dorsalis* breeding in the same vicinity. The treatment of the ground with DDT, 28 gallons of solution containing ½ gallon of 25% concentrate or 1 pound DDT per acre, was applied.

The first larvae were found March 12th in the upper ½ inch of soil. About 250 acres were found to be producing gnat larvae. Soil samples were taken at regular intervals. Cultivated ground near by and the filled surface of the Salt Lake Refining Co. do not produce gnats. 17 plots 6′ x 11′ were staked out for testing larvicides to kill the larvae. One plot was left untreated. All others were treated with varying strengths of DDT and BHC (benzene hexachloride' gamma isomer. The kill was made by spreading 1 pound of DDT in 25 to 28 gallons of water per acre.

The Dodge 4-wheel-drive truck was used, mounted with a Bean sprayer pump, tank capacity 150 gallons. The solution was conducted through an 8′ spray boom, set 18″ above ground, with 6 Tee-jets 8001 attached, using 150-200 pounds pressure. The buildings were treated with 5% DDT emulsion applied with the power spraying equipment in the Dodge truck. The spray was used until the surfaces were thoroughly wet, but only the lower 2′ of buildings and tanks were treated. Residual DDT was very effective in destroying flies, deer-flies, and other noxious insects so abundant in 1948.

A smoke aerosol of 7½% DDT content was used to destroy adult gnats, from the thermal aerosol smoke generator on the exhaust of the Dodge truck. This method was used frrom April 22nd through May when needed. The workmen testify to the immediate relief, lasting for a few hours, after each smoke screen. The smoke aerosol is spectacular and among the workmen has excellent psychological effects.

The ground treatment with 1 pound DDT per are resulted in nearly 90% kill, as determined from accurate soil samples containing gnat larvae before and after the application. Before treatment the average number of gnat larvae per 2.45 cu. in. of soil, the basis of all samples, was 57 larvae. In addition to the larval counts, the gnat production in a given area was determined by the trap catches.

No gnats were found alive on the treated buildings.

Reports from the residents and personnel of the industrial companies indicate the control was very effective.

Mr. Washburn: Thank you, Mr. Wilkins.

I understand that one of our speakers scheduled earlier on the program has now arrived. I don't understand his title, "The Best-Known Summer Playground"; I thought that California had that. Apparently Cape Cod has it, and so we will hear from Oscar W. Doane, who is Superintendent of the Cape Cod Mosquito Control Project. He has come a long, long way to be with us here in California and I'm sure that we'll be interested to hear about another summer playground. Mr. Doane.

Mr. Oscar W. Doane: I am pleased to be here this morning and to bring greetings from the State of Massachusetts.

When this subject was allotted to me it was three days before I started off on my vacation and we had but very little time to prepare this paper, but we do think that Massachusetts is the best-known playground in our part of the States.

MOSQUITO CONTROL IN MASSACHUSETTS— BEST-KNOWN SUMMER PLAYGROUND

By Oscar W. Doane

Superintendent, Cape Cod Mosquito Control Project

Mosquito control in Massachusetts has come a long way in the past twenty years. The first Massachusetts Mosquito Control legislation was enacted by the General Court in 1929. Inhabitants of Cape Cod, who had suffered both physically and financially from the depredations of these vicious pests, were not slow to act once the means for retaliation were made available. Within one year after the passage of this Act, public-spirited citizens had rallied around the Cape Cod Chamber of Commerce in preparation for aggressive action; in May, 1930, legislation was enacted authorizing the formation of a Cape Cod Mosquito Control Project, a plan was promulgated to raise funds by private subscription, an experienced contractor was obtained, and by the end of 1930 approximately 1,170,000 feet of mosquito control ditching had been installed on the salt marsh which was the principal source of mosquitoes.

The 1930 accomplishments represented the first cooperative action against the mosquito hordes which annually overran the Cape. During the ensuing years the attack on these mosquito invaders was intensified, and at the present time, the 20,000 acres of salt marsh which fringe Cape Cod contain a drainage network composed of 1,500 miles of mosquito control ditches. In addition, the 1,200 fresh water swamps, totalling more than 2,500 acres, which in the past produced *Mansonia perturbans* abundantly, either receive mosquito control treatment or are under constant surveillance.

After the termination of World War II and the advent of DDT, our mosquito control project took on a new look. Although we continued to add some minor drainage facilities from time to time and conducted our salt marsh ditch maintenance program as in the earlier days, the introduction of DDT into our spray schedule resulted in a reorganization of our personnel and the acquisition of more modern equipment. Although these changes created new problems, they were far outweighed by the improvements in operation and the increased effectiveness of the newer control techniques.

We are well on our way toward the solution of these new problems, some of which are as follows: (1) our difficulty with the old type 3½-gallon galvanized manual spray tanks, whenever they were used as a means of distributing DDT as an emulsion or a solution which contains a solvent other than oil. We have found that the emulsifiers, and many of the special solvents, readily destroyed rubber valves and also had a deteriorating effect upon galvanized surfaces. We have noted, also, that nozzle clogging became more frequent because of the finer nozzle orifice used with DDT sprays. As a result of these difficulties, we are prepared to adopt a 2-gallon copper spray tank having a ball-and-spring valve at the base of the air pressure cylinder and a nozzle rack on the side of the tank. Placing nozzles in such racks after each spraying operation eliminates much of the clogging which resulted previously from contact of the nozzles with the ground.

(2) Experience has taught us not to depend upon liquid DDT formulations which have been subjected to low temperatures while held in storage through the winter months. Temperatures in the Cape Cod area go to zero and below at times. We look with suspicion, also, upon formulations which have been stored for long periods in metal containers. There has been no difficulty with DDT (technical grade) or DDT (50% wettable) which has been carried over from one season to the next.

(3) We are sold on DDT (50% wettable) for use in pre-hatch treatments, particularly on cranberry bogs located in the sand dune areas. However, DDT (50% wettable) requires constant agitation for effective use. It follows, therefore, that this suspension is not adaptable for hand equipment. For DDT suspension spraying we now have a 150-gallon power sprayer equipped with an agitator and mounted on a 4-wheel-drive Dodge Power Wagon. With this unit, one never worries about roadways, soft going, or lack of traction.

(4) In the old days, all the men on mosquito control work participated in oiling operations. Today, because DDT spraying requires a more thorough knowledge of mosquito control and more technical knowledge of the spray material and its limitations, we have trained a special spraying crew to operate the hydraulic spraying equipment and another to operate our TIFA fogging unit.

From the time when the Cap Cod Project was initiated until DDT became available, we had faced certain mosquito conditions which had defied solution. These involved either a financial consideration, difficult terrain conditions, or the somewhat unique habits of a particular species. Some of the more aggravating of these problems were solved shortly after DDT became available because of the DDT residual effect and its efficacy as an adulticide. Our successful pre-hatch residual treatments have been very gratifying, since use of this type of treatment extends the spray operation period, allows an almost continuous use of our hydraulic spray equipment, and provides for a leveling off of spraying activities so that we are better able to provide year-round employment for the specially trained crew. In addition, pre-hatch sprays have made possible treatment of fresh water swamps during periods when they are most accessible. Although we have experienced some success with such treatment on brackish marsh areas, they have failed where the marsh is flooded daily by the high tides.

On Cape Cod many of the fresh water and brackish swamps contain extensive stands of cat o' nine tails. These serve as host plants for heavy broods of *Mansonia perturbans*. As you know, larvae of this species take oxygen directly from the stems of aquatic plants. It is unnecessary, therefore, for these larvae to come to the surface for air. Under such circumstances, the older type larvicides such as oil and paris green were not effective in controlling this speies. Because of the dense stands of cattails, it did not appear practical to attempt control with applications of DDT emulsions. Although we anticipated little if any difficulty arising from the effect of the prescribed dosages of DDT on other forms of aquatic life, it seemed evident that lack of dispersion of this material through the thick network of root growth would tend to render the emulsion ineffective. The real solution to this problem involved two well-known characteristics of DDT, namely, (1) its residual effect and (2) its adulticidal qualities. During the original trials, we laid down a residual spray on surfaces most readily used as resting places by recently emerged adults. This consisted of an application of residual DDT to the cattails and also to the grassy areas in the immediate vicinity of the breeding sites. The residual treatments were followed by fogging operations, with a TIFA fogging unit, whenever adults became prevalent. As the work progressed, it became evident that fogging alone would provide reasonable control of this pest.

To date, we have turned to airplane spraying only in a few isolated instances where emergencies arose rather unexpectedly. These occurred in Army bombing areas or where the breeding areas could be reached only by transportation by water. In the latter instances, airplane spraying proved less expensive than transportation of a crew by boat to an island or sand spit, where ground crews usually encountered a series of discouraging obstacles.

In any attempt to evaluate the progress made by the Cape Cod Mosquito Control Project over the past four or five years, one must give considerable weight to the attitude of the people making up the communities being protected. From this basis alone, we have concluded that the favorable comment received from local civic organizations, and statements made by various observant individuals, justify our claims that the changes in project organization and field operation, previously mentioned, have provided more effective mosquito control.

Mr. Washburn: I see your playgrounds have mosquito problems the same as some of ours do.

I have a special paper to insert at this point. It is rather short but I think it is pertinent and definitely to the point. Bill Reeves is going to present a short paper on some work that was done in the Kern Mosquito Abatement District on the effect of DDT upon the eggs of *Aedes dorsalis.*

Dr. William C. Reeves: We can't quite say that all this was done in the Kern Mosquito Abatement District. This is a very brief abstract of Richard Hayes' Master's Thesis at the University of Utah. However, Art Geib and I did start Dick out in this problem in Kern County and the materials used in this study are all materials from Kern County as far as mosquitoes are concerned.

We suggested this problem to Dick because we thought it would be one of considerable importance to control operators. The title is "The Effect of DDT upon the Eggs of *Aedes dorsalis and Aedes nigromaculis.*" The results and conclusions herein are taken from the Thesis bearing the same title. This problem was proposed to determine the effect of DDT upon the viability of the eggs of *Aedes dorsalis* and *Aedes nigromaculis*. There are no records to date of succesful attempts to control mosquitoes with chemicals while still in the egg. Publications concerning preflight control continue to indicate the results of the study in terms of larvae.

THE EFFECT OF DDT UPON THE EGGS OF *AEDES DORSALIS* (MEIGEN) AND *AEDES NIGROMACULIS* (LUDLOW)

By R. O. Hayes

This study was undertaken as a thesis problem for the degree of Master of Science at the University of Utah. The results and conclusions herein are taken from the thesis bearing the same title.

This problem was proposed to determine the effect of DDT upon the viability of the eggs of *Aedes dorsalis* (Meigen) and *A. nigromaculis* (Ludlow.).

There are no records to date of successful attempts to control mosquitoes with chemicals while still in the egg stage. Publications concerning preflooding control continue to indicate the results of the study in terms of larval counts and do not refer to an ovicidal effect.

The mosquito eggs used during the experiment were obtained in the laboratory from engorged females of the given species. The eggs remained viable on damp cellucotton pads placed within stender dishes. Eggs which were allowed to dry, collapsed, and the embryos subsequently disintegrated.

The eggs were sprayed in batches of twenty. Each concentration of DDT applied was tested at exposure rates of 1, 48, 168, and 336 hours. For each lot of eggs exposed to the DDT and oil mixture, there was a corresponding lot exposed to an oil control under similar conditions. DDT was applied in amounts equivanent to .3, 1, 5, and 10 pounds per acre. For each batch of eggs of the same age group, a lot was submerged without previous exposure to either DDT or oil.

Viability of the eggs was determined by hatchings and by dissections. Embryos which were active were recorded as being viable.

In these trials, involving 854 *A. dorsalis* eggs and 1014 *A. nigromaculis* eggs, no significant ovicidal effect was observed. Since applications of DDT at concentrations greater than 10.0 pounds per acre would be, in most cases, neither feasible nor economically practicable, DDT cannot be considered to be an effective or practical ovicide for these species.

Mr. Washburn: I don't know whether we should title Mr. Lindquist as the man from Oregon or the Lake County Gnat Man, but anyway he is here, and he will present the paper from Oregon as well as the following one on reports on recent research of the Corvallis Laboratory.

Mr. Lindquist: Mr. Chairman, ladies and gentlemen, the day before I left Corvallis I received a letter from Mr. Arthur Woody asking if a would read his report at this meeting.

This is the report of the Portland, Oregon, Mosquito Association.

REPORT FROM PORTLAND, OREGON

By Arthur H. Woody

Supervisor, Bureau of Insect Control
City of Portland, Oregon

Owing to adverse conditions, we are unable to attend your Mosquito Control Conference this year. We hope, though, that our little report can be read, as there are many questions that we would like to have answered and we are in hopes that some of you will write and give us the answers.

As we have reported in previous papers, the control of mosquitoes through the use of scientific methods is in its infancy here in Portand and vicinity. However, our efforts the past three years have been so effective that moer additional areas are asking for our services than we are at present equipped to handle.

Our territory now consists of three counties in Oregon and three counties on the Washington side of the Columbia River. This constitutes an area of approximately 250 square miles.

Our organization differs greatly from the abatement districts of California, for existing legislation provides that cities may contract with county governments to abate mosquito nuisance, and pursuant to such legislation the City of Portland contracts to do the work of any counties or municipalities wishing control work done. This type of administration presents some difficulties not experienced in an abatement district, as various counties' budget and fiscal years do not correspond, which makes it almost impossible for us to plan our control until the mosquito season is practically upon us. Nevertheless, excellent results were obtained last year.

Our mosquito season starts with the first spring freshets in both the Willamette and the Columbia rivers, which usually occur the early part of May, receding during the last weeks of June and first weeks of July. It is during this period that we have our heavy hatching of *Aedes sticticus* (*lateralis and aldrichi*), *A. vexans*, and *A. increpitus*.

As the summer advances, hatches of *Culex pipiens, C. tarsalis, Culiseta incidens, Anopheles maculipennis freeborni,* and *A. punctipennis* appear, and with these species our control work continues to the latter part of September.

Because of the rough character of the terrain where our work is carried on, the airplane is still our principal means of dispersal of insecticides, using both exhaust aerosol, which has proved to be the most efficient means of controlling areas densely covered with underbrush, and booms, which we use in open areas where exhaust aerosol is not as effective.

We have recently purchased a new airplane — an all-metal North American AT-6, which we are equipping with a large tank in the rear cockpit, and we are also utilizing one of the 55-gallon gasoline wing tanks for our insecticide. This is the first AT-6 equipped for aerial spraying in this area, and we have high hopes of its proving to be superior to the smaller aircraft formerly used in this type of work in this vicinity.

We make extensive use of the Plumber's Nightmare in and around our large housing projects and similar locations when and if adulticiding is necessary. We even have a Plumber's Nightmare on a motorcycle with sidecar, and it really puts out an amazing amount of insecticide fog for such a small unit. We have our Lawrence Aero-Mist and make frequent use of it for both larviciding and adulticiding in smaller areas where airplane control is not feasible. The 2000-gallon tank truck with pump that we got from the War Assets Administration has speeded our loading operations and provides plenty of insecticide for a day's work.

From numerous sections of the country reports have been filtering in to the effect that mosquitoes and insects which have over a period of time been treated with DDT are setting up a resistance to that insecticide and are developing an immunity hitherto unknown. But already in our own area we had noticed signs of such resistance, and without waiting for reports from other parts, we began to work on a new formula which would provide an insecticidal agent calculated to defeat the hostile immunity which would otherwise render our control work otiose. We hope to be able to report more fully on this next year after we have seen the results. In the meantime we would appreciate knowing what experience, if any, some of you may have had with this condition and what steps may have been taken to combat the evil which threatens our work.

Although we are unable to attend the conference this year, we are just as intensely interested as ever, and would appreciate hearing what you can tell us of new developments in the field of application equipment and new techniques devised in application of insecticides.

Can you tell us of any new publications that may be of interest to us? We wish to continue our associate membership and desire to continue receiving your publication THE MOSQUITO BUZZ, which is avidly read by all members of our staff.

We would like to thank you for all past consideration and for the invaluable assistance you have rendered us. It is to be regretted that we cannot appear in person to extend our heartfelt thanks, but we do offer our warmest wishes for the continued success of the association.

Mr. Lindquist: Mr. Yates, a member of our staff, and myself have prepared a short paper on some recent research at the Corvallis Laboratory. In this discussion we will deal with a few of the mosquitoes that we have been working on.

A large share of our work is on the sheep tick, deer fly, house fly, and cattle grub, and we try to fool a little bit with cattle lice also. Besides that we do considerable laboratory testing, but we have a little information here that may be of value.

SOME RECENT RESEARCH ON MOSQUITO PROBLEMS AT THE CORVALLIS, OREGON, LABORATORY

By ARTHUR W. LINDQUIST and W. W. YATES

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

A few of the mosquito problems being investigated at the Corvallis, Oregon, laboratory of the Bureau of Entomology and Plant Quarantine will be discussed in this paper.

NEW INSECTICIDES

In the search for better insecticides for mosquito control, new materials are first compared with DDT and other chlorinated hydrocarbons in the laboratory. These comparative tests are made as the candidate chemicals or insecticides become available from commercial companies or other laboratories.

Tests are usually conducted in beakers containing 400 ml. of water to which the desired amount of chemical dissolved in acetone has been added. Fourth-stage larvae are placed therein, and mortality readings made after 24 and 48 hours. Floodwater *Aedes, Aedes dorsalis* Meig., snow-water *Aedes,* and *Culex tarsalis* Coq. are generally used. Floodwater *Aedes* mosquitoes are a mixture of *A. sticticus* Meig. and *A. vexans* Meig. The proportion of these two species varies in different soil samples, but an effort is made to use samples containing either about 50% of each species or about 90% of one species. Of the two species, *A. sticticus* is somewhat easier to kill with DDT. Snow-water *Aedes* include *A. communis* Deg., *A. hexodontus* Dyar, and *A. cinereus* Meig.

Soil samples taken from areas where eggs are known to be present are dried, and a suitable amount is flooded with water to cause the eggs to hatch. The larvae are reared in pans at a constant temperature of 80° F. and fed finely ground dog food containing 20% blood albumin.

Few insecticides have given better results than DDT on floodwater *Aedes* larvae. Dieldrin, aldrin, heptachlor, and parathion have proved up to 2½ times as toxic. Dieldrin gave as good kill at 0.002 p.p.m. as did DDT at 0.005 p.p.m. Lindane was considerably less effective than DDT, but was only about twice as toxic as technical benzene hexachloride (gamma isomer 12.8%), even though it contains about seven times as much of the gamma isomer. The new synthetic pyrethrin-like material (*dl*-2-allyl-4 hydroxy-3-methyl-2-cyclopenten-1-ester with *dl-cis-trans*-chrysanthemum monocarbolic acid) was not so effective as the natural pyrethrins.

Effect of Temperature on the Toxicity of Insecticides to Mosquito Larvae

The effect of temperature on the insecticidal action of DDT and other chlorinated hydrocarbon insecticides against flies and other insects has been studied by several investigators. Fan, Cheng, and Richards (1948) demonstrated that DDT is more effective against *Aedes aegypti* L. at low temperatures than at high temperatures. Hoffman *et al.* (1949) showed that DDT, TDE, and methoxychlor consistently knocked down and killed house flies faster at 70° F. than at 90°, and that heptachlor, parathion, chlordane, toxaphene, and dieldrin were more effective at 90°.

Recent work at Corvallis with twelve insecticides on two species of mosquito larvae has shown that the effectiveness of the insecticides varies considerably when the tests are conducted at different temperatures. Toxaphene, dieldrin, and parathion were more effective at 90° than at 55-60°, but all the others were more effective at the lower temperature (Table 1). These findings have a practical significance, since water in which larvae breed in nature ranges from lower than 50° to 95° and sometimes higher.

Mosquito Resistance to Insecticides

In Florida salt-marsh mosquitoes have developed a resistance to DDT, and in California mosquito-control operators are not obtaining the control with DDT that they have in the past. Apparently it is only a matter of time before resistance to DDT will be so pronounced that the control of mosquitoes with this insecticide will not be practical. The question is then — What can be done in mosquito control? It has been stated that when an insecticide (DDT) becomes noneffective, another such as lindane or chlordane should be substituted. Reports indicate that this procedure has not worked very well in practical fly control. However, other insecticides should certainly be tried in cases where mosquitoes are resistant to DDT.

One of the needs appears to be an exact evaluation of the resistance in various counties or districts. Perhaps the best way to obtain a close evaluation is to compare in the laboratory both larvae and adults from intensively treated areas with those from untreated areas.

If mosquitoes continue to develop resistance to insecticides, their control in the future (3-4 years) may become a discouraging and difficult problem. The use of oils alone may again be necessary. Fortunately this method of control was greatly improved in 1943, just at the time DDT came into prominence. Knipling (1943) reported that with oil emulsions the amount of oil necessary for control of larvae was reduced from 20-40 gallons to about 6 gallons per acre. Further research along this line — i. e., determining the best oils, the best wetting agents, and the proper mixtures of these materials — may yield information that will make mosquito control practical even though the present insecticides eventually fail. The Corvallis laboratory is directing its efforts towards the improvement of oil emulsions.

Field Tests

The pressure of other projects during the past year left little time for field work. One test will be reviewed, however. A commercial operator sprayed by airplane about 300 acres adjacent to Diamond Lake in Oregon, an area in the high mountains where snow-water mosquitoes are prolific. Most of the breeding is in a 100-acre marsh at the south end of the lake, although scattered areas on the west and north also contribute to the problem. The plane used was a Stearman biplane equipped with an underwing boom system, such as is used for weed control. All except six nozzles were capped, and approximately 1.1 quart per acre was delivered in a 50-foot swath. The spray formula was 15% of TDE, 15% of motor oil (SAE 40), and 70% of Shell Solvent 42 (a petroleum aromatic solvent). A small amount of Triton B-1956 (phthalic glyceryl alkyd resin) was added as a spreading agent. The area was sprayed at 6:50 a.m. on May 20. The air temperature was 37.5° F. and that of the lake water was 42°. The sky was overcast and rain threatened. Approximately half the area was covered with snow, and large numbers of mosquito eggs had not hatched. In the open water of the marsh there were millions of larvae in all stages.

Excellent coverage was obtained under trees on the south meadow, but not on the northwest side of the lake. However, all the larvae were destroyed within eight hours at all places checked. Surveys seven to thirteen days later showed a few small spots where larvae were developing. The over-all control was estimated as at least 90%. Checks on adult incidence made on July 10 showed just as many mosquitoes as had been found the previous year. The results were disconcerting, since it had been established that a high degree of larval control was obtained. Apparently there was extensive mosquito breeding outside the treated area which had not been indicated in previous surveys. Nevertheless, it is clear that every mosquito-breeding area must be determined or a solid block of sufficient size must be sprayed thoroughly.

Table 1 — Effect of temperature on the toxicity of various insecticides to floodwater mosquitoes (90% *Aedes sticticus*, 10% *A. vexans*).

Insecticide	Concentration (p.p.m.)	Per cent mortality in 48 hours at — 55°–60° F.	90° F.
DDT	0.005	83	29
TDE	0.01	51	35
Methoxychlor	0.01	93	30
Fluorine analog of DDT[1]	0.01	44	7
Heptachlor	0.0033	52	24
Benzene hexachloride (gamma isomer 12.8%)	0.01	86	40
Lindane	0.005	37	29
Toxaphene	0.01	37	57
Chlordane	0.01	46	60
Dieldrin	0.0025	43	**76**
Aldrin	0.0025	26	**75**
Parathion	0.0025	43	76
Untreated checks	——	11	6

[1] 1,1,1-trichloro-2,2-bis (*p*-fluorophenyl) ethane.

LITERATURE CITED

Fan, H. V., T. H. Cheng, and A. G. Richards (1948). The temperature coefficients of DDT action in insects. Physiol. Zool. 21(1). (Incomplete.)

Hoffman, Robert A., and Arthur W. Lindquist (1949). The effect of temperature on knock-down of house flies (*Musca domestica* L.) exposed to residues of several chlorinated hydrocarbon insecticides· Jour. Econ. Ent. 42 (6): 891-93.

Knipling, E. F., C. M. Gjullin, and W. W. Yates (1943). A new oil-emulsion mosquito larvicide. U.S· Bur. Ent. and Plant Quar. E-587, 4 pp. (Processed.)

Mr. Lindquist: We are just beginning laboratory studies on the possibilities of using radio-active tracers in studying the flight range of mosquitoes. The material that we are using is phosphorus 32, which is suitable for the reason it has a short half-life, 14.2 days. The means of determining whether a mosquito was treated, of course, is very easy by the use of appropriate instruments, such as the Geiger-Muller counter. The big trouble is going to be, How can we collect mosquitoes in big numbers. *Aedes,* for example, don't go to lights too well and it may mean that we will use animal traps. I don't think they work very well, so it may have to be perhaps fifteen to twenty fellows out collecting mosquitoes from their persons. We haven't gone far enough to know what can be done. We don't know whether the Atomic Energy Commission will take a dim view of our using it in the field. They are very cautious. They might say no completely, although they might go along if the experiment is carried on in an area removed from human beings. I just thought I would mention that because we think, aside from the tracer part of it, you can do some very interesting things with these new radio-active materials. I don't know how important they are, but you can make dissections and find where the stuff lodges, and with our housefly work we think it might be possible to rear a colony that had some type of deformity that we wish all natural flies had. I don't know what we'd do about it, but there is that possibility anyhow.

Mr. Washburn: We're getting just a little bit behind schedule. I'm wondering whether you ought to remain or try to actually get back sharply at one o'clock. Our next speaker will need at least one-half hour in order to present his paper. Do you want to go on? All right, Dr. Hu, who is Chief of the Bureau of Mosquito Control, Department of Health, Territory of Hawaii, has come a long ways and I'm sure we'll have something very interesting to listen to. Dr. Hu·

Dr. Hu: We have a playground area too. Mr. Chairman and fellow mosquito control workers, we wish to thank you for your invitation extended to us to come to attend your annual meeting. I bring to you our Aloha from the mosquito control workers in Hawaii. I will just show a few slides to give some idea of the problems that we are up against in the Islands.

Our mosquito control work seriously started from 1943 during the war when we had an epidemic of dengue fever and the Public Health Service sent to us Captain Arve Dahl and also Professor Usinger, so we are indebted to you Californians for starting the ball rolling in Hawaii.

Right now we have a team of twenty-eight. One species (*Aedes aegypti*) we are trying to control are household breeders, breeders in containers — they never breed in ground water — and they are day-biting mosquitoes· Another of our day-biters is this oriental form, from the Orient and South Pacific. It's *Aedes albopictus*. Fortunately you do not have these forms in California. Both of these day-biters carry dengue, and experimentally *Aedes albopictus* can carry yellow fever. Our work is really backyard work so to speak, house to house inspection. Inspection, education, and correction. We have only one other mosquito in Hawaii, the *Culex quinquefasciatus,* which you also have here in the southern part of California. We haven't paid much attention to *Culex* until last year. I believe it was at one of your annual meetings here when Dr. Hammon reported that Japanese B encephalitis had occurred in Guam, over 2000 miles away. Well, it appeared in our paper in Honolulu, and it certainly scared the Legislature, which was in session at the time. It gave quite a boost to mosquito control· This *Culex* breeds in ground water as well as in containers, so I guess we have another problem on our hands.

This is the City of Honolulu with the harbor. It's a view looking down from a little extinct volcano right back of the city called Punch Bowl, and you notice the amount of vegetation throughout the city; that's what's breeding these day mosquitoes so much. Everybody has gardens, and even shops and stores with any little space behind them try to keep some potted plant or rockery, so you have plenty of back yards, and it's a problem trying to keep down the breeding of these mosquitoes. Of course the idea is to reduce the occurrence of the day-biters, *Aedes,* to less than 5% of the premises throughout the city. We have about 50,000 premises. During the epidemic we had a force of 398 inspectors and they completed one cycle of inspection and correction in ten days. Now we have a fore of twenty-eight and it takes us two and a half months to finish one cycle, but with the use of 2% DDT we are able to keep the *Aedes* index down to about 1%.

This is looking toward Waikiki Bay with Diamond Head in the background from the same angle. You see the city is quite widespread and we have breeding all the year around. Now I turned the camera around and we are looking toward these mountainous regions· You see a series of valleys with the city extending to and also up into these hills. This is the National Cemetery right in the crater of the Punch Bowl; it has just been completed. In these valleys you have heavy rainfall, in fact it rains almost every day, so that makes quite a problem with the containers, and another problem we have with these water plants and tree holes. Now *Aedes aegypti* is rather particular, it only breeds in containers, so I think we pretty nearly eradicate the *Aedes aegypti* from our routine work. It's only confined to a small area in the city now, but *Aedes albopictus* breeds in any water held in the leaf base of plants or in tree holes as well as containers, and extends right up to the forest and the mountains. That makes it a problem to eradicate that *Aedes*.

We have many tropical trees with roots holding water, and in Honolulu we do not have a dry summer like you have here. I remember when I was a student we used to go to Mt. Tamalpais camping; we didn't bring a tent along; we slept under the skies, because it never rains, but over there we have what they call liquid sunshine. It rains and pours for about fifteen minutes and it's over, so we seldom carry an umbrella or raincoat along, we just get under some shelter. After a few minutes it's over and after a while you see it coming again.

These are breeding places of *Aedes albopictus,* like these palms which hold a lot of water. Some of these leaf bases hold about a half pint of water. These are spider lilies; during the dengue epidemic it was a state of emergency and we had to chop all these down.

These plants are called the Elephant's Ear. That holds quite a lot of water. Of course when you dust some powder in there the new leaves keep coming on up. It's quite a job keeping track of these plants.

They say Hawaii has sugar and pineapple as the main industries, but the fourth industry is tropical flowers, and the third one is tourists. Evreybody goes in for orchid culture there. You don't need a glass greenhouse, just a lath house is enough. In fact you can grow them right out in the open under the trees. We find water gathering on these ant traps breeding the *Aedes* mosquitoes.

Our control work actually is centered only in the city of Honolulu where half the population of the island is, and also in the second largest city, that's Hilo; that's on another island where the people go to see the volcano. The reason why we concentrate only in these two cities is because our main purpose is to try to prevent an epidemic of insect-borne disease. These are the two ports where cases of insect-borne diseases would come in, so by reducing the densities of *Aedes* mosquitoes to the extent that if any case came in we would not have enough mosquitoes there to spread an epidemic, we protect the whole territory.

We have the canoe problem and the boat problem. When the rain comes and they don't use the canoe often enough that's a nice breeding place. You have thousands of *Aedes* larvae in there. We teach them to cover up the canoes. The cocoanut is another problem. The rats eat a hole through the cocoanut and water gathers inside cocoanut shells.

With our *Culex* mosquito, a ground breeder, of course we try to use *Gambusia* as much as we can, otherwise we have to do spraying work. In the sugar fields when the water is not running in the irrigation ditches, that's the way a lot of *Culex* breed, but we have no problem with the pineapple fields because they are high up on the mountain. They depend only on the rainfall, no irrigation water.

The City of Honolulu is the biggest city in the world; it extends 950 miles down to the Island of Palmyra, which is in the city and county of Honolulu. That eclipses Los Angeles in size. We have to give some service to Palmyra as well. Palmyra really is a dream of a Hollywood director of what a tropical island should be. Before the war we had no mosquitoes in Palmyra; they were brought in during the war. That shows how much mosquitoes are migrating across the Pacific, and we are on the lookout for that.

We find *Culex quinquefasciatus* here, but so far that's the only one. Evidently it feeds on birds, they have millions of these birds, so tame you can almost touch them. When I was down there last year there were only about eighty people in the whole island. Now I think there are hardly any because the Civil Aeronautics Administration has moved out. It's just a deserted island now. The cocoanut crabs eat holes through the cocoanuts; you see piles of these cocoanuts all over the ground with holes and water in them and some of them breeding mosquitoes. That's a problem. Disease-bearing insects are traveling across the Pacific at a more rapid pace. It was just two years ago that Professor Reeves found *Anopheles albopictus* in Guam for the first time, and also in Wake Island he found *Aedes aegypti* and *Culex quinquefasciatus* also. So the Civil Aeronautics Administration asked us to cooperate with them in the work of clearing up some of these stepping stones, so we're extending our work to Wake Island and Midway, and doing something in Guam and Palmyra, Canton, and maybe down in Samoa. The thing is to get after the mosquitoes before they get to Hawaii. In fact we have to act as a screen to keep these disease-bearing mosquitoes from getting to California.

We have no Anopheles in Hawaii yet, very fortunately. We have malaria cases in boys coming back from Guadalcanal and Italy, so we're trying hard to keep the *Anopheles* out of the Islands, because once they get in I'm sure they will breed. Filariasis is another thing we are very concerned about now. There's a team in Fiji working on it, and another Navy team in Samoa and in New Caledonia. They are all working on filariasis. We have some Samoans with it in Hawaii and we are trying to keep the infection from spreading.

Mr. Washburn: Thank you very much, Dr. Hu. What would you do if you had our some forty species in California to contend with?

Dr. Hu: We would have to increase our staff.

Mr. Washburn: That's right. We are adjourned until one o'clock.

The meeting reconvened at 1:15 p.m.

Mr. Washburn: Dr. Reeves will now present a paper with a very interesting title.

Dr. Reeves: This title has a rather interesting history. As usually happens originally, Art assigned a title as Chairman of the program committee that I didn't find very stimulating, and so he sat over at the house with me one night and we kicked around titles until we finally came up with this one. Admittedly it's slightly facetious; however, I don't know when in my experience I've had more people say things to me to indicate that they are laying for me, and I had better be pretty careful what I say. Art Lindquist tells me that the boys up at Corvallis decided that I'd really gone over the border completely this time, and they want him to bring back a psychological report on what has happened. Roy Fritz tells me that as far as fly control men are concerned they are just waiting because I'm really putting them on a spot. Well, we'll see what happens.

YAKIMA, WASHINGTON, CONTROLS MOSQUITOES AND FLIES AT NO COST—WHY CAN'T WE?

By WILLIAM C. REEVES

Associate Professor of Epidemiology, The George Williams Hooper Foundation for Medical Research and the School of Public Health, University of California, San Francisco and Berkeley

The Yakima Valley in Washington has not been mentioned in these Conferences since 1941.[1, 2] As some of you remember, epidemics of encephalitis in the Valley in 1941 and 1942 led to intensive studies of the mosquitoes in this area by the Hooper Foundation of the University of California and the Division of Insects Affecting Man and Animals of the U.S.D.A.[3, 4]

In these early studies 19 species of mosquitoes were found. The mosquito population was of the magnitude you would expect to encounter in an agricultural area where an unlimited supply of cheap water is used for irigation; where for a 4-month period summer temperatures are equal to those of the Central Valley of California; and where there are no mosquito abatement practices in effect, not even levelling of fields. There is no need to enlarge on this picture, as the representatives at this convention can readily appreciate the situation.

My last visit to Yakima was in August of 1944. At that time the conditions had not changed.[5] I felt that this was most unfortunate, as the studies of 1941 and 1942 could have served as, and were in part intended to be, a basic survey for the establishment of a mosquito abatement program. The mosquito species of the area and their ecology had been determined, and maps of permanent breeding areas had been prepared. It was obvious that control was feasible and that the area could support it, but nothing had been done.

Last winter we began to hear rumors that mosquitoes and flies had disappeared from the Yakima Valley. Considering the lack of a control program, I was most skeptical. This past summer our curiosity overcame us, and our epidemiological team returned to Yakima on August 1 to conduct further cooperative studies on encephalitis with state and local authorities. Word had reached us that the local health officer was offering a dollar for every house fly caught in the Valley, and the entomologists in our group were eager to cash in.

On entering the Valley, my reaction was that things had certainly not changed any. The flooded pastures and crops, gravel pits and the sloughs along the river were still very much in evidence.

I believe that you will be interested in what we found in the two weeks of intensive study.

Mosquitoes and flies had not disappeared from the Valley, but it was not hard to find people who thought they had. Because of the absence of flies or mosquitoes in pest numbers, screens had been removed from many homes. But we couldn't find a Health Officer willing to offer a dollar for every fly collected.

Some of our data may be used to demonstrate the decrease in numbers of mosquitoes. Figure 1 illustrates the marked differences in average nightly collections in New Jersey light traps for the first 2 weeks of August in 1942 and 1949. In 1942 the average nightly collection of *Culex tarsalis* was 164 specimens per trap, while in 1947 it was only 27. Other species, such as *Culex pipiens, Anopheles freeborni, Aedes dorsalis,* and *Culiseta incidens,* showed the same marked decrease in numbers for the 1949 collections.

Comparisons of adult shelter records for 1942, 1944, and 1949 show the same change for *Culex, Anopheles,* and *Culiseta* (Figure 2). One might say that the shelter collections for 1949 are still relatively high, as 65 *Culex tarsalis* were found in the average collection. However, this is not true, as the innumerable searches of shelters in which no mosquitoes could be found are not included in obtaining this figure. In the studies of 1941, 1942, and 1944 it was unusual to find a premise on which mosquitoes could not be found in shelters. In 1949 it was unusual to find a premise on which detailed search would reveal adult mosquitoes in shelters.

Although irrigation practices and availability of water had not changed, close inspection of flooded pastures, borrow pits, dredger pits, roadside ditches, river sloughs, tule sloughs, waste irrigation water collections, etc., rarely led to discovery of mosquito larvae.

As for house flies, which formerly were very abundant in the area, they were still present, but only in small numbers. Few specimens were encountered on inspection of dairy barns and animal shelters. There had been no marked change in sanitary practices on farms, and insofar as could be determined there had been no concerted effort to residual spray farm buildings with the newer insecticides.

Several persons had suggested that the general reduction in mosquitoes and flies was a result of widespread application of DDT as an agricultural insecticide. Insofar as we could determine, no effort had been made to gather the facts and critically evaluate the situation. I am sure you all see the ironic humor in the question, "What harm has been done to mosquitoes and flies by the indiscriminate use of the new organic insecticides on agricultural crops?"

The Yakima Valley is a very fertile valley with between 400,000 and 500,000 acres of irrigated land. Of this total, over 50,000 acres is planted to fruit trees and 60,000 acres is in small field crops. These are subject to insecticide spraying each summer for control of a variety of plant pests.

With respect to the insecticides which have been and are being used,* in earlier years the standard spray for fruit trees in the area was lead arsenate. Total sales in the area were between 4 and 6 milion pounds per year from 1940 to 1946. However, beginning in 1945, DDT quickly replaced lead arsenate as the insecticide most frequently used. In addition, DDT is being applied as an insecticide to large acreages of other crops such as potatoes, asparagus, tomatoes, sugar beets, alfalfa seed fields, etc. In the fiscal year1948–49, 1,224,408 pounds of 50% DDT dust and 368,250 gallons of 5% DDT spray were sold for local application. In 1945, the first year DDT was used, total sales were only 700 pounds (Figure 3).

In additon to DDT, other insecticides are widely used, which are of known or potential toxicity to mosquitoes and flies. In the fiscal year 1948–49, the following sales were made: BHC 71,032 pounds; parathion 16,258 pounds; Hexaethyl 615,700 pounds of dust and 4,000 gallons of spray. Large amounts of T.E.P.P. were sold, but accurate figures are not available at this time (Figure 4).

I hope these figures have impressed you. If the total amount of DDT used in this Valley in the past year were distributed over the entire irrigated area, it would be the equivalent of more than 2 pounds of 50% DDT dust and a gallon of 5% spray to the acre. Of course the distribution is not even. As an example, the 33,000 acres of apples and pears are receiving approximately 20 pounds of 50% DDT dust and one pound of Parathion per acre, and residuals on trees and vegetation are great. Needless to say, pastures and other crops interspersed between orchards are getting their share of insecticide by drift. In some parts of the Valley, where mosquitoes had been particularly abundant in earlier years, either none or very few could be found in 1949. As

*We are indebted to W. D. Turney, Supervisory Sanitarian, Yakima City-County Department of Health, and Bill Luce, Yakima County Agent, for furnishing the insecticide data referred to in this paper.

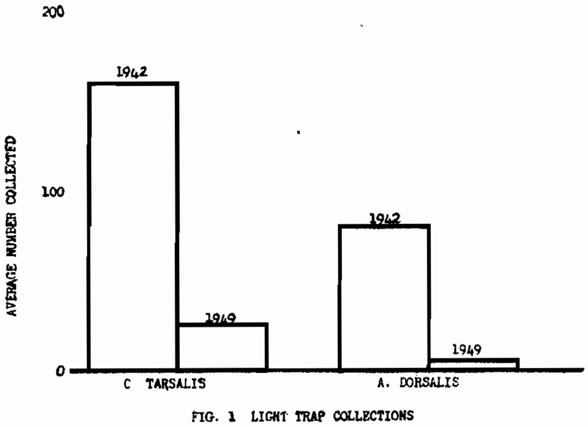

FIGURE 1

Average Number of Mosquitoes Collected Each Night New Jersey Light Traps were Operated, Yakima, Valley, Washington, 1942 and 1949.

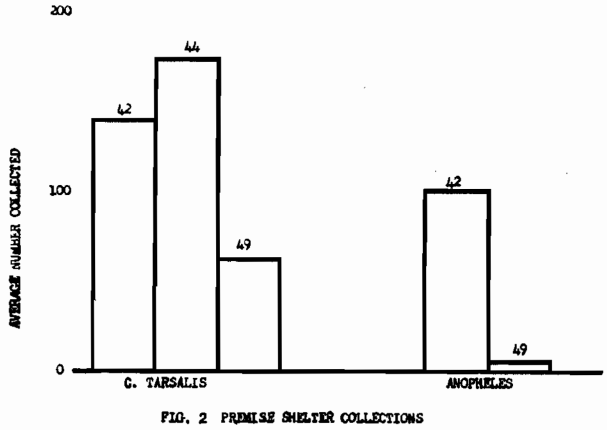

FIGURE 2

Average Number of Mosquitoes Collected Each Premise Shelter Collection, Yakima Valley, Washington, 1942, 1944 and 1949.

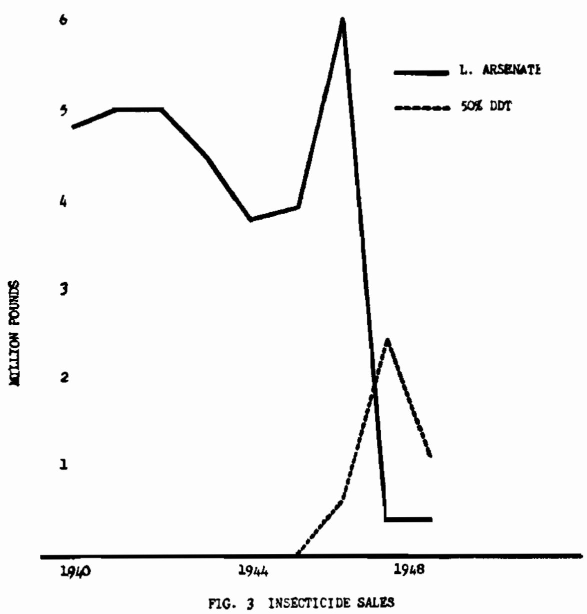

FIGURE 3

Sales of Agricultural Insecticides, Yakima Valley, Washington, 1940 - 1948.

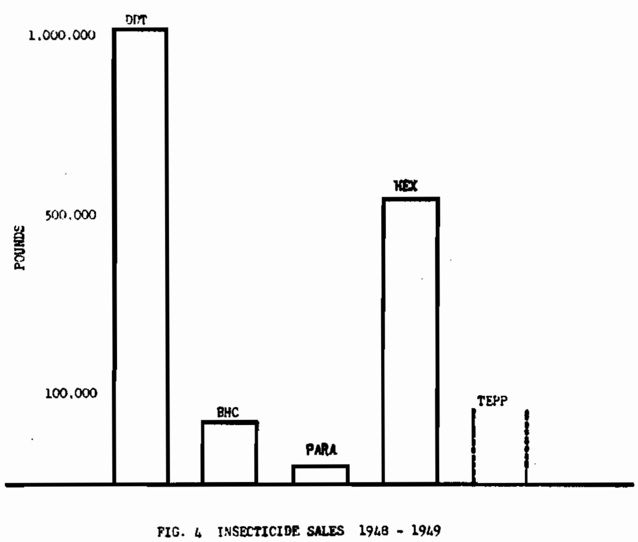

FIGURE 4

Sales of Agricultural Insecticides, Yakima Valley, Washington, 1948 - 1949 Fiscal Year.

a rule, these were orchard areas. In other parts of the valley, where pastures and unsprayed crops predominated, relatively large numbers of mosquitoes still could be found.

I believe it is safe to assume that the marked reduction in numbers of flies and mosquitoes in the Yakima Valley is due to extensive agricultural application of heavy dosages of insecticides, which. as it happens, are also toxic to these insects. This is strictly an accidental byproduct of a program, and has been achieved at no cost or intentional effort. Some of the other possible effects of this program are subjects for conjecture.

I hope that you now understand how Yakima, Washington, has controlled mosquitoes and flies at no cost, and also why we can't. If a mosquito abatement district were to apply similar amounts of insecticides to their entire district, they probably would control mosquitoes, but they also would be bankrupt, in court, and in jail.

It would be better if you talk the people in your area into planting apple trees. It's cheaper.

Literature Cited

[1] Reeves, W. C. (1941). Newer developments in knowledge of insect hosts and vectors of Western Equine and St. Louis Encephalitis. Proc. & Papers 12th Ann. Conf. Calif. Mosq. Cont. Assoc., Dec. 15 & 16, 23–36.

[2] Hamon, W. McD. (1941). Animal reservoirs, general epidemiological summary, and possible control measures for the American summer encephalitides. Proc. & Papers 12th Ann, Conf. Calif. Mosq. Cont. Assoc., Dec 15 & 16, 37–51.

[3] Hammon, W. McD., W. C. Reeves, B. Brookman, and C. M. Gjullin (1942). Mosquitoes and encephalitis in the Yakima Valley, Washington: V — Summary of case against *Culex tarsalis* Coquillett as a vector of the St. Louis and Western Equine viruses. J. Inf. Dis., *20:* 278–283.

[4] Hammon, W. McD., W. C. Reeves, S. R. Benner, and B. Brookman (1945). Human encephalitis in the Yakima Valley, Washington, 1942. J. A. M. A., *128:* 1133–1139.

[5] Hammon, W. McD., and W. C. Reeves (1947). Inter-epidemic studies on arthropod-borne virus encephalitides and poliomyelitis in Kern County, California, and the Yakima Valley, Washington, 1944. Amer. J. Hyg., *46:* 326–335.

Mr. Washburn: Anybody want to take Bill on now? We're going to back-track to this morning's program. We'll hear from one of our friends in the State of Utah, Dr. Orson Whitney Young, who is Superintendent of the Weber County Mosquito Abatement District at Ogden, Utah. He's also a distinguished member of the State Legislature of Utah.

Dr. Orson Whitney Young: I'm a school man by profession and at heart, and I feel something like a freshman speaking before a noted colloquium of Professors when I look up into the faces of these men who are experts in mosquito abatement. I'm grateful for this opportunity of speaking before this body and hope that whatever I say this afternoon will be of help to you.

In the first place, the reason that I am enthusiastic about mosquito abatement is that it fits into the broad picture of conservation. It actually is something which harmonizes very nicely when it is properly carried out with a whole and harmonious conservation program. And I mean by that when it is properly carried out that the emphasis isn't too much, as it has been in my case, upon DDT and things like that, but that wise measures of drainage and things of that nature are carried out in such a way as to preserve this balance of nature. We didn't make these natural conditions. We aren't, properly speaking, a party to their manufacture in the first place, so we are in the position of being merely stewards, and so our efforts should be directed along those lines that will work more in harmony with the natural forces than against them.

I have been very pleased with the papers so far. I think that this sort of attitude is to be detected in the papers that have been presented. "With all thy getting, get undersanding," is what the good book says, and we should hark back to such essential principles as the web of life, and the essential unity of life in this nature which we have control over.

Now in Utah we have a number of problems which center around irrigation. That isn't new to any of you, I'm sure, because most of you come from irrigated lands. The fluctuating water level which we have in floods, resulting from the spring run-off in the Wasatch mountains that sweeps down into the valley where Weber County is situated, introduces one of the problems that we have to do with in mosquito abatement. Furthermore, we have the same problem that you have in trying to educate farmers to drain their pastures and to watch their water, not only on account of mosquitoes but also on account of the tremendous amount of soil that is being washed off by their wasteful methods of irrigation. So I think that those are significant problems, which is the title of my paper. I think we ought to go right to the slides and I will show you just what I mean by these problems which are current to us all.

This is Weber County and this is the map which we have prepared. It changes constantly. You see here a bunch of red specks which indicates the breeding places that we have discovered, but when we get these breeding places located, a month later they are not there and the irrigation picture has changed and we have a new set of breeding places to look after. That's a familiar problem to you all, I'm sure.

This is Ogden, and we have up here a recreation area which has been mentioned so prominently. This is Pine View Lake, located, by the way, very near to the center of Scenic America. I now have paid my debt to the Chamber of Commerce. Ogden is well drained. We don't have much trouble with Ogden so far as mosquito abatement is concerned, but our problem is out here in the realm of the lake where the land is very flat. Weber County is mostly situated in a fossil lake bed; some 20,000 years ago it was covered entirely by Lake Bonneville, so it's very flat here, and Weber River rolls down and divides into a number of streams that go out to the north and to the west and drain into the Great Salt Lake.

You can see how much of Weber County is watershed. We don't have to worry about the water that is shed, it's the water that is standing, and that's down in these irrigated lands that we have our difficulty. We have a very concentrated population in Utah for the land that is cultivated, and our water is caught by these mountains and then comes to us down through these streams that I presently will show you.

This is the recreational area and one that gives us a certain amount of trouble because it's a reservoir, and the fluctuating water level bares large areas of muddy flats which are of course mosquito breeding areas. Here is another picture showing this area in about September of the year, and you can see the general picture of the mountainside there. That's the picture of the canyon where this stream from the dam comes down and you see the roadway encroaching upon the canyon stream. That again isn't very much of a problem as far as we're concerned, but that's our water supply; and then it goes down into the valley, the flat valley, where it remains ponded and has to be drained. So irrigation here is carried on in this arable land out through here and then that drainage from that irrigation goes out in these very flat lands here toward the lake. One of our big problems is with the canal here; they have borrowed from this land adjacent to make this canal, and the borrow pit is a good mosquito breeding place. Again the canal is high on the hillside, and seepage water goes down through the ground, and all this area out here is mosquito breeding areas. We have to check on that. In such places as that it is common to find this hummocky ground, and in between these hummocks it is common to find *Aedes dorsalis* and others. We're trying to educate people to build cement-lined ditches, but it isn't hard to get ditches lined with clay that will serve the purpose very well.

We also have a good many flowing wells. The pressure of the water up in the mountains which are shown in the background there, presses down through this gravely soil and comes out at certain places in flowing wells. These wells are not capped. The owners just allow them to run at any time and as a result they form mosquito breeding areas. In attempting to drain, the county has dug drainage canals in places and thrown the spoil dyke up in such a way that right behind it is a mosquito breeding area. This is the type of thing that we have to combat most of the time. It's very familiar to you.

This one was made in 1944 by the county and then just simply allowed to accumulate plant growth, and of course that constitutes part of our work. We're now getting a sufficient amount of money to go into the drainage program a little bit better. Down in the lower reaches, almost to the salt flats, the drains are clogged by plant life and constitute a very serious problem.

Where the farmers build roadways across these drains farther out into the county they back up the water considerably, and the water table is very high, resulting in an alkaline condition. This is a typical picture of the salt flats area out almost to the lake. Of course right out next to the lake it is white alkali and very flat. This is a mosquito breeding area where water stands with a very high water table. This is one of the main streams that flows out toward the lake, rather sluggish in its flow. In some places there is only one inch drop to the mile, consequently the flow is very slow. I think these pictures give you a fair idea of the type of problems we have in Weber County.

Mr. Washburn: Thank you, Dr. Young, for the excellent pictures and the description of your problems in Weber County, Utah.

The next item on the program is a symposium on "The Place and Use of Toxicants in California Mosquito Control." It will be led by Arthur F. Geib, Manager of the Kern Mosquito Abatement District.

TOXICANTS AND THEIR USE IN CALIFORNIA MOSQUITO CONTROL

(Introduction to Symposium)

By Arthur F. Geib

Manager, Kern Mosquito Abatement District

The place and use of toxicants in California Mosquito Control is a very broad subject, one that is not only controversial but could be discussed all day. The need for and extent to which toxicants are used will vary widely due to differences encountered in all areas where mosquito control is practiced. Therefore, I hope that following the presentation of papers in this symposium we will make it just as informal as possible and get into some real discussion regarding insecticides and their use.

We have now been through a four-year period in mosquito control during which chlorinated hydrocarbons have replaced diesel oil as the basic toxicant in our operations. This change from oil to organic insecticides has been most revolutionary and resulted in a drastic change in that phase of operations concerned with insecticides.

It should not be overlooked that a good program must first and foremost follow the old tried and true concept, that the most effective and the most economical method to control mosquitoes is to eliminate their breeding sources. Actually, the change from oil to organic insecticides has been of such magnitude that a very large share of our time, effort, and interest has been devoted to this alone and in some cases to the detriment of a well-balanced mosquito control program. I am confident that most mosquito control agencies practice this concept of eliminating mosquito breeding sources, but I also feel that it has been too easy since the advent of chlorinated hydrocarbons to rely on the insecticides for control rather than giving adequate emphasis to the eliminative phase. Now that we have had approximately four years in which the newer insecticides have absorbed our interest, I believe the pendulum will slowly swing the other way until we are in better balance between the eliminative and insecticiding phases of the well-rounded control program.

It should be pointed out, however, that under the conditions which most districts operate in California, insecticides will probably always be indispensable. There are many situations, too numerous to mention, where it will be necessary to use toxicants to carry on an effective mosquito control program; in addition there will always be many cases where it is not economically practical for farmers to eliminate mosquito breeding sources created on their lands due to irrigating pratices. All too often it may mean a prohibitive expenditure by the farmer that would never be repaid in profits from crops. In cases of this type the only answer seems to be repetitive treatment of mosquito breeding sources with appropriate toxicants.

This being the case, together with the development of resistance in mosquitoes to the newer insecticides, it appears that we are confronted with the necessity of continuous search for the best types and proper methods in using toxicants for mosquito control and at the same time making sure that all insecticides are used in such a manner that they are non-injurious to man and animal.

INVESTIGATIONS OF INSECTICIDE-RESISTANT HOUSE FLIES IN SOUTHERN CALIFORNIA

By RALPH B. MARCH and ROBERT L. METCALF[1]

University of California Citrus Experiment Station, Riverside, California

Failures of DDT residual sprays in controlling house flies (*Musca domestica* L.) in southern California were first observed in the spring of 1948. Laboratory and field studies were undertaken at this time to determine the causes and to find remedial measures for these failures.

DDT-RESISTANCE

Initial studies (March and Metcalf, 1949a) showed that the primary cause for the ineffectiveness of DDT residual sprays was the development of house fly resistance to DDT. Samples of natural fly populations were collected in the field, and the susceptibilities of their laboratory-reared progeny to various insecticides were compared with those of a known nonresistant strain of flies. In these tests, twenty-four hour LD_{50}'s in microgtams per female fly were determined by the topical application of insecticides in acetone solution by means of a micro-syringe, and then compared for the various fly strains (see Table 1).

Table 1 — Measured drop tests showing comparative 24-hour topical LD_{50}'s in micrograms per female fly for laboratory, Bellflower, and Pollard strains.

	24-hour LD_{50}'s in micrograms per female fly for following fly strains:		
Compound	*Laboratory*	*Bellflower*	*Pollard*
DDT	0.033	11	> 100
DFDT	0.10	4.0	1.2
DTDT[1]	0.16	0.70	2.7
DETDT[2]	0.11	1.3	2.7
Methoxychlor	0.068	0.96	1.4
DDD	0.13	60	> 100
Lindane	0.010	0.080	0.25
Heptachlor[3]	0.032	0.060	1.5
Aldrin	0.044	0.076	0.78
Dieldrin	0.031	0.050	0.86
Toxaphene	0.22	0.62	3.4
Parathion	0.015	0.020	0.023
Pyrethrins	1.0	0.94	1.6
Allethrin[4]	0.41	0.97	0.50

[1] 2,2-bis(*p*-tolyl)-1,1,1-trichloroethane.
[2] 2,2-bis(*p*-ethylphenyl)-1,1,1-trichloroethane.
[3] The most toxic ingredient of technical chlordane.
[4] Allyl analog of Cinerin I.

[1] The authors wish to acknowledge the able assistance of Mr. Lewrence L. Lewallen and Miss Bernice McGill in conducting these studies.

The most DDT-resistant field strain collected (Bellflower strain) is more than 300 times as resistant to DDT as the nonresistant laboratory strain. This resistance is not entirely specific to DDT, but exists as well. though to a lesser degree, for structurally similar compounds. The Bellflower strain shows no resistance, or at the most a resistance of low order, to certain other insecticides including lindane, heptachlor, aldrin, dieldrin, toxaphene, parathion, pyrethrins, and allethrin.

A number of insecticides including methoxychlor, toxaphene, chlordane, and benzene hexachloride were investigated as replacements for DDT in the field. The most effective of the commercially available insecticides has been benzene hexachloride used at the rate of 17–20 pounds of the 10–12% gamma-isomer wettable powder, or 8 pounds of the 25% lindane wettable powder per 100 gallons of finished spray. Residual deposits from throrough application of these formulations to the point of run-off have provided satisfactory fly control in southern California for about 4 weeks during the hottest summer weather, and 8 weeks during the cooler spring and fall weather.

Because of its high toxicity and long residual activity, equally effective control was obtained with 4–8 pounds of the 25% dieldrin wettable powder per 100 gallons; however, this material is still available only on an experimental basis for fly control.

RESISTANCE TO OTHER INSECTICIDES

In August, 1949, information was received that benzene hexachloride was not accomplishing satisfactory fly control at the Pollard and Sons Poultry Ranch, Santa Ana, California (March and Metcalf, 1949b). This ranch had been treated in March, 1949, with 40 pounds of 50% DDT wettable powder per 100 gallons with unsatisfacory control. This result was to be expected in light of the widespread occurrence of DDT-resistant flies in southern California. In April an application of 17 pounds of the 12% gamma-isomer benzene hexachloride wettable powder per 100 gallons gave satisfactory control for about 4 weeks, but a third application in July gave control for only about 5 days. Applications of 50 pounds of the 12% gamma-isomer benzene hexachloride wettable powder and 8 pounds of the 25% dieldrin wettable powder were not any more effective.

A sample population of flies (Pollard strain) was collected and the relative degrees of resitance of the laboratory-reared progeny to various insecticides were determined in the same manner as had been accomplished for DDT-resistant flies. These tests showed (see Table 1) that the Pollard strain is even more resitant to DDT than the Bellflower strain, and similarly it is resistant to compounds structurally related to DDT. In contrast to the Bellflower strain, it shows considerable resistance to other chlorinated hydrocarbons such as lindane, heptachlor, aldrin, dieldrin, and toxaphene. The Pollard, Bellflower, and laboratory strains all show approximately the same levels of susceptibility to parathion, pyrethrins, and allethrin.

OUTLOOK

Thus, there are now two types of resistant fly strains in the field in southern California. The Bellflower type is resistant only to DDT and related compounds, and the Pollard type is resistant to other chlorinated hydrocarbons such as lindane and dieldrin, as well as DDT and related compounds. Neither strain is resistant to parathion, pyrethrins, or allethrin.

Although resistance of the Pollard type had appeared only on a limited scale in the late summer of 1949, a considerable number of reports of such resistance have now reached us. We have been able to verify three of these reports from widely separated areas. One example is that of a strain of house flies received from the U.S. Public Health Service Fly Control Project in Phoenix, Arizona. Limited tests with this strain have shown that it is as resistant as the Pollard strain to DDT and even more resistant to lindane and dieldrin. It would appear that there will be progressive and widespread development of this type of resistance throughout southern California during this next fly season.

The above levels of resistance are even more striking if one compares the LD_{95}'s, which more closely approximate the desired level of field control, instead of the LD_{50}'s (see Table 2). On this basis, for example, the Bellflower strain is more than 1500 times as resistant to DDT as the laboratory strain in contrast to a value of 300 times for the LD_{50}'s.

These results point out the great range of individual susceptibility in the field-collected resistant strains. Tests with the Pollard strain have shown that although the LD_{50} for dieldrin is 0.86 micrograms per female fly, 1 fly out of aproximately 200 is able to survive 100 micrograms of dieldrin. It has been possible to develop super-strains in the laboratory by selection, with further insecticidal treatment, of the most resistant individuals from the field-collected strains. A super-Bellflower strain is more than 3000 times as resistant to DDT as the laboratory strain, and a super-Pollard strain is approximately 10,000 times as resistant to lindane as the laboratory strain and more than 3000 times to dieldrin. Continued selection in the field may be expected to produce widespread levels of resistance such as this, which is in fact already the case with the resistance of the Pollard strain to DDT.

Table 2 — Measured drop tests showing comparative 24-hour topical LD_{50}'s and LD_{95}'s in micrograms per female fly for laboratory, Bellflower, and Pollard strains.

	24-hour LD_{50}'s and LD_{95}'s in micrograms per female fly for following fly strains		
Compound	*Laboratory*	*Bellflower*	*Pollard*
DDT			
LD_{50}	0.033	11	> 100[1]
LD_{95}	0.060	> 100	> 100
Lindane			
LD_{50}	0.010	0.080	0.25
LD_{95}	0.040	0.37	1.3
Dieldrin			
LD_{50}	0.031	0.050	0.86
LD_{95}	0.060	0.11	6.5
Parathion			
LD_{50}	0.015	0.020	0.023
LD_{95}	0.020	0.041	0.037

[1] This is the maximum amount of DDT which can conveniently be applied by topical application of 1 cubic millimeter of acetone solution containing 10% DDT. More concentrated solutions cause plugging of the needle due to deposits of solid DDT.

It is apparent that the degrees of resistance shown by the Bellflower strain to DDT and by the Pollard strain to DDT, lindane, and dieldrin, are sufficient to make it impracticable to use these materials for residual house fly control where such strains are present. The development of resistance by a single strain of house flies to a number of chemically unrelated insecticides poses a most serious problem for the continuation of house fly control by the residual application of insecticides and presages the further development of resistance to other insecticides which may be substituted for those against which resistance has developed.

At present we have found no indications in the laboratory that resistant strains will revert to more susceptible strains following nonexposure to insecticides. The Bellflower strain has been reared in the laboratory for over 35 generations and the Pollard strain for over 15 generations without exposure to insecticides, and there has been no appreciable change in resistance of the progeny.

In the field, the picture is more complicated because there is continuous selection by insecticides in current use. This is shown by the results of the subsequent sampling and testing of the field population at the location where the Bellflower strain was collected (see Table 3). In 1949 there was no appreciable change in the resistance of the strain in the field, but in 1950, following the use of benzene hexachloride since August, 1948, not only had the resistance to lindane increased approximately 12 times, but the resistance to DDT had increased more than 10 times, although DDT had not been used. This increase in resistance to DDT emphasizes the improbability of any rapid decrease in resistance in the field after an insecticide is no longer used.

Table 3 — Measured drop tests showing comparative 24-hour topical LD_{50}'s in micrograms per female fly for 1948, 1948, and 1950 field collections of the Bellflower strain.

	24-hour LD_{50}'s in micrograms per female fly for following collections of Bellflower strain		
Compound	*1948*	*1949*	*1950*
DDT	11	10	> 100
Lindane	0.080	0.048	1.0

Basis of Resistance

The fundamental basis of this resistance has been a subject of considerable interest. Studies (March and Lewallen, 1950) have shown that there is no statistical difference in the general vigor of the Bellflower and laboratory strains as evidenced by length of life cycle, average weight of individual flies, and susceptbility to immobilization by heat and cold. No differences were found in the gross morphology of the two strains. Differences in the dimensions of the tarsal segments were not uniform enough or large enough to indicate that they contribute to the resistance. Measurements of the cuticular thickness of the tarsi and the thorax were of the same magnitude. Injections of DDT directly into the flies showed the same relative degree of resistance as external applications, thus demonstrating that the resistance is not caused by the failure of DDT to penetrate the fly cuticle.

Since rabbits have been shown to metabolize DDT (White and Sweeney, 1945) through DDE (2,2-bis (*p*-chlorophenyl)-1,1-dichloroethylene) to DDA (bis (*p*-chlorophenyl) acetic acid), both of which are relatively nontoxic to insects, and the large milkweed bug has been shown to rapidly metabolize DDT (Ferguson and Kearns, 1949) to unknown metabolites, it was proposed that DDT-resistant house flies might have developed an increased ability to detoxify DDT by this metabolic mechanism. Studies, which are still in progress, show that DDT-resistant flies (super-Bellflower strain) are able to metabolize larger quantities of DDT at a greater rate than nonresistant flies (laboratory strain). Although the metabolic end products have not been completely defined, there is evidence that the degradation process proceeds principally to DDE, but there is no evidence of the formation of DDA. It is aparent that the increased ability of DDT-resistant flies to metabolize DDT contributes considerably to their resistance. The extent of this contribution in relation to possible changes in the competing mode of action system is not known, however, and is of considerable importance as significant amounts of DDT in relation to the LD_{50} dose for nonresistant flies remain in living DDT-resistant flies for 72 hours following injection.

Support for this detoxification theory of DDT resistance may be found in the results of laboratory toxicity tests with 1,1-bis (*p*-chlorophenyl)-2-nitro propane[2] and 1,1-bis (*p*-chlorophenyl)-2-nitro butane[3] (see Table 4). These compounds, although structurally related to DDT, obviously cannot be detoxified by the same dehydrohalogenation mechanism. Thus, the fact that laboratory, Bellflower, and Pollard strains all show the same degree of susceptibility to these compounds, may indicate the importance of the detoxification mechanism in DDT-resistance. Preliminary field studies with these compounds have shown promise in the control of DDT-resistant flies.

Further toxicological, physiological, and genetic studies are in progress to characterize the nature of fly resistance to insecticidal action more completely. These include the development of resistance by flies to various insecticides in the laboratory, by topical application to the adults, and by treatment of the larval breeding media; and attempts to find synergists or activators for DDT against DDT-resistant flies.

It has been shown, for example, that fly larvae, initially unable to survive in media containing 1 p.p.m. of parathion, are able after 11 generations bred in media containing increasing amounts of parathion, to grow normally in 80 p.p.m. and to produce normal, fertile adults. These adult flies are also significantly resistant to parathion, and preliminary studies indicate that they have a type of cholinesterase which is more resistant to inhibition by parathion than that of nonresistant flies.

A recent report (Anonymous, 1950) has indicated that the pyrethrin-synergist, piperonyl cyclonene is effective in increasing the toxicity of DDT to resistant flies. Trials made by applying mixtures of DDT and piperonyl cyclonene to super-Bellflower flies produced only slight indications of increased effectiveness. For example, when applied at 100 micrograms per fly with 10 micrograms of DDT, the mortality of the flies was 50% as compared with 5% with 10 micrograms of DDT alone. One hundred micrograms of piperonyl cyclonene alone caused no mortality No indications of effective synergism for DDT against DDT-resistant flies were obtained with other pyrethrin-synergists including piperonyl butoxide, N isobutyl undecylene amide, piperine alkaloid, sesamine, di-*n*-propyl-2-methyl-6,7-methylene-dioxy-1,2,3,4-hexahydronaphthalene-3,4-dicarboxylate[4] or N-(2-ethylhexyl)-bicyclo-(2,2,1)-5-heptene-2,3-dicarboxyimide.[5]

Table 4 — Measured drop tests showing comparative 24-hour topical LD_{50}'s in micrograms per female fly for laboratory, Bellflower, and Pollard strains.

Compound	24-hour LD_{50}'s in micrograms per female fly for following fly strains		
	Laboratory	*Bellflower*	*Pollard*
1,1-bis (*p*-chlorophenyl)-2-nitropropane	0.095	0.15	0.11
1,1-bis (*p*-chlorophenyl)-2-nitrobutane	0.15	0.18	0.11
DDT	0.033	11	> 100

A recent paper by Ranganthan et al. (1949) has suggested that beta-methyl anthraquinone is an effective synergist for DDT. Trials with this compound applied topically or as residual deposits have shown little indication of activity as a DDT-synergist either against nonresistant (laboratory) flies, or DDT-resistant (super-Bellflower) flies. Tests with a number of other quinones have also been negative. These studies, however, are being continued with the hope of discovering a compound with synergistic value. It is hoped that these and other approaches will aid in the solution of the entire problem of resistance to insecticides, as well as the resistance of house flies.

Control Suggestions

The following practices are suggested for the present control of house flies:

(1) Practice every possible means of sanitation, especially the disposal of manure and other materials to which flies are attracted, and in which they breed.

(2) Supplement sanitary practices by residual applications of benzene hexachloride and lindane formulations in locations where they are still effective.

(3) Use space sprays or aerosols containing at least 0.1 per cent pyrethrins, or the equivalent of pyrethrins and an activator such as piperonyl butoxide, or at least 2.5 per cent of an organic thiocyanate such as isobornyl thiocyanoacetate[6] or beta-butoxy-beta′-thiocyano diethyl ether[7] in an odorless petroleum distillate. These sprays should be fogged into the air. They are particularly effective in producing a rapid knockdown of the flies, but have almost no residual action. Their use represents, at present. the only satisfactory means

[2] Commercial Solvents Corp. CS645A.

[3] Commercial Solvents Corp. CS674A. A mixture of 3 parts of CS674A and 1 part of CS645A is marked as Dilan.

[4] *n*-propyl isome.

[5] Octacide 264.

[6] Thanite.

[7] Lethane 384.

for the chemical control of flies resistant to both DDT and benzene hexachloride.

(4) Apply fly-repellent materials such as activated pyrethrum formulations or polypropylene glycols to livestock as required.

(5) Supplement other methods with mechanical and baited fly traps and poisoned attractants.

|6) Mechanically exclude flies from restricted areas with proper screens where practicable.

Literature Cited

Anonymous (1950). Pepper extract lets DDT kill superflies. Farm Journal *1950 (March)*: 17.

Ferguson, W C. and C. W. Kearns (1949). The metabolism of DDT in the large milkweed bug. Jour. Econ. Ent. *42*:810-17.

March, R. B. and R. L. Metcalf (1949a). Laboratory and field studies of DDT-resistant house flies in southern California Bul. Calif. State Dept. Agr. *38*:93-101.

March, R. B. and R. L. Metcalf (1949b). Development of resistance to organic insecticides other than DDT by house flies. Jour. Econ. Ent. *42*: 990.

March, R. B. and L. L. Lewallen (1950). A comparison of DDT-resistant and nonresistant house flies. Jour. Econ. Ent. In press.

Ranganthan, S. K., T. Koshi and N. L. Sitaraman (1949). Methyl anthraquinone (tectoquinone) a synergist for 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane (DDT). Nature *164*: 1095.

White, W. C. and T. R. Sweeney (1945). Metabolism of 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane (DDT). I. A metabolite from rabbit urine, di(*p*-chlorophenyl) acetic acid; its isolation, identification, and synthesis. U.S. Pub. Health Rept. *60*:66-71.

Mr. Geib: Thank you, Dr. March. I feel sure that some of you have some questions you want to ask him, but I think we had better go to the other papers before you do, but try to keep in mind the questions that you are thinking about. Next we will have Dr. W. D. Murray, Manager of the Delta Mosquito Abatement District, Visalia, speaking on DDT Resistance and *Aedes nigromaculis* Larvae.

W. D. Murray: As our spray men are driving or walking though our many irrigated pastures they have the opportunity of glancing to the east and seeing those beautiful Sierra mountains, knowing that there are tremendous Sequoia trees and beautiful mountain streams; we have recreation too.

One thing that puzzles me a little bit — I think maybe some others may be puzzled likewise — is how in Yakima, Washington, they can spray fruit trees and kill mosquitoes and in the San Joaquin Valley we can spray mosquitoes and can't kill them.

During the past summer some of our districts in the San Joaquin Valley, especially in the southern part, ran into the situation where using DDT in quantities of half a pound up to a pound per acre, the *nigromaculis* larvae were swimming right through it, turning into pupae and into adults. There was no question but what we had resistance. There were a number of different possible answers to our problem, and I thought that we should look into each one as far as we could go. A paper that just came out — some of you may have already seen it — compiled by Harvey Magy, is very good in presenting several different possible answers, and I suspect that all of those presented have a bearing on the problems. The preceding paper left no doubt that there is strong resistance in house flies. *Aedes nigromaculis* is a species of insect that competes with the house fly in speed of development, in number of generations per year, and therefore it can develop resistance, if that has anything to do with it, just as fast as the house fly.

One thing that puzzled us was how, for instance, in killing the house flies with a residual spray, the house fly may have a chance to get away, and if it has any resistance at all it gets away before it is killed, but with our *Aedes nigromaculis* larvae in the water they have no chance to get away — there they are, they can't swim away from it — yet with quantities of up to one or two pounds per acre we still didn't kill them.

To help us with this problem we asked Dr. Bohart to perform the basic testing work, while we would furnish the mosquitoes, as we had plenty of them. The following paper presents the results of these studies.

DDT RESISTANCE IN *AEDES NIGROMACULIS* LARVAE

By R. M. Bohart

Assistant Professor of Entomology, University of California, Davis

and W. D. Murray

Manager Entomologist of Delta Mosquito Abatement District, Visalia

Introduction

Since the San Jose scale was found by Melander (1914) to be resistant to lime-sulphur spray, a number of insects have been proven resistant to chemical. Quayle (1943) has summarized this information and lists several scale insects, the coddling moth, the primary screw worm, and the citrus thrips, as well as other possible suspects. More recently, bedbugs have been reported resistant to DDT by Johnson and Hill (1948) and several workers have given proof of resistance of house flies to DDT and other chemicals. The problem with respect to house flies has been nicely summarized by March and Metcalf (1949), and these authors have pointed out a pattern in which flies resistant to DDT are usually also more or less so to DDD, methoxychlor, and other related compounds. Similarly, a strain resistant to chlordane was found to react similarly toward benzene hexachloride and toxaphene.

Considering the great amounts of larvicides applied yearly for mosquito control in California, it is not surprising that resistance should develop. In 1949 several Mosquito Abatement Districts had unsatisfactory results in the control of *Aedes nigromaculis* with DDT formulations. This condition was first reported by Smith (1949) in Kern County, but was experienced at about the same time in Tulare and Merced counties. Successive spray failures caused several districts to switch to toxaphene for *Aedes nigromaculis* control, with greatly improved results.

In order to back up this circumstantial evidence of resistance with experimental data, the writers collected fourth instar larvae from six irrigated pastures in Tulare and Kings Counties.[1] Three of these pastures (fields 4-6) were within

[1] L. W. Issak assisted in carrying out the tests.

the Delta Mosquito Abatement District and had a history of repeated DDT larvicide applications with recent failures in spite of greatly increased dosages. Field 4 had been sprayed once by hand and twice by airplane; field 5 had been sprayed twice by hand and twice by airplane; and field 6 had been treated on numerous occasions over a 3-year period, the 1949 attempts totaling four by hand and two by airplane. The other three pastures (fields 1-3) were in an area not known to have been previously sprayed with DDT. The larvae were slightly different in size, being largest in field 6 and successively smaller in fields 3, 2, 5, 4, and 1. Thus the average size was about the same in fields one to three as in fields four to six. Maturity varied somewhat, also, the larvae in fields 2, 6, and 1 being nearest pupation.

The larvae were exposed for 24 hours to emulsified toxicants[2] in paper cups, 10 larvae in 100 cc of a mixture of irrigation water and tap water. One to 5 cups were used at each of 7 concentrations ranging from 1 part in 1 million of water to 1 part in 400 million. Larvae which formed active pupae within 14 hours were judged to be too mature and were arbitrarily removed from consideration. Mortality counts of the remainder were taken after 24 hours. Results are shown in Table 1. LD_{50}[3] for the average of the larvae from the three previously untreated fields was close to 1 part in 200 million parts of water. The average per cent mortality of the larvae from the three previously treated fields places the LD_{50} by interpolation at about 1 part in 10 million of water. Thus, it can be said that based on the amount of DDT required for a 50% mortality, the average larva from three previously treated fields was about ten times as resistant as the average larva from previously untreated fields. Obviously, this figure must be considered with caution, since the resistance factor must vary with individual fields, and, according to the results in Table 1, it was much greater in field 6 than in fields 4 and 5. However, the least resistant of the larvae from previously sprayed fields (field 4) was decidedly more so than the most resistant of the previously unsprayed fields (field 3). This resistance differential of about 3 times, based on the LD_{50}, can be compared with that of approximately 60 times between fields 6 and 1.

Using larvae from fields 1, 2, 4, and 5, but not 3 nor 6, a comparative laboratory test was performed with results as shown in Table 2. Based on LD_{50} it can be seen that DDT was slightly more toxic to "non-resistant" larvae than toxaphene, but the situation was sharply reversed with the "resistant" larvae. Furthermore, the "resistant" larvae with an LD_{50} for DDT of about 1 part to 25 million showed a resistance factor of only 4 times instead of 10 times as in the previous comparison where three fields were taken instead of two. Also, the fact that larvae from fields 4 and 5 appeared to be less resistant to toxaphene than those from fields 1 and 2 may be significant or may mean that data based on two fields are not enough to give an accurate picture.

A small-scale test using DDD was performed at the same time, and although this chemical had not been used on the fields in question, the resistance picture was similar to that of DDT.

[3] Concentration at which 50% of larvae succumbed.

[2] Technical grade insecticides in xylene and Triton-x-100.

Discussion

The present system of larviciding, in which a single toxicant is applied repeatedly to the same area, probably operates as a method of natural selection. The fact that larvae of the same age, size, and species may show great differences in susceptibility to a given chemical is well known to those who have done laboratory larvicide work. If such differences are heritable, the eventual production of a resistant population is extremely likely wherever spraying is done regularly. It is probably more than a coincidence that first evidence of resistance has appeared in a mosquito whose reproductive potential is extremely high. With a possible complete cycle from egg-laying adult to egg-laying adult of about 10 days during favorable conditions, an estimate of perhaps 15 possible generations a year can be made for *Aedes nigromaculis,* depending upon temperature and the irrigation cycle. On the other hand, species with only one generation a year, such as *Aedes squamiger* in the San Francisco Bay region would not be expected to develop resitance for some years.

The apparent trend toward resistance is parallelled by the reaction of bacteria and related forms, some of which have developed resistance to antibiotics. Medical men have switched to other compounds and in so doing are finding better drugs than ever before. As the factor of resistance has not meant a return to a high rate of epidemic diseases, there is no need as yet to be too pessimistic about the future of mosquito control.

It is too early to conclude that all regularly sprayed larvae will eventually become resistant to chemicals. However, with an eye to the future, the lines of attack which might be followed are (1) increased attention to more permanent methods of control such as drainage and improvement of irrigation practices, (2) annual or more frequent rotation of larvicides to prevent exposure of successive generations to a single chemical, (3) emphasis on thorough coverage and if possible a large enough dose to ensure practically a complete kill.

Literature Cited

Johnson, M. S. and A. J. Hill (1948). Partial resistance of a strain of bedbugs to DDT residual. Medical News Letter *12(1)*:26–28. Bureau of Medicine and Surgery, Washington.

March, R. B. and R. L. Metcalf (1949). Laboratory and field studies of DDT-resistant house flies in southern California. Mo. Bul. Dept. Agric. Calif. *38*:93–101.

Quayle, H. J. (1943). The increase in resistance in insects to insecticides. Jour. Econ. Ent. *36*:493–500.

Smith, G. (1949). Kern MAD has circumstantial evidence on DDT resistance. Mosquito Buzz *3(8)*:2.

Table 1 — Comparison in the laboratory of average per cent mortality of *Aedes nigromaculis* larvae from 3 fields not previously DDT-sprayed with those from 3 fields previously sprayed.

DDT Concentration	Per cent mortality in fields not previously sprayed				Per cent mortality in fields previously sprayed			
	Field 1	Field 2	Field 3	Average Mortality	Field 4	Field 5	Field 6	Average Mortality
1-1 million	100	100	100	100	100	100	100	100
1-10 million	100	100	100	100	100	98.0	0	66.7
1-30 million	100	100	100	100	30.0	50.0	0	26.7
1-50 million	95.0	66.7	76.5	79.4	40.0	20.0	0	20.0
1-100 million	100	100	0	66.7	15.8	2.0	0	5.9
1-200 million	76.4	66.7	15.0	52.7	15.0	0	0	5.0
1-400 million	31.5	33.3	11.7	25.6	5.0	0	0	1.7
Check	10.0	——	16.7	13.3	——	0	0	0

Table 2 — Laboratory comparison of DDT and toxaphene on larvae from 2 fields not previously DDT-sprayed with larvae from 2 fields previously sprayed.

Concentration	Average per cent mortality in fields 1 and 2 not previously sprayed		Average per cent mortality in fields 4 and 5 previously sprayed	
	DDT	Toxaphene	DDT	Toxaphene
1-1 million	100	100	100	100
1-10 million	100	100	99.0	100
1-30 million	100	80.0	40.0	100
1-50 million	85.8	62.5	30.0	94.5
1-100 million	50.0	35.0	8.9	80.0
1-200 million	45.7	26.3	7.5	0.0
1-400 million	21.6	2.5	1.5	16.1
Check	13.3	13.3	0	0

Mr. Geib: Thank you, Don. I think that as we get into the discussion others may be able to add instances in which they have encountered what we may call resistance. Next we have Dr. Richard Bohart, Assistant Professor of Entomology, College of Agriculture. University of California at Davis.

Dr. Richard Bohart: I can't claim that I did this work in any recreational area. It was all done at Davis. There has been enough experimentation now, partly by the U.S.D.A. and partly by other workers, so that there is still, I'm sure, an element of doubt in the minds of many as to the ultimate value of laboratory studies. I feel that such studies have their limitations, but they also have their useful points. They are useful, primarily, as a means of rapidly getting some idea of a given situation, and getting it much more rapidly than possible under field conditions. In California we have perhaps twelve important species of mosquitoes. There have been at least ten chemicals proposed by insecticide manufacturers and backed up by experimental data which might or might not be of value against these species. You can do a simple mathematical problem on twelve species and ten possible chemicals under varying field conditions on different stages of the mosquitoes, and if you've got your slide rule with you, you will find that it becomes a very tough proposition to try to find out in a hurry in the field the relative effects of these chemicals on the twelve species. You may go out and find an ideal place to put on a test, and by using one chemical at one concentration you get one result. The next day or the next week you go out and use another chemical at another concentration on a different field, with the larvae in perhaps a slightly different stage, and with the temperature and a few other things different, and you get another result. Then you try to compare the two results and I dont' believe you have very much.

In the laboratory you can at least make comparisons under constant conditions of temperature, age of larvae, and other significant conditions. The criticism immediately arises as to whether the laboratory results can be compared with field results. First of all I think it's obvious that the laboratory results are purely comparative. You can't find in the laboratory that one part to ten million will kill certain larvae, and then take that directly to the field, calculate your amount of material, put on one to ten million and necessarily expect to get exactly the same result. There are too many obvious differences, but I do think that in this matter of comparison much preliminary field work can be eliminated by means of laboratory tests. On the other hand, you can't run one laboratory test and arrive at a definite conclusion even if it's an extensive test with many containers. There is nothing more aggravating than to run ten separate experiments at different times, and get a fairly even pattern of results, and then to decide to run one more to clinch the thing and have the larvae do just the thing they weren't supposed to do. I would say that any results from less than three sets of laboratory tests are hardly worth mentioning.

I have made a few attempts with the help of some of the mosquito abatement men to carry the laboratory results into the field and try to see if the field results were comparable to the laboratory results. These tests were made on *Aedes squamiger, Aedes dorsalis,* and *Culex stigmatosoma.* I have been much encouraged to find that the results were comparable.

I have run a series of tests over a three-year period on many species with many materials. Actually the numbers are fifteen species of mosquito larvae, and ten chemicals that have shown some promise, as well as others that have shown no promise whatever. For the purpose of this talk I have reduced the chemicals and the species to six of each. The six economic species and six chemicals still involve some 63 different experiments and a total of about 15,000 larvae that were individually handled. The technique was some what as described by Mr. Murray in a previous test. We used xylene solutions of the various chemicals, with Triton X-100 as the emulsifier.

I have condensed the results into two tables. The species are *Culiseta incidens,* which is a pest, particularly in Alameda County; *Aedes squamiger,* a serious Bay Region species; *Culex stigmatosoma,* which is a nuisance, although it doesn't seem to bite much; *Aedes nigromaculis, Aedes dorsalis,* and *Culex tarsalis.* The chemicals are Aldrin, DDD .sometimes known as TDE), chlordane, DDT, lindane, and toxaphene. These I have arranged, more or less, according to their descending toxicity to all larvae; all of them, however, are definitely in the upper ranges of toxicity. I have aranged the species roughly in their descending order of susceptibility, that is to say, *Culiseta incidens* is probably the most resistant, although in certain cases ***Aedes squamiger*** would be more so. *Aedes nigromaculis* is not an especially resistant type under ordinary conditions. I have used the LD_{50}, the dose which would be theoretically expected to kill 50% of the larvae, as I think it gives the best comparative figures. Note the rather large differences in the amounts of chemical necessary to kill some of these larvae. There appears to be a specific reaction rather than a generic one.

As for the materials that these were run in — first of all I tried distilled water for all of the species, but that had some disadvantages in the case of, for instance, *Aedes squamiger,* which is always found in brackish water in the field. In any case where I had more than 10% mortality in a check, I threw out the test. *Aedes squamiger* and *Aedes dorsalis* were both run in brackish water, and *Culex stigmatosoma* was run in sewer water. Last summer we went to a local sewer farm, brought in sewer water, and made enemies of ourselves in the laboratory. People ran up and down the halls sniffing and complaining, particularly the zoologists, and we had to point out to them that we had to stand the rats and the sharks all during the semester and they could stand a few weeks of sewer water. We also made a comparison with *Culex stigmatosoma* in distilled water, and oddly enough the results were almost exactly the same. That may be surprising to those who have tried to control *Culex stigmatosoma* in sewer farms. It is my personal opinion that this isn't because the *Culex stigmatosoma* larvae are hard to kill but because they come back so fast. Actually it doesn't take very much of the proper type of emulsion to kill these larvae in sewer farm areas, if the water is sufficiently stagnant. On the other hand, if you have a sewer farm where the water is running rapidly you can't expect to get very much control. The larvae are going to be back within about a week, regardless of what you use. We had very fine results in the laboratory with Aldrin, good results with DDD and Chlordane, and somewhat inferior results with other materials. We tried some field tests and our immediate results were good, but in a week the larvae were back.

In all of the species that I've tested there were always a few specimens that were much more resistant than the most susceptible ones. This leads to speculation as to the nature of the resistance, and it's something I think we should like to know more about if possible. A study of resistant strains is obviously indicated for the future.

Mr. Geib: Thank you, Dick. I think that the evidence you have presented here is certainly of value, undoubtedly of considerable interest and pertinent to those of us who are actively engaged in control activities. I am sorry to say that Dr. Abrams will not be present; however, he has sent down Mr. Schmelzer.

PUBLIC HEALTH ASPECTS IN THE USE OF INSECTICIDES

By L. Schmelzer

Chemist, Bureau of Adult Health

Any agent that affects the health of the community can properly be called a public health hazard. That insecticides fall into this classification is, of course, evident. In fact, the insecticides are probably one of the most widespread hazards to the health of the general population that we now know. The toxic effects are first felt by the factory worker who manufactures the material, subsequently by the truckers and stevedores who handle and transport it, by the farmers and pest control operators who use the material, and finally by the consumer who eats this food that may be contaminated. In view of the wide possibility of injury by insecticides one might conceivably suggest the disuse of such toxicant materials. There, of course, excellent reasons for their continued use. First, the economic advantage gained by the control of insect pests is of such magnitude as to stagger the imagination. The estimated damage to food products by insects in the United States is four billion dollars annually. Second, the efficiency of insecticides in controlling insect-borne diseases is of great public health significance, as you all well know. Third, by control of all the operations where insecticides are involved, toxic reactions can be re duced to a minimum. Since the use of inseticides is now so widespread and will no doubt increase in the coming years, it behooves all persons associated with their use to concern themselves with the effects these materials have on the general population as well as on those individuals intimately concerned with their use. It is reasonable to say that any compound that is toxic to insects will probably be toxic to man, the only difference being the dose required.

Insecticides may be divided into three major groups: first, the inorganic poisons; second, the poisons of plant or animal origin; and third, the organic chemicals. The first group, which contains such compounds as lead arsenate, sodium fluoride, and so on, have been used for such a long period of time that they are now under reasonably good control. In addition, their use is rapidly being discontinued in favor of the organic compounds, as has been shown in the case of Yakima in a previous paper. The second group is generally considered to be the least toxic to man of all insecticides and is therefore not of as great importance as the others. This is true with the possible exception of nicotine, which is one of the most toxic of the plant poisons. The third group, the organic chemicals, are of greatest interest today. With few exceptions these compounds were developed in the laboratory and are new in their application as insecticides. They vary widely in their toxicity and in their efficiency. The most important of these organic compounds are the chlorinated hydrocarbons and the organic phosphates, both of which are recent developments. The halogenated hydrocarbons compose the largest significant group of insecticides; included are DDT, chlordane, benzene hexachloride, toxaphene, and others. These compounds are only slightly soluble in water, but are freely soluble in many organic solvents. They are usually applied as a dusting powder or a liquid spray, which sprays may be a simple solution in an organic solvent, or an emulsion of a concentrated solution in water. They are of the residual type, that is, the toxic material remains on the sprayed surface for a considerable time after the spraying. They are neither hydrolized by water nor appreciably oxydized by contacts with air. This is one of the most important of their physical properties in regard to their toxicity and importance to public health.

The lethal dose of chlorinated hydrocarbons varies greatly, toxaphene at one end of the scale having a toxic dose to man of two to seven grams, methoxychlor at the other end having a toxic dose of four hundred to four hundred and fifty grams. DDT, the most widely used of these compounds, has a toxicity of about thirty grams. This figure varies with various investigators and various animal groups used. Chlorinated hydrocarbons produce two effects in poisoned individuals. In severe chronic and in acute cases the major effect is on the central nervous system, producing chacacteristic tremors, depression, convulsions, coma, and eventually death. The other effects produced by small chronic exposures are similar to the effects of the chlorinated solvents such as trichlorethylene and carbon tetrachloride. These are manifested by damage to the heart, liver, and other internal organs. DDT and other solid chlorinated hydrocarbons are not absorbed through the skin to any appreciable extent. Solutions of these materials are absorbed, but this mode of entry to the body is not the major one. Inhalation of the vapors and mists of sprays is not considered to be a very important mode of entry to the body. This may be disputed by some authorities, but present experimental evidence does not give credence to this mode of entry. Ingestion is by far the most important means of entry into the body. In cases of severe acute poisoning accidental ingestion of large amounts appears to be a common factor. In cases of chronic poisoning, poor personal hygiene and industrial hygiene can usually be demonstrated.

The two properties of chlorinated hydrocarbons that make them of special interest to public health are, first, the residual characteristic; it can be readily seen that animal fodder and leafy vegetables for human consumption that have been sprayed with these materials will remain toxic for a long period of time. This condition acts to increase the importance of the second factor, the selective absorption of the comopunds into the fats of animals ingesting them. DDT may be found in chronicalily poisoned animals, in a concentration four times that ingested, and this storage is almost completely in the fat of the animal. DDT appears in the milk of cows and especially in the butterfat and finds its way to the public in this manner. DDT is also stored in the fat of meat animals and presents a public health hazard through this group. It has been demonstrated experimentally that animals fed with a low concentration of DDT, such a low concentration that chronic symptoms will not appear at the time of feeding, will store it to such an extent in the fat that if starved thereafter, symptoms of the poisoning will appear due to the metabolizing of the animal's own fat which is contaminated with DDT. These symptoms usually occur within one to four days after the cessation of the normal diet. Drawing a parallel to that, if a person received a steady small dose through the ingestion of leafy vegetables contaminated with DDT, at some later period when he became ill and had to metabolize his own fat he might then show symptoms of DDT poisoning.

The organic phosphates represent the newest large group of insecticides. Hexaethyltetraphosphate and tetraethylpyrophosphate, which is the active ingredient of parathion, are the most widely used of this group and are very effective against many insect pests. They are not residual in type, and disappear rapidly after spraying. They are the most toxic of all insecticides now in use. Twelve to twenty milligrams is considered to be the toxic dose for man. Organic phosphates act to destroy the enzyme cholinesterase in the human body. This destruction allows an accumulation of acetyl choline in the body, which stimulates the parasympathetic nervous system. Early symptoms are vague and varied, and include headache, vomiting, cramps, nausea, dizziness, blurred vision ,and pulmonary difficulties. A common symptom shown in most pest control operators is a feeling of tightness of the chest and difficulty and breathing, together with a blurred vision, and it has been demonstrated that a good number of automobile accidents that happen to pest control operators that handle parathion are due to the blurred vision effect that they get from their chronic poisoning. That's a rather interesting sidelight.

Serious effect on the central nervous system and the muscles is also possible, as is gastrointestinal damage. The most striking picture in parathion poisoning is the apparent disorder to the plumbing system of the human body. Severe lacrimation and salivation occur, vomiting and diarrhea occur to a great extent, and the entire vascular system of the human body is just completely out of order. The organic phosphates are rapidly absorbed through the skin, but are only slightly irritating. This lack of irritation makes it difficult for exposed individuals to realize the extent of their exposure. Absorption through the respiratory and gastrointestinal tracts is also possible. The extreme toxicity and rapid absorption through the skin make the organic phosphates the most dangerous insecticides in use today. Protective measures against both chlorinated hydrocarbons and the organic phosphates consist of the practice of good personal hygiene and good industrial hygiene, and the sound use of protective clothing. The free use of soap and water cannot be over-emphasized. Recently a bulletin gotten out by the Bureau of Adult Health listed eleven items to be considered in the control of parathion. We recommend the banning of large-sized field packages of the wettable concentrate; maximum sized packages for field use should be about five pounds. The dust for field use should be limited to 2% parathion and the use of liquid parathion formulations should be prohibited. The retail sales of parathion formulations for home garden use should of course be prohibited. Improved wording and form of warning notices on labels should be instituted. Wide circulation should be given to competent medical information on symptoms of parathion poisoning and treatment.

With parathion or any organic phosphate the use of protective clothing is far more important than with any other insecticides we know, with perhaps the exception of nicotine. The reason for this is the rapid absorption of parathion through the skin. You can readily understand that should a person become drenched with the spray and remain in the clothing that is drenched, he will absorb such a terrific amount of parathion that death will usually ensue very shortly. The thing to do in that case is to remove the clothing at once should it become drenched and bathe the exposed individual completely in soap and water. These organic phosphates, as I mentioned, are easily hydrolized and once they are hydrolized their toxicity disappears completely. Hexaethyltetraphosphate and tetraethylpyrophosphate are both hydrolized in water alone, but parathion requires an alkali or soap. Most soaps are alkaline, contrary to all the manufacturers' baloney. So if you use good soap and water you can do a good program of preventing the absorption of parathion once it has been spilled on the skin. The main thing is dont' spill it on the skin.

Mr. Geib: Thank you, Mr. Schmelzer, for so ably telling us about this important phase in the use of insecticides. I think it behooves us all to be most judicious in our use and choice of various toxicants under our control. In that respect I might comment on our own experience in our district. I think one of the major problems that we're confronted with is to get the operator who is daily handling the material to have some respect for what he is handling. You can call to their attention time and time again that it is a poison and not to get it on themselves in concentrated forms or even in dilute forms, and when they do wipe it off, to really wash it off, but it's a difficult thing to impress them with that after they daily come in contact with it for a period of months, but it certainly is something that we should keep after.

I will introduce the next speaker on the symposium, Allen B. Lemmon.

REGULATORY CONTROLS IN THE USE OF INSECTICIDES

By Allen B. Lemmon

Chief, Bureau of Chemistry, California State Department of Agriculture, Sacramento

There's a short course on for pest control operators at the same time as this up at Davis, and I had to be on the program up there this morning, so I've missed out on a good deal of the discussion here which I would like to have heard.

The laws which affect the use of economic poisons or pest control materials divide themselves in my mind into three classes or categories. First those that have to do with the manufacture or sale of the materials themselves, labeling and so forth; then a new group that we now have in California affecting the use of the materials; and then, of course, the third one, our old friend the spray residue law. We probably had best start with the federal Insecticide, Fungicide, and Rodenticide act, which applies only to the materials shipped in interstate commerce. Each product, each pest control material, that is, must be registered with the U.S. Department of Agriculture before it can be shipped in interstate commerce. The purpose, of course, is to prevent the sale of worthless products, and to require proper labels that give adequate directions for use and any necessary warnings or cautions that the user must follow. Then in the State of California we have the economic poisons article of the Agriculture Code, which follows the same general principles as that of the federal law. Each economic poison sold in the State must be registered here, and it applies to all economic poisons whether they are manufactured in the State, or shipped in, or whether or not they are federally registered, giving an additional check and cooperative work with the federal office.

We draw samples of the materials offered for sale or sold throughout the State; we have a staff of inspectors to check these samples against the guarantee given on the label and in the application for registration, to make sure that the purchaser receives what is guaranteed to him. We found in one case that a manufacturer delivered to a mosquito abatement district a DDT solution guaranteed 25%, which was considerably below guarantee. Now, that is an unusual case. We took action, and, as I recall, the Judge imposed a rather substantial fine on that manufacturer. We have drawn samples through a good many of the districts, and I don't recall any others that haven't been up to guarantee, showing that the manufacturers are doing a good job in delivering materials in accordance with the guarantee. If at any time in any of your work you have a suspicion of a particular material, please get in touch with our office; and if it's in an original package, suitable for evidence, we can draw an official sample, make the analysis and render you a report, and a copy of the report also goes to the manufacturer, or to any dealer involved. We draw, in the course of our administrative work, about 1500 samples of economic poisons in any one year. It's about all our laboratory can analyze.

There were registered last month a total of 8300 different economic poisons for sale in the State, so you can see that even though we do a lot of work, we aren't covering the field even to the extent of getting a sample from every product that is offered or registered for sale in the State. Of course some products are sold in minor amounts, and some of those that are registered are probably no longer sold, but the size of the job is well illustrated by that figure. Every year we have a greater number of formulations and different manufacturers registered.

So much for the general laws governing the sale of materials. I would like to mention the three new laws that were passed by the 1949 Legislature. Senate Bill 221 added Section 1066.7 to the Agricultural Code with regard to injurious herbicides. It provides that after departmental determination through hearings, rules and regulations can be set up with regard to the use of injurious herbicides. Hearings were held in September and October and regulations issued in December, with regard to the use of 2,4-D, 2,4,5-T and that type of material, which have been declared to be injurious herbicides. In the central part of the State, the great cotton-growing areas have been declared hazardous areas, and in those areas every single application of a 2,4-D herbicide must have a permit secured from the County Agriculture Commissioner if it is in excess of one pound of commercial product per day. Outside the hazardous area it is five pounds per day as a limit. The commissioner can give up to annual permits, but if a particular farmer or pest control operator is doing good work and the commissioner feels that he could give him a permit to operate in a certain vicinity, he may do so, or he can hold it down to make it individual permits. This is altogether a new type of legislation. It's rather a trial, and it will also be a a trial both to our office and to those who are using the material to get through the red tape of getting permits, but it was felt necessary from the presentations made to the Legislature on account of the large damage that resulted from misuse of 2,4-D. At the same time that law was passed Senate Bill 477 also was passed. That adds Section 1080 to the Agricultural Code with regard to injurious materials. It provides somewhat the same way that the other bill does with regard to injurious herbicides, but any of these highly toxic materials can be, at the determination of the Department of Agriculture, declared injurious materials and then rules and regulations can be set up even to the extent of timing of applications, with different rules for different areas of the State; if they are declared injurious materials anyone applying them must secure a permit from the Agricultural Commissioner. The two materials besides 2,4-D that were discussed at greatest length at the different legislative hearings were calcium arsenate, with risk of injury to bees and to livestock, and parathion. The law is written broad enough so that if evidence was submitted and the declaration made, it could even include DDT. I can tell you at this time that there is no mind, at least in the Department of Agriculture, to extend the list of injurious materials to include any more substances than are absolutely necessary. We even haven't got to the point of calling hearings. We're still talking among ourselves trying to line up something that looks like workable regulations so that we will have something to start on when we go into hearings.

I would expect from hearing the legislative testimony that calcium arsenate and parathion would probably be two of the materials included in the hearings when they come, but that is only a guess on my part because there may be others, and something may come up to change the picture with regard to them. I expect, though, that hearings will come about in the course of the next four or five months, and then when they are held and the general procedure followed as set up in the Administrative Code, regulations will be promulgated and they will become effective thirty days after filing with the Secretary of State. I would like to emphasize that so far there are no regulations with regard to injurious materials, that is the use of them, other than those with regard to 2,4-D and the similar herbicides.

Then there was a new law, Senate Bill 485, that had to do with regulation of commercial pest control operators doing agricultural pest control work. There has been Section 150 in the Agricultural Code which was repealed, that set up a certain amount of control, but the regulations were to be made by the Department of Agriculture and the enforcement solely through the Agricultural Commissioner. That obviously was a difficult job to hand to the Agricultural Commisioner because he became examining officer, prosecuting attorney, judge, and jury, and it was very difficult and subject to criticism because he had to take a license away, and he had to gather the evidence to do it. Under the new law each agricultural pest control operator will secure a State license at an annual fee of $15.00, then he will have to register with the Agricultural Commissioner in each county in which he intends to do business. There will be variation in the county rules and regulations as to what is required with regard to registration, because we have different problems in the different counties. For example, the southern citrus counties will look at the problem a great deal differently than perhaps those in the San Joaquin Valley, or perhaps those in northern California. In addition to registering with the Commissioner he must file reports as to treatment. The definition of pest control is in the law, and I think this is of interest to all of you.

Pest control means the application of any substance, method or device to prevent, destroy, repel, mitigate or correct any disorder of plants or to control or eradicate any pests as defined in Section 100 of the Agriculture Code. In the definition of pests it includes any insect or animal life or vegetable life that is detrimental to agriculture. It would be quite reasonable perhaps to make a determination that a mosquito was an agricultural pest because it carried a disease to animals, or it might be carried further to the extent that they were a pest of the agricultural workers and therefore an agricultural pest, but at this time we certainly have no thought in the Department of Agriculture of considering mosquitoes as an agricultural pest. Pest control operators who are doing only mosquito work will not require licensing under this act, but those of you who employ operators who are licensed under this act because they do other agricultural work should find an improvement in their work because they will have to know more about their business in agriculture and I think that will extend over to your work, particularly with regard to airplane application. The law provides that pilots must qualify and secure a certificate of qualification. The fee is $25.00 for a pilot to get his certificate of qualification. He is to be examined on his ability to conduct pest control operations and his knowledge of the nature and effect of the materials used in pest control. Frankly, we don't know yet what kind of an examination we're going to have to give the pilots. This law went into effect January 1. We are getting in the applications and our office is swamped with them.

As soon as we can get cleared away as to how many pilots we have and where they are located, we plan to give written examinations, and it is one of the purposes of the short course that the Extension Service is giving now at Davis for three days, to allow those pilots to get familiar with some of the pest control problems and the materials used. About half the audience up there, and I understand the registration was six hundred, raised their hands as being interested in aviation or agricultural pest control using airplanes, so that the men are taking it seriously. I think that it will be an aid to everyone to have the pilots familiar with the materials and the hazards involved in their use, so that materials will not be used in such a way that the pilot himself will become groggy and not be able to fly the plane properly.

Now as to the spray residue law, in the Agriculture Code; there are tolerances for fluorine, arsenic expressed as arsenic trioxide, lead, and DDT. Those tolerances apply to fresh and dried fruits and vegetables. They don't cover forage or any type of feed, which are not under the spray residue article of the code. This only applies to fresh and dried fruits and vegetables. So those tolerances give a leeway by which a farmer or packer can rest assured that if his fruit has less than that amount of residue it can be sold without being held in the State of California. If it has more than that he can be reasonably sure that it will be picked up, because we have a rather thorough and extensive inspection service in connection with the enforcement of the spray residue law. Right at present a hearing is going on in Washington, D.C., to set up federal tolerances under the U.S. Food and Drug Administration. The U.S. law has no formal tolerances, but only informal tolerances or a statement of policy on apples and pears, that they would not be seized if they had DDT not in excess of seven parts per million, which is the same tolerance that is written into our California State Law, only ours covers the whole field, including vegetables. We are hoping that as an outcome of these federal hearings there will be a good scientific basis on which to establish tolerances for aditional materials in this State, so that those who buy materials for pest control can figure out their programs to know whether or not there will be any hazard to the user.

Mr. Geib: Thank you, Mr. Lemmon. We greatly appreciate your time and effort in leaving the meeting at Davis this morning and driving eighty miles to come down and talk to us here this afternoon.

I notice considerable restlessness; as a matter of fact, I'm getting that way myself. The time is getting short, but I think perhaps some of you have questions you might like to ask some of these speakers. I would like to open it up for discussion. If you do have any, please ask your questions.

Question: I was just going to ask Dr. Bohart, what temperatures those tests were made under.

Dr. Bohart: The temperatures were all laboratory temperatures within a rather narrow range, about twenty-three to twenty-seven degrees Centigrade. We only ran a single test comparing temperatures on DDT, and I did that on *Culex stigmatosoma;* the results were inconclusive.

Mr. Roy Fritz: I'd just like to make one statement for the record concerning resistance of flies to chemicals. That is, that the Bureau of Vector Control of the State Health Department has been preaching the gospel of environmental sanitation for the control of flies all the past year and a half. We've met opposition all along the line from people who are interested in chemical control. While chemical control has a proper place in fly control, basically fly control depends upon the removal, destruction, modification, or protection of the organic materials in which flies can develop. Chemical control is a supplement to these basic sanitation measures. and not a substitute for them.

Question: I'd just like to ask Mr. Lemmon what the present status of our DDT regulation is in regard to dairies.

Mr. Lemmon: DDT regulations with regard to labeling require that they not be recommended under conditions where there will be contamination of milk. With regard to use, there are no regulations; there are no spray residue tolerances on hay, but under Food and Drug laws it would be subject to seizure if found with any amount on. I am hoping that one of the things that will come out of these Food and Drug hearings will be tolerances on a sound basis.

Mr. Gray: I'd like to ask Mr. Lemmon if there is anything that can be done to represent ourselves at these hearings in Washington at the present time.

Mr. Lemmon: The hearings going on at present are with regard to establishing a necessity for use of materials. Those of us who have been in pest control work know that in order to get good crops you have to use insecticides, but in order to establish tolerances they have to have in the record a statement with regard to the necessity of use. It is my understanding that the present hearings have only to do with harvesting, that is up to harvest of fruits and vegetables. I will know more about that in a couple of weeks, because I am going back to the hearings called for the 16th of February. At that time I will present information which we have accumulated in the Department of Agriculture with regard to the actual qualtities of the different spray residues that we have found in our enforcement work, also data from the University of California Experiment Station with regard to the necessity of use.

Question: I would like to ask the same question I asked in your office for the benefit of some of the groups who hire their own pilots. What is the interpretation of these laws in regard to strictly mosquito abatement pilots?

Mr. Lemmon: There hasn't been any decision made one way or the other; we haven't asked for one. As far as we're operating at present, if pilots are doing solely mosquito control work they are not in agricultural pest control operations and do not come under the scope of the new Agriculture pest control law; but if pilots are doing agriculture work too, of course they come under that, and so you would get the benefit of whatever training and certification there is for the pilots who are doing both types of work. but if they are doing solely mosquito work I do not believe they are included in the law.

Mr. Ted Aarons: Originally when DDT first came into use in California in the districts, there was a general tendency for districts to use very small amounts per acre. Amounts were in the neighborhood of one-tenth pound, and many districts have gradually increased to four-tenths or one-half pound per acre. On the basis of the discussion that Don Murray gave on this matter, I'd like to know what he considers an adequate amount of the toxicant for satisfactory control per acre.

Dr. Murray: I'd like to enlarge on that just a little bit by mentioning one other item. This involves the desirability of absolutely perfect control, which is not possible. The more we applied insecticides to a field and the closer we came to perfection of control, the more resistance we got. Our most resistant mosquitoes were in the field which had been controlled almost perfectly. I think Art Geib at Bakersfield will substantiate that. Where they used a syphon system, and had practically no mosquitoes in the fields, those fields produced the most resistant mosquitoes. Isn't that right?

Mr. Geib: That's right.

Dr. Murray: Now the question is, how much material. With DDT, under an air temperature of over 100° in the field we have found that two pounds to the acre failed to give satisfactory kill. Maybe it gave 50% kill, but with ten million mosquitoes that still leaves too many. We found that with toxaphene we got by with roughly one-half pound to the acre, as satisfactory.

Mr. Geib: Thanks, Don. Perhaps we could have Gordon Smith, Entomologist of the Kern District at Bakersfield, discuss that a little bit.

Mr. Gordon Smith: In our experiments at Bakersfield, as Art said, DDT resistance developed in the fields where we were using the syphon. We don't want anybody to get an erroneous impression and condemn the syphon for that reason. It happened to be in the fields where we were doing intensive test work. In those fields the dosage changed pretty constantly every two or three weeks; it went down to low minimum lethal dose and then up above; it kept jumping around. We worked with it and changed the syphon trying to get constant dosage, and because of that we probably hastened the development of resistance in that field. In another field where we developed resistance, we had the syphon; it was a field where we had continuous application for approximately two and one half months at what I would consider a minimum lethal dose for that method of application. DDT was running into that field at fifteen hundredths parts per million in the irrigation water, and that's pretty low. If you want to try the syphon, I recommend that you don't use a minimum lethal dose. Any time that we use it again, we are not going to go that low. In our experience in the field, I think maybe we have had a little better luck with toxaphene than Don Murray. I don't believe we've had quite as much resistance. We have been able to use toxaphene very successfully in the aircraft, and our figures as to dosage running between two-tenths and twenty-five hundredths pounds per acre give what we term 100% kill.

Mr. Magy: I would like to concur with Dr. Bohart as to certain toxicity results that the Bureau of Vector Control obtained this summer for the control of *Aedes nigromaculis* larvae. With the exception of gamma isomer, the toxicity range ran closely parallel to Dr. Bohart's results; however, for some reason, we found that BHC was about four times as toxic as DDT. I don't recall whether Dr. Bohart ran any tests with methoxychlor?

Dr. Bohart: Not on *nigromaculis*. I tried it on several other species and the results were always poor.

Mr. Magy: Well, our results concurred in that respect also. I know that methoxychlor is used quite extensively in fly control, and of course there's a lot of difference. In msoquito control we found it to be one-tenth as toxic as DDT.

Mr. Geib: I'd like to make a comment or two on that myself. We're very interested in the work that Mr. Yates and Lindquist had done on temperature with the different insecticides. We learned of that last year. We started to do a little ourselves. We've encountered a problem where sometimes the water temperature in which we find *Aedes* larvae will be up to 102° and they are getting along very, very nicely. It's in those locations and during the summer season when the temperature is extremely high that we've had trouble in getting a good kill. By good, I mean what we consider a 95% or 100% kill, or an absence of larvae. Following along with that I think it may be of interest to know what we're doing in the way of testing some larvicides, and I think Gordon Smith can very briefly elaborate on that.

Gordon Smith: Our method followed Dick Bohart's to a great extent. I used the same half-pint ice-cream cartons; I'm too lazy to wash glassware— everybody who's seen my lab knows that. The normal set-up is ten containers to the test, with ten containers of larvae for control. I use only tap water; fortunately I don't have any salt marsh, so I don't have to work with two waters. I use twenty larvae in each container. From the junk pile of the Kern General Hospital I came into possession of a rather large constant-temperature incubator.

With our rather high summer temperatures, and the work that Mr. Lindquist has done, we thought it best to run these tests under a constant temperature, so all of our test work done now on toxicants is done under a temperature of 90° Fahrenheit. Our readings are taken at the end of twenty-four and forty-eight hours. I think that my work pretty much agrees with Dr. Bohart's.

Unfortunately I haven't got around to having all the work analyzed that I did last year, so that I can't say anything definitely as to species. I don't sit down and sort mine out; I just get a mixture of *Aedes dorsalis* and *Aedes nigromaculis*. I hope to have them counted before the season is over.

Mr. Geib: One other difference I think should be pointed out is that the larvae rather than being reared in the lab are field-collected, usually at third stage.

Mr Lindquist: I think that it's been amply demonstrated that you have some tough mosquitoes here in California. What are, or what's going to be done about them? Can we learn anything from the house fly work that Dr. March is doing, and others are doing, that might guide mosquito control work? We might put the question this way: assuming that we started out from the beginning with DDT. how would we change our application so as to avoid these tough problems?

Mr. Geib: I think that is a most pertinent and important question. I'm just wondering if there is anyone who is prepared to answer it?

Dr. Tinkham: I'm not going to surprise you and give anything more than a suggestion of what I think may be underlying this chemical resistance. It may be of value to you and it may not be. I'm from the Coachella Valley, where we do not have even temperate conditions. During the summer we are in a tropical zone and there is a high emigration from there, and in the winter when we have unseasonable conditions in other parts of California we have quite a bit of immigration into the valley. During this past summer when the State had two operators down there, my phase of the studies was on chemical control in the laboratory of *Hippelates* flies. I used six or seven different chemicals, 36% gamma BHC, also 20 and 11% gamma BHC, also Lindane, then 118, 497, DDT, Rhothane or DDD, toxaphene, and chlordane. Those were the principal chemicals I used in a series of tests, starting from one-tenth dilution down to one to one-thousandth dilution. I used the Hoskins and Caldwell spray chamber. I cut my experiments down to fifteen seconds of the spray and one minute settling time, because I feel that at least the experiments showed that whether you give them 10 minutes or 1 minute settling time the important thing is whether you give them a minimum lethal dose or not. If you give them more than that minimum lethal dose, it doesn't matter as long as they get enough to kill, so to approximate field conditions I cut it down to one minute settling time. Using 36% gamma BHC there was usually a 100% knock-down of all the gnats inside of six minutes and it started in about three minutes, so it was usually a straight-line function. Lindane was a little faster but not very much, not enough to warrant the greater expense. There was hardly any difference between any of those isomers of BHC. We started knock down with 497 or Dieldrin in about fifteen minutes: it starts off slowly and rises rapidly. 118 is very close to it, and so was chlordane. DDT started much quicker, but got up only to about 95% kill and then tapered off, not getting 100% kill. Most of these tests can be represented by sigmoid curves, where the most susceptible insects are rapidly killed, the insects of average susceptibility will appear as represented along the middle part of the curve, and the resistant minority will appear in the upper portion of the curve. These are the insects that are hard to kill and are the ones that are causing your chemical resistance because they are the ones that were not killed and are breeding and developing your chemical-resistant strains.

Toxaphene was even slower yet, and Rhothane was just about the same. The mortality curve for the 118 was usually a little faster than for 497, because of the characteristics of the chemical.

It would be senseless to carry out the one to 1000 dilutions on DDT, toxaphene, Rhothane, and that group because the gnats would die before the chemical had a chance to take effect. The gnats are very difficult to keep in a jar overnight, so if a chemical does not kill them rapidly it is not worth working with. The chemicals, then, that we used in the very weak dilutions were the best BHC, 497, 118, chlordane, and of course lindane. A very interesting thing developed with the BHC. With high concentrations of insecticides the rapidity of knock-down is so rapid that there is no opportunity for a clear indication of a sigmoid curve, but at one to 360 or one to 640 to one to 100 dilutions the 36% gama isomer and the 20% and the 11% BHC began to show that sigmoid curve that would indicate that there was an oportunity for chemical resistance to develop. With 497 and 118 the experiment showed that although they started a little more slowly, so that when the knock-down was initiated in the first minute or two, 497 went through to more rapid conclusion than the BHC, and the 118 was very close to it, and chlordane was about fourth place.

A very interesting thing developed with lindane at high dilutions. Lindane actually activated the gnats so that the gnats actually lived longer after treatment with lindane in weak dilutions as compared with the check. The checks were all dead the next morning, but 20% that did not die from lindane were living the next afternoon. I discussed that matter with Dr. Metcalf and Dr. March and they said that that had not been shown before, and I just present it to you now. Something like this may develop in your work, especially in the weaker dilutions. Although this is a laboratory experiment only, and some experiments are based on only one test, I believe that these experiments are indicative even if not absolutely accurate. The result may point the way to what is causing resistance to these chlorinated hydrocarbons.

Mr. Geib: Thank you, Dr. Tinkham. You will recall when I initially opened this symposium, I made a statement that this could be a little controversial, and I also said that we could talk about it all day. Unless someone has something that they would really like to bring up at this time, we had better catch up with the schedule a little and get on to the next speaker after a recess.

Mr. Washburn: Before we introduce our next speaker, I'd like to call upon a man — I'm really ashamed I haven't called on him long before this — Lester Smith from Metuchen, New Jersey, who is President-Elect of the American Mosquito Control Association.

Mr. Lester Smith: Mr. President and fellow members, I wish to bring the greetings of the New Jersey Association to the California Association. Dr. Pepper, who was asked to speak, could not be here, because of other engagements. I feel that I should put in a plug for New Jersey. We do have a recreation area there. Atlantic City is a little place we call the playground of the world. The New Jersey meeting will be held there early in March, and we do hope you will come and bring as many as you can. Virginia has set up a wonderful program, and on the caravan from Virginia Beach to Atlantic City you'll see some extensive work on salt marsh and uplands, and I think you'll find it very enjoyable.

Mr. Washburn: Thanks, Les. This last item is called a symposium; I don't know whether that is quite right or not, but we'll let Ted Raley take over. It's a review of equipment, I guess most of it here in California.

Mr. Ted Raley: Thank you, Ed. This is only on California equipment. We deal only with the best in this association. Art didn't settle the insecticide problem. I won't pretend to settle the equipment problem, but I do hope to show what is being used in California with the help of the districts that have already contributed pictures, and those districts that are here today and have not contributed pictures but do have thoughts that they would like to add to the panel. I have been after you for some time to send me pictures of your equipment that could be shown at this Conference. These pictures have been edited for brevity, realizing the time would be drawing near to closing and you wouldn't want to sit too long. I have tried to show a fair representation of the slides. The best way, I felt, to show them would be alphabetically; but just because Consolidated starts with a "C" and comes early in the program, don't get the idea that I think my equipment is the best. It's pretty good, but there's other good equipment in the panel too.

As each district sees their slides come on the screen will they be ready to make comment on the equipment.

In editing I have tried to show the innovations near the end of each series, so in the early sequence of your pictures generally it will be just the vehicular equipment that is pretty standard, and we'll run through those quickly.

[*Editor's Note:* Mr. Raley proceeded to show a series of slides illustrating various types of equipment in use in a number of California districts Each was explained by a representative of the district. As the comments as recorded lack meaning without the illustrations — most of them color slides — this symposium has been deleted.]

Mr. Washburn: The hour is late, and we will now adjourn until 7:30 p.m., in this room, when we will hold the annual business meeting of this Association.

The business meeting of the California Mosquito Control Association convened at 7:30 p.m., in Room 113, Agriculture Hall, Berkeley, February 2, 1950, President G. E. Washburn presiding.

Mr. Washburn: Although a quorum of district representatives is not yet present, we will proceed with certain reports and other matters first. Mr. Peters will please report on the long-delayed publication of last year's joint meeting with the American Mosquito Control Association.

Mr. Peters: We have 750 copies that were published and there was a registration list of about 150 persons who attended the Conference last year. I propose we ought to send a copy to those persons who had the foresight to pay the two-dollar registration fee. In addition, there is a normal mailing list of around two hundred persons. Harold Gray and I will have to review this list very critically again, but still it will come out around two hundred, making a total of three hundred and fifty. I'm sure that there will be a pretty good request for copies which we can sell at $2.50 apiece.

I estimate that twenty-five to fifty can be sold, so that's roughly four hundred copies; fifty copies should be held in reserve, then there would be three hundred copies left. There are a total of forty-six mosquito abatement agencies in California, of which all forty-six are not now members of the CMCA. Probably those who are members of the CMCA should be given the privilege of having as many copies as they feel there are literates in their respective organizations. To establish a base, we suggest something around three copies per agency.

Mr. Washburn: You mean only a third of us are literate?

Mr. Peters: No, I base that reasoning on this, we presume that the manager is literate.

Mr. Washburn: That's really a presumption.

Mr. Peters: We presume that he has some assistants. We presume that he has at least one assistant who could read and we'll presume that among the Board of Trustees, they will pass it around, they all being literate, but each one wants to read only a page or two, so that will give a basis of at least three copies per agency.

Mr. Gray: If you put it on the basis of three for forty-four agencies you only come out with about one hundred and fifty copies, roughly.

Mr. Peters: I've already borne in mind that there are a few districts that want as many as fifteen copies. Those agencies that want more than three copies should be entitled to them without any questions asked, but three copies per district should be the routine or base distribution.

Mr. Geib: I wonder if there aren't some districts that perhaps don't make use of even three copies.

Mr. Peters: I know of no better way to cultivate use of them than to make them available.

Mr. Washburn: As far as our district is concerned, most of them are on file there, behind my desk, and I refer to them but I don't think that the Board members do; it's brought to their attention and they look at them if they want to at one or two board meetings and that's about the end of it.

Mr. Peters: One thing that we ought to bear in mind is that some of the Board Members may be wondering what this money is going into. We ought to make more of them available so as to allay any suspicion of the Trustees as to tangible results produced.

Mr. Washburn: Are there any objections to sending three copies to each of the individual districts except in cases of request for more than three?

It was moved by Mr. Smith, seconded by Mr. Gray, and passed by unanimous vote, that three copies, and more if requested, be sent to each agency in good standing as a member of the Association.

Mr. Washburn: The minutes of the Executive Committee have been sent out all during the past year. I don't think it's necessary to read them. We should have a motion to the effect that this body goes on record as approving the action that has been taken by the Executive Committee in those minutes. [This was moved by Chester Robinson, seconded by Rolland Henderson, and passed by unanimous vote.]

Mr. Washburn then presented the Annual Address of the President.

PRESIDENT'S MESSAGE

Gentlemen:

In years gone by it has been the practice of the President to review briefly the history and activities of the California Mosquito Control Association. The history of this Association has been recorded numerous times and need not be reviewed here again; however, the progress and accomplishments of this past season should be brought to your attention.

In 1949 no new Mosquito Abatement Districts were formed, although several areas were doing promotional work toward that end. Two areas, however, did institute mosquito control; the Eureka City Health Department has established mosquito control procedures around the City of Eureka, an area of approximately ten square miles; the San Diego City and County Health Departments have also begun a program of mosquito control throughout the County of San Diego. In all, a total of forty-six (46) agencies in California are actively engaged in Mosquito Abatement practices at this time.

Early in the year the problem of insecticidal tolerances became real with the issuance of warnings by the United States Department of Agriculture regarding the use of DDT. At present no real answer has been found to the problem. Your Executive Committee is cognizant of the situation. While no dire results have been recorded in California through the use of the many insecticides as applied by mosquito control workers, it behooves all of us to exercise due caution when using these materials.

During the past year a need was felt for meetings on the field operator's level to discuss the current problems affecting field operations, and to observe equipment. One such meeting was held during April of 1949 with the Fresno and Consolidated Mosquito Abatement Districts as host districts. This was a highly successful venture and one which your Executive Committee recommends should be continued in years to come.

As an outgrowth of the operators' meeting a gradual development of the regional concept of the California Mosquito Control Association has come about. This is good. This idea finally crystallized when the San Joaquin Forum held its first meeting early in the fall in Fresno. In December it really took shape when three regions held meetings, each discussing problems pertinent and peculiar to themselves; these were the Bay Area's Districts, the Sacramento Valley Districts, and the San Joaquin Valley group. Only one region has not as yet organized on such a basis, the Southern California Districts. These meetings or "bull sessions" have been very well attended and much real good has come from them. Consolidation of thought and purpose has been gained by these sessions, as well as constructive planning for the future. I hope they will expand and afford a means of showing many districts the value of a state organization.

As I attended the sessions of these regional meetings it appeared to me that one problem was confronting all of the districts — the lack of basic information regarding the life-history and habits of the very mosquitoes we are doing our best to abate. As you know, the California Mosquito Control Association enlisted your assistance to help carry out an operational research project on *Aedes nigromaculis;* however, this financial assistance did not culminate into a contract due to the fact that another means of carrying out the project came along. This project is continuing through the cooperation of the Turlock Mosquito Abatement District, Bureau of Vector Control, and Public Health Service. Your Executive Committee has gone on record favoring projects of this nature. In fact, they have asked that the Bureau of Vector Control consider setting $25,000.00 aside annually from subvention funds to further research on operational projects such as the *Aedes* study, the *Anopheles* problem, and the *Aedes squamiger* flight range study. Basic knowledge is lacking and is sorely needed on certain phases of these studies. It is hoped that these studies will result in knowledge which will lessen the cost of mosquito control.

At the present time over $2,000,000 is being spent annually for mosquito control in California, and it is most likely that this amount will be not less in the future, with mosquito control becoming an integral part of our every-day life it seems highly important that we have a strong, active mosquito control association to further the work of local mosquito control and to act as a clearing house for all individuals and agencies interested in mosquito control activities. Unfortunately several districts do not see the wisdom of joining hands toward a common endeavor. The old saying of "in union there is strength" can be as effective with our group as elsewhere. Too many districts, their managers and other personnel enjoy the benefits of the Association, such as this conference, yet do little or nothing toward its support. At present only 73% of the mosquito control agencies of this state are members of the California Mosquito Control Association. There is no valid reason why we can't have 100% membership each year.

Don't you think it's about time this Association grew up and accepted its full responsibilities, or, as Harold Gray so ably said this morning, "Which Way Now"? We have been riding along for two years now on a "trial" constitution and By-Laws. Most of you voted for such a formal organization in 1947, but since then have shown exceedingly little interest in the matter, excepting a rather small group to keep the Association going. Before you will be a choice of adopting this constitution or starting proceedings to formally organize as a non-profit corporation; there are advantages and disadvantages in both plans.

I wish to express my deep appreciation to the members of the Executive Committee who have worked hard and diligently for you, and often on very short notice. Also, my thanks go to the many committee members who have functioned so admirably this past year. Especially do I wish to thank Art Geib, who had the responsibility of obtaining and organizing the speakers of this conference — Art, you have done an exceeding fine job. My thanks go also to Dick Peters; without him and his associates much of the success of this conference could not be. We owe Dick a great deal for his untiring effort on behalf of the California Mosquito Control Association. To the Bureau of Vector Control staff and its chief, Arve Dahl, I wish to express my appreciation for their efforts in our behalf. They have contributed much time and considerable money toward the advancement of mosquito control in this state. Without their willing aid this association would be "hard put" at times to meet its many obligations and responsibilities.

It would be difficult indeed to find a place where more constructive mosquito control work is being accomplished than right here in California. There is a great deal of experimental work being done by our different districts. Very careful attention is being given quantitative measurement of the work we are doing. So let's all get behind the new officers and the Executive Committee to make this the greatest mosquito control association in existence.

Mr. Washburn: We will now discuss the matter of incorporation of this Association.

Mr. Gray: The Legislative Committee has given some consideration to the incorporation of this Association as a non-profit corporation under California law. If there were any large sums of money involved in our transactions probably incorporation would be desirable or even necessary: for example, our District Attorney has suggested to me that there might be legal difficulties if the unincorporated association were to go into a large-scale cooperative buying project. At present the amounts involved are relatively small. Until such time as our financial transactions are on a much larger scale there does not appear to be any necessity for incorporation, and there appear to be some advantages at present to remain as we are. We therefore do not advise incorporation at this time.

[It was thereupon moved, seconded, and carried that the Association do not incorporate at this time.]

Mr. Gray: It is understood that this is the present recommendation and doesnt bind any future officers or committee. It does not establish a policy.

Mr. Peters: What Harold has mentioned is the proposal that has been made that the Association give thought to purchasing of insecticides. I don't know whether incorporation would facilitate that or hinder it.

Comment: If you are to do cooperative buying the Association wouldn't have the money to buy the material.

Mr. Peters: That depends on whether it would be handled as an official transaction or an unofficial transaction.

Mr. Washburn: Chet, what are the disadvantages particularly in our incorporating?

Mr. Robinson: Well, first you pay $27 or $28 a year to the State for a non-profit corporation. It'll cost you $150 legal fees. You might, if the Legislature wanted to get real tough, get into a lobbying registration setup.

Mr. Washburn: Well, the only real big disadvantage is that as an organization, we would have no right or privilege to lobby in Sacramento, isn't that right?

Mr. Robinson: You'd have to register as a lobbyist.

Comment: I think we've done very well with the Legislature and I think that anything within reason that we want from the Legislature we can get.

Mr. Washburn: Well, you've heard the motion and the discussion. All in favor of accepting the committee's recommendation for this year signify by the usual sign. Opposed? Carried. That puts us right back in the same old hole again. What are we going to do with the trial constitution and by-laws we have — try them again or adopt something else?

Comment: Mr. President, to start the ball rolling I'll make a motion that this Conference adopt the present trial constitution and by-laws.

Mr. Washburn: Art Geib seconds it. What did you say, Dick?

Mr. Peters: I just wanted to submit the facts on the quorum for this evening. We still haven't got fourteen designated representatives present.

Comment: Well, we've got to go ahead, we can't wait all night. We'll have to waive that action.

Mr. Washburn: Well, since we are operating on a trial-basis constitution I suppose we can. There are two or three points where there have been conflicts that have never been ironed out. Perhaps if we put it on a definite basis, we'll have to iron them out.

Mr. Kimball: Before you adopt this motion any changes in the by-laws should be made now. I suggest that a proposition for change in the Executive Committee be considered.

Mr. Washburn: Well, Norman, since Ed Davis is not here, do you want to explain that proposition?

Mr. Ehmann: I'll read it the way it was formulated.

"The Nominations Committee proposes that no Member-at-large be elected, but rather that this office be filled by four members who shall be elected representatives of each of the four geographical sections of the State, namely: (1) Sacramento Valley Area, (2) San Francisco Bay and Coastal Area, (3) San Joaquin Valley Area, (4) Southern California and Southern Coastal Area. They shall be elected at the first sectional meetings following the Annual Conference."

Mr. Gray: That's somewhat the same idea that was included in the new by-laws of the American Association.

Comment: Oh, I see, in other words have each region elect its own representatives.

Mr. Washburn: The feeling is that perhaps the region would have a little better idea as to who should be its representative than would the officers of the Association.

Mr. Peters: May I make a slight technical suggestion on that report? I urge that an election of sectional representatives be held by a specified date, in order that you have a complete executive committee at the time of the annual meeting, so that such things as stationery can be printed, because you are going to have business immediately following each annual meeting. Perhaps we should provide that the executive committee can arbitrarily elect members to represent the sections if the sections do not elect their own representative by a certain date before the annual conference.

Comment: Couldn't the sections elect at the last quarterly meeting of the year prior to the Annual Meeting?

Mr. Peters: The only conflict there would be that they may be choosing men who are going to be officers of the Association, if the sections do the electing in advance.

Mr. Gray: I suggest that you amend so that at the annual meeting there shall be a meeting of the regional areas, and their representatives then elect a member of the executive board for that region.

Mr. Peters: That would be a better way to do it.

Mr. Geib: I make a motion that we accept it as it is. We can make a change during the year at any time.

Mr. Washburn: Art Geib made a motion that we adopt the Constitution as it is, which was not seconded.

Comment: Mr. President, I have something I would like to ask; is it the intention that the regional representatives shall be members of the Boards of Trustees or Managers of the Districts, or does it make any difference?

Mr. Washburn: I would like to see it be some members of the Boards of Trustees. It could be either.

Mr. Robinson: Mr. President, since the motion died for want of a second, I'll make a motion that the Constitution and the By-Laws be accepted with the change suggested by Norman Ehmann.

Mr. Washburn: Well, I guess we can do that. Read that again, Norman.

Mr. Ehmann: I think this is the way it will read now. "The nominations committee proposes that no member-at-large of the Executive Committee be elected, but that in place of this office there shall be four regional members who shall be elected representatives of each of the four geographical sections of the State, namely: Sacramento Valley Area, San Francisco Bay and Coastal Area, San Joaquin Valley Area, and Southern California and Southern Coastal Area. They shall be elected before the present meeting adjourns, and thereafter shall be elected at the annual meetings.

Mr. Washburn: That covers it. Do I hear a second to that motion? [Mr. Aarons seconded it.] Any discussion on that?

Mr. Gray: It will be up to the President to get the regional groups together to elect their representatives.

Mr. Washburn: All in favor of that motion, then, to accept the changes in the Constituion the Nominating Committee suggested, indicate by saying aye. Opposed? Carried.

Mr. Peters: I would like to make a request for definitions, so that you will all know what you are talking about when you are talking about the Sacramento Valley region and the Bay region and so forth. An appropriate map should be prepared so that from this point on there will be no question as to who belongs to what region.

Mr. Washburn: That will be so ordered. Now we'd like to hear the standing committee reports. We don't like to hear them, I suppose, but we're going to. First is Mr. Buchanan, as Chairman of the Central Valley Canal and Irrigation Laws Committee.

Report of the Committee on the Central Valley Project Mosquito Control Problem

Because of the changing nature of the Central Valley, its crops, its agricultural practices, and the very wants and necessities of the people in it and the consequent adaptation of mosquito control services to better serve its needs, it is unlikely that a final report on the subject can ever be written.

Some committee, or committees, to study these changes and to propagandize the interests of mosquito control should be continued indefinitely and memberships of these committees should be changed to conform to the conditions of a changing environment and an evolving mosquito control problem.

The committee met only once during the year, but in the pursuit of their normal endeavors its members have encountered a number of problems which appear to be of more than ordinary significance with regard to the Central Valley Project. The importance of these problems we hope are properly emphasized in the paragraphs which follow.

The Committee recognizes that the mosquito control problems associated with the Central Valley Project result from three major sources: the storage reservoirs used to capture and hold water, the canals and channels used to transport water, and the irrigable acreages which are the ultimate consumers of the water.

Since the problems related to storage and major transportation systems involve relationships with Federal and State agencies and since the Bureau of Vector Control is currently engaged in efforts to resolve these problems, the Committee believes that constructive assistance may be rendered these efforts by resolution, or such other supportive action as appears to be warranted and proper on the part of the Association, to aid the Bureau. In this regard it may be that certain of the member districts should be encouraged to enter into cooperative investigations with the Bureau for the purpose of studying the effects of these projects.

With regard to the problems associated with irrigation, we feel that the subsequent committees which have been suggested should follow the problems closely and make every attempt to disseminate pertinent information and current information to Boards of Trustees of the various Mosquito Abatement Districts, the U.S. Bureau of Reclamation, the State Division of Water Resources, the Irrigation Districts Association of California, the Agricultural College Extenison Services, State Department of Public Health, U.S. Soil Conservation Service, Farm Bureau, Chambers of Commerce, locals of the National Grange, and similar bodies who are vitally concerned with irrigation and should be apprised of mosquito control interests.

The importance of decisive and prompt action in this regard may be appreciated from the following comments which the Committee offers.

It is estimated from the Bureau of Reclamation Report on the Central Valley plan that ultimate development of the Valley will result in the average annual irrigation of 6½ million acres. Although we were unable to secure more recent data, it is significant to note that in 1943 about 3½ million acres were under irrigation in the Valley, and 1943 was a good water year.

It is the opinion of the Committee that the increase in permanent pastures, alfalfa, and mixed forage crop plantings which has taken place during the past few years is principally a result of the increasing demand of a rapidly growing population for milk and meat products We believe that many more acres of land now considered marginal will be planted to these crops as more water becomes available. The relatively low cost of planting, maintaining, and harvesting these crops makes them an attractive investment for planters, and so far these crops have escaped acreage limitations such as have been placed on cotton, potatoes, etc. The low assessed valuations currently being placed on these acreages makes them still more attractive for a planter's investment but reduces the tax yield which mosquito abatement agencies might otherwise enjoy.

We do not suggest that all, or even a major portion of the increase in irrigable area due to the Central Valley Project will go into pasture and forage crops. We do believe that there will be a marked increase, however, and further believe that the ready availability and dependability of an adequate supply of water will contribute little or nothing toward the reduction of irrigation practices which are resulting in the production of most of the mosquito problems in the Valley. We believe that although the acreages under irrigation each year will rapidly grow during the years to come, plans for drainage will not develop until drastic need therefor has been demonstrated. We believe that the increased availability of water will tend to accelerate the reclamation of alkali lands and that the practice of such reclamation by excessive irrigation will cause a considerable increase in mosquito problems.

At the risk of being considered alarmist in its viewpoint, the Committee believes that the member districts should be forewarned that in the foreseeable future we must expect the mosquito production potential in the Valley to at least double and possibly to multiply many times while revenues from tax yield may be expected to increase slowly and quite out of proportion to the mosquito control requirement.

The Committee urges that the subsequent committee on this problem be first charged with assembling pertinent factual data with particular reference to at least the following:

1. A two or three year record of the rate of increase in acreages planted to forage crops and other crops associated with major mosquito production problems.
2. The resultant increase in cost of control due to 1.
3. The tax revenue gained or lost due to conversion of the acreages in 1.
4. An estimate of losses or wastage of water due to careless irrigation practices.

A summary or a digest of the information so assembled should be forwarded to the agencies listed previously in this report with the request that these agencies recognize the importance of the problem and the further request that they aid the Mosquito Abatement Districts in the districts' efforts to reduce the indiscriminate and careless use of water.

To facilitate and expedite assembling this information the appointment of sub-committees within each major committee could be assigned specific portions of the problems to report on and member districts should be urged to cooperate in the gathering and assembling of the data.

Respectfully submitted,
R. F. Portman
W. D. Murray
W. J. Buchanan, Chairman

Report of the Legislative Committee

A resolution requesting the State Legislature to change Chapter 5 (Mosquito Abatement Districts), Article 3, Section 2248, to increase the allowance of Board of Trustees expenses to ten dollars ($10) per month, to read:

2248. The members of the district board shall serve without compensation; but the necessary expenses of each member for actual traveling in connection with meetings or business of the board shall be allowed and paid. In lieu of expenses, the district board may by resolution provide for the allowance and payment to each member of the board of a sum not exceeding ten dollars ($10) per month for expenses incurred in attending business meetings of the board.

The reason this request is being made is because there are now in California a number of mosquito abatement districts whose trustees must travel over 60 miles in the attendance of their meetings. This will also make the Mosquito Abatement Act conform with the expenses granted to mosquito abatement districts formed under the Pest Abatement Act.

This resolution respectfully submitted to you by the Legislative Committee of the California Mosquito Control Association.

Respectfully submitted,
E. Chester Robinson, Chairman
Harold Gray
Dick Sperbeck

Report of the Nominations Committee

Nominations for 1950: President, Jack Kimball; Vice President, Edgar Smith; Secretary, Theodore Aarons; Executive Committee, Ed Washburn; Board of Trustees Member, Adolph Pruess; Member at Large — recommended no member at large be considered pending possible constitutional changes.

The Nominations Committee proposes that no member at large be elected, but rather that this office be filled by four members who shall be the elected representatives of each of the four geographical sections of the State, namely: (1) Sacramento Valley Area, (2) San Francisco Bay and Coastal Area, (3) San Joaquin Valley Area, (4) Southern California and Southern Coastal Area. These members shall be elected during the annual conference.

Respectfully submitted,
Members of the committee??

Mr. Washburn: Shall we accept the committee reports as they are read, or at the end of all of them? It is moved and seconded that they be accepted as they are read. Carried.

The next committee is the Publications Committee. R. F. Peters.

Mr. Peters: The Publications Committee is still working on three bases. There are three members. This is a working committee, because we produce in volumes. The item before you is the Proceedings and Papers of the Seventeenth Conference, conducted jointly with the American Mosquito Control Association. The committee is proud of it and I hope that you are likewise affected by it. There are a few mistakes in it, mostly our fault for trying to read proof two pages at one glance, but by-and-large, I think it is a credit to the Association, and I think it is a step further along in having the Association receive professional acceptance on a national scale. The second item that the Publications Committee is involved with is the Operations Manual. I am not as proud of the amount of material that went out this last year, but the amount of material that came in was exceedingly little and it's hard to put out what you don't get in.

The intent of the Operations Manual is to keep workers abreast of new things that are going on, improvisations, techniques, and what have you. A lot of new things happened about last year and very few of them have been recorded. There is a release about to come out as soon as I can clear the deck a little bit, on the section concept, inluding the forms and the background material. During the year we received a request from the United States Army, not for six copies, or for a dozen copies, but for forty-four copies of the California Mosquito Control Association Operations Manual. It was the opinion of the Publications Committee that it wouldn't do a bit of harm to advertise even through the Army, and as a consequence there are forty-four copies of our manual now being used by Army posts throughout the United States and I don't know how many foreign points; so we are getting recognition through our Operations Manual. We sold them at a profit of about $100 to the Association. We still need material in order to produce and get into your hands more inserts for the Operations Manual, so please come forward.

Lastly, the Mosquito Buzz. I think I have fourteen guilty corporate members. Ted Raley is always reliable. Thank goodness for Ted Raley, but there are at least thirteen who are guilty of expecting the thing to be produced by spontaneous generation. It'll keep coming out, but some day it's going to come out with a couple of blank pages; but it is rather gratifying to get such a letter as was read from Mr. Woody of Portland, stating that somebody reads it and somebody appreciates it. I might add that there are several other letters in the same vein that have come from other parts of the United States and even points outside the United States, in which they appreciate getting it, so I guess it's worth it. I can't tell for sure that the State Health Department is overly keen about getting involved in its publication. I have heard indications that they are and I have heard indications that they aren't. I only work there, but nevertheless there is quite a bit of work involved, and there have been several suggestions that some day the Association might very well prepare itself to assume these responsibilities independently. There is a departmental survey going on within the State Health Department right now, and as a result of this departmental survey there could be consequences, so I'm just merely making mention of the situation, as this decision may come sooner than we anticipated.

Mr. Washburn: Thanks, Dick. Robinson moved and Sperbeck seconded, that we accept the Publications Committee report. All in favor signify it by saying aye. Opposed? Carried. We will now hear from the Membership Committee.

Mr. Raley: The Membership Committee have been marking time until the Association took definite action on the Constitution and By-Laws. We have actually nothing positive or concrete to offer. Several proposals have been made, but each time proposals have been made questions have been raised as to the setup of the Association. Now that we have taken definite action I feel assured that the Membership Committee will be able to move with confidence and with more concrete and positive information to present to potential members. The committee has reported.

Ed Washburn: Do we accept the committee's report? Well, do we reject the committee's report then? I think in the recommendation we accept the committee's report we should recommend that the committee chairman be retained. Do I hear a motion of acceptance? Moved and seconded. All in favor signify it by saying aye. Opposed?

Mr. Gray: I now make a motion that the Publications Committee be directed to prepare a mimeographed copy of the Constitution and the By-Laws as amended and adopted and make them a part of the Operations Manual.

Mr. Washburn: Any second? [Seconded by Ted Raley.] It has been moved and seconded that the Publications Committee be instructed to prepare and send forth the newly adopted Constitution and By-Laws as amended, as a part of the Operations Manual. All in favor signify it by the usual sign. Opposed? So ordered.

The next report will be from the Committee on Survey Methods and Ecology.

Mr. Aarons: The Survey Methods and Ecology Committee consists of Herb Herms, Harvey Magy, Barney Brookman, and myself as Chairman.

This last season we discussed and had up for consideration the *Aedes* density technique, something that we have been talking about for two years. There was a general evaluation of present methods that are used, including light traps, sweeping, bait traps, biting, dipping, larvae counts, counting eggs in soil samples, gross mapping of breeding areas, and the cloth or flag method. The cloth or flag method is a development of D. C. Thurman's technique.

The section survey concept has been under consideration since 1946, has been reviewed at some length this past year, and at the fall meeting of the committee a group consisting of Dick Peters, Ed Smith, and Don Murray were requested to consolidate the existing thinking on the matter. At the San Joaquin Valley Regional meeting which occurred a short time after that, the major portion of the meeting was devoted to the section survey concept, and out of that has been developed a plan which is now in preparation for presentation and inclusion in the Operations Manual.

The Adult Mosquito Collecting Station requirements were discussed this past year and a recommendation has been drawn up regarding the minimum number of stations required or recommended for a district, taking into consideration the size of the district, and this section is broken into two parts: (1) A preliminary period which will be a three-year program of collecting stations; and (2) a continuous period of sampling after the preliminary three-year period.

It has been urged by this committee that many of the districts now are entering into a phase where their methods are somewhat routine. They have gotten a lot of bugs and quirks out of their operations and are having a chance now to become more critical of results and methods. This committee has urged that wherever possible, and as fast as possible, individual districts write up their observations, operational and scientific, and get this material into print. There is a general plan afoot in California to eventually get a "Mosquitoes in California" book written. Numerous individuals are interested in this, and the way is open as to what the ultimate method of gathering up the material and presenting it will be, but if we as an Association can write up our work at a more rapid rate than we have been doing in the past, keeping the most critical approach in mind, it will certainly speed this thing along and aid in identifying this Association for what it's worth, that is, the biggest and I think the most valid association of its kind in the world.

The Committee has a number of recommendations. One is to continue this committee with an alteration of membership, from Chairman on through to the entire committee. This following year there is apparently a good deal of discussion regarding flight range studies. There's talk of three studies, one in the San Francisco Bay Area, considering the migration of *Aedes squamiger,* which would be a co-operative project involving nine districts and the Bureau. The study already under way for *Aedes nigromaculis* will take shape this summer, and there is also talk of flight range studies and longevity work with *Anopheles freeborni.* The committee recommends that, if possible, this coming year this standing committee consider flight range studies as they will be developed, and prepare, if possible, a standardization form for flight range studies both on a large scale, involving many districts and individuals, as in the *nigromaculis* and *squamiger* studies, and smaller studies which individual districts can handle on a local basis. For example, a study somewhat similar to the *Culex tarsalis* study was developed by Bill Reeves and associates at Bakersfield.

The recommendations also include continuing consideration of present problems that are by no means solved, and last, the committee wants to go on record as urging a continued coordination of activities and cooperation with the other committees for the general good of the Association.

Mr. Ehmann: I'd like to ask if these recommendations on collecting stations have been submitted to anyone up to the present time? Has any definite action been taken?

Mr. Aarons: They have been submitted to the Executive Committee, but no definite action has been taken.

Mr. Ehmann: The reason that I bring that up is that I question the value of collecting stations in the Los Angeles area. While I realize that we have a peculiar situation there, we have a large district and a lot of cars, with heavy traffic and a lot of space between our collection stations. In trying to evaluate the stations that we have I cannot see that we are getting the benefit of the time spent on the stations. I found, in the first place, that the return on the mosquitoes from the individual stations was not great because when the control crews found mosquitoes in the stations they would double their control efforts in the area.

We would like to propose as an alternate to run a process that we have been trying out; that is, identifying a routine sampling of the larvae or of the adults that the control crews bring in every day at the end of a day, thereby getting larger reprsentative sampling of mosquitoes in any entire area. At one time I thought I had a clearance to do such a thing, but during the last quarter there was a letter written to Los Angeles asking where are our collecion station records. Well, we had some good records from all over the city, but we can't say that we had collected them from the same place every week, though we rould say we had collected them from the same general area.

Comment: Ted, isn't it right that Norman's suggestion was a part of the recommendations of your committee?

Mr. Aarons: Yes, but that was after the initial period. When a new district is organized a set number of stations is recommended, but after the initial period it is recommended that the same number of stations be maintained, but instead of weekly interval collections, monthly intervals could be maintained. However, this detail is left to the discretion of the district, as to whether they use natural resting places, or light traps, permanent localities, or roving stations. The details are left to the discretion of the districts.

Comment: And that suggestion was submitted to the Executive Committee?

Mr. Aarons: Yes.

Mr. Raley: Art Geib has discussed quite fully this same thought that Norman has and we all agree that it is practical, but Mr. Stead still felt that the State should continue to require certain fixed stations.

Mr. Walker: I think that meeting preceded this subsequent work that was done by the survey committee, and the later recommendations again went to the Executive Committee.

Mr. Peters: The report of the Committee on Survey Methods included the following points: B. Routine surveys: (1) First season of operation. Weekly collections from a series of permanent adult resting stations will probably be needed for a period of one year only. (2) Second season of operation. By the beginning of the second season a district should have a procedure established whereby records of all inspections should be kept systematically. This would require routine larval biting records, from adult resting stations, etc. A summary of these data could be made as a part of the regular monthly report; a proposed form was submitted for adults and larvae for three categories: number of inspections, number of samples identified, and species in order of abundance.

Comment: Dick, I don't think that has anything to do with the requirements of the Bureau of Vector Control.

Comment: Yes, it does.

Mr. Peters: I think the whole thing is that this has never been made a positive referral by the Executive Committee to the Bureau.

Comment: I'm sure that's the case.

Mr. Washburn: In that case I take the blame. It certainly should have been done.

Mr. Gray: I move that the incoming administration be directed to take this matter up with the Bureau of Vector Control.

Comment: I second that.

Mr. Washburn: Is there any discussion on it?

Comment: In the matter of running these collecting stations, particularly in the winter, we should take into account the factors which cause the population of adults to fluctuate, particularly where we have freezing weather for weeks at a time in the winter, such as in Lake County, where there may be very few mosquitoes to be collected. You can go to a station one week and collect a small number, and perhaps there won't be any next week, but then there comes a spell of warm weather and the number will increase very greatly.

Mr. Washburn: I think that has been taken into consideration in some districts. I know in our own case we don't collect but once a month in winter. Still our district got a letter about the report. Any further discussion on that motion? Murray seconds it. Norman, do you have something more?

Mr. Ehmann: Oh, I was just going to reiterate that I can't see why we should have to go to one particular spot.

Mr. Washburn: Any further discussion? All in favor of the motion signify by saying aye. Opposed? Carried. What are we going to do with the committee's report? Accept it?

Comment: I want to make an amendment.

Mr. Washburn: To the committee's report?

Comment: Yes. The committee requested that they should be discharged; I think that is the prerogative of the new President, not of the committee.

Mr. Peters: I thought that the recommendation was that the Chairmanship be rotated.

Comment: If we accept the report that's a recommendation to the incoming President to put an entire new committee in. I think that's the prerogative of the President.

Mr. Washburn: If you accept the committee's report the President is pretty nearly duty-bound to change his officers.

Comment: I'd like to make an amendment that this recommendation be deleted.

Mr. Washburn: Are you then in favor of accepting the committee's report as deleted? All in favor of that signify it by saying aye. Opposed? Carried. All right, Jack, you're going to have a free hand then to go ahead with it. The next report is from the Committee on Education and Public Relations.

Mr. Peters: The Education and Public Relations Committee hasn't a considerable report, other than that they have met and have become stalemated. I will, first of all, mention their accomplishments. Some of you undoubtedly saw a box where that group of diagrams is, containing a lot of specimens in plastic. If you will look at that box carefully you will find that these are permanent mounts, that lend themselves admirably to public education. They are fine aids in giving talks to groups and attempting to illustrate where mosquitoes come from, that they are not an object that grows from little mosquitoes into big mosquitoes out of grasses and so forth. Through action of the Public Relations and Education Committee, we caused Mr. Munich, of the B. K. H. Chemical Company, to do some experimental work on imbedding mosquitoes in plastic. He has done a very remarkably fine job. He has included the egg stage, the four larval stages, the pupa, and a male and female adult, of individual species. He has submitted to the committee a price estimate on a series of specimens of that nature. He will do any and all species, depending upon how many you want for either $4.00 or $5.00 per specimen. There is prospect that that price may be reduced, if and when his techniques and the materials that he can obtain will facilitate his cutting the cost.

The $5.00 figure was for individual ones and the $4.00 figure was for twenty or more. There's a lot of work involved, and for your information, if you don't know, Ward's or other establishments that have these for sale generally charge between $2.50 and $5.00 for a single, individual specimen embedded in plastic; here you get an egg and four larval stages, a pupa and a male and a female, all for approximately the upper range of that standard listing. So we are prepared as a committee to act to assist you in obtaining these if you wish to place orders. I can see a tremendous advantage to it and I would personally, as an individual, like to see them in every sub-depot and every agency in mosquito control in California, so that they would be of use. I don't see any reason to mount the rare species, but it is desirable for you to have mounts of your dominant species.

One little string is attached to the proposition. Mr. Munich has to have specimens in order to make up those plastic mounts. Your cooperation in furnishing them wil be appreciated, and if you want specimens from your own locality, that is the best way to be sure that they are your own strain of whatever mosquito you are interested in. So that's enough for that, but if you do wish some action on it the commitee is ready to act, provided the President wishes to continue the committee next year.

That is the tangible activity of the committee during the year. We made a proopsal, or more or less discussed it among ourselves, as to whether it would be desirable to have a mosquito prevention week, or mosquito control week, in which all of the agencies in California would join together and do a publicity stunt and get the public aroused at the start of the season. After much thought and discussion we figured that we haven't time to do it this year. We would defer it until next year, so nothing more than the thought is transmitted here. We recognize a need to have the Association represented at the State Fair, if not at various County Fairs, and although the committee didn't take action in that regard in the past year the need is still recognized by the committee. Lastly, the reason that we haven't gone far in getting out propaganda, particularly propaganda to neutralize some of the things that have been said in regard to chlorinated hydrocarbons used in mosquito control, is that the Committee on Public Relations and Education didn't feel that it was in a position to render propaganda, because there has never been an established policy by the Association in regard to those matters. It's very difficult for a committee to reflect policy and to propagandize in behalf of the Association until policy is established. So the committee respectfully asks that one of the things that the new Executive Committe take into consideration will be the establishment of the position of the Association in regard to matters of controversy that have any bearing upon mosquito control in the future. Then I think the committee can be more useful in rendering a Public Relations and Education Service.

Mr. Washburn: Thanks, Dick. Do we accept the committee's report? Any suggestions about it?

Mr. Aarons: Mr. President, a matter came to mind this last week that I meant to bring to your attention, but due to all the activities, I've never been able to get to you. The California Academy of Sciences in its new building program will have, I understand, this coming year, added facilities for various exhibits along with their planetarium and auditorium and a few other things. Ed Ross, the Curator of Entomology there, has brought to my attention the possibility of this Association donating a sum of money to the Academy, the largest part of which could be used for a permanent exhibit for the Association. It would be arranged in a case and shelves. The details of the plan have not yet been put forth, but the general idea was that space would be made available in a short time and we would be given consideration if we were interested in an Association permanent exhibit.

Mr. Peters: We have enough talent within the Association who might very well prepare such an exhibit without a fund being necessary.

Mr. Washburn: Do we have to buy space as a permanent thing?

Mr. Aarons: It's a perpetual space, but we don't have the details as yet. Dr. Ross has promised to send a letter which has not yet arrived, but it should be referred to the Executive Committee.

Mr. Washburn: Any second to that motion that we refer that to the incoming Executive Committee for consideration? [Seconded by Harold Gray.] Any further discussion? All in favor then signify by saying aye. Opposed? Carried. We havent' accepted the committee's report; do you accept it? It's been moved and seconded that we accept the Education and Public Relations Committee report. All in favor say aye. Opposed? Carried. We will now have the report of the Legislative Committee.

Mr. Robinson: We have a resolution requesting the State Legislature to change Section 2248 of the Health and Safety Code to permit Boards of Trustees to increase the "in lieu of expenses" to $10.00 per month. There's no reason to read the whole thing. Section 2248 now allows $5.00 in lieu of travel expenses. The request came from Orange County to raise it to $10.00. The reason that this request is being made is that there are a number of Trustees who travel sixty miles to attend these meetings. This resolution is respectfully submitted to you by the Legislative Committee, Chester Robinson, Harold Gray, and Dick Sperbeck.

We have another one which is not written up, requested by Dick Sperbeck, that aerosol machines used at night or early in the morning during the dark hours, be allowed to be listed as emergency equipment in order to get the red blinker lights, which seems to be about the only way we can get them. We submit that for your approval, and that's the entire report of the Legislative Committee.

Mr. Washburn: What's your pleasure on these? Did you make a motion?

Comment: I move that they be accepted.

Mr. Washburn: Any second on the motion? Any discussion? All in favor then by the usual sign. Opposed? Carried. Before we get into the reports of Special Committees, I think it would be in order if we have a summary of our financial standing as near to this point as we can find it.

Mr. Smtih: The state of the treasury as of February 2, 1950, is $2936.45.

Mr. Washburn: What's encumbered against us?

Mr. Smith: Commitments for the rest of the fiscal year will be approximately $600.00 for the recording and transcribing of the Conference and approximately $1200.00 for the publication of the Proceedings. I would like to read a list — we call it the Honor Roll — of those districts that have paid up their contractual obligations as of this date: Durham, Hanford, Alameda County, Delano, Anderson, East Side, Sutter-Yuba, Los Molinos, Corcoran, Marin County, Oroville, West Side, Redding, Tulare, Los Angeles City Health Department, Ballona Creek, Three Cities, Fresno, Pine Grove, Madera County, Eureka, Northern San Joaquin, Merced, Pulgas, Coachella Valley, Consolidated, Compton Creek, Delta, Turlock, Solano County, Matadero, and Orange County, which makes thirty-three districts out of the forty-six possible ones, bringing you a total of $1770.00, leaving then the following agencies delinquent as of this date: Butte County, Carpinteria, Clear Creek, Contra Costa, Cottonwood, Lake County, Monterey County Health Department, Napa County, Sacramento-Yolo, Sheridan, Sonoma, and Mount Vernon. That is still a potential source of income of $2000.00 for the year.

Mr. Gray: Does this report include all the expenses of putting on this annual meeting?

Mr. Peters: I believe I can answer that. Our expenses of this particular Conference are going to be very close to being neutralized by the income.

Comment: At the Executive Committee meeting the other day we discussed the matter of rendering a financial statement, and we made the recommendation that such statement be rendered as of the 31st of December.

Mr. Wahsburn: It's difficult at the time of the annual conference to make a financial statement as of the conference date. This time we are more than usually involved with just having finished the publication of the last year's Proceedings. We hope that won't happen again. We thought the financial statement as of December 31st would at least give us a definite date-point. We know it won't be the condition as of February. That was the recommendation of the Executive Committee and of course will go into the minutes as such.

Will somebody move to accept the financial committee's or the secretary's report as its standing to date? Mr. Gray so moves. Is there a second on that? Seconded. All in favor signify by the usual sign. Opposed? Carried. Now we come to the Resolutions Committee. We can't hold a Conference without resoluting about a few things. Ted, do you have those Resolutions? The Resolutions Committee is Ted Raley, Ed Smith, and Tommy Mulhern.

Mr. Raley: May I add that Harold Gray has just been brought into it? May I suggest that we read all of these and then offer them for adoption, rather than individually. Harold, will you present your resolutions?

Mr. Gray: Two resolutions were given me to prepare. I suggest that they be tentatively accepted subject to a little polishing and then typing.

Resolution

Whereas, since 1909 Professor William B. Herms of the University of California was the guiding spirit of mosquito control work in California, initiating through his enthusiasm and boundless energy much of the work which has resulted in the present widespread public acceptance of this service to the people of this State, and

Whereas, he was foremost in research work in this field, and the teacher of many who are now active in the work of mosquito control, and through that research and that teaching the State of California will be forever his debtor, and

Whereas, he was to us more than an initiator or research worker or teacher, being a well-beloved friend, an inspiration to better service, and a wise and understanding counsellor in our varied problems, now therefore

Be It Resolved, by the members of the California Mosquito Control Association assembled for their eighteenth annual convention this 2nd day of February, 1950, at Berkeley, California, that we hereby express our sense of great personal loss in the death of our friend, William B. Herms, on May 9, 1949, and that we extend to Mrs. Lillie M. Herms and to his sons our most sincere condolences on the loss of their distinguished husband and father.

California Mosquito Control Association
by Theodore Aarons, *Secretary-Treasurer*

Then I have one here for Harold Lilley.

Resolution

Whereas, since August, 1935, Harold C. Lilley was actively engaged in mosquito control work in Merced County in California, and actively took part in the work of this Association, and

Whereas, he demonstrated by well-executed projects in his own area the effectiveness of drainage and other permanent measures as the basis of mosquito control under California conditions, and

Whereas, he was earnest, conscientious, and faithful in the conduct of his work for the benefit of the people, now therefore

Be It Resolved by the California Mosquito Control Association, assembled this 2nd day of February, 1950, in its 18th Annual Meeting at Berkeley, California, that we greatly regret the death on November 15, 1949, of our fellow worker Harold C. Lilley, and that we hereby express to his widow our condolences.

California Mosquito Control Association
by Theodore Aarons, *Secretary-Treasurer*

Any suggestions?

Mr. Peters: The only suggestion I have is that letters have already come out from the Executive Committee to Mrs. Herms and Mrs. Lilley. Did you intend for this to be sent independently or just to be incorporated into the minutes?

Mr. Gray: If letters have already been sent independently then it will be better to incorporate the resolutions in the minutes of the proceedings.

Mr. Raley: Tommy, do you have a Resolution ready to read?

Resolution

Whereas mosquito control in California has for several years been attended by very great success; many areas where intensive programs are under way have been kept free of severe mosquito annoyance; malaria has been practically absent; and the occurrence of encephalitis has been at a low ebb; and

Whereas there has occurred in recent years a substantial increase in irrigated areas and corresponding increase in mosquitoes emerging therefom, particularly the species *Aedes nigromaculis;* and

Whereas little is known about this mosquito, which occurs in great numbers in the irrigation water on lands used for the production of permanent pasture, alfalfa, cotton, and other crops, the extent of which is certain to increase markedly as the Central Valley Irrigation Project goes into operation; and

Whereas more investigation is desperately needed to produce the information which will enable the operating mosquito abatement districts to meet the problem, now therefore

Be It Resolved that the California Mosquito Control Association commends the Bureau of Vector Control for its efforts to supply the needed information through the operational investigations program adopted on an emergency, cooperative basis in 1949, and

Be It Further Resolved that the Bureau of Vector Control be, and is hereby urged to make ample budgeting provisions in its planning for operational investigations for the future to insure having facilities available for such activities related to this and other phases of the mosquito work, and

Be It Further Resolved that the Secretary of the Association be hereby directed to forward copies of this resolution to the parties concerned.

California Mosquito Control Association
by Theodore Aarons, *Secretary-Treasurer*

Mr. Raley: Do you want to take these individually or as a group? Any question or discusion on this one Tommy just read before we move on?

Mr. Peters: You mentioned that encephalitis is at a low ebb. It seems to me that if we are going to be presumptuous and mention encephalitis as being at low ebb we might as well be overly presumptuous and mention that malaria is also at a low ebb.

Mr. Gray: The difficulty is, we don't know whether encephalitis is at a permanent low ebb or is just at a cyclic low ebb.

Mr. Raley: This next one I will read as we had prepared it, but with the report of the Central Valley Committee I am going to recommend that this be expanded to include all of those agencies that were enumerated in the Central Valley Committee's report. This is the Committee Report.

RESOLUTION

WHEREAS the present use of irrigation water has resulted in the creation of large numbers of mosquito-producing areas which constitute a public nuisance and health hazard, and

WHEREAS the area of irrigated land will be vastly increased as the Central Valley Project progresses, and

WHEREAS this increase in irrigated area will have proportionately increased the mosquito problem, thus increasing the need for greater expenditures to control mosquitoes, now therefore

BE IT RESOLVED that the California Mosquito Control Association, in conference assembled, does hereby memorialize the California State Department of Water Resources to recognize the existence of this serious mosquito hazard, created frequently by over-use and/or mismanagement of irrigation water, and

BE IT FURTHER RESOLVED that the California State Department of Water Resources be and is hereby requested to cooperate with the Mosquito Control Agencies represented by this Association through organized joint planning to correct existing mosquito hazards, and avoid the reoccurrence of future mosquito hazards caused or aggravated by irrigation water use.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION
by Theodore Aarons, *Secretary-Treasurer*

Now, if I may open the discussion, the thought is that this be enlarged upon or amended to include all of those agencies as outlined in Mr. Buchanan's report. The resolution will have to be sent individually, but certainly Buck brought out a very good thought that we're missing a bet by not approaching the Farm Bureau and those interested agencies, and at least requesting their awareness of the problem.

Comment: Well, wasn't there a request on Buck's report that these agencies be contacted?

Mr. Raley: Well, that is what brought it to mind. Buck has expanded his report to include the many agencies, while this committee was only concerned with one, so it seems an incomplete job. May I re-read these names: U.S. Bureau of Reclamation, the State Division of Water Resources, the Irrigation Districts of California, the Agricultural College Extension Services, the State Department of Public Health, U.S. Soil Conservation Service, Farm Bureau, Chambers of Commerce, Locals of the National Grange and similar bodies, who are vitally concerned with irrigation and should be apprised of mosquito control interests.

Do you as a committee concur in that?

Mr. Gray: The only thing I had in mind is on the local Granges and Farm Bureau. Isn't there a State Association?

Comment: Yes, there is a State Grange.

Mr. Gray: Why not keep this on a State basis to start out with as far as the Association as a whole is concerned, instead of trying to send this Resolution to every local Grange and every Farm Bureau.

Mr. Raley: The State Department of Public Health may be deleted, I think, from this.

Comment: I can't help feeling that if this is going to so many deversified types of organizations that we should reconsider the whole thing from all angles and revise it so as to give a lot more information than is contained there, because a number of these organizations don't have any background whatsoever for understanding the problem as we see it.

Mr. Raley: We might consider a new resolution covering other interested agencies; we certainly shouldn't ignore these that are brought out in Mr. Buchanan's report. We were lax in my committee in that respect.

Comment: I agree that they certainly should all be contacted, but I feel that more study should be put on it.

Mr. Raley: We might present this as I read it and prepare a new resolution as new business.

Comment: I believe that we should hold this resolution, and pass it some time tomorrow afternoon; in the meantime you can rewrite it.

Mr. Raley: Time is a factor. There is a suggestion that the matter be referred to the new Executive Committee.

Mr. Gray: A simple way of doing it would be to amend to direct the incoming Executive Committee to make the proper representations to all agencies which would be interested or affected by it.

Mr. Raley: That is perhaps an idea. I will then present this as read and we'll later reopen the discussion on the best method for handling these other agencies. I will now present the other Resolutions that we have prepared.

RESOLUTION

WHEREAS the success of the 18th Annual Conference of the California Mosquito Control Association has been made possible by the active participation and cooperation of many agencies and individuals, now therefore

BE IT RESOLVED that the appreciation of this Association be made known to all who have contributed, and the secretary of the Association is hereby directed to send suitable written acknowledgment to each individual and agency.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION
by Theodore Aarons, *Secretary-Treasurer*

I move these resolutions be adopted as read.

Mr. Washburn: Do I hear a second to that? Any discussion? All in favor of the adoption of these resolutions signify it by the usual sign. Opposed? Carried. What do you want to do about that proposition that's included in Buck's report? Leave that up to the Executive Committee for action later? There's a whole year's work for some committee right there.

Mr. Peters: If they don't do it early in the year it's not going to do much good.

Mr. Washburn: That's true. Any action on that, or shall we just leave it and note there's an action to be taken by the Executive Committee at its first meeting?

Mr. Gray: To get it on the record, I make a motion that the matter of these other agencies and the representation to them be taken up by the incoming Board of Directors.

Mr. Ehmann: I second it.

Mr. Washburn: Any further discussion? All in favor signify it by saying aye. Opposed? Carried. Now the Nominations Committee, the report of nomination of officers. In the absence of the Chairman, Ed Davis, Norman Ehmann is taking over.

Mr. Ehmann: The Nominations Committee duly met on February 1st, at five o'clock, and nominated the people that you see on the board in front of you; President, Jack Kimball; Vice President, Edgar Smith; Secretary-Treasurer, Theodore Aarons; Executive Committee, Ed Washburn as Past President; Board of Trustees, Adolph Pruess.

Mr. Washburn: What is your pleasure? Any further nominations?

Comment: I move we adopt the report of the Nominating Committee and that the Secretary cast the unanimous ballot for those nominated.

Mr. Washburn: All those in favor signify it by saying aye. Opposed? Caried, and the nominated officers are duly elected. Jack Kimball, come up here and take over.

Mr. Kimball: Thank you, Ed. As much as I would like to adjourn the meeting like he did last year, I can't take that action right now without subjecting him to a little discussion on what he's done in the past year. I think it's worth a few minutes just to go over the month-by-month actions that have been taken in 1949 to realize the amount of work that Ed's gone to in trying to stir up some kind of concrete action. I know it's been tough for him to get Orange County up to all his Executive meetings. He had, I think, nine or ten meetings throughout the year, but when you analyze these meetings, he's always had a very good reason for calling these meetings and it's always been an action that was necessary and which has resulted in keeping the Association going. He started out the year with a meeting in March, reviewing the standards and recommendations for the governing of the subvention funds. That was one of the big things that had to be straightened out, and you know that venture finally took shape, and as far as we're concerned in Orange County has worked satisfactorily as far as our subvention program goes.

In April, following that meeting, the actual hearings in the State Health Department were held to put those recommendations on file officially. During this time he was working with his legislative committee on the various bills that went through the Senate and Assembly. Out of the four bills that were in the State Legislature, three which were recommended by the Committee were approved, and the one that was rejected by the Association did not reach the floor. One was of interest to Orange County in that it permitted an annexation of a city within the district without the involved petition form. The other two were technical. One suspended the operation of the Districts Investigation Act for two more years.

The meeting at Fresno was an operators' meeting; that was one of the outstanding meetings. Our operators saw Consolidated and the Fresno district in operation, and their equipment, and evidently this meeting was more or less a starter of the regional meetings. In May Ed Washburn had us up in Berkeley again to go over the regulations on DDT, as to the effect on forage crops. That resulted in a lot of discussion, and we tried to arrive at some conclusions by which the districts could continue their operations and yet be on the safe side. You also remember that a few days before that meeting Professor Herms passed away.

I think at this meeting the Executive Board appointed a committee for setting up a perpetual memorial for Professor Herms. The Executive Board has decided to furnish a sum of money each year to send one or more underprivileged Boy Scouts in the Berkeley-Contra Costa area to summer camp. It was felt that that was a fitting memorial because, as you know, one of Professor Herms' important activities in the youth program was the Boy Scouts.

The Executive Committee also convened in Santa Ana, and again on November 16th we went to Turlock when the *Aedes nigromaculis* study was getting under way, in order to work out the details. Ted Raley, Ed Smith, and Chet Robinson were appointed on a committee for working out a contractual agreement between the Association and the various districts in order to finance the *Aedes* study program. It was with a bit of relief that the State took over the financing of that program. If you read over their contracts and their budget and setup, it showed a considerable amount of effort and thought in getting all that work together, and even though it wasn't used, it still had to be done, and you might say we're lucky that we didn't have to go into it.

On January 10th he called another meeting in Fresno and worked out the various programs for this meeting, and tried to correlate the papers that were being presented at the Eastern meetings, so that this Association wouldn't be overlapping in presentation from the West.

Getting the regional meetings organized and under way I think is a great accomplishment. It was the feeling of the Executive Committe that these regional meetings would really be the heart of our every-day operation. These regional meetings are largely on an operators' basis and a work-day problem basis. I know we want to get together on that basis. It was our thought that we could plan our Executive meetings with each one of the regional meetings throughout the year, say on a quarterly basis, starting out with the Bay region, and San Joaquin, and the Sacramento, and the South, so that the Executive Committee would get better acquainted with each one of these regional meetings and in that way get around and get better acquainted. Also, we would have our meetings scheduled so that any regular business that had to come up before the Executive Committee could be scheduled for that particular time.

The other thoughts that we have on our 1950 program are more or less on a tentative stage. We want to suggest for discussion at the regional meetings the possibilities or the desirabilities of having our annual meeting in the South next year instead of at Berkeley. After Professor Essig's welcome here this morning I question whether that suggestion should ever be made, but we are making it on the basis that the regional sections are so organized now that they can pass on what they think of the idea, and possibly set up alternate meetings in the South and in the North, say every other year. We do have the University of California down there also, and a change to different surroundings might be welcome. Also, the fact that the Association has met or would meet in the South brings the importance of mosquito control to that area, and an emphasis of that sort would help in the Los Angeles area and in the southern counties like San Bernardino and San Diego, which, more or less, have been on the verge as to how far they should go in mosquito control. So it may be a considerable advantage in the mosquito control program to meet down south. We hope that you will consider that matter.

After listening to Harold Gray this morning and his suggestions as to permanent control operations as basic objectives of the Association, I assume that we reflect the same attitude in trying to get cooperation with the various governmental agencies that deal with water resources and uses. But we can't pass a resolution at this meeting and ask the secretary to send out copies to a lot of agencies and expect any fruits to come from such action alone. Resolutions are an excellent way to bring these matters to the attention of the heads of these organizations, and it should be done. But we must keep plugging away at these agencies so that they become aware of them, and also that they see where they may take advantage of our program also.

You all have your own farm advisors, your farm bureaus, and your reclamation districts. If you get acquainted with those individuals, if you get them to come to your meetings, and also if you go to theirs, a continuous selling job can be done by each district. As an example, I may cite the Orange County Agricultural Round Table that was started the last year by the University of California Extension Service. All agencies interested in agriculture are invited to get together once a month to see what the other agencies ar doing. We have learned quite a bit about our Soil Conservation program in Orange County, and the various irrigation set-ups, and that may be our way of putting our objectives before these agencies.

On the appointment of regional representatives on the Executive Committee, if the various members in each region can get together by tomorrow noon and make your selection, we can have our Executive Board completed and announced tomorrow afternoon. There are several items the Executive Board will have to take action before we adjourn. After the business meeting tomorrow at 4:15 or whenever it adjourns, please stay right here and finish up that business of the Executive Board and then we'll be all set to start out the new year.

I think we should now introduce our new officers. The Vice President should come first. Ed Smith, you'll have to come up here and be presented.

Mr. Smith: Thank you all.

Mr. Kimball: Ted, will you come up? I'd like to introduce our new Secretary-Treasurer, Ted Aarons from Alameda County, and our reappointment of our representative from our Boards of Trustees, Mr. Pruess. Would you care to say a word, Mr. Pruess, before we adjourn?

Mr. Pruess: It's getting rather late, I think we had better adjourn.

Mr. Kimball: Okay, we will now adjourn.

FRIDAY, FEBRUARY 3, 1950

The meeting convened in 113 Agriculture Hall, University of California, Berkeley, at 9:15 a.m., President G. E. Washburn presiding.

Mr. Washburn: There are a couple of announcements that I would like to make at this time. A few tickets are yet available for the Smörgåsbord Banquet and Dance this evening. If you find that you can attend and don't have your tickets as yet be sure to take care of it promptly. The girls are still in the hall and have a few tickets available.

If you have not registered, please do so, as we would like to have your name and where you are from, so we know who are in attendance.

I also wish to again call your attention to the plastic mounts of mosquitoes being prepared by Mr. Munich. He is making complete series of mounts of mosquitoes, the eggs, different stages of the larvae, pupae, male and female adults, all mounted in one slide. I'd like to have you look at these. They are extremely useful, some of us feel, for identification purposes and study and as exhibit material for the public. You must furnish the complete series of each species for him to mount. The prices, I believe, are about $5.00 for a complete series of any one species, which is reasonable.

I have the pleasure this morning of stepping down from this office, but before I do so I wish to introduce to you the new officers for the ensuing year of the California Mosquito Control Association. The newly elected President is Jack Kimball, who is Manager of the Orange County Mosquito Abatement District. Jack, will you stand up? They will see you the rest of this morning, I am sure. The newly elected Vice President is Edgar Smith, Entomologist-Manager of the Merced County Mosquito Abatement District. Our new Secretary-Treasurer is Ted Aarons, Entomologist of the Alameda County Mosquito Abatement District. On our Executive Board we have re-elected Adolph Pruess, Trustee of the Consolidated Mosquito Abatement District at Selma. I will now turn the meeting over to your new President, Jack Kimball.

Mr. Kimball: I think Dick Peters has one more announcement to make. Was it the one about the Proceedings?

Mr. Peters: We issued the 1949 Proceedings last night to the CMCA agencies present, putting out the number of copies each agency wished to have. We will send three copies as a base to all other paid-up agencies; and if you wish more than three, so request and more will be furnished.

Mr. Kimball: The symposium for this morning is on the subject of "Water Resources Development as Related to Mosquito Abatement." Our Moderator will be Mr. Arve Dahl, Chief of the Bureau of Vector Control, California State Department of Public Health, Berkeley.

Mr. Arve H. Dahl: My position as Moderator is a privileged one, and before I get into the topic at hand I would like to express my personal welcome to everyone attending the Conference, and assure you we are looking forward to continued relationships during the coming year. As most of us are now getting over the newness of our occupations, we are in the position of actually performing and attacking our problems on a real down-to-earth basis. I say that with the realization that it does not apply to all of us, because Harold Gray and Chet Robinson and others have been working in their districts for a long period of time, but I'm primarily referring to the period since 1946. Not only have the district personnel grown but the Bureau staff likewise has grown and we hope that we can be of more use to you in the future. I think that the organization within the Bureau has matured to a point where we are of much more service to the mosquito abatement agencies of the State.

This key-note brings up the topic we have before us now, "Water Resources Development as Related to Mosquito Abatement." This is a problem that involves practically all of the vested interests in the Central Valley and many other parts of the State. It's an economic, a social, and a public health problem. As far as we're concerned we are interested in one aspect of the problem, that is, the prevention of the development of situations which will create more mosquito problems for the mosquito abatement agencies to handle. Ours is a preventive program largely. As we look at the program, there is one facet that has not been indicated, and that is the public health aspect of this problem. I think we can cover that with a few words.

Dr. Reeves and Dr. Hammon in the past Conferences have discussed the problem of epidemiology and research on the mosquito-borne encephalitides. We are assuming, when we start this discussion, that the diseases are mosquito-borne and that our primary problem is in connection with that species on which the most work has been done, namely, *Culex tarsalis*. In addition, of course, we know and acknowledge the questions that are before us with regard to the importance of the *Aedes* species. As far as malaria is concerned it is of dubious importance in the minds of most of us. This past year we have had very few cases. In the Central Valley there were only two counties in which indigenous malaria was reported, Tehama and Tulare counties. From the records of the past, we know it has been a bad problem. We do not know exactly why it could not be a problem in the future. We are therefore considering to some extent the problems of anophelines in these areas.

As to the type of program we are interested in developing, I think you will see from the speakers that follow that this is an action program. I think we should let the speakers present their opinions, and I call first upon Dr. John H. Rowe, who is Senior Scientist of the Public Health Service. He is in charge of the Mid-Western CDC activities in Kansas City. Dr. Rowe is going to talk on the Relation of Interested Agencies and Organizations in the Finding and Execution of Water Development Programs.

Dr. Rowe: Before I read what I've prepared I would like to personally thank the Mosquito Control Association of California and Mr. Geib and others who so graciously invited me to come out here to attend the meeting. This is the second time I've been to these meetings, and both times I've learned a lot and am very much impressed with the progress, the type of work and the technology evident in this Association and elsewhere in health work in California. I'm very much dismayed at the subject which Mr. Dahl handed me. It's one that doesn't lend to concreteness nor to specificity. It's one that we don't know too much about. It is sort of like writing a job history; you write and write and then you're not quite satisfied with what you have because it doesn't tell the story.

I've tried to sit back on the mountain, so to speak, and take a broad over-all look at the aspects of this program I've been working on and I hope you'll appreciate that many of the relationships that will eventually evolve, probably will come from trial and error, but certainly will come.

THE RELATION OF INTERESTED AGENCIES AND ORGANIZATIONS[1] IN THE PLANNING AND EXECUTION OF WATER DEVELOPMENT PROGRAMS

By John A. Rowe

Senior Scientist, U.S. Public Health Service

Communicable Disease Center, Kansas City, Missouri

Introduction

Water is essential to all animal and plant life. It is a prime factor which limits or regulates the distribution of living things in the universe. It is the prerequisite of all civilized development. Because of its importance to the well-being of the individual, the community, and the state, everyone, either collectively or individually, is consciously, or otherwise, interested in this vital natural resource. Although interest in water is ever present it is rarely manifested in those areas where supplies are adequate. However, in those areas where the supply is inadequate, or where there is comparatively "no water," the individual and society alike are striving for increased supplies and are jealously guarding their attainments in this regard.

The Continental United States has a land area of about 1,900,000,000 acres. More than half of this acreage — 1,160,000,000 acres — is in seventeen of twenty-two states west of the Mississippi River. These states comprise what is known as the "West." It is an area of infinitely varied ecology and terrain — but with one predominant characteristic of climate — *that of dryness.* Rain and snow are scarce and, with the exception of certain local areas, there is generally not enough precipitation for the growing of crops. In many sections, because scant supply has not been stored and made available for use, there is hardly enough water for the maintenance of civilized life. Consequently, this vast area, despite its tremendous natural wealth, has only one-fifth of the country's population, one-fourth of its farms, and a still smaller proportion of its industries.

The proper development of the water resources of the West has always been a prime interest and effort of its people and of its local and state government. These groups have been greatly assisted by federal agencies having responsibilities for water resources development. In spite of extensive developmental work carried forward through many decades, much remains to be done before complete utilization of available supplies is attained.

According to Bureau of Reclamation figures, the seventeen western states have about 400,000,000 acre-feet of stream run-off annually. Of this total only 135,000,000

[1] From the Office of Midwestern CDC Services, Communicable Disease Center, Public Health Service, Federal Security Agency, Kansas City, Missouri.

acre-feet — one-third — is presently considered susceptible of development. "The remainder is not in the right places, thus creating an unpleasant paradox of simultaneous surpluses and shortages in western water supplies." Of the total run-off susceptible of development (135,000,000 acre-feet) about half 74,600,000 acre-feet) has been developed and put to use. The figures also indicate that of the 1,160,000,000 acres of land in the west only 37,960,000 (3 out of 100) acres can be irrigated to produce crops. Already, 21,120,000 acres are under irrigation, leaving about 16,-840,000 acres possible of development. Although past achievements in irrigation development have been sizable indeed, about 40% of the acreage presently irrigated still lacks an adequate season's supply.

It seems quite evident that the general development of the west has continued and will continue to be paced by the development of its water resources. It is likely that the ultimate water development activities will involve two broad phases:

1. Because of general scarcities, available run-off supplies in each of the natural areas or basins will be fully conserved and fully utilized;
2. Because of localized lack of balance of available run-off supplies, the exportation and importation of water between natural basins or areas will be attempted.

Current Water Developement Activities

The West is currently engaged in an accelerated program for the development of water resources within and between the natural supply units or basins. Reasons for increased efforts in this activity are not only related to local, state, and federal problems but, in certain instances, international ones as well. The scarcity of natural supplies and hence the value of the water itself makes it imperative that development programs be designed in such a manner as to assure the fullest conservation and utilization possible. Natural run-off supplies must be saved and stored and they must be utilized to serve and serve again those purposes for the ultimate good of the people.

Natural run-off supplies of water within an area can and are properly being developed for many uses, all of which contribute wealth and advancement. Utilization for irrigation, flood control, hydroelectric power, public water supplies, pollution abatement, fish and wildlife conservation, recreation, navigation, and others are being considered in developing programs now under way.

Over-all Relation of Agencies

Maximum and efficient multipurpose use of water requires detailed and thorough evaluations during the over-all developmental planning stages. The designation of priority uses is, of course, quite necessary, but consideration of any single use alone —by itself — may not be most practicable, epecially in areas of low run-off supplies. Since the effective use of water for any one of the purposes mentioned is an intricate task involving special skills and techniques, effective multipurpose use would seem to require a coordinated combination of a variety of interests and technical skills. This is especially significant if, through water development problems or create new ones disadvantageous to the area. Effective and scientific planning should not ordinarily result in the alleviation of one problem and the creation of another. In water development activities such can be avoided to a considerable extent, if the groups representing the various interests and responsibilities actively contribute their specific evaluations, techniques, and skills and earnestly cooperate in a coordinated and concerted approach to developmental planning. An active and coordinated approach of all interested groups is, then, the first step in the planning of multiple water-use programs. Obviously such an approach is essential at all levels — federal, state, and local. It is realized that such an approach is not an easy one. The pitfalls, blocks, and deadlocks so often experienced in human relations must be overbalanced by patience, tolerance, and an appreciation of total values. The various cooperative groups must be prepared to contribute promptly the concrete, practical, and detailed considerations which they desire to be incorporated into the program. This may involve

1. the prosecution of a wide variety of investigative or field research programs on the part of all or a portion of the interested groups, and will certainly involve
2. a careful study and analysis of each unit or project of the program.

Especially is this true in those fields where past experiences have not yielded sufficient technical information to deal effectively with problems which may be confronted.

Relationship of Health Agencies

Health interests, or agencies, are vitally concerned in water development programs for numerous reasons. Some of those already mentioned have to do with the use of water to alleviate critical problems which already exist — particularly in the field of public water supply and pollution abatement. We *here* are interested for another reason — that of the aggravation of existing problems or the creation of new ones, particularly those of disease vectors and specifically mosquitoes.

We are interested in actively participating in water development programs for the purpose of preventing, or at least minimizing, those conditions or situations which create mosquitoes. Considerations for the attainment of these objectives will probably not be included in development programs unless interested groups and those charged with these responsibilities actively and cooperatively participate in development programs.

What, then, are the responsibilities of health agencies in vector problems relating to water development programs? Some of the more specific ones would appear to be:

1. The determination of the relationship of water development programs to mosquitoes, mosquito-borne diseases, and other vectors;
2. The determination of the specific features of design and operation of water systems and the features of water use which cause health hazards;
3. The development of practical techniques for eliminating or minimizing these undesirable features;
4. Active participation in the planning and execution of water development programs in order that proper considerations are assured;
5. Development of suggested corrective legislation, if such is needed, and
6. Development of adequate vector control programs.

These responsibilities are shared by local, state, and federal health agencies. The division of responsibilities between these various health groups appears to be quite well defined, but the arbitrary division of them is not always practical or workable in areas which lack local health services or where technical personnel are limited in number.

Division of Responsibilities of the Various Health Agencies

With this in mind an attempt has been made to analyze, in a general way, the responsibilities of federal and those of state and local health agencies in this work. A definition of the responsibilities will be indicative of programs and activities relating to water development.

Federal Responsibilities

1. Technical consultation to federal construction and operating agencies and to state health departments.
2. Coordination of health interests with interests of other federal agencies concerned.
3. Collaboration with state health departments on field investigations, surveillance, and reports on federal projects.
4. Technical development of control methods, materials, and equipment — preventive, cultural, and insecticidal.
5. Preparation and dissemination of technical information and training materials.

State and Local Responsibilities

1. Adoption of appropriate legislation and the enforcement thereof.
2. Technical guidance and advisory services, i. e., state to to local and local to local non-health groups.
3. Promotion of local vector control programs.
4. Vector control operations.
5. Collaboration with other state and local interests.
6. Surveillance and analysis of vector-borne disease trends.
7. Field investigation, surveillance, and reports on private water development programs.

Summary

During the course of this meeting considerable time will be given to the review and analysis of problems relating to mosquitoes and their control. All of these problems and the program designed to solve them, are directly associated with the storage and utilization of surface water. An attempt has been made to emphasize the need for cooperative and coordinated actions on the part of all groups interested in water development programs. This is believed to be essential to developing of water resources in a manner consistent with the maximum utilization of the scarce supplies available. Health agencies are concerned with water development programs for various obvious reasons. The proper regard of health aspects in the over-all program planning is dependent largely upon the extent to which these agencies participate in development schemes. Active participation must come from local, state, and federal health groups, and the contribution of these agencies must be concrete and properly evaluated in terms of the over-all need of the people.

Mr. Dahl: Thank you, Dr. Rowe. We will open a little discussion as soon as we finish with the three speakers. Is there any specific question that anyone has?

The next speaker is Dr. Gordon E. Smith, also from Kansas City on Dr. Rowe's staff. He is a Scientist (R) of the Public Health Service, and his paper will be "Investigation and Evaluation of Water Development Programs Relative to Arthropod-Borne Diseases." Dr. Smith.

Dr. Gordon E. Smith: Thank you, Mr. Dahl. Ladies and gentlemen:

INVESTIGATION AND EVALUATION OF WATER DEVELOPMENT PROGRAMS RELATIVE TO MOSQUITO PRODUCTION

By Gordon E. Smith

Officer in Charge, Vector Investigations Branch
Public Health Service, Communicable Disease Center
417 East 13th Street, Kansas City, Missouri

I. History of Water Development Programs In America

Water development programs probably date back to man's first attempts to grow plants, and the practice of irrigation has followed him through history to all parts of the world. Irrigation in America was started under the direction of Brigham Young in the Salt Lake Valley in 1847. Although the Mormons demonstrated the feasibility, *and need,* for irrigation in the United States, the building of large dams and extensive canals was too expensive for groups of individuals to undertake throughout the United States where irrigation was needed. It was 55 years later, 1902, under Theodore Roosevelt's administration that Federal aid was made available to Water Development Programs by the creation and activation of the U.S. Reclamation Service. This small, enthusiastic group of individuals set out to develop methods of control and use of water which would take into account the laws of Nature, *and of man,* with their *application* benefiting humanity.

In writing of the early days of the Reclamation Service (1917), James states that great care was exercised to make everything healthful and sanitary for the workmen employed, and to plan for the future. He stated that while flies and mosquitoes were frequent at certain seasons of the year, it was his belief that as people understood better their scientific control they would speedily disappear.

We have learned many things about mosquitoes and their control since that day, but they are still with us in considerable numbers.

The numerous water development projects *under construction* and *consideration* by the Bureau of Reclamation *and* the Corps of Engineers, will increase to a considerable degree the mosquito breeding potential in the Western States. This is of vital importance and interest to public health personnel charged with mosquito investigations and control.

II. Reservoir Studies and Investigations

Each reservoir will require a separate study and special investigation. It may be true that not all of the impoundments will create a serious public health problem, but *each* should be investigated and evaluated according to its mosquito breeding potential and public health importance *by personnel well trained in mosquito control.*

The *sponsors* of water development programs assume legal and moral responsibility to see that a public health problem is not created by their activities. Therefore, an investigation and evaluation should be made to determine a project's mosquito breeding potential, while it is still in the planning stage, so that the mosquito control problems will be given due consideration *at the time* of the original planning and selection of a location for the project. *If* the impoundment *will* cause a serious public health hazard by producing disease vectors, then mosquito control should be given consideration in the program of design, construction, and *operation* of the dam, for water level fluctuations, in order that the control of mosquitoes will not be made unnecessarily expensive or *even impossible*. This important fact was recognized in the Tennessee Valley, and the TVA dams were designed especially to give water level fluctuations *for mosquito control,* and this control method has become the most economical and effective one to be used.

Detail methods have been worked out for investigating and evaluating impounded water projects relative to anopheline mosquito production in the Southern States. These details have been described in the TVA-PHS publication *Malaria Control on Impounded Water.*

Although the Western States have an added problem of culicine vectors of encephalomyelitis to consider as well as the anopheline malaria vectors, the investigative procedures as set forth in the *Malaria Manual* have become pretty well established, and, with certain modifications, may be adopted for Western use. (For example, a deviation from the mosquito control methods described in the manual might be in "shoreline grazing." While this method is recommended for anopheline control in Alabama, such a practice in California is likely to create conditions favorable for the production of culicine mosquitoes.)

In making an investigation and evaluation of a multipurpose reservoir relative to its mosquito breeding potential, the investigator studies all of the available project data pertaining to the *design* and *operation* of the dam, purposes of the reservoir, water elevations, miles and types of shoreline, and acres of mosquito breeding flats. Marginal drainage projects are located, and the timber and aquatic vegetation is surveyed. The climatological records for the area are considered together with the *present* and *projected* human populations, both permanent and transient, within mosquito flight range of the reservoir. Plans for fish and wildlife developments must be viewed and appraised relative to their significance from a public health standpoint. Epidemiological data showing the incidence of mosquito-borne disease in counties contiguous to the reservoir must be collected and interpreted. All biological factors and general ecological conditions of the reservoir basin are studied, and a detail mosquito and aquatic plant survey is made.

After a complete analysis is made of the above factors a *conclusion* may be drawn setting forth the predicted mosquito problem, which will be created by the impoundment, together with the need and detail recommendations on reservoir preparation and operation for mosquito control. The public health importance of the project may *then* be classified according to its mosquito breeding potential.

III. Irrigation Studies and Investigations

While the details of mosquito production and control on impounded water has become firmly established, *little* is known about mosquito production on irrigation projects *except* that wherever irrigation occurs, mosquitoes are produced in considerable numbers. There seems to be a lack of concrete data relative to the *specific* causes of mosquito prodution on irrigated land. In order to make logical recommendations for mosquito control, all of the *causes* responsible for mosquito production must be understood and evaluated.

According to the currently proposed reclamation program, approximately 5 million acres of new land in the West will be placed under irrigation. Because of the favorable ecological changes that will be created by watering 5 million acres of land, it is logical to assume that the mosquito populations will be substantially increased over this area.

In order to accumulate basic data relative to the specific causes and amount of mosquito breeding on irrigated areas, study plots should be set up throughout the area representing all of the various geographical locations, soil types, and methods of irrigation, such as canal (gravity), well, sprinkler, border dyke, row or furrow, contour, or corrugation, etc. For comparative purposes, it would be desirable to establish study plots on land that is now dry but which will subsequently be placed under irrigation, as well as plots already under irrigation. It is felt that a representative sample to be used as a plot study should be about 4 square miles in size and set up in the following manner: Before mosquito production starts in the spring, a complete water survey of the plot selected must be made. All places that will probably hold water are located on a map and are given a permanent station number. A mosquito light trap should be located on the plot and operated nightly throughout the season to measure the adult mosquito population. The plots must be inspected *each week* throughout the summer, at which time all stations will be dipped for mosquito larvae, and the following data recorded for each station: number of dips, larvae found, average per dip, type breeding place, total watered area, total breeding area, and the amount of water due to *natural* causes versus the amount due to *irrigation.* If the water at a station is due to irrigation, it must be determined whether it came from a faulty irrigation-system resulting in seepage, leakage, overflow, or other causes, or whether it came from faulty irrigation-practice due to excessive irrigation, improper preparation of land, or the mismanagement of water resulting in waste and mosquito production.

The Bureau of Reclamation is extremely interested in the work in close cooperation with health personnel in working conservation of water and will probably be more than willing to work in close cooperation with health personnel in working out the details or correcting faulty irrigation systems or practices resulting in a waste of water and the final production of mosquitoes.

After determining the specific conditions which produce mosquitoes on various types of irrigated areas, recommendations for effective and economical control measures, to be incorporated into project planning and construction, can be made *for mosquito abatement.*

During the summer of 1949 thirteen widely separated 4-square-mile study plots, as described above, were selected for detail study and investigations in the Missouri River Basin area. Eight were located on irrigated land and five were on "dry land areas' which are to be placed under irrigation during the next few years. The data collected from the "dry-land" plots will indicate the base line mosquito breeding level in the absence of irigation water, and will later be observed after irrigation starts. It is hoped that from the irrigated plot studies, some of the answers as to the causes of mosquito breeding will be learned and some of the control problems solved.

To date, only two of these study plots have been completed and analyzed. One is a bottom "dry land plot" and the other, 30 miles away, is a loess plain-canal irrigated plot. The following graph shows a comparison between these two plots as to:

1. Total amount of rainfall on each plot.
2. Total amount of water resulting from natural causes that caused mosquito breeding versus total amount of irrigation water responsible for mosquito breeding.
3. A volumetric measurement of the larvae produced on the plots by multiplying the average number of larvae found per dip by the acres of breeding area, and
4. Adult mosquito populations.

As may be seen from these comparisons the rainfall was approximately the same on each plot, yet on the non-irrigated plot the mosquito breeding water started disappearing about the first of July and the mosquito collections were negligible or negative during the latter part of the summer. On the other hand, the initial watered area and subsequent amount of mosquito breeding was much greater on the irrigated plot than on the other. With comparable rainfall, the high total watered area on the irrigation plot is difficult to explain unless it can be attributed to a high water table due to irrigation. The irrigation plot is located on a loess plain area while the non-irrigated plot is in a river valley area. An unusual amount of rainfall in May and June, 1945, made irrigation unnecessary during these months.

The significant point in this study seems to be the fact that the irrigation water was responsible for bringing the mosquito populations up in July and holding them at a high level throughout the summer while the mosquito breeding on the non-irrigated plot disappeared in July.

Mr. Dahl: Thanks, Gordon. The next speaker we have on our program is one of our own members in the Bureau, Mr. Buchanan, who will speak on "The Central Valley Project and Its Potential Effect on Mosquito Control in California." Mr. Buchanan.

THE CENTRAL VALLEY PROJECT AND ITS POTENTIAL EFFECT ON MOSQUITO CONTROL IN CALIFORNIA

By W. J. BUCHANAN*
Sanitary Engineer, Public Health Service
Communicable Disease Center Activities

Dr. Rowe has told you of the relationships of interested agencies and organizations to the planning and execution of water development programs. Dr. Smith has presented points for consideration in the investigation and evaluation of the arthropod-borne disease problems associated with these programs.

In 1921, the State Engineering Department launched an intensive investigation of the water resources of California. These investigations continued during the next ten years and resulted in a comprehensive plan for the coordinated development of water resources in the State. The plan was designated as the "State Water Plan" and presented to the Legislature in 1931. First priority for immediate development was given to the urgent water problems in the Sacramento and San Joaquin Valleys and in the adjacent upper San Francisco Bay region. This portion of the State Water Plan was designated as the Central Valley Plan, and actual construction of the project was begun by the Federal government in 1937, interrupted by the war years and is again in full swing with major units already completed or scheduled for completion and operation by June, 1951.

Because of the known endemicity of the arthropod-borne encephalitides in the Valley, the rapid progress of construction, and the opportunities which we foresee for reducing the mosquito production potential associated with this project, we have selected the Central Valley Project for our discussion at this time.

THE CENTRAL VALLEY PROJECT

Before I embark upon a description of the Central Valley Project let me state that although the Bureau of Reclamation and the Department of the Army are the principal constructing and operating agencies responsible in this gigantic undertaking, the projects of various irrigation districts, municipal water districts, and other local conservationists and users are integrated into the comprehensive plan for development of the water resources of the Valley.

To understand the Central Valley Project, we must understand the physical conditions which prevail and the changes which are taking place to correct them.

The Central Valley floor is a gently sloping, pratically unbroken plain about 400 miles long, averaging about 40 miles in width, located between California's principal mountain ranges. The drainage basin for this area comprises some 58,000 square miles, the northern portion being drained by the Sacramento River, the largest drainage basin in California, and the southern portion by the second largest, the San Joaquin River. The flow from these rivers is joined in the delta area and from these makes its way through several bays into the Pacific Ocean.

The Bureau of Reclamation estimates that during the seven-year critical period, 1928-34, the available supply of water from natural run-off and carry-over storage averaged 19,400,000 acre-feet annually. Utilization by irrigation, municipal and miscellaneous withdrawal, evaporation, and that portion of the outflow which was effective in repelling salt water from the low-lying delta area accounted for 10,000,000 acre-feet. The remaining 9,000,000 acre-feet were wasted to the ocean.

Under full development it is estimated that the water requirement for the Central Valley is 20,000,000 acre-feet annually. The Central Valley Plan is designed to provide just this by increasing storage facilities and importing water from the Trinity River. In addition to capturing and holding water several other major problems will be cared for by the Central Valley Plan.

It is something of a paradox that about two-thirds of the water supply of the Valley originates in the Sacramento Valley, wherein approximately 2,500,000 acres of irrigable

*Assigned to California State Department of Public Health, Bureau of Vector Control, in charge of Water Resources Development Investigations.

agricultural lands are located, while only one-third of the water supply originates in the San Joaquin Valley, where almost 6,000,000 acres of irrigable agricultural lands are situated.

It is obvious that to more nearly equalize this situation, to prevent this enormous waste, and to reduce the present heavy over-pumping of available ground water supplies, particularly in the San Joaquin Valley, a coordinated system of works designed to store and distribute available surface water must be constructed.

Other major considerations concern: ground water replenishment by direct infiltration, flood control, the improvement of navigable streams, the development of hydroelectric power, the repulsion of salt waters from the rich delta area, the development of recreational areas, and assurance of an adequate supply of water for municipal and industrial use in the Valley and the San Francisco Bay area.

Shortly, I will ask our operator to project a slide which will, I hope, give you a clearer picture of the water resources development program which has been undertaken in this State. Although the purpose of this discussion is to present the Central Valley problem I am sure that the magnitude of the State-wide plan will be of interest to you.

The 20 reservoirs in the Central Valley basin which you see indicated by the solid black circles have an aggregate capacity of more than 13½ million acre-feet, and these reservoirs are either completed or are under construction. In addition to these, 36 other reservoirs are included in the Central Valley Plan, most of which are indicated by the white circles. This latter group has an aggregate capacity of slightly more than 21 million acre-feet.

Insofar as the major transportation systems are concerned, you will note that exclusive of the Delta Cross Channel, which is essentially composed of existing sloughs and channels, four major canals whose aggregate length is 364 miles and whose total capacity is 11,450 cubic feet per second are either constructed or are under construction. Nine other major canals which will total 999 miles in length and which will handle an additional 24,700 cubic feet per second are proposed for construction.

For those of you who may be interested in astronomy, I have done a little calculating and find that the filled capacities of these Central Valley reservoirs exceed 11 trillion gallons, and, when all are flowing, more than 23 billion gallons of water per day may move through the 1,363 miles of canals during the period April 1 to September 30, which is practically coincident with the season of significant mosquito prodution.

In addition to the storage and transportation problem we should understand what further changes of primary concern to us are planned. In this respect, it is well to consider irrigation.

In 1943, there were 3½ million acres farmed to irrigated crops in the Valley and this was a good water year. The real gravity of the problem is better appreciated if we understand that during the seven-year critical period, 1928-34, an average of only 2,970,000 acres were under irrigation each year and the average deficiency in supply during that period is estimated at 250,000 acre-feet per year. It is true that part of this deficiency was offset by over-drafts from the underground water supply, but it is obvious that continued over-drafts seriously deplete even that source of supply, resulting in excessive pumping costs. The Central Valley Plan is designed to provide a firm supply for these less than 3 million acres and, in addition, will permit irrigation for another 3½ million acres annually. It is assumed that in accordance with present farming practices an average 2 million acres will be summer fallowed, will remain idle or will be put to non-irrigated crops each year.

This, then, is the reason and is, perhaps, indicative of the extent of the problem we must resolve. The plan is fully described in the Bureau of Reclamation's *Comprehensive Plan for Water Resources Development, Central Valley Basin, California,** and many of the figures and statements I have used are taken therefrom.

The Problem

It is readily apparent to the experienced observer that these vast storage and distribution facilities, developed for the many purposes and ultimate uses briefly described above, are bound to present complexities and intricacies of design, installation, location, etc., that will undoubtedly have a great influence on mosquito production and may well have an impact on other sanitary features.

History provides us with numerous examples of instances where conditions favorable to the increased production of mosquitoes have resulted from failure on the part of design or construction personnel, inexperienced in the ways of mosquitoes, to incorporate these important considerations into their planning and design.

The ready availability of "new water" for irrigation purposes, the increase of water supplies for presently under-irrigated lands, the tendency to pasture certain areas and to increase yield by excessive irrigation, are problems involved aside from the problems related to structural defects and are problems for which practical corrective methods must be devised if we are to limit mosquito production to tolerable levels.

In the Bureau of Vector Control there has been established a section whose principal objective is to investigate these problems with the view to obtaining such information as may be necessary to formulate specific plans of action in this regard. The section is limited in size, and due to policy decisions which are beyond the scope of this presentation, must give priority to investigation of the major construction projects which are planned, in the process of construction, or completed.

During the past year, we completed some investigations which, it is hoped, will provide us with factual information to guide our appraisals and recommendations. This next season it is planned to supplement this information and to attempt a study of the increase in mosquito production due to the availability of the "new water" in an area.

It is interesting to note that although final analysis of last year's studies has not been completed, it appears that we now have records to support many of our earlier expectations and, in addition, have arrived at some bases for estimating the potentialities of proposed reservoirs and canals.

**Comprehentive Plan for Water Resources Development, Central Valley Basin, California,* U.S. Dept. of the Interior, Bureau of Reclamation Project Planning Report No. 2-4.0-3, November, 1945.

In April of 1949, we made a reconnaissance of Madera Canal and an 11-mile section of Friant-Kern Canal as well as Friant Reservoir and the re-regulating Madera Reservoir. No water was being released into the canals at that time and the water in the reservoirs was at relatively high levels. Moderate to heavy mosquito larval production was found in association with the canals and in the reservoirs. As a result of this initial survey, 60 larval inspection stations were set up along the canals at points where larval habitats were expected to occur. In addition to this, 8 larval inspection stations were set up on Friant Reservoir in the vicinity of the existing and proposed recreational areas and 4 in other reservoirs in the general area. These 72 stations were observed routinely during the period extending from mid-June to the latter part of September. It was found that along the canals 87% of the stations produced mosquitoes during the inspection period; the other 13% remained dry or failed to retain water long enough for us to detect the presence of larvae. In the productive stations we were able to pick up larvae an average of 75% of the time and the larval count averaged 8 per dip. There were three general types of situations associated with the canals which produced these mosquitoes, and I give them to you in their order of relative importance:

1. Seepage through dike or canal banks into borrow or other low-lying areas were observed at 17 stations, and they produced larvae 84% of the times inspected, the average dip containing 12.1 larvae.
2. Structural leaks or seepage from underdrains, turnouts, and siphons were observed at 32 stations, producing larvae 72% of the times inspected, and the average dip contained 6.5 larvae.
3. Seepage or run-off which occurred on the high side of the canal and which was blocked by the canal itself was observed at 3 stations and produced larvae 70% of the times inspected; the average dip contained 6.9 larvae.

With the exception of the canal bank seepage situations described above, it should be noted that these conditions prevailed whether canals were concrete-lined or not.

It is interesting to note that in either case properly located and graded cross drainage facilities and, in the case of dike seepage, intercepting drainage, would either eliminate these problems or reduce them to the level of insignificance.

The problem found in the reservoirs does not appear to be of such significance or proportions as that along the canals. The canals wind along the foothills, frequently passing close by farms and the more populated areas. The reservoirs are generally located well into the hills and out of the mosquito flight range from populated areas. They do, however, attract campers, fishermen, and other recreationists in great numbers, and may not, therefore, be ignored. The problems associated with the reservoirs will generally be those occurring contiguous to these recreational sites.

This past season's observations on Friant Reservoir during the mid-June to September period may be indicative of what we may expect from these reservoirs, whose water levels are subjected to wide fluctuations during the season of mosquito production, which is practically coincident with the recreation season.

Six of the situations observed to produce mosquitoes resulted from ponding in depressions or pooling in drainage channels, primarily occurring during the period when water levels were receding. Larvae were found 61% of the times inspected, and the average dip contained 4.7 larvae.

One stream head remained wet throughout the season, and larvae were found 42% of the times inspected, the average count per dip being 5.8.

One fishpond contained water during most of the season and produced larvae 58% of the time, the average count being 4.6 larvae per dip.

Here again we must conclude that proper drainage connecting the depressions with the main body of fluctuating water and proper grading of the stream and drainage channels would have reduced the mosquito problem to a tolerable level, and the further conditioning of the shoreline of the fishpond to reduce the prevalence of water-tolerant vegetation would have rendered the mosquito problem insignificant.

There is no reason to doubt the economy of utilizing equipment and manpower already on the job site to correct such situations while construction is in progress rather than correcting these same situations after the project has been completed and is in operation. The additional cost of transporting equipment and manpower to the various points; the cost of waiting to work in certain of the areas until water levels, weather, and availability of manpower and equipment are favorable; and the cost of temporary control neasures pending completion of the work is incontrovertible evidence to substantiate this statement.

The preventive type program is the one we are urging upon responsible constructing and operating agencies, to be supplemented by such repetitive measures as are indicated.

I have spoken principally of the problems associated with the canals and reservoirs. You will recall that 1,363 miles of major canals and about 56 reservoirs are planned. Obviously, the aggregate mosquito production potential associated with them is of significant proportions and is so distributed that its effect will be felt over almost all of the Valley. I have also mentioned that this is the problem on which we have been obliged to focus our immediate attention. We do plan, however, to devote as much time as we can afford to study the impact which the doubling of acreages under annual irrigation will undoubtedly have on the mosquito production picture. We recognize the vast potential which this constitutes and are shaping our program toward gathering together specific information with which to impress upon responsible agencies and individuals the necessity for careful irrigation practices. We hope to accomplish this through the cooperation of existing water-interested agencies, but have not lost sight of the fact that some states have found it necesary to obtain legislation or regulation in this regard.

Mr. Dahl: Are there questions or comments? It's been fairly long so far and we've used up all our time, but brief comments or discussions are invited. Hearing none, I assume you are all pretty well satisfied, or after the hospitality hour and all day yesterday and last night, you are ready to just sit back and listen, I don't know which. I would like to summarize, briefly, what has happened here.

As I indicated in my opening remarks, the comments here are pretty much related to the problem itself. We are accepting as complete so far, the work that has been done on the public health aspects of mosquito control in relation to disease. With respect to Dr. Rowe's paper, we can't lose sight of the fact that in his summary he pointed out three things: that water use is multiple, that all interests must be considered; and one cannot be expected to override all other interests. He listed certain other things that are important and I think we ought to keep them in mind; what might be responsibilities and programs of Federal agencies, and then again, what might be the State and local responsibilities. The first one regarding the Federal was the technical consultation to Federal agencies on their problems, like the Bureau of Reclamation projects. The next point was consultation with other Federal agencies, such as the Fish and Wild Life Service. so that there can be a rationalizing of the vested interests. The third was collaboration with State and other health agencies in their particular interests.

The next point that he mentioned (I may have missed one or two) was the development of techniques and advice on these particular problems and also the development of model legislation which might be used by a State wishing to work on this particular problem. Finally they have a responsibility for the development and presentation of information on the subject, to include training aids. As far as State and local agencies were concerned, he pointed out several things: (1) Adoption of and enforcement of legislation to govern the situation. In many cases existing legislation may be adequate. (2) Technical guidance and advisory service would be provided to local agencies conducting these projects in our interests. (3) There should be a promotion of local vector control programs to take care of the problems where they are affecting the public health. There should be a development of vector control operations to meet problems wherever they may be needed. (4) The collaboration with other State agencies. And (5) the final thing that I had was the field surveillance and reports on private and State projects that do not come under Federal development funds.

In conclusion he pointed out two other points: That health workers are interested and must be prepared to cooperate in solving this problem. There cannot be a lackadaisical attitude as far as the health worker is concerned. In this case it would include mosquito abatement personnel. They must have an action program. Finally, that health workers must be prepared to provide practical suggestions on how to handle this problem.

Dr. Smith talked about the studies he is conducting and his interpretation on some of the problems. First of all, as far as reservoirs are concerned, the important thing was that there is a lot of relationship between the work that you've done in the past and what you are trying to do today. With modifications, the information learned on reservoirs, TVA and elsewhere, can be put to use as supportive data for our recommendations on reservoirs here in California. He particularly referred to the TVA-PHS manual on malaria control on impounded water.

As far as irrigation projects are concerned, he pointed out that there is a lack of concrete data on causes of mosquitoes in these particular areas. We have a lot of information, but no concrete material to refer to. He also pointed out how there will be an aditional five million acres of land in the West to be placed under irrigation in the not too distant future. He proposed two things that are really of importance, and they are: first, to determine whether it's management or mismanagement of water that causes the major problem; and, second, to correlate such with those practices that develop, that are studied in connection with determining the necessity of agriculture for that particular project.

Finally, he suggested a method of making studies, and he brought out the point that in his work in the Missouri Valley they had thirteen 4-square-mile plots, five of which were in dry-land areas and eight of which were in irrigated areas, and he had these two charts with which he illustrated his work, and he suggested this is a plan which we, or other areas, might follow in making such studies. I think that his studies also are indicated, particularly the pictures, in that they are similar to the problems here in California.

Mr. Buchanan, in opening his talk, presented the facts and figures on the Central Valley Plan, or the State Water Plan it is really, and the features of the Central Valley Project within the State Water Plan. Of importance is the fact that the majority of the water for irrigation in the Central Valley is available in the Sacramento River Valley, in fact two-thirds of it, and one-third in the San Joaquin Valley from sources there. Yet, about two-thirds of the land requiring irrigation is in the San Joaquin Valley and one-third in the Sacramento Valley; so we just have a reverse, and there must be water transportation. He pointed out some figures on total land irrigation. One thing he pointed out to us was that the chief uses of this water that's going to be made available to us immediately is the development of permanent pastures, which we know is going to create more *Aedes* problems, and inevitably there is going to be over-irrigation. He reported on our survey, the surveys he has conducted during the past year on the Delta-Mendota and Madera Canals. He pointed out the major problems asociated with them, particularly the point that structural problems are resulting from these projects. He pointed out some of the importance of seepage and the production of mosquitoes within the canals themselves. He also indicated on the basis of Millerton Reservoir, where they conducted a study last year, that they feel they can minimize the mosquito problem within the reservoir, with the methods known today. If adequate drainage had been instituted, today there would be very little problem. However, he mentioned that there is a fish farm there, developed at the instance of the Fish and Game Commission. So there is an interdepartmental relationship that must be considered in order that our interests and their interests are certainly compromised.

He also pointed out, in conclusion, that the problem is distributed over the entire Central Valley. Do the speakers have any further comment?

Mr. Kimball: Thank you very much, Arve, for that symposium. I'm sure your talented speakers have certainly brought out and emphasized the importance of our California problems, and actually it probably is a challenge to this Association to take its proper part in the future solution of some of these problems.

We will now hear from Frank M. Stead, newly appointed Executive Officer of the State Water Pollution Board.

PROBLEMS OF WATER POLLUTION IN RELATION TO MOSQUITO CONTROL

By Frank M. Stead

Executive Officer, California State Water Pollution Board

It seems fitting that we retain our present idea on the past subject and realize that we're not introducing a new subject now. This is a continuation on the three papers which you have just heard on the general subject of Water Resources Development and Its Implications as Related to Mosquito Control. We all recognize, I'm certain, that water is very seldom consumed; it's merely used and passed on. Consider, for instance, an industry like a food canning plant that uses a million gallons of water a day; almost a million gallons of water a day come out as waste water. Even water used to water crops, as you've seen from the slides, only a portion of it is consumed by the vegetation and the rest is passed on, and that water that is passed on must be used and re-used several times. So really, what we're talking about in the field of disposal of wastes is really the management of water. You fellows are not strangers to the whole concept of the management of water, and that's the line or the attitude in which we ought to approach the subject of pollution control.

Before we can consider the effects of the program of pollution control on mosquito abatement, I think we've got to know a little about the new pattern of control of pollution in Califrnia. That pattern is just now getting under way under the brand-new set of laws — and there are eleven of them — adopted at the last session of the Legislature. I'm not going to describe them in any completeness, but just give a bare thread or skeleton of the new program so that we can have something to relate our major discussion to. The theme of the new legislation is as follows: The effects of waste disposal shall be divided into three kinds or concepts of effect. First, those effects that relate to the transmission of disease or poisoning, the public health effects, and that kind of effect from faulty waste disposal is given the name "contamination." Secondly, that broad group of effects that interfere with all the beneficial uses of water but do not constitute a hazard to health, those effects are referred to as "pollution." And, thirdly, the effects of odors or unsightliness resulting from poor waste disposal, is given the title "nuisance." And, all through the new legislation when it says "pollution," bear in mind that it means the middle segment, that is not contamination, and is not nuisance, but it does interfere with beneficial uses of water.

The structure of the new organization lies in the creation of a State Water Pollution Control Board of thirteen members, four of them ex-officio officers of State government and nine appointed by the Governor, representing special interests in water use, and nine regional boards in the nine watershed regions of the State, which are composed of five men each, appointed by the Governor for four-year terms, and representing five types of interest in water pollution. First, production and supply of water. Second, industrial waste disposal. Third, the use of water for watering crops, agricultural irrigation. Fourth, city government. And, fifth, county govrernment. Those aren't the only interests, but these are five that are designated to be represented by the members of the board.

As you read this complicated set of laws — and we'll make copies available to your President if he wishes — you're impressed by their complexity and the speculatory aspects, in other words the gamble. Will it work or will it not work? The answer as to whether it will work or whether it will not work I believe lies in the men who are going to administer the laws. First of all, the stature or the caliber of the men appointed to compose these boards. Most of you gentlemen are from the Central Valley in California, and I would just like to indicate to you the nature of men who compose the Central Valley Regional Water Pollution Control Board: appointed and now acting, the Chairman is Carl Hoskinson, Superintendent of the Sacramento City Water Department and a nationally known figure in the field of water supply; second, Mr. A. M. Paul of Fresno, who speaks rather authoritatively and representatively, I think, for the wine interests in the Central Valley, which are a principal industrial activity related to waste disposal; thirdly, Dr. Lynn Knight, Tulare County Health Officer, whom many of you know; next, Clift Plummer, Chief Engineer of the Modesto Irrigation District, a man who has had experience not only in the problems of irrigation, but in the municipal and industrial problems of waste disposal which fall within his area; and lastly, Mr. Ed. Westgate of the Delta area, who is not only possessed of experience in California, but particularly in his Army experience, where he had heavy responsibility in the development of agricultural activities in European countries. They represent, I think, all told, a board of considerable merit. The next thing of importance with respect to man are the type of men who will be the executive officers of the regional boards, and although none have yet been appointed, the candidates who have presented themselves for consideration and are being reviewed by these boards, some of whom I have heard of, are surprising. They are men of outstanding stature in California and in the United States. So that I think the manpower augurs well for the success of this program.

One of the fundamental changes which the new law makes is to replace the permit system, whereby all activities of waste disposal were regulated previously by the State Department of Public Health through its Board of Health, by means of permit system, with regulation through the State and Regional Water Pollution Control Boards, not by means of a permit system, which reviews the type of units that are built for the treatment of sewage and industrial wastes, but enunciates the requirements of the end results of that activity and leaves it to the discretion and resourcefulness of the applicant to reach those end results. It specifies what kind of an effluent shall be discharged, where and how it shall be managed to prevent any of these effects, contamination, pollution, or nuisance. That program is accomplished by the enunciation by the regional board in every case of a set of requirements. Let me read one section; I'm only going to read, all told, three sections of the law, but they are extremely important, and listen carefully because I will refer back to it.

Section 13054 of Chapter 1549 reads as follows: "Any person proposing to discharge sewage or industrial waste within any region other than into a community sewage system shall file with the Regional Board of that region a report of such proposed discharge. The Regional Board after necessary hearings shall prescribe requirements as to the nature of such discharge with relation to the conditions existing from time to time in a disposal area or receiving waters upon or into which the discharge is proposed and notify the person proposing the discharge of its actions. Such requirements may be revised from time to time. After receiving such notice, the person so notified shall provide adequate facilities to meet any such requirements with respect to the discharge of sewage and industrial waste."

Now what does that presribing of requirements with respect to any discharge and the conditions of the area into which it takes place mean — what does it mean to you fellows here in the room? Put all these things that I mentioned together, and what are their relations to mosquito control districts and vector control interest? I would say about as follows: First, when liquid wastes are to be disposed of either by discharge into bodies of water or by disposal onto land, there is to be considered the potentiality of a health hazard, namely, contamination, in the meaning of this new act, resulting from the breeding of the vector mosquito and the requirements pertaining to that discharge must contemplate that. Now, how could that be visualized? Let's say that an industrial waste or a municipal waste is to be discharged by land disposal and there are two alternatives. First, it might be disposed of after certain preliminary treatment by percolation into the ground. The successful control of odors would probably require that the effluent be placed into the soil and disappear from impoundment on the surface, let's say, within forty-eight hours, so that percolation should have a good forecast from the standpoint of mosquito control because its cycle is so small.

The other alternative might be oxidation ponds or lagoons, which is a continuing or permanent body of water. That might have a greater mosquito breeding potential. Secondly, consider the chemical and physical nature of that waste; it may contain nutrients which will cause prolific growths of algae, with floating blankets of algae; that might intensify the mosquito control problem in what was a previously permanent impoundment with little mosquito problem. Consider that if it is necessary to have a permanent pond or lagoon it may be very important to consider the accessibility of all portions of that pond for mosquito control, and you can see some of the things that you may need to write into those requirements that are issued by the Regional Board. I think you can begin to see some paths beginning to be worn between you and the Regional Board.

Second, let's say there is to be disposed of solid wastes like cannery screenings, garbage-like material. That could be a contamination from the potential of the breeding of flies or the breeding of rodents in an area where such an activity would be closely related to the transmission of disease. I think you can see that there is another very real likelihood in which you may help the Regional Board think out those requirements, so that a contamination from the disposal of solid waste will not result.

Now let's say that there is no health hazard to be considered. There are still the other environmental effects, usually referred to as "nuisance," not only from the standpoint of odors and unsightliness, which is nuisance under the new law, but those factors that result from the annoyance, the pest activities of the breeding of insects or mosquitoes that interfere with recreation or the comfortable enjoyment of life and property. If recreation is interfered with by prolific breeding of insect life, that is a pollution within the meaning of the new law, because the beneficial use of water for recreation is interfered with, even though there be no health hazard. I think you can see that for both liquid and solid wastes the Regional Board needs your counsel to prevent those effects which are their responsibility.

Now there are two other sections of the law. I hardly think I need enlarge on them if you listen very carefully, because they are two of the most phenomenal provisions of law that have ever been written into California statutes. I don't know whether they will continue in their present form or not, but they are there for a year.

First, Section 13020G: "The State Board shall have the power to require any State or local agency [that's you] to inspect and report on any technical factors involved in water pollution." Water pollution is those things that we have just been talking about; and the next section gives a similar power to the Regional Boards, and it is as follows:

"Each Regional Board with respect to its region shall require any State or local agency [again you] to inspect and report on any technical factors involved in water pollution or nuisance." Why are those unusual? Because these new agencies of government are given the authority to call upon you, not to request, but to require you to render service to them out of your own specialized technical knowledge without any particular plan for reimbursement. Now the change that may be made in this law next regular session will be to provide for payment for that service if it becomes necessary, but the powers, I think, are likely to remain.

Now I could enlarge on this from here on out, but I'm trying to set a record. That's where I propose to quit any formal presentation. Should there perchance be a question, I will do my best to try to answer it. Thanks a lot.

Mr. Kimball: Thank you very much, Mr. Stead. I'm sure that we can all squeeze in a minute for a question on this particular subject. Does anybody have a short question he would like to ask Mr. Stead now?

Comment: I'd like to ask Mr. Stead if this Board, which I understand has the power on new developments, has any power over old systems.

Mr. Stead: Yes. Without going into a quoting of the other sections, I can summarize it with this: every new development is required to serve advance notice of intention to the Regional Board leading to the promulgation of a requirement that is mandatory. Any existing development may ask the Board what the requirements are and the Board must give them an answer; or if the board discovers that any existing situation constitutes, or threatens to constitute a pollution, or nuisance, or contamination, then the Board is empowered to exercise these same powers. One thing that I did not make clear is that the responsibility for abatement of the health hazard type contamination rests still with departments of public health.

The sections that I have read to you I have related to mosquito abatement districts. Up to this morning we have been talking over their implications with relation to the technical staff of all departments of government, and those are the things that have received the greatest attention. In other words, this program makes the engineering staff and the regional water resources the engineering staff for this program for investigation. It makes the Sanitary Engineering staff and the Department of Public Health part of the engineering staff for this program. Similarly the engineering and biological staffs in the department of natural resources, but I wanted to particularly point out this morning, if I can read English, it means the know-how of mosquito abatement districts, too.

Mr. Gray: I'd like to ask one question, and that is: Much of our abatement work falls under the nuisance classification, because after all, under Section 2271 of the Health and Safety Code, mosquito breeding as caused by use of the land, is defined as a public nuisance. When you come, however, to contamination of natural waters, would that be under the contamination phase, rather than nuisance phase, or have you given any thought to that?

Mr. Stead: How the distinctions are made is on the basis of, How does it affect people? If it affects their health, through disease or poisoning, it's a contamination, regardless of whether it's a new situation, or an old one, disposal in the water, disposal on the land, or anything else. If it is an odor or an unsightly condition, it is a nuisance under the water pollution statutes; if it is an impairment of the comfortable enjoyment of life and property and particularly recreational activities, it's a nuisance in common law, it's a nuisance in civil code, it's a nuisance in penal code, but it's pollution under the water pollution laws. The water pollution laws do not supersede any other laws, so that the old remedies are still there, still to be exerised by District Attorneys, by county health departments and so forth; but the new one is put in there in case the others fail, as they have in many instances failed for one reason or another in the past. So, it's an over-ride without there being any substitutions. Thus there are about five ways to get at a nuisance that is a pest or mosquito problem as the case may point. It can be a civil action under the civil code; it can be a criminal action under the penal code, if it's a public nuisance; it can be a water polution requirement under this act; and there are probably other remedies. There are many ways to get at the same old problems. This is one new way and, it looks like it's got some pretty good steam behind it.

Dr. Tinkham: I'd like to ask one question in relation to your paper, and it's a question that I had to deal with expressly this fall. In fact, I found that my biggest fight was not with the mosquito, but with men of the Coachella Sanitation District. I tried for three months to get action to correct the sewage plant that had gone into neglect for about ten years. We had one of the representatives from the State Engineering Bureau down there, and it seems to me that the State is rather lax in its laws. I wanted to get some action and I didn't know how to get action. Finally, through an editorial program in the local paper which threatened State action we got some action from the Sanitation Board after three months. Of course, if they hadn't acted, then I dont' know what would have happened, because from what I've heard the State is rather recalcitrant, or would not press the matter because it would take a year or two to get action out of the State to put pressure on the Sanitation Board. Now does this new setup change that situation? How can you get action on the Sanitation Districts that won't act on your suggesions?

Mr. Stead: You've asked two questions. Will the new laws be an improvement over the administration of the old laws? Everything considered, I certainly believe they will. Beginning right at the main question, which I might paraphrase by simplifying into a few words — What's been wrong with the State Department of Public Health? — that's really what you are saying and that's what everybody's been saying. It's a complicated answer. It would take a good deal of time to answer it, but I wouldn't back away from answering; for if you've got the time to listen, I've the time to tell you. An understanding of the issues raised by that question has been lacking, quite largely, throughout the State, but there isn't time to deal with that one this morning. With respect to your second question — Do the new laws have teeth or hand-holds to them so that you can get at a question and get at it quickly and get a quick solution? I believe they do, because the new laws have honestly faced the real causes of delay in the past. What are those causes of delay? Enough appropriation and financial backing and provision for manpower so that the studies and facts can be divulged. Second, a more clear-cut and clean abatement action than we have ever had by the rather dilatory method of revocation of a permit. Third, these laws together with other laws have recognized the biggest stumbling block to progress. which is dollars and cents. How can you build if you don't have the money, how can you get the money if the people won't vote it? These laws face that problem in a realistic, although perhaps not yet an adequate fashion. In other words, the laws are intended to put the pressure or attention to the key stumbling blocks of the past which have been present. Now, how successfully they will do that, only experience will tell. No one believes these to be final. No one believes these to be the laws of any one person in California the way they are written, because they are frankly a compromise; but the very fact that the compromise was possible to end up with something that could move is in itself a step forward. A compromise is far better than an impasse, and an impasse is about where we were before.

Mr. Kimball: Thank you, Mr Stead.

Mr. Dahl: Mr. Chairman, may I add one comment? It will only take half a minute. This opens up a challenge to us for the need of certain basic information. We in the Bureau realize that we are not going to be able to provide all information needed nor are we going to have all the technical ability even if we could devote all our resources to solve and provide the information. It's one more point that presents itself to indicate that we must work together, and that those of you who do have a problem and have a solution must try and solve it and extend that information to the rest of the fellows who are working on this joint problem.

Mr. Kimball: Thanks, Arve. Well, Frank, I think we certainly will take you up on your offer as far as the extra copies of the law. I believe that our districts would appreciate one for their file if that is possible on our request to your office.

Mr. Stead: It sure is. I'll send to Mr. Dahl whatever copies he thinks are needed.

Mr. Kimball: That will be the easy way, thanks. We'll go right into the subject that I know that this Association has been trying to emphasize in all their programs and in all their meetings, and that is getting the trustees aware of our programs and out to our meetings. So, it's a pleasure to have Mr. Pruess present A Trustee's View of Mosquito Control. As you know, Mr. Pruess is the President of the Consolidated Mosquito Abatement District.

A TRUSTEE'S VIEW OF MOSQUITO CONTROL

By Adolph F. Pruess
President, Board of Trustees
Consolidated Mosquito Abatement District

My past experience as a district superintendent and at present as the president of a Board of Trustees should make me well qualified to give a paper entitled: "A Trustee's View of Mosquito Control."

A trustee's view and also his opinions of mosquito control can no doubt be many and also quite varied due to his attitude toward his district and also the cooperation that he obtains from the district manager and the various employees.

As a rule our first thought of mosquitoes may be that of the pest variety and not the disease carriers, because it seems to me that in most instances the people within an abatement district want control so that they may be rid of the mosquito nuisance in order for them to enjoy outdoor recreation and also outdoor living during the summer evenings. It seems to me that with most of the people within an abatement district there does not seem to be enough concern about the types of diseases that may be carried and spread by mosquitoes unless a person may have had personal knowledge of an instance where a certain disease may be due to a mosquito bite. In this respect I feel that perhaps the many mosquito abatement districts in cooperation with the Bureau of Vector Control have gone a long ways in trapping and studying the disease carriers, and through their combined studies and findings shall make the people within any district perhaps more conscious of the presence of such disease carriers within their own district.

I believe that we cannot overemphasize the publicity that is necessary to go along with a research program so that the public shall stay aware of the fact that a constant effort is being made to learn more about the different species of mosquitoes but also newer and better means of controlling them. Public relations work is very important in mosquito control work and should not be overlooked in any district, and only by doing a thorough job in this line will the people in a district have a favorable opinion of a district.

My views and also my opinions of a district is that the work of such a district is both preventive work and control work. It can be considered preventive because we are on the alert at all times to keep the mosquito population at an absolute minimum, therefore minimizing the possibility of an outbreak of a mosquito-borne disease, but should such an outbreak occur we will have an organization with sufficient men and facilities available to cope with the situation on very short notice and bring the outbreak under immediate control.

Upon my return from participation in the armed forces, I was a bit concerned about the possibility of mosquitoes and also mosquito-borne diseases being brought into our country from foreign lands. One can very easily understand that from the large numbers of troopships arriving at our seaports and also the cargo planes arriving at our airbases that the possibility of an outbreak of a mosquito-borne disease could very likely happen. In a recent issue of a leading farm publication, Mr. A. P. Messenger, Chief of the Bureau of Plant Quarantine, reported that in November a total of 890 ships arrived in ports of this State and all were inspected. The Bureau also inspected 360 airplanes and found all kinds of materials which are hosts of many pests that could create havoc if they got a foothold in our orchards and fields. In this report of his he dealt mainly with orchard and field pests, of course but a report of this kind makes it possible for us to visualize that there still exists that possibility of an introduction of moquitoes and mosquito-borne diseases from foreign countries. It was very gratifying to me to see the great advancements that had been made by mosquito abatement districts since shortly before the war and the rapid increase of new mosquito abatement districts throughout the state immediately following the close of the war. To me that was an indication that the people within our State, after having heard about various tropical diseases, were on the alert about our servicemen returning from foreign soil and they took the necessary steps to expand and redouble all efforts to keep all mosquitoes under control so that we would not be faced with a major epidemic of some type.

Due to the advent of newer insecticides in the past few years I feel that great strides have been made in the handling of control methods, and no doubt in another few years some of these new insecticides may be replaced very rapidly by still newer ones, and a district must strive to keep abreast with them all.

To me it is most regrettable that so few district trustees are in a position to attend any of the various meetings pertaining to mosquito control that are always being held at various times throughout the State. One of these meetings in particular is this yearly conference, where we as trustees can sit among you and not only listen to your reports of the great achievements that some of you have made but also hear about the many difficulties that you men encounter in your daily work. However, we must understand that perhaps most trustees are either professional men or men whose business requires their ever presence. In this respect I believe that all the district managers do appreciate the great efforts that are made by the many trustees to even attend their own regular meetings.

In closing, I wish to say that it has been a pleasure to present this paper to you and I also wish to acknowledge that I feel that I have been able to obtain some good in attending these yearly conferences, even if for nothing else than to get acquainted with you men from the various districts. I want to see your continued cooperation in the future to be the same as it has been in the past in regard to your mosquito control problems. I feel that by giving a certain amount of time to regional meetings your men will be in a better position to talk and compare your control problems with other districts whose problems may be quite similar.

I have tried to attend as many of the Valley meetings as possible and hope to be able to continue meeting with you men, as I feel we are all interested in but one thing and my definition of that would be "absolute mosquito control."

I thank you.

Jack Kimball: Thank you, Mr. Preuss. It's always a pleasure to hear from a Board member not at a Board meeting. By the way, we haven't had a count of Board members here. Could we have all of the Board members stand and just see what kind of attendance we have? [It developed that Board members were present from the following districts: Turlock, Fresno, Consolidated, Butte County, Salt Lake City, Delta, Orange County, and East Side.]

Mr. Kimball: We have a little addition to add to our program, which I know you are interested in. Mr. Lindquist has been prevailed upon to give us just a short review of his work on the gnat control in Lake County, and as you know Mr. Lindquist is the Entomologist in charge of the Corvallis Laboratory in Oregon. We are certainly pleased to call on you, Mr. Lindquist, to give us your report.

Mr. Lindquist: There seems to have been considerable interest in the gnat program in Lake County. I think the program is pretty well tied up with interests of the Bureau of Vector Control and to a lesser extent the mosquito control districts. The Lake County people took upon themselves the problem of doing something about their scourge and nuisance, the Clear Lake gnat. It was a major decision on their part, and they consulted with a number of agencies before going ahead. They discussed the problem with the California Fish and Game Commission, and this agency gave them considerable help in a research way as well as advice. They talked with the California Bureau of Vector Control and of course they seemed to lean rather heavily on our agency, the U.S. Bureau of Entomology and Plant Quarantine. Anyhow, they took the full responsibility and it was decided to treat the lake with DDD, which has resulted in nearly 100% reduction of gnat larvae. Even with such a good reduction you can well see that there might be a few million survivors in the lake. Will this gnat eradication, if it gets almost to eradicaiton, have any particular effect upon the economy of the lake? We don't know; I don't suppose anyone knows. The Lake County people seem to be willing to assume the responsibility of going ahead. We think that the fish will be perfectly all right. There will be other forms of food that they can feed on. We will have other gnats, not necessarily the Clear Lake gnats, but the lake is a heavy breeder of chironomids, so the folks down there may have chironomids to fight instead of the Clear Lake gnats, although I would not expect them in such great numbers as the chaoborid gnat.

I have been very happy to have had the opportunity to work with Arve Dahl and his men, particularly Mr. Walker, on this gnat problem, and we feel that our work is about at an end on it. We are going to take one more series of samples about the first of April and then I think it will be up to the local people, aided and assisted by the Bureau of Vector Control, to continue any observations and any studies that they might see fit to determine what will be the final result of this so-called eradication program.

Mr. Kimball: Thank you very much, Mr. Lindquist. Dick, I would like to take a few minutes to have you introduce the new districts, I believe, that have been formed this last year. Isn't Lake County one?

Mr. Peters: Not in the last year. However, it's very recent.

Mr. Kimball: Have they been at these Conferences before?

Mr. Peters: No, they have not yet, but we might introduce Eric Winkler, who is the Entomologist for the Lake County District.

Mr. Kimball: That would be the latest addition, then?

Mr. Peters: There was a new district formed in Placer County called the Mt. Vernon Mosquito Abatement District. We've sent letters to Placer County attempting to identify it and we've had every bit of correspondence returned. There is also a district in Placer County at Sheridan, but neither is presently operating there.

Mr. Kimball: Are there any announcements anyone would like to make? I will ask for a report on the elected regional members to the Association Executive Committee.

From the San Joaquin Valley, Rolland Henderson has been unanimously elected. How about the Sacramento Valley, Joe?

Mr. Joe Willis: Mr. Portman was selected tentatively until a Board of Trustees meeting next week. He thinks the Butte County MAD is going to become a member of the Association, and it's contingent on that.

Mr. Kimball: That will be swell. Who will represent the San Francisco Bay area?

Mr. Aarons: We selected Mr. Howard Pangburn.

Mr. Kimball: Swell, Mr. Pangburn. Now, the South, Dr. Tinkham?

Dr. Tinkham: Mr. Norman Ehmann has been selected as the Southern California representative.

Mr. Kimball: That will complete our Executive Committee and we are now in shape to have a meeting. I warn you now that we would like to hold our first meeting right after our afternoon session; it will be just a matter of half an hour or an hour. as there are three or four things that we can settle with everybody here. We have to form committees and programs and make several appointments immediately in order to get our program started without waiting for the next several months. So, if you will plan on staying here right after this afternoon session we will roll it through fast so that you can get out and relax before too late tonight.

We are going to start now with our old friend, Dick Peters on this session on Special Problems. I think Dick needs no introduction, so I'll turn this over to Dick, who will be the Moderator.

Mr. Peters: Thank you, Mr. President. I don't know why I was chosen to handle this particular discussion other than that I seem to be the most frequent tourist of California and thereby probably manage to run into more aspects of special problems, but I do want to emphasize that from here on in, formality goes out; here is where we begin to break it down; here's where the session opens up so that everyone who has a special problem, who would like help on his special problem, has the floor and will be so honored.

I'm going to give a brief review, if I may, on a few items, but the first thing I want to touch upon in opening special problems is a very disturbing impression I received upon having gone to the top of this auditorium and looked down. I found a lot of personal special problems able to be seen from above which are not nearly so, or at least very detectable from here. There are lots of people who are in need of a hair restorative. There are obvious new moons creeping in, some half moons, and some full moons. Now, to me, having observed this group for a period of a decade or a little better than that, it's very startling, because it suggests to me that we'll have to ask Harold to move over a little bit. However, there are a few others, I also noticed, who have been in this game for a long time, and I think I might cite Ernie Campbell as the supreme example who appears not to have lost a hair on his head. So I guess it is not necessarily a corollary that if you keep working on mosquitoes long enough you are going to lose your hair. Some people can still justify a comb in their pockets. So that is by way of a personal outlook upon the subject.

The matter of special problems is as liberal as any subject that I could think of introducing. It reminds me of a maze of a sort, in which we could start down a path and every blind alley we came to might be a special problem. If we had good judgment, or the resources for solution, we would move on; if not, we would go down and hit our heads on the end wall, until finally we worked our way through the maze and came out with the mosquito control solution. A rather liberal proposal has been made by some as the object of mosquito control — the absence of mosquitoes; eradication some people call it. Such would be through the outlet of that maze. I will be utterly amazed if we get there.

Now, as far as specific problems are concerned, they are many and varied. In the course of this meeting I have itemized several leading suggestions which might possibly stimulate the discussion of problems.

The CMCA had a special problem last night. It requires a quorum of fifteen persons in order to conduct business, fifteen representatives of corporate members, in order to conduct business. that is. There were only fourteen there last night, but fortunately since the Constitution hadn't been officially adopted, it didn't make any difference; however, in future meetings I think your President is going to hopefully look forward to solving that problem. That might promote some discussion.

The keynote address in this Conference was to the effect that if, and when, we persist in permanent measures we will have our ultimate solution. I want to defend in part the Sacramento Valley people who consider that everybody else in California has a minor mosquito control problem, because in addition to irrigated pasture they have a matter of rice, which has continuous water use throughout the growing season. It doesn't lend itself to very good permanent control, and as such it is a problem that deserves discussion. Some of you in the San Joaquin Valley have likewise indicated that you can drain the water from the extremes of the field, but how about those spots in the middle of a pasture, do they lend themselves to permanent control? This might constitute a special problem.

There is more than one person in this audience who considers that *Aedes nigromaculis* is a special problem. I think Ed. Davis will still give you a blank expression if you ask him where his *Aedes nigromaculis* came from last August, and Art Geib and Gordon Smith, I think, are going to have to do the same thing.

There is a problem in regard to local financing of mosquito control if and when a given agency has a problem in excess of the amount that the governing body is going to provide them to control mosquitoes; that is a problem. There is certainly more than one agency represented here that has a situation of that kind. Further, there is such a possibility as a problem characterizing certain agencies where even if a governing board would give them the maximum provided, would they be able to adequately cope with it under present day methods? That is a decided problem.

There exists as a problem the distinguishing of where services of a mosquito abatement district should leave off and where private obligation should begin. That is a decided problem which could take the rest of the afternoon.

The answer to what we do to resistant mosquitoes is still a little bit hazy in my mind. I think it still is very much of a problem unless you can get eradication.

Another thing, fly control is on the verge of being a reality in some parts of California and a mosquito abatement district is a logical means of handling fly control. Do you want it or don't you want it? It's a problem.

We have heard it expressed that there may be a cyclical nature to the occurrence of encephalitis in California. Is it on the upswing, and if it is, how are we going to solve the problem and still not be embarrassed by the presence of encephalitis cases in our mosquito abatement agencies? Particularly with other things complicating it like the presence of aggressive *Aedes* mosquitoes that may force a priority in your program.

There is a last very sobering thought, supposing we have another depression — I shouldn't say supposing — when we have another depression, what are we going to do in the way of adjusting to it? That is the most fundamental problem, I think, which can ever be discussed for the near future. It's a question of which year it's going to be.

By way of getting down to special problems that have already been met, this little gadget that you see here is in response to a problem. This is an adaptation of an adaptation of an adaptation of the "Plumber's Nightmare." The "Plumber's Nightmare," as you all know, was conceived and executed by Ted Raley and Bill Miller in the Sutter-Yuba District back in 1946. It has taken many forms and shapes. One thing that has been difficult to correct in it has been the carbonizing of the liquid as it came into this unit. Now, through the very careful thinking, or what you could call applied engineering, of one of the members of the Sutter-Yuba Mosquito Abatement District, Mr. Al. Flemming, an innovation has resulted which looks to be not only a means of reducing carbonizing but also of pre-heating the liquid and making for the dispensing of a volume of material that was previously not thought possible through a motor vehicle exhaust venturi aerosol. I want Al. Flemming to stand up and be recognized. He told me he wouldn't give a talk here, but I think he certainly ought to be recognized for his ingenuity in this regard. I will mention nothing more about this unit other than that it will be featured in the next issue of the *Mosquito Buzz,* and I am going to try to get the facts on it and then present them to you.

You noticed on this blackboard this morning a diagram. In the Northern San Joaquin Mosquito Abatement District, which district my twin brother happens to manage, he and his staff met their problem by adapting this Al Flemming principle to their York-Hessian. They used the development that had come through Jack Kimball and Archie Perkins of the Orange County District, and the same principle that has been improvised here, and they feel that they have now produced out of the York-Hessian machine the ultimate in aerosoling. That is also in response to a problem. I don't know who to give the credit to for this. Bob, who deserves the credit for that?

Mr. Bob Peters: Well, let's wait and see what it will do.

Mr. Dick Peters: Anyway, there have been many, many unique pieces of equipment and other responses to problems in California. They're happening daily in California mosquito control. In drawing my remarks to a close, I wish to mention I have a personal problem too that I might explain to you. This tie was given to me for Christmas. If you have ever visited Ed Smith's home, he has a kitchen called — it's decorated, actually, in a color called shocking pink. Well, I'm wearing this tie and Ed's living in his house and we're both happy.

Now I'm going to invite anyone and everyone to express himself on his own personal problem in regard to California mosquito control. I'm going to take the liberty of being rather short in allotting time for the expression of problems, because we have two symposia that are coming up that are really worth listening to, above and beyond individual problems. So, the floor is now open, and when you do arise, if you will please state your name and state clearly your problem, please. Dr. Tinkham.

Dr. Tinkham: I'd like to start it off. Can you give me a few minutes? I have problems; if I develop a moon it will be from — I hope from — pulling my hair out of my head. Yesterday I intimated that one of our problems was gnats. a different kind of gnat than has been mentioned here; but before I go into that I just want to make a few comments about mosquito control, because I know that that's far more important and interesting to you than my own particular problems on gnats.

We have in our valley two types of mosquitoes in one area where we have an impervious layer of silt superimposed over the sand, and that causes standing water. In that area we have two types of mosquitoes breeding, *Aedes vexans* and *Psorophora confinnis.* I won't say more than that. I know you'll hope that I do a good job of controlling *Psorophra confinnis* so that it won't invade the rest of California. If that happened, you'd have thirteen major mosquitoes to deal with in California.

The second problem in mosquitoes I mentioned briefly this morning was in connection with the Coachella Sanitation District. The chief breeder there — in fact, I think the only breeder there — is *Culex quinquefasciatus.* Dr. Hu yesterday suggested or intimated that in Hawaii it was a vector of Japanese B encephalitis. In connection with your statement of encephalitis, is it on the upswing? I believe that down in our area it is. Just this fall through my efforts I may have nipped an incipient epidemic in the bud, because there were two cases in Coachella Valley this fall with 50% mortality. A member if the Bureau of Vector Control came down late in November and discovered twelve horses sick with encephalitis. So, I think the matter of control of that species is very important, although here in California I don't think that *quinquefasciatus* is incriminated in the transmission of encephalitis.

I want to bring up two points in connection with Mr. Arve Dahl's summary this morning, in which he said that no problem should be promulgated to the exclusion of others or all others. Yesterday I saw flashed on the screen here a picture of some bulldozers going to work on a river bank that was quite well forested, and the thought struck me then and there that that seems to me to be a very expensive way to go into the control of mosquitoes. There was little information provided, so I assumed that all the trees were going to be pushed down, and the thought that struck me is in that connection. Have the interests of the Soil Conservation Service and the Soil Reclamation Service and a few others been taken into consideration there? Just as soon as those trees are bulldozed down along the banks of the river you'll have some very important problems opening up that I think are even more serious than the mosquito problem, and that is the washing away of our soil.

Our big problem down in Coachella Valley is gnat control. and I want to try and give you the idea that our problems or any investigation is likely to open up avenues of research. You don't have to be brilliant, or anything like that, but usually when you work along in a problem a new avenue opens up. For instance, in my talk yesterday I reviewed briefly the results of our chemical lab tests of last summer. Now it's quite different story when we want to apply that to the field. Dr. Ralph March and Dr. Metcalf were down there in the initial stages. We found, after our chemical control efforts in the field were over, more gnats in the area than before. How would you like to find more mosquitoes in your area after you had treated it than before? Well, that's one of the problems that's liable to remove a few hairs from your head, but that opens up a very interesting possibility, the fact that the gnats, we think, moved into that area. They must show a positive chemotropism to that chemically treated area, and it opens up a possibility of developing a chemical bait.

Mr. Peters: Dr. Tinkham, we're getting awfully pressed for time. Might I suggest postponing your remarks since the next symposium is on ecology, and it sounds to me as though, from what I know of your background material, it's probably going to be on ecology, is it not?

Dr. Tinkham: Yes, I'll try and just wind this up and then I won't have to take any time later on. What I would like to have, why I'm bringing this matter up, is to raise this question. If any of you have had any experience with chemicals that could be used in irrigation water or drilled into the soil, or dusted or sprayed on the soil before irrigation, thta could be used for control of gnat larvae in the soil, I would be very happy to receive any comments or suggestions as to what chemicals to use, keeping in mind that we don't want a chemical in the soil that the roots of the date trees or the citrus will pick up and deposit in the fruit. I think that's a problem. I had a few other things, but I will cut them out right now.

Mr. Peters: We appreciate the fact that you would like more time, but the pressure of time is considerable. Is there some one now? Jack Arnold.

Dr. Arnold: Just one word concerning the reclamation pictures shown yesterday. That area was impenetrable on foot. We could not take pictures there to show the preliminaries. Last year, there was one spot that the only way we could dust it for *Aedes vexans,* was by helicopter. In the meantime, I believe, they are getting some ten acres of useful land there of vast agricultural value that was not even level.

Mr. Peters: That was a very constructive rebuttal. Would anyone else like to offer a problem or further comment on problems that have been raised?

Mr. Kimball: I'd like to ask Jack Arnold one. How do you arrange the cost of that type of work?

Mr. Peters: The question has been asked, Dr. Arnold. how do you arrange for the cost on that type of work?

Dr. Arnold: I'd ask the manager.

Mr. Dick Peters: Manager?

Mr. Bob Peters: May I suggest that this will be taken up also at a later symposium?

Mr. Dick Peters: Problems, please? You are the happiest-looking bunch I've ever seen. Pete Pangburn.

Mr. Howard Pangburn: I wish Dr. Isenhour would come in, as I'm looking for some chemical, some herbicide, to kill tules.

Mr. Peters: That's a serious problem. Is there anyone here who can offer a solution? Joe Willis? Could you supply us with an answer on how to kill tules? [Reply inaudible.] Do you have any suggestions, Gordon Smith?

Mr. Smith: I'd like to pose the same question. We're a little interested in killing tules too.

Mr. Ernest Campbell: The Bureau of Reclamation has quite a little background of experience on that.

Mr. Peters: Can you recite any of their recommendations, Mr. Campbell?

Mr. Campbell: No. we used some and killed the tules. We didn't have a very serious problem. We haven't gone into it, but I do know that they've quite a background of experience on the use of these herbicides.

Comment: What sort of dosage do you have to have?

Mr. Campbell: I think for your express problem, if they have it they can give it to you.

Mr. Peters: Is there any other district in California that has recorded *Psorophora confinnis* in its boundaries? If you have you've been holding out on a lot of people. That problem will also be touched upon in the ecology symposium. I'm perfectly willing to let such contented people remain cotented. I think probably the solution to mosquito control is well nigh here. Ted Raley.

Mr. Raley: Now that we have solved the mosquito problems, we too have a problem in our district concerning a retirement plan.

Mr. Peters: Is there anyone here who is engaged in a retirement plan?

Mr. Gray: As far as I know our district, Alameda County, is the only one which is at present under the State Employees Retirement System.

Mr. Robinson: East Side is in the Stanislaus County Retirement System under a special State law. At the present time our rate for the district is about 5.7% of the payroll, and for the employees it runs from nearly 8% in the case of one down to about 4% for some of the youngsters who have just come in.

Mr. Raley: Does Alameda County have a county plan?

Mr. Gray: No, we had a special county plan in Alameda County under the county charter, but without an amendment to the charter we would have been unable to get into the county plan as it's set up. Now the county has given up their own county charter plan and gone into the State setup, the same type as the East Side District. I think all the districts ought to get in.

Comment: Harold, may I ask, did the plan that Chet is under require an actuarial investigation?

Mr. Gray: Yes, I think it does, and it's under very definite control by the State laws.

Comment: It's quite similar to the plan that you are under.

Mr. Gray: Except that I think it's simpler for us because the State Retirement System has its own actuarial and everything and I think the cost is a little lower, lower than it would be the other way.

Mr. R. Coburn: In the West Side District in Kern County we're under a county retirement plan — Kern County. I think our rate is a little higher than the State rate, but it was a little simpler for us to get in. We were able to get in on a retroactive basis. We have a compulsory retirement age at 70; arbitrary retirement at age sixty, or twenty years' service. We've found it very successful.

We've never got any returns on it yet, but I think it's a very fine thing. As to the actuarial plan, the county offices have that setup in operation, but it is compulsory that any special district that gets into this plan has to stay in it 100%.

Mr. Peters: Ed Washburn, hasn't your district conducted investigation into retirement sytems and didn't you draw conclusions on it?

Mr. Washburn: No, we did not.

Mr. Peters: Is there any district which has conducted investigation and drawn conclusions upon the matter? Paul Jones?

Mr. Jones: In Marin County the people voted for a retirement plan for all of the county employees. I think it's under the 1937 Act setting up these pension programs. If you put in twenty years you get one-third of your monthly salary in pension, and if you should die while you are still in the employ your wife gets the amount that you have put in plus interest ,and she also gets six months of your salary. Our board is going in on that this year.

Mr. Peters: Is there someone here who has investigated retirement plans and who would give some argument about why a district doesn't get the maximum of return from such a plan? It seems to me that I can recall some people having indicated that where their personnel turnover is considerable the district stands to lose the maximum, and they didn't think that it was desirable for that reason.

Mr. Robinson: Dick, I might mention a point there, under the same law that the Marin County MAD is planning to operate. For the men who are putting in that money, that is returned to them when they quit. I think our rate is whatever they put in, plus 2½% interest. Also, your so-called temporary employees are not listed on that, so your day-laborers or six-month operators or any of that sort are not in on that program. You don't have to put it in on your entire salary in the districts.

Mr. Kimball: I'd like to make just one point on that. Orange County has been with the county retirement which is set up on that county retirement act, I believe the one you are referring to. In that act any district within the county is eligible to be a member without the consent of the Board of Supervisors. They are automatically eligible if they wish and apply to the Board for permission to do so.

Mr. Peters: From the last Regional Meeting, or rather from a discussion with George Umberger of the Sacramento-Yolo Mosquito Abatement District I learned that they either are in or are contemplating going in the State plan very shortly. Is there anybody from the Sacramento-Yolo District here who could explain that? [No response.]

I think probably this discussion has gone about as far as it could go. Ted, I don't think that you've been rewarded terribly.

Mr. Raley: I'm glad to see that there is an interest and hope the Association will take this up in the near future.

Mr. Gray: You see the difficulty (if I might interject here) is this, that MAD employees at the present time, unless we go into the State sytem or one of these county systems where it's set up in the county, have no retirement provision at all except what you can save yourself. We are excluded from Social Security, so are in an unpreferred position all the way around. It doesn't seem to me to be exactly fair that because we are public employees in a special category we should be excluded both from the opportunity of going in with the State system or our local system or having any benefits whatsoever under the National Federal Security, yet we are contributing our taxes to the darn thing just the same, don't forget that.

Mr. Peters: A good pointed remark, Harold. Paul Jones?

Mr. Jones: There's another thing there of group insurance. I know it's awful reasonable. That might be something to consider.

Mr. Peters: Alameda County has it and I'm sure Consolidated MAD has a group insurance plan, but in my mind the biggest problem at the present time is whether or not we're going to get out of here at five o'clock. so I'm going to arbitrarily close this session, and if there is any other time following the two symposia we'll be very happy to resume with special problems.

Mr. Kimball: Thank you, Dick. I know that a session of this type is one of the most interesting and one of the most valuable we can get into on a setup like this, and its' only because we are pressed for time that we have held back in our questions. I know if we had plenty of time we'd get into some real interesting discussions. So, we'll turn the meeting right over to our Vice President Elect, who will be the Moderator for the next symposium, which is on "The Place and Scope of Ecology Related to Mosquito Control." You all know Ed Smith, who is the Manager of the Merced County Mosquito Abatement District.

Mr. Smith: Ladies and gentlement: So far in this Mosquito Conference we have discussed problems of equipment, problems of insecticides, and water problems. We now come to the point where we are going to discuss the mosquitoes themselves.

First a definition is in order. The title of the Symposium is, "The Place and Scope of Ecology as It Is Related to Mosquito Control."

THE PLACE AND SCOPE OF ECOLOGY AS IT IS RELATED TO MOSQUITO CONTROL

By EDGAR A. SMITH

Manager, Merced County Mosquito Abatement District

Mosquito ecology is that part of biology which deals with the relationship of the mosquito to its environment. Control, abatement, or extermination of mosquitoes is impossible without a knowledge of mosquito ecology. However, the application of such knowledge to control methods often lags far behind the discovery of ecological facts.

As early as 1665 it was reported by Robert Hocke that the adult mosquito developed from a larva generated in rain water. This was confirmed by Swammerdan, De Geer, and Kleeman, but the next great advance in knowledge didn't come until 1734 with Réamur's work on the complete life history of *Culex pipiens,* which was accepted as representative of all mosquitoes everywhere for the next 150 years. The next stimulus to research into the biology and habits of mosquitoes was a direct result of Manson's discovery of the role of the mosquito in the transmission of filariasis in in 1880. This in turn led to the work of Ross, Grassi, Celli, Manson, and others, in 1897-99 demonstrating malaria and the indictment of *Aedes aegypti* as the yellow fever vector in 1900 by Reed, Carroll, Agramonte, and Lazaear.

These ecological discoveries of the role of mosquitoes in the transmission of disease stimulated the first large-scale attempts to control mosquitoes. Probably the first practical application of ecology to mosquito control was L. O. Howard's experimentation with kerosene applied to water to kill mosquito larvae and pupae in 1892. (The subsequent success of mosquito campaigns in Malaya, Panama Canal Zone, the Suez Canal, etc., are so well known as to require only a brief mention in passing. These campaigns were all aimed at preventing the production of mosquitoes by eliminating their aquatic larval habitat or destroying the larvae, and were based on a knowledge of the apparently simple fact that the larval stage of the mosquito must have water. That part was discovered over 200 years before it was put to a practical use in controlling mosquitoes, and it is not universally accepted even yet. Mosquito control workers still run into individuals who claim that mosquitoes "breed" in their lawn, shrubbery, or trees, and that it is a waste of time to look for mosquitoes out in their pastures.

During the past fifty years knowledge of mosquito species, life histories, habits, and habitats has grown tremendously. Control methods have also come a long way since Howard's experiments with kerosene in 1892. Mosquito control took a great upsurge during and immediately after the late war, with large-scale application of new ideas in engineering and chemistry such as aerosoling, large-scale liquid airspraying, and of course the new insecticides.

We in California mosquito control today face two major problems. First is the necessity of controlling mosquitoes in irrigation water which cannot be eliminated because it is essential to the farmer in the production of his crops; and second is the the failure of DDT to effectively control mosquitoes as it has in the past.

Perhaps what we need is a new and different approach to the problem, or possibly an older and more basic approach. In Herms and Gray's *Mosquito Control* there is the statement: "It is entirely probable that progress toward effective control of mosquitoes will from now on depend increasingly on the extension and application of biological knowledge."

Possibly we should stop and take stock of our efforts in mosquito control. Perhaps we are overlooking some simple facts about mosquitoes which might be used in the fight against them. Maybe we should direct more of our efforts toward basic research on the ecology of mosquitoes. But, first — what do we already know about the ecology of mosquitoes in California. Dr. William C. Reeves will now tell us something about the Present Knowledge of Mosquito Ecology in California.

Dr. Wm. C. Reeves: That's really a build-up. The first thing I want to do is to thank Ed very sincerely for being so liberal in his definition of ecology. Believe me, I need it, because that really lets me talk about anything I want to, and that's what I propose to do.

THE PRESENT STATUS OF KNOWLEDGE OF MOSQUITO ECOLOGY IN CALIFORNIA

By WILLIM C. REEVES

Associate Professor of Epidemiology, the George Williams Hooper Foundation for Medical Research and the School of Public Health, University of California, San Francisco and Berkeley

Those of us who are participants in this Symposium have been faced with a most difficult assignment. Naturally I felt my assignment was particularly difficult. How can the present status of knoweldge of mosquito ecology in California be discussed without infringing on the more specific subjects of all the other participants? I trust they will forgive me if I happen to mention the ecology and control of *Aedes, Anopheles,* or *Culex* mosquitoes. I assure you that if it happens I will have done it on purpose.

A study of this subject has convinced me that few areas of the world have as comprehensive a knowledge of the ecology of their various mosquitoes and apply this knowledge in their control operations as does California today. Many eyebrows may be raised at this statement. but I believe we can substantiate it with examples.

As a rule, the discovery of ecological facts receives one of two treatments. If it is a fact which leads to new control methods or is incorporated in existing methods, it is quickly accepted and becomes a part of control procedures. It is too frequently and too soon forgotten that the original discoverer may have required keen perception to make this discovery, and deep insight to apply it properly. On the other hand, an ecological finding for which no immediate use can be found is frequently held at arms' length, regarded sceptically as a scientific oddity, and considered the product of an impractical scientist's or observer's worthless efforts. Our knowledge of the ecology of California mosquitoes includes many facts of both the above types.

The mosquitoes of California have been the subject of intensive study since the early 1900's, yet few people are intimately acquainted with the extensive contributions made in the first thirty years in this field by pioneer workers such as Quayle, Dyar, Freeborn, Herms, and Gray. The product of their ecological studies and applications is so basic to present-day control methods and so widely accepted that we forget its origin. Today many of us who think we are embarking on new biological studies are brought up short. when in reviewing the literature, we come across our supposedly new problem or hypothesis and answers concisely presented in the earlier work.

To refresh my background for this discussion, I again reviewed for my own benefit the available published data on the ecology of California mosquitoes. I am sure you will be surprised at some of my conclusions. I assure you that this is not to be an exhaustive review of every detail of our knowledge, but rather a general historical story.

Reports of the extensive early studies in California are scattered in the scientific literature. The first complete compilation of available information is Dr. Freeborn's *The Mosquitoes of California,* published in 1926 by the University of California Press. Here the earlier work, including nine years of study by Dr. Freeborn, is made available in concise summary. The basic reason for this study may be quoted from his introduction: "The real science of mosquito control, and the efficient application of control measures, rest upon an acurate knowledge of the taxonomy of the group and a thorough acquaintance with the ecology of the species involved."

It is interesting to note that in this study mosquitoes are divided into three main groups of importance: (1) salt marsh pests; (2) mountain *Aedes,* an obstacle to enjoying the Sierra Nevada mountains; and (3) the malaria-carrying anophelines. Since this time our interests and problems have obviously broadened and shifted. As an example, Freeborn discussed the increase of *Aedes dorsalis* in California due to expansion of irrigation, and felt that only in recent years had this species risen to the importance of being the most troublesome non-malaria-bearing mosquito in the central valleys.

Thirty species and subspecies were known from the state at this time, and available ecological facts were presented for each species. At that time many of these species were not believed to be as important as subsequent developments have revealed they are. This basic information was the starting point in later years for further ecological study and control operations. While subsequent studies on the taxonomy and ecology of California mosquitoes have increased the number of species, our knowledge of ecology, and the techniques of control procedures, they in no way detract from the value of the earlier work.

For additional information on subsequent developments in our knowledge of ecological findings and their acceptance and incorporation into control procedures, there is no better soure of information than the Proceedings of the seventeen Conferences of Mosquito Abatement Officials of California. I do not know of a single important new finding, with regard to the ecology of California mosquitoes and its application to control problems, which has not been presented at these meetings *either before it was published elsewhere,* or it was reviewed and discussed here within a year of publication in scientific journals. This is an outstanding tribute to the value of these conferences. In addition, let us not forget that many of these observations and applications have been made by the control operators, as well as the entomologists.

Perhaps it will be of value to review briefly what has been presented in the Proceedings in the way of ecological facts and their applications to mosquito abatement problems.

At the first Conference of Mosquito Abatement District Officials in California, held in 1930, Professor Herms told of the University mosquito survey project which was started in 1909 to determine the extent and types of mosquito breeding in every county in the state. This information was generously made available to all persons interested in control problems.

In 1931, most of the conference was devoted to discussion of ecology as it applied to control. Flight migration habits of *Anopheles maculipennis, Aedes squamiger.* and *Aedes vexans* were compared, with emphasis on the control problems they presented. The biology of *Anopheles maculipennis* was discussed at great length by control operators and University entomologists.

In 1932, by popular demand, the Conference held their first laboratory demonstration on mosquito identification, which was accompanied by presentation of corollary information on mosquito habits. The officials cited many examples where such knowledge had been the key to difficult field problems. Homer Lowe, Alameda District Entomologist, presented his "Observations on the Breeding Habits of *Aedes squamiger*," which included data on *Aedes dorsalis.* This paper led to the clarification of several field situations.

A question on the habits of *Culex tarsalis* and *Culex pipiens* led to heated debate. Widely divergent opinions were expressed, emphasizing the lack of accurate knowledge of these species at the time.

One of the few available discussions of the problem of controlling Mountain *Aedes,* and their ecology in the Yosemite Valley, was given at the 1932 Conference.

In 1933, Homer Lowe presented another study on "Life History, Habits, and Control of the Tree Hole Mosquito." This information was real news to many officials, leading to the statement, "I bet that was my problem this spring when we never could find the source of many complaints in my district."

Up until 1934 the principal interest in California had been centered on the ecology and control of salt marsh *Aedes* and the malaria vector *Anopheles maculipennis.* At the Fifth Annual Conference in 1934 Professor Herms reported that fresh water *Aedes dorsalis* of California experimentally was capable of being a vector of Western equine encephalomyelitis. Thus a new facet of the biology of this mosquito came under scrutiny. Also, by this time this species had been accepted as the principal pest of the Central Valley.

At the Seventh Conference in 1936, Dr. Freeborn presented information on the seasonal migrations of *Anopheles,* and emphasized the potential value of intensive control of early spring broods of larvae in areas other than rice fields. It was recommended that districts carry out such a program, inasmuch as ecologically it seemed feasible. How widely or conclusively has this premise been tested, even today?

One of the very few available studies on *Culiseta* was presented in 1936 when Mr. Wieting, Entomologist for the Alameda District, read a paper on "Notes on *Theobaldia incidens* with Special Reference to its Ecology." This study was carried out in answer to the dispute as to whether this species would bite man, and to furnish information as a basis for control.

At the 1937 Conference Tommy Aitken gave the first of his many contributions to these meetings, "The Distribution of California *Anopheles* with Remarks on Collecting Methods." He separated the three recognized species by the types of breeding places in which they were found and offered this as an approach to selective control. A series of very interesting tables at the end of the Eighth Proceedings lists the primary and secondary control problems for each existing district, based on the mosquito species and their known ecology.

At the 1934 Conference Aitken reported on "Observations on the Mosquito Problems of the Dr. Morris Mosquito Abatement District." This paper was the result of a consultative service in which certain perplexing control problems were solved by an explanation of the ecological facts leading to the problem. Interestingly, no *Aedes nigromaculis* were noted as complicating the problem at that time.

At this meeting Fred Rush presented the first paper on "Re-flooding and Re-draining Salt Marshes for Mosquito Control." This should be listed as a classical example of the application of ecological information to a control problem.

Discussion of the Proceedings of the 1939 Conference might be prefaced by a statement Ernie Campbell made in introducing a symposium on control problems: "A thorough understanding of the life history of the specific mosquito involved is of course the starting point of all procedure." Tommy Aitken reported on "Mosquitoes belonging to the Genus *Culex* in California." The habits and morphology of nine species were given, but only *C. pipiens* and *C. quinquefasciatus* were considered distinct pest mosquitoes, with *C. tarsalis* occasionally. This led to some argument, with one school saying *C. tarsalis* bites like hell, and the other saying not on me.

The separation of *Anopheles maculipennis* into *A. freeborni* and *A. occidentalis* and differences in their ecology were introduced and discussed by Aitken. Also, *Aedes nigromaculis* was reported as a new arrival in California, the first record having been in 1937.

A flight range of 35 or 40 miles was announced as established for *Aedes taeniorhynchus* in Southern California.

At the Eleventh Conference in 1940, Aitken read a paper on "The Relationship of the Distribution of Cases of Equine Encephalomyelitis (Human and Equine) and Mosquitoes in California." Thirty-seven species and subspecies of mosquitoes were discussed as compared to the thirty reported by Freeborn in 1926. Many records of *Aedes nigromaculis* had accumulated since its discovery in 1937.

Reeves reported on further studies on *Aedes varipalpus,* including factors affecting the hatching of *Aedes* eggs. The Conference considered the possible application of the egg findings to field work on flooding and re-flooding for control. In spite of the two comprehensive reports on the biology of *A. varipalpus,* several districts of the Central Valley failed to recognize this species as the source of yearly sieges of complaints. Field demonstrations on this problem by consultants were still necessary in 1943.

In 1941, what we might term "the Encephalitis Era" was born. *Culex tarsalis* was suddenly taken seriously, and Harold Gray emphasized the problem involved in expanding control measures to cover the previously neglected *Culex* species, and the need for more intensive study of their habits. There ensued considerable debate on the status of *Culex tarsalis* and *Culex stigmatosoma,* one school believing that they were morphological variants of a single species, the variation being controlled by ecological factors. I trust this point will be clarified conclusively by Dr. Brookman today.

It was also reported that *Mansonia perturbans, Psorophora confinnis.* and *Orthopodomyia signifera* were present in California. It might be mentioned that if *Psorophora* were to spread from Southern California to the Central Valley area present problems would be even more complicated.

At the Twelfth Conference in 1941, Aitken presented the essence of his Ph.D. thesis in a paper on "Clarification of the Anopheline Complex of Western North America," with emphasis on the ecological information of value to control programs.

Reeves and Peters discussed the problem of *Aedes nigromaculis* taking over *Aedes dorsalis* breeding territories, thus posing a new problem in control. Another laboratory identification period was held, with a key for 38 species, including general ecological notes.

Mr. Kelley discussed cemetery mosquito breeding problems and the result of special studies on means of control.

In 1944, the California vectors of encephalitis were discussed by Reeves, and in 1945 the problem of *Culex tarsalis* control was presented, including the first detailed account of larval sources, the need of close inspection services, and use of shelter collections for evaluation of control.

I believe these brief notes I have taken from the first thirteen Proceedings of these Conferences indicate quite conclusively the wealth of ecological facts we possess and their application to control problems. There is no single source of information which would serve so well for indoctrination of a stranger into the problems in California. The two editions of Herms and Gray's *Mosquito Control,* while in no way limited to California problems, include this wealth of biological information on the mosquitoes of California; and one only has to read this book to realize how well ecological facts and control procedures have been integrated. They are inseparable.

In deference to subsequent speakers and the audience, I have purposely omitted any consideration of developments in our knowledge since 1945. In conclusion I would say: we are rich insofar as a knoweldge of the ecology of California mosquitoes is concerned, but in the true fashion of man let us continue building on this fortune. We can't retire yet.

Mr. Ed Smith: I started out by putting Bill on the spot, but I think he has quite effectively turned the tables and put me on the spot. However, it is a spot that I think I share with every other district manager. The next speaker will be Gordon Smith on "The Application of Ecological Facts to Mosquito Control Problems in California."

Mr. Gordon Smith: Dr. Reeves claimed he had the tough one. I think I've got it. Just as a sidelight before we start this, I think that the Dr. Morris Mosquito Abatement District or now the Kern takes a bow on the olive grove fiasco. That was ours.

Ed Smith and I independently started off in the same way. However, I still think it holds, so I will read a definition of ecology too.

THE APPLICATION OF ECOLOGICAL FACTS TO MOSQUITO CONTROL PROBLEMS IN CALIFORNIA

By Gordon F. Smith

Entomologist, Kern Mosquito Abatement District

Webster's International Dictionary defines the term ecology as "Biology dealing with the mutual relationships between organisms and their environments." If this definition is interpreted liberally, as I believe it should be in the field of mosquito control, then all of our efforts past, present, and future are directed toward changing the environment in order to make it impossible or at least as difficult as possible for mosquitoes to survive. Diking and draining or otherwise eliminating water to remove the mosquitoes' natural habitat. Brushing and training streams and cleaning ditches to keep the water free-flowing. The introduction of mosquito fish into their native habitat to destroy the larvae. The contamination of the water in which they breed with chemical toxicants and oils, and as a last resort the contamination of the air through which the adults fly and the surfaces upon which they rest with aerosols and sprays.

So, even in considering the broadest bases and the most elemental methods of mosquito control, it is evident that the attack is against the broadest or most general facts of mosquito ecology. The facts that the larvae live in water (quiet or semi-quiet), have natural enemies, and the adults fly freely and rest on surfaces other than water. By attacking through these points alone, we can obtain a certain amount of mosquito control. However, in the interests of efficiency, and concurrent refinements in techniques and methods, much more knowledge of larval and adult biology is necessary.

An understanding of the larval ecology and egg-laying habits of the adults has told us many things. Through the study of larval ecology we now know which species of mosquito larvae we will find associated with the general types of water, *i.e.,* polluted, clear, slowly moving, in artificial containers, etc. This type of information allows us to set up more efficient programs for the control of mosquito-borne diseases in that knowing where to find larvae of the vector species we may direct a maximum of effort toward that particular habitat. It allows us to assess the possible importance of places which may, at a future time, become possible mosquito breeding places. By knowing the species of adults present and the habitat of the larvae of that species, we may run down their breeding place more rapidly. In the case of *Aedes varipalpus,* several districts were in considerable trouble until it was discovered that the larvae of this species developed in tree holes. And, last but not least, knowledge of the length of time that it takes the larvae of the different species to develop at different periods of the year is of considerable assistance in the planning of the whole program of mosquito control, especially as to the numbers of personnel and the area over which they may reasonably be expected to maintain effective control.

In considering the ecology of the adults much has been done, but there is also much more which can be learned.

Is the control of all species necessary? The little knowledge we now have of biting habits indicates that it is not. In the Kern Mosquito Abatement District we make no attempt to control *Culiseta spp* or *Anopheles franciscanus* because if they bite human beings it is so rarely that no complaints result. Also, the knowledge of the biting habits which we now have has allowed for some degree of assessment of pest significance of the species present. It also tells us that we cannot readily determine presence or absence of small numbers of *C. tarsalis* through complaints, since they rarely bite human beings to the extent that a complaint is registered even though they are present in considerable numbers.

Knowledge of the choice of resting places of the various mosquitoes can aid greatly in determining whether or not a residual adulticiding program may be worth while. If it is apparent that a species prefers to rest or hibernate wild it is self-evident that residual work is pure waste. This knowledge with other habits of the adults will also aid us in discovering preferred resting places or other methods by which we may determine more accurately the prevalence of adults in an area and so assess the effectiveness of the control program.

A knowledge of the flight range of *A. freeborni* with its flight dispersal patterns has already been of aid in the rice-growing areas of the State. I think that some of us in the Central Valley would have given our left arms last summer for a little of this information on *Aedes nigromaculis*. It might not have got rid of the adults, but may have helped us explain to the taxpayers as well as oursleves where they came from. Knowledge of a differential range of male and female of the same species may also aid in determining the approximate distance of a breeding place from the location of adult collection.

The knowledge of the effect of temperature and relative humidity on the adult may also give us much information. It is known already that these factors have a direct bearing on the length of life of adults, a question which we are often asked in the field. There are indications that lowering of temperature and increase of relative humidity during the mosquito season may lengthen the life of adults present, causing an increase in adult numbers which may be mistakenly thought to be an indication of increased breeding.

We might well, at the same time, give consideration to the problem of the effect of the environment of the mosquito, both larval and adult, on the insecticides which we use, and there is much more room for study here. We know that so far the chlorinated compounds tested are of little value in normal dosages against larvae in highly polluted water. A complete explanation has not been put forward.

It is also becoming more apparent that temperature has a direct bearing on the effectiveness of the compounds. Just how much effect it has on the various materials used and how this can be best offset in control procedures needs more consideration.

We have accomplished much through knowledge of mosquito environment toward bettering control methods, but I believe that there is still a great deal to learn which will in one way or another make our work more effective.

Ed Smith: Thank you, Gordon. We now come to three gentlemen who are actively engaged in research into ecology of mosquitoes, and they are going to give us some idea of the possibilities of practical applications of their information.

First is D. C. Thurman on "The Ecology of *Aedes* Mosquitoes in California."

THE ECOLOGY OF *AEDES* MOSQUITOES IN CALIFORNIA

By Deed C. Thurman, Jr.[1]

S.A. Sanitarian (R), Bureau of Vector Control
California State Department of Public Health
Berkeley, California

Ecological observations on *Aedes* mosquitoes in California have been coordinated with control operations since the beginning of both entomological investigations of mosquitoes and their control from the standpoint of disease vectors and pests.

The group which received some of the very earliest attention included the salt-marsh pests, *Aedes taeniorhynchus* (Wiedemann, 1821), *Aedes squamiger* (Coquillett, 1902), and *Aedes dorsalis* (Meigen, 1830). Herms and Gray (1940, p. 139) state: "On the Pacific Coast . . . the pickleweed, *Salicornia ambigua*, is the typical salt-marsh growth. For all practical purposes it is a correct statement that breeding of *Aedes dorsalis, Aedes squamiger,* and *Aedes taeniorhynchus* occurs on the Pacific Coast only in association with the *Salicornia*."

A second group of *Aedes* which is less important to the control program in California at the present time is that group associated with mountain areas; the adults of this group emerge from larvae living in the water of melted snow in the early spring. These will take on increasing importance as the human population in the mountain areas grows and as there is increased use of the more remote mountain areas for summer recreation; as any fisherman will tell you, the high mountains in early spring months can rarely be endured without adequate supplies of mosquito repellents!

Another group of *Aedes* is represented in California by *Aedes varipalpus* (Coquillett, 1902), the Pacific Coast mosquito which breeds in water-filled holes in trees. This species, often an important pest where numerous holes are present in trees, is reported by Reeves (1940) to occur in fifteen species of trees as well as in a rock pool, a barrel, and a watering trough. Lowe (1933) reported that *A. varipalpus* was not restricted to tree-holes, since he reared them from eggs to adults in tap water.

The fourth group, which will be dealt with in greatest detail, is that group of *Aedes* associated with floodwaters and irrigation waters. Actually in the Central Valley this major grouping should be further divided into those mosquitoes which are of major importance due to overflow of rivers and those which are of importance during the summer irrigation season. *Aedes increpitus* (Dyar, 1916) has a peculiar transitional position in this grouping. This species occurs at low altitudes as well as in the mountains, in fresh-water shallow grassy lakes, temporary to permanent (such as marshes and mountain meadows), and might be considered a link between the true "Snow *Aedes*" and the species of the floodwater group.

The species involved with floodwaters are *Aedes sticticus* (Meigen, 1838) (=*lateralis*) (see Gjullin, 1946) and

[1] From the Bureau of Vector Control, California State Department of Public Health, and the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

Aedes vexans (Meigen, 1920). *A. sticticus,* while it may occasionally be abundant in limited areas where it is best adapted to shaded flood pools, is not as great a problem as *A. vexans.* Though generally associated with wooded flooded areas during spring freshets, *A. vexans* may become a problem in irrigation ditches and drainage sloughs where shade is sufficient. *A. vexans* is reported by Aitken (1940a) to be abundant primarily throughout the Central valleys, where it is found along wooded banks of streams and rivers. It is primarily a floodwater mosquito, appearing in great numbers after spring freshets. There is, however, apparently another group of the *A. vexans* population which can be found breeding with *A. dorsalis* and *Aedes nigromaculis* (Ludlow) in pastures, especially late in the year. More than one generation per year was observed by Aitken.

A. dorsalis, on the other hand. prefers the more sunlit areas and is found throughout the season in irrigated pastures as well as flooded areas and drainage areas which are intermittently flooded. *A. nigromaculis* is associated chiefly with irrigated pastures, being well adapted to the hot summer period and the intermittent flooding and drying.

The extent of the problem related to irrigation has grown as the *Aedes* problem related to river flood plains has decreased. This has been a change brought about by the tremendous increase in irrigation projects and the control of river floods. The biological adaptation of *A. dorsalis* and *A. nigromaculis* to the irrigated crop areas has resulted in an increase in the total mosquito problem. In the river flooded areas, one, two, or three large broods were to be expected during the season, while at present in irrigated pastures, as many as six to eight or more broods may be reasonably expected.

According to the last Bureau of Census reports (1945), the acreage of land under irrigation in California increased from slightly over 4 million acres in 1939 to almost 5 million acres in 1944. This has been the result of a steady increase of about 100,000 acres placed under irrigation each year, 60,000 of which are in the Central Valley. The National Resources Board (1948) estimated that 1¾ million acres of new land soon will be in irrigation and that 2½ million acres now under irrigation will receive supplemental water. This same board estimates that California has an ultimate 16⅔ million acres of irrigable area, 8½ million acres of which are in the Central Valley. With relation to the *Aedes* problem, the acreage which will be used for permanent pasture is the most important at the present time.

One of the most conspicuous changes in the mosquito problem of the past fifteen years has been in the apparent introduction and adaptation of *A. nigromaculis* to the irrigation system of the Central Valley of California. Prior to 1937, *A. nigromaculis* was unknown to California, having existed in the Great Plains area of the United States and Canada, where it was associated with flooded and irrigated areas. Freeborn (1926) did not list this mosquito as existing in the California fauna, and Aitken (1940a) reported that an examination of the extensive collection of mosquitoes built up by Drs. W. B. Herms and Stanley B. Freeborn during the early years of the California mosquito survey revealed no specimens prior to his 1937 collections. Aitken (1938) in a survey of mosquito problems in Kern County, July 1938 (Dr. Morris Mosquito Abatement District) did not report the presence of *A. nigromaculis. A. vexans* and *A. dorsalis* were the principal biting pests in Bakersfield. The first reports of *A. nigromaculis* in California are those of Aitken (1939) from Anderson, Warm Springs, and Fall River Valley, Shasta County, June 20, 1937, and from Stanislaus and Tulare Counties in 1939. Aitken (1940a, p. 11) before the California Mosquito Control Association's meeting December 16, 1940, stated the following about *A. nigromaculis:* "*Aedes nigromaculis* appears to be a newcomer to California, only having first been found here in 1937. It is a rather widespread species of the western plains regions extending from the Mexican border northward on both sides of the Divide into Southern Canada. Since its original collection in California in the Fall River Valley in northeastetn Shasta County. it has been found in an increasing number of places each year. Its distribution at present appears to be restricted to the interior valleys from Greenfield, Kern County, north to the Redding region in Shasta County; from here it spreads northeastwards through the low Sierras into the Fall River country and on up on the Modoc plateau. Careful search this past fall failed to indicate its presence in Siskiyou County, although *dorsalis* was very abundant (Yreka-Grenada area); on the other hand, *nigromaculis* was the dominant, if not always the only, *Aedes* biting in the Fall River Valley."

Ehmann (1950) states that the area in California in which *A. nigromaculis* has been found has been extended during 1949 to include the San Fernando Valley in Los Angeles County. Shanafelt (1950) reveals that *A. nigromaculis* has been found in Orange County during 1948 and 1949. The first year only a few were found; the second year the infestation was more general. Aarons (1950) reports the finding of *A. nigromaculis* in Alameda County during 1948 and 1949.

At the time of his 1940 studies, Aitken felt that the breeding habits of the fresh water *A. dorsalis* and *A. nigromaculis* were about the same. They are both pastureland species. *A. dorsalis* had, at that time, a much wider distribution than did *A. nigromaculis;* some were recorded even in areas bordering Mexico.

At the 1941 meeting of this Association, discussion of the *Aedes* problem elicited the comment from Dr. W. C. Reeves (1941) that: "*Aedes nigromaculis* seems to be taking over where *Aedes dorsalis* was formerly prevalent. *Aedes dorsalis* appears early in the spring and *Aedes nigromaculis* comes later."

Changes in mosquito species population densities are not uncommon. Provost (1949) at the 1949 meeting of this Association, referred to a change taking place in Florida mosquito ppoulations during 1948. *A. taeniorhynchus* for many years has been the principal problem on the East Coast of Florida. During 1948, *Aedes sollicitans* (Walker, 1856) populations increased in both total numbers and in relative proportion to *A. taeniorhynchus.*

The vectorial potentialities of the *Aedes* mosquitoes related to irrigated lands need to be mentioned. *A. nigromaculis, A. dorsalis,* and *A. vexans* have been shown to be efficient laboratory vectors of one or more of the arthropod-borne virus encephalitides (Madsen and Knowlton, 1935; Madsen, Knowlton, and Rowe, 1936; Herms, 1939; Hammon and Reeves, 1943). In nature, *A. dorsalis* has been found naturally infected with encephalitis virus (Hammon and Reeves, 1945). From the epidemiological-entomological work of Hammon and Reeves in the past few years, the importance of *Aedes* as compared to that of *Culex tarsalis* in transmission of virus encaphalitides, at least in California, appears less than formerly believed. Yet, with the complexities of the vectorial relationships of these diseases still being demonstrated, all potentialities must be as fully explored as is justifiable. With the likelihood of a considerable increase in the *Aedes* populations in the irrigated areas in the next ten to fifteen years, the vectorial potentialities of these mosquitoes cannot be ignored.

An expansion of our knowledge of the ecology of *Aedes* mosquitoes in the Central Valley is under way at the present time as a project of the Turlock Mosquito Abatement District and the Bureau of Vector Control. This project has received the support of the Executive Committee of the California Mosquito Control Association, and along with other ecological studies has been recommended for support by the Bureau and cooperating mosquito abatement districts receiving subvention funds. Realizing the extent of the problems, almost all of the districts in the San Joaquin Valley have offered their individual support either in facilities for the staff of the investigating units or in conducting various phases of ecological investigations in which their particular interests lie. It cannot be overemphasized that the work of district entomologists in these ecological studies will be of great value not only to their own districts but to all the districts in California faced wtih similar problems.

The next section of this paper is entitled "We Need to Know," since it is desired to include a discussion of what some of the immediate problems are. Perhaps many of the districts will find in their own experiences the answers to many of the questions raised.

We Need to Know

1. What is the extent of the habitats of *A. dorsalis, A. nigromaculis,* and *A. vexans,* and the relative importance to the control program in each district of such habitats as: (a) irrigated pasture, (b) cotton, (c) rice, (d) hay crops, (e) orchards and vineyards, (f) vegetable crops, (g) drainage ditches and sloughs, as well as the special problem, (h) duck clubs.

2. We need to know the flight range of *Aedes* mosquitoes in order that we may be able to determine how far to search for the origin of the mosquitoes causing the "service requests" to come to the abatement district headquarters. The variability of the flight range due to climatic factors in various parts of the valley and the effect of seasonal changes must be learned. In this, observations by district entomologists will play a great part.

3. We also need to know the details of the time periods of the stages of the life cycle: eggs, larvae, pupae, and adults, throughout the year, and the effect of environmental conditions on these stages. Proper timing of control work, particularly the application of toxicants, is the key to the most efficient use of man power.

As a summary to our need for knowledge of mosquito ecology to aid the abatement program: We need to measure the various environmental, ecological factors which affect the *Aedes* mosquitoes in all their life stages at all times of the year throughout California. We include relationships of mosquitoes to the transmission of human disease as a phase of ecology that needs more investigation.

As an example of one of the types of biological relationships involved, Markos (1950), who has been responsible for the Sacramento Valley mosquito biology studies, has been making observations of mosquitoes in rice fields, and has imparted to us valuable information with regard to a specific ecological problem. Each season, with the initial floodings of the rice fields, a heavy density of *Aedes* mosquitoes *develops*. This may be as early as the middle of April and the first part of May. At this time, for a period of about two weeks they are a special problem for the districts in which they occur. As the rice fields are under continuous flooding all summer, no subsequent broods of *Aedes* are produced. The fields may be drained any time from the latter part of August to October 1 depending on when the rice fields are flooded in the spring and the particular seasonal climatic conditions. The question arises: At what time do the rice fields become infiltrated by adult female *Aedes* in sufficient numbers to deposit the eggs which are responsible for the early brood the next season? If this could be ascertained, then it might be possible to develop certain practices which would render it virtually impossible for the *Aedes* females to infest the rice fields with appreciable numbers of eggs. To obtain this information. we must know some of the factors influencing the female mosquito in her choice of time and place for oviposition.

Of course rice fields are only a relatively minor part of the total *Aedes* problem, as indeed the *Aedes* are a minor part of the total rice field mosquito problem. The principal problem with *Aedes* exists in the permanent pastures subjected to frequent intermittent irrigation. Therefore, the study of the egg-laying habits of *Aedes* in permanent pastures presents itself as a problem of paramount interest. And from this study we may be able to determine what are the reasons for the occasional infestations of such other crops as cotton, fruit, and rice.

Studies of *Aedes* eggs under natural conditions promise to yield much information which may be of value in directing our activities. How long and how much drying are *Aedes* eggs able to withstand under natural conditions? When fields are allowed to lie fallow for several years, what is the effect on the *Aedes* eggs present in these fields? Following plowing of pastures or fields which have been well "seeded" with *Aedes* eggs, what is the effect on the eggs?

These and other questions of a similar nature should occupy the study unit of the Bureau of Vector Control as well as the entomologists of the abatement districts for a considerable period. As possible new approaches or refinements in control methods seem indicated from ecological information, field trials should be made. For, after all, is not control of mosquitoes an ecological process — that is, simply an attempt by man to render the environment of the mosquito unsuitable?

Available Literature

Freeborn (1926), Herms (1939), Aitken (1939, 1940a, 1940b), and Reeves (1940) have published a great deal of informaion with special regard to California *Aedes*. Lowe (1932) made some valuable observations of the biology of *A. squamiger*. Bohart (1948) has added to the knowledge of *Aedes* systematics, and it is our understanding that other valuable papers are in press and in preparation. There is a movement under way by the mosquito abatement districts of the Bay Area, assisted by the Bureau of Vector Control, to learn more about the flight range of *A. squamiger* as well as to increase the knowledge of the bionomics of the saltmarsh species.

Outside of California, studies of *Aedes* mosquitoes have been made which are particularly significant and provide valuable guides to methods of approach in the study of California *Aedes.* Stage (1935) reported ecological observations in Washington and Oregon with especial reference to mountain *Aedes, A. vexans,* and *A. aldrichi* (*sticticus*). Also among these studies is the work of Gjullin (1938) in developing a machine for removing *Aedes* eggs from soil with which we have been successful in obtaining *Aedes* eggs from pasture soils. Stimulants for producing a hatch of *Aedes* eggs have been studied by Gjullin, Yates, and Stage (1939) and by Gjullin, Hegarty, and Bollen (1941). Dormancy of *Aedes* eggs was studied by Gjullin and Yates (1946), and the effect of drying on the viability of *Aedes* eggs was studied by Yates (1945). Rees and Neilsen (1947) studied the biology of *A. dorsalis* with many results applicable to the California mosquito control problem. Johnson and Thurman (in press) have reported an additional *Aedes* (*A. pullatus* from the Sierra Mountains). Studies by the Bureau of Vector Control on the biology of *Aedes* during 1949 are in press (Thurman and Mortensen in press).

Using the accumulated knowledge of others and adapting methods and techniques they recommend to our studies, along with innovations we develop as we pursue the studies, we hope to be able to obtain timely and useful knowledge of the biology of *Aedes* mosquitoes. Our work will be significant in mosquito control only insofar as the results can be made to fit into the activities of the abatement programs; and in this phase of the work, the entomologists in the respective districts doing highly practical ecological studies of their own will lead the way to maximum utilization of the knowledge of the ecology of *Aedes* mosquitoes.

Acknowledgments

The author wishes to acknowledge the valuable assistance of other members of the Biological Section of the Bureau of Vector Control in supplying basic information and suggestions which have been incorporated into this paper. Many of the Subvention personnel of the Bureau as well as the Publications Committee have made valuable suggestions.

Literature Cited

Aarons, T. (1950). Personal communication.

Aitken, T. H. G. (1938). Observations on the mosquito problems of the Dr. Morris Mosquito Abatement District. Proc. 9th Ann. Conf. Cal. Mosq. Cont. Assoc. 56–60.

Aitken, T. H. G. (1939). Two new *Aedes* records for California (Diptera, Culicidae). Pan-Pacific Ent. 15:13–14.

Aitken, T. H. G. (1940a). The relationship of the distribution of cases of equine encephalomyelitis (human and equine) and mosquitoes in California. Proc. 11th Ann. Conf. Cal. Mosq. Cont. Assoc., Dec. 1940, p. 8.

Aitken, T. H. G. (1940b). Notes on *Aedes nigromaculis* Ludlow, *A. increpitus* Dyar, and *Culex territans* Walker in California (Diptera, Culicidae). Proc. Ent. Soc. Wash. 42:142–147.

Bohart, R. M. (1948). Differentiation of larvae and pupae of *Aedes dorsalis* and *Aedes squamiger.* Proc. Ent. Soc. Wash. 50:216–218.

Bureau of Census (1945). Census of agriculture, Vol. II. Washington, 1947.

Ehmann, Norman (1950). Personal communication.

Freeborn, S. B. (1926). The mosquitoes of California. Univ. of Calif. Pub., Tech. Bul. Ent. 3:333–460.

Gjullin, C. M. (1938). A machine for separating mosquito eggs from soil. U.S. Dept. Agric. BEPJ Circ. ET 135.

Gjullin, C. M. (1946). A key to the *Aedes* females of America north of Mexico (Diptera, Culicidae). Proc. Ent. Soc. Wash. 48:216–236.

Gjullin, C. M., C. P. Hegarty, and W. B. Bollen (1941). The necessity of a low oxygen concentration for hatching of *Aedes* mosquito eggs. J. Cell. and Comp. Physiol. 17:193–202.

Gjullin, C. M., W. W. Yates, and H. H. Stage (1939). The effect of certain chemicals on the hatching of mosquito eggs. Science 89:539–540.

Gjullin, C. M., and W. W. Yates (1946). The survival of *Aedes vexans* and *Aedes lateralis* eggs in nature. Proc. 14th Ann. Meeting Cal. Mosq. Cont. Assoc. 89–92.

Hammon, W. McD.. and W. C. Reeves (1943). Laboratory transmission of St. Louis encephalitis virus by three genera of mosquitoes. J. Exp. Med. 78:241–253.

Hammon, W. McD., and W. C. Reeves (1945). Recent advances in the epidemiology of the arthropod-borne virus encephalitides. J.A.P.H.A. 35:994–1004.

Herms, W. B. (1939). Medical Entomology. The MacMillan Co., New York. 582 pages.

Herms, W. B., and H. F. Gray (1944). Mosquito Control. The Commonwealth Fund. 419 pages.

Johnson, P. T., and E. B. Thurman (in press). Occurrence of *Aedes pullatus* (Coq., 1904) in California.

Lowe, Homer J. (1932). Studies of *Aedes squamiger* in the San Francisco Bay region. Proc. 3rd Ann. Conf. Mosq. Abt. Officials in Calif. Paper No. 1.

Lowe, H J. (1933). Observations on the tree-hole mosquito *Aedes varipalpus* (Coq.) D. and K. Proc. 4th Ann. Conf. Mosq. Abt. Officials in Calif. Paper No. 1.

Madsen, D. E., and G. F. Knowlton (1935). Mosquito transmission of equine encephalomyelitis. J. Am. Vet. Med. Assoc. 86:662–666.

Madsen, D. E., G. F. Knowlton, and J. A. Rowe (1936). Further studies on transmission of equine encephalomyelitis by mosquitoes. J. Am. Vet. Med. Assoc. 89:187–196.

Markos, B. M. (1950). Personal communication.

National Resources Board (1948). Irrigation agriculture in the West. U.S. Dept. of Agric. Misc. Pub. 670.

Provost, M. W. (1949). Mosquito control and mosquito problems in Florida. Proc. 17th Ann. Conf. Calif. Mosq. Assoc. 32–35.

Rees, Don M., and Lewis T. Nielsen (1947). On the biology and control of *Aedes dorsalis* (Meig.) in Utah. Proc. 34th Ann. Meet. New Jersey Mosq. Ext. Assoc. 160–165.

Reeves, W. C. (1940). Research with *Aedes dorsalis* (Coquillett), the Pacific coast tree-hole mosquito. Proc. 11th Ann. Conf. Cal. Mosq. Cont. Assoc. December 1940. p. 39.

Reeves, W. C (1941). Discussion. Proc. 12th Ann. Conf. Calif. Mosq. Cont. Assoc. p. 98.

Shanafelt, J. (1950). Personal communication.

Stage, H. H. (1935). Mosquito control activities in the Pacific Northwest. Proc. 6th Ann. Conf. Mosq. Abt. Officials in Calif. 3–6.

Thurman, D. C., and E. W. Mortenson (in press). Studies on the biology of *Aedes* mosquitoes in irrigated pastures in California during 1949.

Yates, W. W. (1945). The effect of drying on the viability of *Aedes* mosquito eggs. Mosquito News 5:98–99.

STUDIES OF THE BIOLOGY OF *AEDES* MOSQUITOES IN IRRIGATED PASTURES IN CALIFORNIA DURING 1949

By DEED C. THURMAN, JR., *S.A. Sanitarian (R)*[1]

and EARL W. MORTENSON, *Entomologist*
Bureau of Vector Control
California State Department of Public Health
Berkeley, California

California mosquito control has made a commendable beginning toward the ultimate goal of state wide mosquito freedom. Initiated by Professor Herms and others, the modern antimosquito program in the State already has expanded to a degree envied by many other states of the Union.

While this beginning is significant, and organized effort is a realization in many areas where the most acute problems have existed, knowledge of the biological background of mosquito behavior is so limited that predictions for the future are so difficult as to be virtually impossible; this, in spite of the fact that mosquitoes are one of the most studied groups of insects.

The need is for mosquito control organizations to be sufficiently alert and versatile so that as changes in basic principles of approach occur, these innovations can be immediately incorporated into the program to provide the greatest freedom from mosquito annoyance and disease transmission.

Physical man-made changes will be responsible for what is predicted to be an increase in the potential of the California mosquito problem in the next ten years. In the last reports of the Bureau of the Census (1945), the acreage of land under irrigation in California is shown to have increased from slightly over 4 million acres in 1939 to almost 5 million acres in 1944. This steady increase of more than 100,000 acres placed under irrigation each year has continued in fulfillment of the proposed rate of development. The National Resources Board (1948) estimated that 1,763,500 acres of new land will soon be in irrigation and that 2,429,870 acres will receive supplemental water.

The same board estimates that California has an ultimate 16,673,000 acres if irrigable land. A large portion of this irrigated area in California is pasture land which, along with many irrigated crops, is located within the range of California's most important pest mosquitoes, *Aedes nigromaculis* (Ludlow) and *Aedes dorsalis* (Meigen). To make estimates of the future problems, knowledge of mosquito biology must be earnestly sought, while concepts of what constitutes the best attack must be constantly revised when new facts become known. The mosquito problem will not remain static, nor can the approach to control remain static. Mosquito control problems in California must be continuously ready to be adapted to the changing mosquito picture.

For example: The *Aedes* problem in the Central Valley is much greater and somewhat different today from that which existed in 1935. In 1937, Aitken (1939) first observed the presence of *A. nigromaculis* in California. In 1949, it was probably the most important single pest species in the State. In just a little more than a decade this change has taken place. Can mosquito control planning keep pace with such rapid changes? To do so must mean the maximum utilization of every bit of obtainable knowledge of mosquito biology.

This brief introduction points out the need for and the usefulness of the gathering of ecological knowledge concerning various species of mosquitoes in California. The Bureau of Vector Control and the California Mosquito Control Association have been and are now aware of the need for more knowledge of the biology of the mosquitoes which are the more important problems at the present time. As facts become available, it is hoped that critical evaluation of the place of biological knowledge in control practices will aid in orienting and increasing the efficiency of such practices. Consciousness of this need for biological knowledge resulted in the instigation of studies of *Aedes* biology in the Central Valley during 1949. A discussion of these studies follows. For continuity, the discussion is divided into sections corresponding to the four life stages of mosquitoes.

THE EGG

Eggs of the majority of species of *Aedes* are deposited singly on the soil, which may be only slightly damp to saturated with moisture. Rees and Nielsen (1947, p. 162) reported that eggs of *A. dorsalis* were deposited "on the ground in groups of one to six in small depressions which are found by repeated probings of the female genitalia." We have found eggs of both *A. dorsalis* and *A. nigromaculis* on pasture soils in the Central Valley. Eggs taken with samples of pasture soil can be made to hatch when flooded with tap water, although the addition of a stimulant may result in causing a higher percentage of hatch. Eggs which float on the surface of the water have not been observed to hatch. These may be nonviable and viable eggs which are supported by the surface tension of the water. Some of these eggs have been observed to hatch when later submerged.

Experiments with wild-caught females fed in the laboratory and allowed to rest on a sample of pasture soil showed that eggs were laid on the surface of the soil in a random manner. Moisture, although the amount might be slight, appeared to be essential to obtaining a deposit of eggs in the laboratory.

Eggs have been found to collapse if the material on which they are deposited dried below a certain moisture content. Collapsed eggs will regain their normal size when immersed in water, but none of these eggs have been stimulated to hatch or to develop viable empryos.

Eggs deposited in the laboratory have been induced to hatch in 6 days after being deposited, and they may hatch even sooner, although we have not observed an earlier hatch. Calculations based on measured samples of soil surface indicate thta the number of eggs per acre of pasture may be as high as 20,000,000. Although distribution of eggs over pastures has not been studied thoroughly, preliminary evidence shows that large portions of pastures have very low densities of *Aedes* eggs while the more suitable places for oviposition in the pastures may have relatively high densities.

We have found the machine for removing *Aedes* eggs from soil, developed by Gjullin (1938), to be useful in ac-

[1] From the Bureau of Vector Control, California State Department of Public Health, and the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

celerating certain of our investigations. More than 100 samples of soil have been studied by use of this machine; results of these studies will be analyzed and reported at a later date.

Demonstrating the fact that all of the eggs deposited on a single sample of soil do not hatch at a single flooding, we have the following record from a sample of about four square inches of soil surface, which was collected near Manteca, San Joaquin County, July 25, 1949:

The first flooding on August 11, after the soil had been allowed to dry in the laboratory, resulted in a hatch of about 20–30 larvae. After the sample dried a second time, a flooding on August 24 resulted in a hatch of about 20 larvae; third flooding, September 6, 6 larvae; fourth flooding, September 19, no hatch; fifth flooding, November 16, 2 larvae; sixth flooding, November 28, no hatch. By this time the growth of moist-mud-inhabiting microorganisms had rendered the sample rather putrid so that it was discarded. Of five other samples of similar size and source, only one produced larvae at floodings subsequent to the first, and this at the second flooding only.

Laboratory observations have shown that the soil samples flooded with tap water have hatched larvae in as short a period as 45 minutes under room temperature conditions during July and August. In one experiment in which laboratory-laid eggs were flooded with tap water containing yeast solution, larvae were observed to appear within 30 minutes after flooding. The water temperature during this period did not exceed 70° F.

Larvae

In observations of *Aedes* near Manteca (Plate I, fig. 1), a detailed study of larval growth and adult habits was made.

The first irrigation water was released in this pasture on July 24, 1949. The first observations in the pasture were made at 4:30 p.m. on July 25. Dipping was begun and continued until larvae were discovered in the northern end of the field at 6:00 p.m. From the results of later observations of the very young larvae of *A. nigromaculis,* it is believed to be virtually impossible to see them in a white dipper until they are several hours old and their head capsules have turned brown. For this reason, when larvae are discovered in a field, it is usually safe to assume that hatching occurred at least 2 hours previous to the discovery of larvae. Following the discovery of larvae at the northern end of the Manteca field at 6:00 p.m., larvae were easily found in numerous other locations scattered over the field.

Larvae were collected twice each day from the field. Despite the fact that some areas were covered with shallower, slightly warmer water than others, no differences were noted in the rate of growth of larvae in different parts of the field.

No particular portion of the field was demonstrated (by sampling methods used) to have a greater larval density than any other portion. From the hatching of the larvae it was apparent that there were preferred *microclimates* selected by the females for oviposition.

Soon after hatching, the larvae distributed themselves more generally throughout that portion of the water medium in their immedmiate vicinity. In apparent contradiction to this dispersal is the characteristic gregarious habit of undisturbed groups of larvae of floating together and forming masses, often at grass clumps or the bases of plants, especially during the early stages. When disturbed, the larvae disperse.

Early second stage larvae were found in the late afternoon of July 26. Third stage larvae were found on the 27th. Late third and a few early fourth stage larvae were found on the 28th. Some fourth stage larvae reached the pupal stage on the 30th. The first adult emergence began late on the 31st, and emergence continued through noon of August 2, with the peak of emergence occurring on August 1. Identification of these larvae (Table 1) revealed that of 1032 examined, only 108 were *A. dorsalis,* the remainder being *A. nigromaculis;* 1148 pupae were not determined to species.

In summary, it may be said that the cycle from flooding of the field to first adult emergence required 6 days; from the observed hatching of the first larvae to adult emergence required 5 days.

A second aquatic cycle was studied during the latter part of August. The pasture was flooded on August 14 between 8:00 and 12:00 p.m. Records were made by the same methods used during the first cycle. A comparison of growth time and temperature for the two cycles appears in Table 2. The temperatures for the period of the second cycle were slightly lower than for the first cycle; the growth period was about 24 to 36 hours longer than for the first cycle. A total of 1072 second-, third-, and fourth-stage larvae was collected and determined; only one *A. dorsalis* was found.

Pupae

While the second growth cycle of *Aedes* at the Manteca plot was being studied, adults were observed to emerge from pupae lying in a pot-holes completely devoid of visible water, although the surface of the soil was "damp." The pot-hole was first observed at 3:00 p.m. on August 22. The general area had been "dry" since the preceding day. Males were observed to emerge from the pot-holes first. They immediately climbed to the highest points on surrounding vegetation. At 9:00 a.m. on the 23d, males were still emerging, though by 11:00 a.m. females began to emerge along with males. Temperature on the surface of the muddy soil was 90° F. at 12:00 noon on the 23d.

On August 23 the irrigation ditch which supplies the water for the Manteca pasture overflowed its banks due to release of water at some point up the canal and flooded the upper end of the pasture which had been "dry" for 3 days. Pupae were observed in the fresh water. These pupae had evidently hidden under vegetation and in other protected pot-hole areas where moisture near the surface had allowed them to exist and develop. Adults emerged from some of these pupae on the following day.

Adults

Daily observations of adult *Aedes* were made in the Manteca pasture. Indexes to adult density were obtained by using New Jersey light traps and by cloth flags. These density reports are being further studied and analyzed. The largest single collection of *A. nigromaculis* for any one night was estimated at 7,416 of which 7,098 were males. For the same night another trap took 4,608 males in a total collection of 7,264 (see Plate I, fig 3).

The cloth flags used for the counts are a yard square with sides tacked to dowel sticks allowing the cloth to be held upright and rigid (Plate I, fig 4). An area 2 feet square is marked on the cloth and the counts are made on this surface. The operator walks for a distance of approximately 30 paces into the pasture, turns his back to the wind, spreads the cloth against his legs, and counts mosquitoes on the leeward side (see Plate I, fig. 2). Counts are made for only the first 30 seconds after the operator stops. Subsequent counts may be made at distances of at least 30 paces over the area being studied until the operator feels the area has been sufficiently sampled. An average or mean cloth count for use as a comparative index can be obtained from a number of counts in the pasture. We have found a dark gray cloth to be the best color for making these counts, with light gray and red serving almost as well. It is important in making comparisons between pastures and between pre-treatment and post-treatment counts that the time of day be taken into consideration, since more mosquitoes will be counted on the cloth in the later afternoon than during the morning and at midday. Cloth count means taken with a white cloth in the Manteca pasture July 31–August 15) varied from a high of 85 for August 2 to a low of 22 during the first week of the adult cycle. On August 7 a cloth count mean of 48 indicated that a large number of female *Aedes* were still in the pasture, 5 days after the peak of emergence.

Summary and Conclusions

1. Eggs of *Aedes* mosquitoes may be found on the surface of irrigated pasture soil in the San Joaquin Valley. In limited areas of pastures suitable for oviposition ,there may be as many as 20,000,000 of these eggs per acre. .

2. A minimum period of 6 days was required from flooding to the first emergence of adults in a pasture located about 17 miles from the Modesto Weather Bureau Station, which recorded a 90° F. average maximum temperature and a 56° F. average minimum temperature for the growth period under observation. A second cycle observed in the same pasture with an average temperature of 3–5 degrees lower, required at least 24 hours longer to complete.

3. Pupae were observed to resist drying to a considerable degree — emergence of adult mosquitoes was observed at least 29 hours after visible water had disappeared from a pot-hole.

4. New Jersey light trap catches of *A. nigromaculis* of more than 5,000 for a single night were recorded. A method of using cloth flags to obtain a population index of adult females in a pasture is described. In tests of the method a maximum count mean of 85 was recorded.

5. The need for the interpretation of biological knowledge in the mosquito control program is emphasized.

Acknowledgments

The authors acknowledge the assistance of Johnson T. Prescott, Student Biologist, in making these observations.

Literature Cited

Aitken, T. H. G. (1939). Two new *Aedes* records for California (Diptera, Culicidae). Pan-Pacific Ent. 15:13–14.

Bureau of Census (1945). Census of agriculture, Vol. II, Washington, 1947.

Bureau of Agricultural Economics (1948). Irrigation agriculture in the West. Misc. Pub. 670, U.S. Dept. Agric.

Rees, Don M., and Lewis T. Nielsen (1947). On the biology and control of *Aedes dorsalis* (Meig.) in Utah. Proc. 34th Ann. Meeting New Jersey Mosq. Ext. Assoc.

Gjullin, C. M. (1938). A machine for separating mosquito eggs from soil. U.S. Dept. Agric. BEPQ Circ. ET-135.

Table 1 — Growth of *Aedes* larvae in an irrigated pasture. Number of larvae determined according to species and stage for collections at Manteca July 25 to August 1, 1949.

1949		*Stage for Each Species* *Aedes dorsalis*				*A. nigromaculis*				*Pupae*	*Total*
Date	*Hour*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*		
7/25	6p	Water released in pasture									
7/26	6–9p	Additional water released in pasture									
7/27	10–11a	3	6			91					100
7/27	4–5p					116	29				145
7/28	9a		1	3		3	316				323
7/28	4p	Sample containing mostly third-stage, a few fourth-stage larvae, deteriorated before determination.									
7/29	10a			4	6	3	316	356			366
7/29	4p				39			328			367
7/30	3–4p				12			225		80	367
7/31	10a				25			365		501	891
7/31	3p				3			17		232	252
Exuviae of 4th-stage larvae					5			78			83
8/1				1						335	336
Totals		3	7	8	90	210	345	1369		1148	3180

Table 2 — Comparison of length of growth period of two larval cycles of *Aedes nigromaculis* (Ludlow) with temperatures recorded at habitat and the maximum and minimum mean temperatures from two Weather Bureau stations, California, 1949.

Manteca Pasture:

First cycle observed: Field flooded July 25, 6:00–12:00 p.m.; adults first emerged July 31, 6:00 p.m.; minimum length of cycle, 6 days.

Second cycle observed: Field flooded August 14, 8:00–12:00 p.m.; adults emerged August 22, 3:00 p.m.; minimum length of cycle, 7½ days.

*Mean temperatures for period**

	Manteca		Stockton W. B. Station		Modesto W. B. Station	
	9:00 a.m.	3:00 p.m.	Max.	Min.	Max.	Min.
First	78	92	91	58	90	56
Second	75	87	87	55	86	50
Difference	3	5	4	3	4	6

*Decimals have been changed to nearest whole numbers.

Mr. Ed Smith: I want to introduce next Basil Markos, who will discuss "The Ecology of California *Anopheles*."

Dr. Markos: As you all know, as is customary with the speaker, I go ahead and Ph.D. everything I do, and this paper is no exception. My paper has to do with the ecology of California *Anopheles*.

THE ECOLOGY OF CALIFORNIA *ANOPHELES*

By BASIL GEORGE MARKOS, Ph.D.
Vector Control Specialist, Bureau of Vector Control
Division of Environmental Sanitation
State of California, Department of Public Health

DISTRIBUTION

In California, *Anopheles maculipennis occidentalis,* Dyar and Knab, extends from Ventura in the south in a narrow strip along the coast north to the Oregon Coast. According to Aitken (1945) it is found around the margins of the Monterey and San Francisco bays and has spread inland along the valleys. Freeborn (1949) reports that Mr. W. W. Crafton has taken specimens of *A. occidentalis* in San Diego County. Mr. John C. Shanafelt, Jr., Entomologist for the Orange County Mosquito Abatement District, reports the following collections of *A. occidentalis* from Orange County:

E/s Laguna Canyon Road 3 miles N. of Laguna Beach, California. One female collected April 2, 1948.

W/s 101 Highway 1 miles N. of San Juan Capistrano, California. One male collected April 1, 1948.

Anopheles punctipennis Say is scattered widely throughout the central and northern parts of the state, but reaches its peak of development along the Sierra foothills of the Mother Lode region as well as along the shaded water courses of the Sacramento and San Joaquin Valleys. Freeborn (1949) states that the range of this species is almost entirely outside the periphery of the endemic malaria areas. (This mosquito is an efficient laboratory vector of malaria, but has never been demonstrated to be a carrier in nature.) *Anopheles pseudopunctipennis franciscanus* McCracken is widely scattered in California and is fairly abundant throughout the Sacaremnto and San Joaquin Valleys. It is very common in the adjacent foothills, and according to Aitken (1945), reaches its greatest development in southern California, south of the Tehachapi Mountains and along the coast. Freeborn (1949) reports that it is the commonest species found in areas around the mouths of rivers entering the Pacific. where the larvae occur in enormous numbers in the shallow pools in the sandy arroyos. *Anopheles maculipennis freeborni* Aitken occurs generally throughout North America west of the Rocky Mountains and reaches its peak of development in California, where it has been found throughout the state (Herms, 1919 a, b; 1920 a, b; 1929; Freeborn, 1926; Aitken. 1937) except along the northern coast, being particularly abundant in the Sacramento and San Joaquin Valleys. It reaches the coast in southern California, from San Luis Obispo southward, and has never been collected in the hot Coachella and Imperial Valleys of the southeastern corner of the state; and although fairly common in southern California, gives way to *A. franciscanus* as the dominant anopheline of the region. It appears that the greatest density of *A. freeborni* is reached in the Sacramento Valley, while in the San Joaquin Valley it fluctuates from moderate to sparse

Altitudinal Distribution

A. franciscanus has adapted itself to varying climate over a wide vertical range. It has been collected 176 feet below sea level in the hot Coachella Valley, Riverside County (Herms, 1929), and in the Sierra Nevada at 7,300 feet in Alpine County, California (Aitken, 1939). *A. freeborni* larvae occur over a wide vertical range, being found from sea level along the southern California coast or near sea level in the delta region of the Sacramento and San Joaquin rivers up to at least 5,480 feet at Sierraville, Sierra County (Herms, 1929). *A. occidentalis* is found at sea level and in the lower elevations of the Coast Ranges, and *A. punctipennis* is probably confined to the lower elevations of the foothills approaching the Sierra Nevada.

LARVAL BIONOMICS

A. occidentalis occurs in a variety of aquatic habitats along the coast, and displays a preference for impounded water: permanent pools, lagoons, and ponded creeks. It has been taken along the coast in small seepage areas from hillsides, watering troughs, and quiet protected streams (Aitken, 1945). It sometimes breeds intensively in individual spots and seldom over an extensive area as do other anophelines (Freeborn, 1949). Larvae of this species have been reported developing in water that was distinctly brackish in the tidal creeks of the San Rafael salt marshes, Marin County (Quayle, 1906). Larvae may occur in almost complete shade, but it is believed that *A. occidentalis* seems to prefer more sunlight than *A. freeborni.*

On the other hand, *A. punctipennis* appears to prefer shade, as it breeds in pools of clear, cool water, which are usually to be found in the beds of wooded creeks that are slowly evaporating. Green algae are frequently a constituent of these pools.

A. franciscanus inhabits arid canyons and valleys, where the immature forms find ideal conditions for growth in the small, moving streams and side pools of receding rivers containing a rich growth of green algae, well exposed to the sun. Aitken (1945) has repeatedly observed it in pools much too warm for *A. freeborni* or *A. punctipennis.* It has been reported, too, as occurring abundantly in dredger ponds. Freeborn (1949) reports that *A. franciscanus* is found in pools beside receding streams. particularly those in full sunlight with luxuriant growths of green algae. The larvae, however, may often be found in the most aberrant locations. Freeborn (1949) reports that workers of the Public Health Service and Navy have found larvae developing in salt water (salinity equivanent to 34 and 64 per cent sea water) near San Diego, California. He has taken the larvae repeatedly in open semi-permanent pools devoid of vegetation, in ornamental fountains in Exposition Park, San Diego, California.

A. freeborni prefers clear, fresh water, sunlit for a part of the day, and has been found in small pools and shallow seepage water, and drainage ditches from rice fields, as well as along the edges of irrigation ditches and canals where there is weed growth. Shallow seepages from careless use of irrigation water seem to be one of its preferred and possibly one of its most typical breeding places. Although usually associated with sunny or semishaded places, *A. freeborni* larvae may be found in deep shade. Freeborn (1949) reports that it breeds in slightly brackish water (salinity equal to 15 per cent sea water) wherever its distribution carries it to the ocean. Within its inland range it is frequently found in desert pools where the total of salt and alkalinity exceed the standard. Freeborn is of the opinion that between an option of water polluted with sewage or other organic material, and clear, clean water that is slightly alkaline, *A. freeborni* will choose the cleaner source.

As early as 1917, Freeborn reported on some observations in the rice fields of the Sacremento Valley, which are very significant and should be closely scrutinized by the abatement districts concerned with the control of rice field mosquitoes.

Freeborn (1917a, p. 5) states: "The water is turned into the fields about June 1. The mosquitoes, however, have been breeding in available pools sine March or sometimes earlier. Every mosquito destroyed prior to the irrigation of the rice fields means the cutting off of its countless progeny that would otherwise breed unmolested in the flooded fields throughout the season. Then, too, at the end of the season, the mosquitoes breed for a month or more in neglected pools after the water is drawn from the fields, producing the adult mosquitoes that overwinter and start the next season's crop. It seems plain, therefore, that if one ardent anti-mosquito campaign were waged before the water is turned into the fields in the spring and after it is drained off in the fall, together with the control of outside pools during the flooded period, that the mosquitoes left to start the rice field generations and hence the number of malaria cases, would be greatly reduced in number." Freeborn further reports that fifty per cent of the malaria mosquitoes are breeding in pools adjacent to the rice fields.

Similar observations have been reported by a number of other investigators. Purdy (1925) in studies of California rice field areas, observed moderate or heavy production of mosquitoes in nearby seepage puddles and natural drainage ditches and practically absent from rice fields. Aitken (1945) found that the greatest production of anophelines is not in the fields proper, but in the drains, seepages, and overflows around the fields. In our studies of rice fields in Colusa County, 1949, we found that in the early part of the season (April-May), shortly after the fields are flooded, the drainage ditches wre generally found to be productive of very large numbers of mosquito larvae, particularly *Culex tarsalis* Coquillett, and *A. freeborni,* while adjacent rice fields showed few larvae by comparison. The rice fields did not become infested until some time later when the rice stood erect out of the water. It was approximately 15-20 inches in height, and afforded at that time conditions suitable for oviposition.[1]

In studies of rice fields in the Butte County towns of Nelson and Durham, Purdy (1925) found that the Nelson fields were the only ones which failed to produce anophelines, although there were breeding places in the seepages and drains, and further reported they were also the only fields in which blue-green algae (*Tolypothrix*) existed in abundance. Aitken (1945) made further observations of the rice fields between Biggs and Richvale; and reports that no anopheline larvae were found in the fields, which contained an abundance of *Tolypothrix.* The soil in the Nelson area was a "hard-pan," so that not so much fresh water was required to flood the fields, and it was reported that thus the water stands for long periods of time and becomes stagnant, *Tolypothrix* merely being an indication of fouling water. The other fields studied had a continual inflow of fresh, clear water which was ideal for the development of *A. freeborni.*

The Bureau of Vector Control in studies of rice fields in Stanislaus County in 1947, observed that rice fields were productive of significant numbers of *A. freeborni,* after the rice had emerged and stood erect from the water; the density of larvae increased gradually to the end of the season, when the fields became dry or were drained.[2]

In extensive investigations carried out in 1949 in Colusa County, we have observed considerable variations in the density of mosquito breeding in twenty rice fields located on four specific soil types. The range in the highest density of mosquito larvae in the above rice fields was found to be from 0.5 larvae and pupae per dip in some fields, to as high as 33 per dip in others. These significant variations were found to exist in some rice fields which were under constant irrigation, and in the opinion of the writer cannot be attributed solely to fouling or stagnant water. Also, the fluctuation cannot be entirely due to activity of larval enemies.

Purdy (1920) quotes work by Dr. Metz (Reprint No. 549 from Public Health Reports, August 8, 1919) showing that *Anopheles* larvae will thrive on non-living organic food of various kinds, mainly of vegetable origin.[3] Thus it would seem well-nigh impossible to control production of *Anopheles* by any practicable treatment of the larval food supply, inasmuch as this food is composed of a great variety of microscopic organisms, both plant and animal. He reports further that if the organism be killed or removed, the non-living organic detritus will suffice for the larval food supply. Purdy (1920) approximated the amount of larval food available in different water where breeding of mosquitoes might be expected, or was actually in progress. He found that the wide variations in larval production noted in three situations during the season could not be explained on the basis of differences in larval food supply. Thus. the larval food supply being about equal in quantity and comparable in kind in rice fields, in seepage puddles, and in drainage ditches, is evidently not responsible for the great discrepancy in numbers of larvae. The discrepancy is not entirely due to activity of larval enemies, because these are most numerous where larvae are most abundant, and least numerous where larvae are practically absent.

The distribution of larvae within rice field checks has received the attention of several investigators. Aitken (1945) reports that although larvae are mainly found around the margins, they may also occur at considerable distances from the checks and are not necessarily associated with algae. He observed this condition in the Nelson and Richvale fields, in spite of the fact that these particular fields did not normally produce many anophelines, as dem-

[1] Markos, B. G. (1949). Unpublished notes on studies of rice fields in Colusa County.

[2] Markos, B. G. (1947). Rice field studies in Stanislaus County, California, with reference to mosquitoes (in manuscript).

[3] Purdy, W. C. (1920). A progress report on biological investigations of California rice fields relative to mosquito breeding. Chico, California, April, 1920. (Unpublished — on file with the Bureau of Vector Control.)

onstrated by Purdy 1925). The Bureau of Vector Control as a result of intensive studies on the distribution of mosquito larvae in rice checks (Stanislaus County, 1947, and Butte County, 1949), has observed that *A. freeborni* larvae and pupae are not confined to the edges, but are generally well distributed throughout the checks.[4] A more detailed report on this study will be made in the near future, and will present actual measurements of larvae from the edges as compared with measurements from midfield during two seasons.

A few studies have been made to show the correlation of density of rice to the presence of anophelines. Freeborn (1917b) states that it is known that a heavy and uniform growth of rice growing well up to the check produces relatively few mosquitoes, while a sparse stand with irregular growth at the checks generally breeds anophelines in large numbers. We have found during the season of 1949, in plots of dense and sparse plantings at the Biggs Rice Experiment Station, that larvae appear from two to three weeks earlier in the dense rice plots than in the sparse rice.[5] However, when the sparse rice plants had stooled out, which rice will do when thinly planted, *A. freeborni* larvae appear in considerable numbers and were just as abundant as in the dense or thick stands of rice. In general, we have found that variations in the density of the rice plants within normal field limits had no apparent influence on the number of larvae that developed.

In regard to the species of anophelines found in rice fields, Freeborn (1917b) reports that the most prevalent species are *A. occidentalis* (now believed to be *freeborni*) and *A. pseudopunctipennis* (now *franciscanus*). In a two-year study, we have observed *A. freeborni* to be by far the dominant anopheline in rice fields in Stanislaus County in 1947, Butte County in 1949, and Colusa County in 1949. We have found *A. franciscanus* larvae and pupae in 1949 in just one rice field, and in insignificant numbers. The author has been informed that in some sections of the Sacramento rice field areas the reverse is true.[6]

Herms and Gray (1944) offer some interesting suggestions in relation to the control of anophelines in rice fields. They report that changes in the physical character of the water in the rice paddies may effect a beneficial change in the species of mosquitoes which will breed therein. They have observed in California that in rice fields where the soil is relatively porous and a considerable amount of water is required for rice culture, *A. freeborni*, a dangerous vector of malaria, bred freely. On the other hand, in rice fields where the soil is dense clay, *A. freeborni* are either absent or relatively few in number, the prevalent mosquitoes being *Culex tarsalis*, and *A. pseudopunctipennis* (now *franciscanus*). Herms and Gray (1944) state further that in clay fields evaporation without appreciable seepage loss concentrates the mineral content of the water until toward the end of the season it is quite stagnant, a condition which is unsuited to *A. freeborni*. If, therefore, the rice paddies in *A. freeborni* regions were more carefully prepared prior to planting, and clay, bentonite, or similar materials were added to porous soil to reduce seepage loss, the breeding of dangerous malaria vectors would be minimized and the savings in water requirements would probably offset the cost of remedial work. The authors conclude that in other areas this scheme might not operate successfully, but it should be possible to make some changes (naturalistic control) in the ecological condition of the rice fields so as to eliminate or minimize the production of the local disease vectors.

The control of anophelines and other mosquitoes in California rice fields is made difficult by the extensiveness of the areas involved. According to Freeborn (1917a), the summer of 1912 saw the first commercial planting of rice in California at Biggs, Butte County, in the Sacramento Valley, which totaled 1400 acres. He further states that the anophelines of the Sacramento Valley find their optimum breeding grounds in the fields flooded for rice culture, and as a result, mosquitoes have increased in direct proportion to the growth of the industry (estimated acreage of rice in 1917 was 80,000 acres). It is of interest to mention that the estimated acreage of rice for 1949 was approximately 300,000 acres.

Overwintering

No significant data on the overwintering of *A. occidentalis* in California has as yet been reported, and Aitken (1945) is of the opinion that it is quite probable that breeding may go on at a slow rate during the winter months.

Attempts on the part of Aitken (1945) to find the larvae of *A. punctipennis* in the northern San Joaquin Valley in the middle of December were unsuccessful, thus substantiating the earlier observations of Herms (1929) and Freeborn (1926). He suggests that along the coast *A. punctipennis* may continue to breed and develop slowly throughout the winter.

In regard to the overwintering of *A. franciscanus*, Freeborn (1929) is of the opinion that in nature, breeding continues throughout the year in the warmer parts of the range, while the adult females hibernate in the region with a cold or cool season. Aitken (1945) reports that Dr. W. C. Reeves collected one male and two females, the latter with mature overies, in Riverside, February 17, 1940.

Dr. Bernard Brookman, of the Hooper Foundation, University of California, has presented the author with some interesting unpublished data based on his winter collections of *A. franciscanus* in Kern County as listed below:[7]

[4] Markos, B. G. (1949). Rice field studies in Butte County, California, with reference to mosquitoes (in manuscript).

[5] Markos, B. G. (1949). The relation of dense and sparse rice plantings in rice fields to the prevalence of mosquito larvae (in manuscript).

[6] Personal communication to the author from Mr. Richard F. Peters, Senior Vector Control Specialist, Bureau of Vector Control.

[7] Brookman, Bernard, Assistant Sanitarian (R), U.S. Public Health Service, Hooper Foundation, University of California. Unpublished field notes.

Date of Observation	*Stages of* A. franciscanus *collected*
12-19-47	Larvae (2nd, 3rd, 4th)
12-11-48	Adults (engorged, gravid — 2 females; 2 males)
12-17-48	Larvae (2nd, 3rd)
1-17-49	Larvae (4th)
1-24-49	Larvae (3rd)
	Adults (engorged — 2 females)
1-28-49	Adults (gravid — 2 females)
2-22-49	Adults (gravid — 2 females)
3-24-49	Adults (gravid — 2 females)

It appears evident, in the light of the above data, that several generations are produced by *A. franciscanus*, at least in its southerly extension.

Seasonal Incidence

It is believed that *A. punctipennis* is relatively more numerous in the early summer, whereas *A. freeborni* is relatively more numerous in late summer.

The seasonal incidence of *A. freeborni* in the Sacramento Valley of California has been well discussed by Freeborn (1932). He states that the spring flight and subsequent oviposition of the overwintering females (*A. maculipennis* Meigen, now *freeborni* Aitken) is reflected in the appearance of the larval generation in February. The hazards of life to which this larval generation is exposed, such as cold and flooding, are also demonstrated in their rapid decline through March and April before the emergence of the first adults in late April or early May. According to Freeborn, the March-April depression marks the interim between the time when the overwintering females have oviposited and died and the emergence of the first brood adults.

Judging from the trend of the larval collection curve the number of adults should mount progressively from May to September. The disappearance of adults during mid-summer last of June, July, and middle of August) must be from other causes than cessation of breeding. According to Freeborn (1932), the only logical solution would seem to be that although the late June and July adults were able to live the three or four days necessary to lay their eggs, they were not able to withstand the climatic conditions long enough to build up a population as they are able to do earlier in June or late September.

Some interesting information on the so-called hibernating form is presented by Freeborn (1932). In an examination of a hundred examples of this migrant form not one was found which developed eggs before January as a result of nutrition received. They are active throughout hte winter, particularly on warm days. During the period of "semi-hibernation," the mosquitoes are prone to bite in warm buildings, or even in the open on warm days or evenings. However their attack is fitful, and might be described as "nibbling" rather than biting (Freeborn, 1949). The winter nibbling, however, is conducive to malaria transmission in heated homes. In February they commence to bite viciously either by day or night, after which egg production and deposition follow shortly. Purdy (1925) has also observed that the adults are active and bite viciously in the early spring. The second week in March generally marks their complete disappearance, and from that date until the emergence of the first brood in late April or early May, the entire population of *A. maculipennis* (now *freeborni*) is in the larval stage (Freeborn, 1932).

Freeborn (1932) states that during October and early November, the so-called "prehibernation" forms that appear have a strikingly different habitus from the summer and spring forms. According to Aitken (1945), the specimens of *A. freeborni* collected in the fall tended to be somewhat larger than the spring forms (4.76 mm. as compared with 4.54 mm.).

It appears that increased humidity has a protective influence on the longevity of *A. maculipennis* (now *freeborni*) kept at constant temperatures, but at a constant of 80° F., no amount of relative humidity can protect them for the full life span of a month (Freeborn, 1932). It is pointed out that the lethal effect may be caused by either a fatal temperature or by desiccation of the insect's body. The ability of a particular species to retain absorbed water in the presence of existing saturation deficiencies undoubtedly explains the variability of resistance of the different species to desiccation, according to Freeborn. The length of life of *A. maculipennis* (now *freeborni*) and other vectors of malaria has important bearing on their ability to transmit the disease.

Flight Range

Freeborn (1949) reports that the fall portion of the migration of *A. freeborni* is in the nature of an infiltration, while the spring emergence and distribution flight takes on the appearance of a serious flight of salt-marsh mosquitoes both in numbers and in the vicious biting in broad daylight. The midseason flight range, which would exclude the migratory flights of the overwintering females, is generally restricted to a mile radius. Males are seldom taken more than a quarter-mile from their breeding places.

No careful work has been done on the flight range of *A. occidentalis*, and Freeborn reports that heavy concentrations of the species are always associated with contiguous breeding areas. As regards *A. franciscanus*, the flight range is believed to be limited to relatively short distances, not in excess of a mile.

Interbreeding

Due to a lack of discretion on the part of the male or female — the author is uncertain as to which sex is responsible — we are confronted with the problem of interbreeding. Aitken (1945) indicates that certain areas are known where interbreeding between *A. occidentalis* and *A. freeborni* probably may be taking place, such as in the vicinity of Stanford University in California, and in Montana and also in Columbia. It is known that overlapping occurs. In the region from San Luis Obispo south to Ventura, *A. occidentalis* and *A. freeborni* occur together. Both have been taken at the same time under the same bridge at Stanford University by Aitken (1945).

Mr. Richard F. Peters in 1942 found larvae of *A. freeborni* and *A. occidentalis* coinhabiting side pools of streams during the summer in San Luis Obispo and Morro Bay.[8]

Feeding Activities

A. occidentalis has little tendency to enter houses, and seldom if ever bites man. The observations of Herms (1921)

[8] Peters, R. F. (1942). Unpublished field notes.

and others in California indicate that *A. punctipennis* is to be considered a so-called "porch mosquito," because it does not readily enter houses. Freeborn 1949) is of the opinion that *A. punctipennis* apparently suffers from claustrophobia! However, it attacks viciously out-of-doors, and it is collected frequently in sheds, barns, and other outhouses. *A. franciscanus* also seldom enters houses, and rarely if ever attacks man. On the other hand, *A. freeborni* is persistent in finding its way into houses. It is considered to be a persistent biter indoors at dusk and after dark, and this is one of the characteristics which undoubtedly makes it so important as a malaria vector. We have observed recently in Colusa County that *A. freeborni* adults may become pestiferous and bite in the open in direct sunlight, particularly toward the end of the rice-growing season, during August and September, when the larvae reach their heaviest densities. It has been shown that *A. freeborni* also shows considerable preference for blood of domestic animals, particularly dairy and beef cattle.

Selective Oviposition

In the course of studies in Tehama County, California, Herms and Freeborn (1920) found pools from which there constantly emerged, in the one case *A. quadrimaculatus* (now *freeborni*) and in the other *A. punctipennis*, with no mixture of the species. Thus, these pools were therefore classified as "*quadrimaculatus* (*freeborni*) pools" or "*punctipennis* pools." From general observations in one study, the above authors noted no retardation in development or diminution in the expected numbers of A. quadrimaculatus (*freeborni*), although found to be breeding in a "*punctipennis* pool." The authors conclude that specific breeding places are due to selective oviposition.

Types of Eggs

Aitken 1945) reports that he has found three types of eggs throughout the range of *A. franciscanus* in California at all times of the year, and in the same localities. The first type was described by Herms and Freeborn (1920), floats vertically in the water suspended by the action of surface tension on a collar-like fringe of exochorion, its floats being depressed, functionless, and joined together on the dorsal surface of the egg. The second type, described by Herms and Frost (1932) is more typically anopheline, with functional floats which are lateral but roll over the edges. The third type consists of batches of eggs laid by single females which show all stages of variation between the two forms mentioned above. According to Aitken (1945), individual females may deposit an entire batch of vertical eggs, or of horizontal eggs, or an assortment of intergrading forms.

Literature Cited

Aitken, T. H. G. (1937). The distribution of California anophelines with remarks on collecting methods. Proc. and Papers 8th Ann. Conf. Mosq. Abt. Officials in Calif. pp. 8–14.

Aitken, T. H. G. (1939). A contribution to the knowledge of the mosquitoes of Owens Valley, Inyo County, Calif. Jour. Econ. Entom., 32:407–412.

Aitken, T. H. G. (1945). Studies on the anopheline complex of western America. Univ. of Calif. Publ. in Entom., 7 (11): 273–364.

Freeborn, S. B. (1917a). The malaria problem in the rice fields. Calif. State Jour. Med. 15:412–414.

Freeborn, S. B. (1917b). The rice fields as a factor in the control of malaria. Jour. Econ. Entom., 10:354–359.

Freeborn, S. B. (1926). The Mosquitoes of California. Univ. Calif. Publ. Entom., 3:333–460.

Freeborn, S. B. (1932). The seasonal life history of *Anopheles maculipennis* with reference to humidity requirements and "hibernation." Amer. Jour. Hyg., 16:215–253.

Freeborn, S. B. (1949). Anophelines of the Nearctic region. Boyd's Malariology, Volume I. W. B. Saunders.

Herms, W. B. (1919a). Occurrence of malaria and anopheline mosquitoes in northern California. Calif. State Board of Health, Month. Bull., 15:1–9.

Herms, W. B. (1919b). Occurrence of malaria and anopheline mosquitoes in northern California. U.S. Pub. Health Serv. Repts., 34:1579–1587.

Herms, W. B. (1920a). Occurrence of malaria and anopheline mosquitoes in middle and southern California. Calif. State Board Health, Month. Bull., 15:211–216.

Herms, W. B. (1920b). Occurrence of malaria and anopheline mosquitoes in middle and southern California. U.S. Pub. Health Serv. Repts., 35:275–281.

Herms, W. B. (1921a). Malaria and mosquito control. Calif. State Board Health Month. Bull., 29 pp.

Herms, W. B. (1921b). Distribution and ecological notes on anopheline mosquitoes in California. Jour. Econ. Entom., 14:410–414.

Herms, W. B., and S. B. Freeborn (1920). The egg-laying habits of California anophelines. Jour. Parasit., 7:69–79.

Herms, W. B., and F. M. Frost (1932). A comparative study of the eggs of California anophelines. Jour. Parasit., 18:240–244.

Herms, W. B., and H. F. Gray (1944). Mosquito Control. New York: The Commonwealth Fund. 419 pp.

Purdy, W. C. (1920). Should rice raising be prohibited near towns? Calif. State Board of Health, Month. Bull., 16:78–81.

Purdy, W. C. (1925). Biological investigations of California rice fields and attendant waters with reference to mosquito breeding. U.S. Pub. Health Serv., Pub. Health Bull. No. 145.

Quayle, H. J. (1906). Mosquito control. Univ. Calif. Publ., Bull. No. 178.

Mr. Smith: We now come to a discussion of the ecology of the *Culex* mosquito by Barney Brookman.

Dr. Brookman: I'll confine myself to generalities in order to save time; at the same time I'll probably repeat some of the things that have been said before.

THE ECOLOGY OF *CULEX* MOSQUITOES

By Bernard Brookman[1]

Sanitarian (R), Hooper Foundation, San Francisco, Calif.

It already has been called to your attention that the ecology of mosquitoes has been discussed many times during past meetings of this Association, and that the attack against mosquitoes for the most part has been based on a knowledge of their biological characteristics. Actually, there is no other reasonable approach. Before we can even start thinking about abatement measures, we must know what species are present in our respective areas, whether they transmit disease or annoy us or our domestic animals by their feeding habits and abundance, in what sort of places they may be found, during what seasons of the year they are most numerous and active, in what stages of their life cycle they may be most easily and economically controlled, and other such factors. Undoubtedly, most of you have gone through this process of reasoning and are using your knowledge of the biology of mosquitoes in effecting their control. However, there is the tendency to forget how dependent we are upon data obtained by scientific (observational) means to attain the practical end desired — namely, reduction in numbers of mosquitoes to a level where they no longer transmit disease or constitute a pest.

In California, five species of *Culex* are important enough to man to warrant their abatement. First and foremost among these is *Culex tarsalis,* a proven vector of encephalitis, a pest of man and domestic animals, and perhaps the most widespread and abundant *Culex* in California. The other species are important primarily as pests, although *Culex stigmatosoma* may also possibly serve as a transmitting agent of encephalitis. In most places, however, it is not as numerous as *C. tarsalis*. The other species, *C. quinquefasciatus, C. pipiens,* and *C. erythrothorax,* are pests only in limited areas of the State, but there is no doubt that, wherever they occur abundantly, they may be the sources of many complaints. Other species of *Culex* in California need not be considered here, either because they are rare or because they do not ordinarily feed on man or domestic animals. For the sake of completeness, *Culiseta incidens* and *inornata* may be included in this discussion, as they are abundant throughout California and may become pestiferous at times, and as their habits in general are similar to those of *Culex.*

Obviously, to discuss in detail all that is known of the ecology of *Culex* and *Culiseta* would take more time than is available. Thus, I would prefer to mention only a few pertinent facts regarding certain of the species, with particular emphasis on *C. tarsalis*.

Succesful control of mosquito larvae depends first and foremost upon a knowledge of their habitats. We have found that in the case of *C. tarsalis* just about any collection of surface water, if quiet or at least not moving too rapidly, may serve as a breeding place. Bates (1949) lists nineteen general types of natural aquatic habitats throughout the world in which mosquito larvae occur; a survey of the literature indicates that *C. tarsalis* throughout its range in North America may occur in ten of these, as follows:

A. Permanent or semipermanent standing water:
Fresh water:

1. Large marshes or marshy zones in lakes.
2. Small ponds or marshy areas in the open.
3. Special situations, such as spring-fed pools.
4. Special chemical conditions, such as peat bogs.
5. Swamps.
6. Forest pools.

Brackish water:

7. Brackish marshes and swamps.
8. Small accumulations of brackish water.

B. Running water:

9. Open streams in association with vegetation.

C. Transient ground pools:

10. Transient ground pools in the open.

In addition, although Bates did not include artificial containers in his list, this is an important source of *C. tarsalis*.

In Kern County we have found that aquatic habitats of mosquitos fall into fourteen more or less distinct ecological types. These may be outlined as follows:

I. Earth-lined containers (natural or artificial):

(a) Various sizes, water temporary to semipermanent, not moving perceptibly; usually stagnant, vegetation more frequently emergent, commonly associated with irrigation (canals, ditches, borrow pits, impoundments, irrigation sumps, ground pools, hoof prints).

(b) Various sizes, water semipermanent to permanent, standing or flowing. emergent vegetation, algal mats, frequently with thick tar scum, effluent from oil wells, (oil sumps, ground pools, sloughs).

(c) Large expanses of flooded land, water temporary to semipermanent, more frequently with emergent vegetation (irrigated pastures, waste land covered with irrigation tail water, duck clubs).

(d) Margins of canals and streams with flowing water; larvae in quiet eddies, algal mats, and emergent vegetation.

(e) Various sizes; water temporary to semipermanent; effluent from cesspools and sewer farms, water carrying large quantities of organic material from human wastes (ground pools, ditches, irrigated fields, settling and drying beds in sewer farms).

(f) Various sizes; water temporary to semipermanent, containing large quantities of vegetable wastes (kitchen drains, wash-water sumps in vegetable packing plants, winery wastes).

(g) Residual pools in stream beds, sandy bottom, maintained by seepage, usually sunlit and containing algae.

(h) Various sizes, water usually permanent, with large quantities of organic wastes from domestic animals (barn, stable, and dairy drains).

(i) Cespools: deep, straight-sided, usually nearly completely covered over, containing highly concentrated human organic wastes.

(j) Semipermanent to permanent marshy areas; water from artesian wells or permanent streams.

---

[1] From the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

II. Artificially-lined containers (concrete, wood, metal, glass, crockery):

(k) Various sizes; water semipermanent to permanent, standing; usually not containing vegetation other than algae; commonly urban, also rural domestic, may be associated with agricultural practices (cans, jars, cemetery urns, pans, barrels, irrigation standpipes and valve-housings, drinking troughs for domestic animals).

(l) Concrete tanks with permanent water, often with decorative plants and fish (ornamental ponds, swimming pools).

(m) Concrete containers with temporary to semipermanent water; no vegetation (catch basins, culverts, street gutters, concrete sumps).

III. Tree holes.

C. tarsalis larvae have been collected in every one of these habitats except tree holes. In any anti-*tarsalis* program we must take such information into consideration since, although *C. tarsalis* more frequently inhabits ground pools, large enough numbers of adults emerge from jars, cans, crocks, barrels, fish ponds, drinking troughs, and other similar places, to make it important that these not be overlooked. Therefore, the inspectors must be trained to examine carefully every possible type of water collection. In urban areas he must be as meticulous as the *Aedes aegypti* inspector and as skilled in discovering hidden containers and small ground pools. In rural areas he must inspect every collection of water, whatever the size, as well as all artificial containers.

C. stigmatosoma larvae are found in artificially-lined as well as earth-lined containers and in waters polluted with animal wastes as well as non-polluted waters. It is interesting that in earlier reports this species was differentiated biologically from *C. tarsalis* on the fact that it did not occur in polluted waters and that in recent years it has been given the common name "banded foul water mosquito." Actually, in our collections in Kern County, it occurred only 16% of the time in polluted waters.

All of you are probably familiar with the habits of *C. pipiens* and *C. quinquefasciatus* and their preference for artificial-container and foul-water habitats.

C. erythrothorax primarily is a field mosquito. The larvae are found most frequently in marshy areas containing tules, and the adults usually remain in the vicinity of their breeding places.

The common species of *Culiseta* occur in nearly all of the habitats in which *C. tarsalis* may be found. In some parts of California they may be particularly abundant in such artificial containers as drinking troughs and concrete pools.

It has been shown by Reeves, Washburn, and Hammon (1948), working in Kern County in 1945, that *C. tarsalis* is most effectively controlled in the aquatic stages. Those authors found that, although residual deposits of DDT on the inside walls of chicken houses and other man-made resting places reduced the population of mosquitoes in such shelters, there was little if any effect on the total population of *C. tarsalis* in the area. The reason for these findings appears to be that a relatively small proportion of *C. tarsalis* adults enter man-made shelters; they seem to prefer natural resting places. So far as we know, *C. pipiens* and *C. quinquefasciatus* are more closely associated with man than is *C. tarsalis,* and it would seem that DDT residues in adult shelters might be an important adjunct in their control.

A knowledge of effective flight range also is important in a control program, since it is necessary at times to keep mosquitoes from invading an area from an outside source. In the case of *C. tarsalis* and *C. quinquefasciatus,* we have found in our studies that individuals may fly as far as two and one-half miles, but that the greatest proportion of released mosquitoes tends to remain within a mile of a release point (or, in nature, a breeding place of moderate extent). However, such results are applicable only in the limited area and under the particular conditions of the experiment, and we cannot assume that the same figures will apply to other areas or different conditions. Population pressure caused by the emergence of great numbers of adults from an extensive breeding area might result in mass migrations of well over a mile as the mosquitoes hunt for food, suitable shelter, and new oviposition sites.

The seasonal occurrence and period of activity of our species of *Culex* depend in large part on climate; thus, we cannot set forth any hard and fast rules with regard to the presence of any given species for the State as a whole. As an example, *C. tarsalis* is present in all stages throughout the year in Kern County. However, adult activity practically ceases late in December and does not commence again until February or March, depending on the temperature. Thus, there is a period of a month or more of relative inactivity, during which the females may move around on warmer days. Apparently there is not a complete hibernation. By April, adults are actively feeding, mating, and depositing eggs. By June or July the population has reached a peak and remains at a high level until September or even into October. Following this, there is a decline in numbers of all stages as well as in adult activity. In comparison, activity of *C. quinquefasciatus* starts later in the spring, and the adult population continues to increase in numbers and to be active much later in the year than does that of *C. tarsalis.* However, it ceases its activity during the coldest period just as does *C. tarsalis.* In contrast to these species, both *Culiseta incidens* and *C. inornata* continue to feed and to lay eggs throughout the winter. This annual cycle of abundance and activity, which differs for each species of mosquito, also varies from area to area. In the northern part of the range of any species of *Culex,* activity may occur only during the warmer months, the rest of the year probably being spent by the surviving females in hibernation. Thus, this cycle must be determined for each area in which we are working. By determining when a particular species of mosquito first becomes active, we could get an early start in controlling the first brood and probably would be able to reduce the population for the rest of the year. Also, control measures should not be stopped until the females have ceased laying eggs in the fall or winter.

Many other points could be discussed here if time were available. Suffice it to say that each species of *Culex* and *Culiseta* in which we are interested has its own biological peculiarities, and that these must be determined area by area before effective, economical control can be accomplished.

The specific distinctness of *C. stigmatosoma* and *C. tarsalis* has been a matter of controversy for a long time. Many of you have heard Dr. Freeborn (1941) state that he believes that *C. tarsalis* and *C. stigmatosoma* are but ecological variants of one species and that he has "seen *tarsalis* and *stigmatosoma* come out of the same egg raft." It is my opinion that *C. tarsalis* and *C. stigmatosoma* are distinct species although closely related. Morphologically they are quite different; however, as is the case of all organisms, there is a certain range of structural variation within which the individuals of each species fit, and in some characters there actually may be some overlapping between the two species. This is particularly noticeable in certain parts of California where, I am told, typical *C. tarsalis* adults may be reared from larvae identified as *C. stigmatosoma* and *vice versa*. Personally, I have not encountered such difficulties in separating the two species as they occur in areas of Southern California in which I have worked. However, we must come to the conclusion that certain morphological characters which have been used to distinguish these mosquitoes (for example, the position of the subapical tuft of the larval air tube) are sufficiently variable to be unreliable in identification. For the most part, the main distinguishing characters of the adults (male terminalia, ventral abdominal markings, presence of a line of white scales on lateral aspects of legs in *C. tarsalis*) are quite stable, and with a little experience it is possible to identify specimens accurately. In the case of the larvae, E. B. Thurman (personal communication) has recently pointed out a character on *C. stigmatosoma* which, I believe, is quite reliable for separating that species from *C. tarsalis*. This is the presence of conspicuous black spinules on the dorsal and apical part of the anal saddle. These are lacking in *C. tarsalis*. Another factor which leads me to believe that the two species are distinct is their distribution. Both species occur on the West Coast and as far east as Utah. In this area they are frequently found in the same larval habitat at the same time. Further east *C. tarsalis* occurs alone. Also, *C. tarsalis* is found abundantly in the western and central parts of Mexico as far south as Mexico City; whereas *C. stigmatosoma* continues on south, being common in southern Mexico and Central America and having been collected in Panama and Venezuela.

The biology of *C. stigmatosoma* has not been studied thoroughly. In Kern County, larvae have been collected from March until October and, from our figures, appear to be relatively more abundant in April and June than at other times of the year. As mentioned previously, they are occasionally associated with *C. tarsalis*. Out of 880 larval collections containing *C. tarsalis*, 104 (12%) also contained *C. stigmatosoma*.

On the basis of their morphology and distribution and the fact that they may be found together in the same habitat wherever their distribution coincides, I have come to the conclusion that the two species are distinct.

Literature Cited

Bates, M. (1949). The natural history of mosquitoes. New York: The MacMillan Co.

Freeborn, S. B. (1941). Proc. and Papers 12th Ann. Conf. Calif. Mosq. Control Assoc. P. 69.

Reeves. W. C., G. E Washburn, and W. McD. Hammon (1948). Western equine encephalitis control studies in Kern County, California, 1945. I. The effectiveness of residual DDT deposits on adult *Culex* mosquito populations. Am. J. Hyg., 47:82–92.

Thurman, E. B. Personal communication.

Mr. Smith: I think it is very easy to see that any one of the speakers could have taken up the entire time allotted for this symposium. I think, also, that if we opened the discussion up for questions we would take up even more time. Since time is extremely limited, I'll wind up this symposium by quoting a statement from Herms and Gray's *Mosquito Control* to the effect that it is entirely probable that progress toward effective control of mosquitoes will from now on depend increasingly upon the extension and application of biological knowledge. I don't know how many questions we've answered here today. I think we can be sure that we've raised many more than we've answered. I think this symposium has been a very distinct challenge to each and every one of us engaged in mosquito control. A challenge first to make use of the present knowledge of mosquito ecology, and second to continue to support additional research into mosquito ecology. Thank you very much.

Mr. Kimball: Thank you, Ed Smith, for that symposium. I must say this symposium has left me absolutely speechless. It does, I think, emphasize the absolute necessity of, as I call it, the entomological approach to mosquito control, and it brings out to me the simplicity of the management side of our district program. I have often said, we just can't get along without an entomologist in our district irrespective of the peculiarities of that species of the human race.

Art Geib has dropped off a few extra programs for those who don't happen to have one; they'll be at the desk here. And I certainly want to compliment Art on the wonderful job of getting the programs together and actually getting down to a very presentable printing job, which to me is the way of selling the program to agencies that are not too familiar with our program. For instance, our own Health Officer, because it was in this shape, took time to read it and recommended that one of his staff attend the meeting on that basis. I would like also, at this time, just to remind you of our executive meeting right after the end of the session, and I would like to request the extra attendance at this meeting for consulting purposes, if they possibly can stay, of Mr. Gray, Mr. Dahl, Mr. Mulhern, Mr. Buchanan, Mr. Geib, and Mr. Raley. If you can possibly stay with us it will make our committee meeting very quick. We'll take a five-minute recess.

Mr. Kimball: The next symposium is scheduled for one hour and thirty-five minutes and I think we have less than an hour to squeeze it in, so we'll start right out with the introduction of the symposium, "The Place and Scope of Eliminative Control Activities in California Mosquito Control." The Moderator is T. D. Mulhern, Vector Control Specialist, Bureau of Vector Control, located at Fresno. Tommy.

Mr. Mulhern: Several of the people who are to speak on this symposium came to see me during the intermission and suggested that they not be called, in consideration of the way the time had gone over. I asked that they all speak and that they make it as brief as they might like; we'll all attempt to do that, and we may be able to let the chairman adjourn this meeting on time. There are more things happening this afternoon after we get through.

Now, whenever a big red fire engine rolls rapidly down the street the people on the streets are, in spite of themselves, more or less thrilled; and I think something of the same impression is created by your pretty red and yellow, green and blue jeeps—somebody's going to have a pink jeep some of these days, I'm waiting to see that — but the people who see that red fire engine often overlook the fact that a real company has done most of its work — it spends most of its time and effort — trying to keep from the necessity of having that equipment roll; and the same think is true of the forward-looking mosquito abatemeit district. They are spending a good deal of their time and a good deal of their effort trying to make it unnecessary to roll those jeeps and do that spraying. The fire company must depend for the success of its work on education, to teach people how to avoid fires, on regulation to handle the people who will not be taught, and of course on proper construction. I think we have a very similar situation with the mosquito work. By education, by regulation, by proper construction, we can reduce the need for spraying. Now, because you use so many jeeps, because you have to do so much spraying in California, people have gained the impression in a great many places that all of California mosquito work is spraying; yet when you dig into what is being done in the different districts you find out that there has been for a long time quite a lot of attention paid to the more permanent methods of mosquito control, and if you will stop for just a minute and consider what we've faced in the way of increased acreage, increased potential mosquito control problem areas, you will see that we must, if we are going to be completely successful in our objectives, find some way to do this job other than by spraying. Now, in attempting to develop this panel I'm very frank to say that I had a lot of help from the people who are going to speak on the panel in developing the outline, and we finally arrived at the thought that we should attempt to present the material in a way which would fit the several broad types of mosquito control which is necessarily being practiced in California, so we have separated our discussion really into five sections or categories, one of those being permanent control on tidewater areas, the second being permanent control in irrigated lands flooded continuously, and the third being permanent control on lands flooded intermittently, again a subject, permanent control in river-bottom areas, and then permanent control on industrial, residential, or other private properties.

Now we hope we may be able to reserve even a little time for discussion at the close of the presentation, so with that little bit of introduction we will go into the presentations by the individuals who will participate, starting with Mr. Gray, and we've asked him to give you a broad objective view of mosquito control methods and processes.

Mr. Gray: Thank you, Mr. Mulhern. I have been just slightly nettled during the course of the Conference by a rather obvious fact, that some of you have heard the words that I have said, but you have not listened to what I said. We'll have them kidding me a little bit about permanent control, and it is not always applicable. You did not hear me say that. The reduction of water to the lowest extent practicable was what I actually said; now you cannot find it practicable to cut the water out of rice fields, so let's understand what terms we are using and the limitations of some of the generalities I put out. Now, these are generalities also which I am going to give you. I have tried to put them precisely so that there can be no misunderstanidng as to what I am saying. I am going to read it, partly for speed and partly for exactness.

A BROAD, OBJECTIVE VIEW OF MOSQUITO CONTROL METHODS AND PROCESSES

By Harold F. Gray

Engineer-Manager
Alameda County Mosquito Abatement District

The primary purpose of all mosquito control measures is to reduce or minimize the numbers of mosquitoes in a particular geographical area. To accomplish this purpose we may use one of three principal methods of attack, or combine two or more methods according to circumstances. Basically, we may (1) eliminate, curtail, or unfavorably modify the available production water; (2) we may kill the immature aquatic forms — eggs, larvae, and/or pupae; or (3) we may kill adults. These measures may be applied (1) against a disease vector species only (species sanitation), or (2) against a pest variety for prevention of economic loss or to promote public comfort, or (3) against all mosquito species in an area, according to the specific requirements of a particular situation, or the economic means available, or the aesthetic and comfort standards of the people.

There are two basic criteria by which mosquito control methods are judged: (1) they must be adequately effective for their intended purpose. and (2) they must be economical — that is, they must be (a) within the ability of the beneficiaries to pay; (b) less in cost than the value of the health or economic gains involved; (c) the least expensive method (in the end) shall be used.

As to the choice of the three principal methods, various factors must be evaluated. So much depends upon the ecology and the habits of the particular species of mosquitoes to be controlled that a valid choice of method can be obtained only after an entomological appraisal of the species involved and an engineering estimate of relative costs and practicability.

In general, under temperate climate conditions, and in areas of average or better than average economic productivity, the elimination or drastic reduction of the area of mosquito production water is ultimately both more effective and more economical than any other possible method. Supplementary larvicidal methods are generally necessary, but become less necessary as the water eliminative measures are completed. The use of adulticides then becomes unnecessary except in emergencies or special situations such as cemeteries.

Methods for the elimination of mosquito production water will vary with the topography of the ground, the amount and seasonal distribution of rainfall, and the extent and type of application of water for irrigation or industry. Dogmatic statements as to what can or cannot be done are either impossible to make, or ill-advised. But a few generalizations can be offered.

Complete elimination of production water may be impracticable, therefore we aim at its reduction to the least practicable area within reasonable costs. At that point.

we should next try to apply those measures which will make the residual water unsuitable to mosquito production. Salinification, controlled flooding and reflooding, constant level flooding with *Gambusia* propagation, are just a few suggestions in this field of operations. We have not adequately explored and exploited such opportunities for mosquito control. Also, I doubt that we have adequately explored and exploited the possibility of using pumps, both stationary and portable, in reducing the area of mosquito production water.

To depend upon insecticides for mosquito control, under temperate climate conditions, and particularly in California, as the primary control measure is a serious error, but it is also a mistake to fail to use them adequately and effectively in their proper place as supplements to eliminative procedures. Much ingenuity has been applied in this sector, some of it probably misdirected in emphasis, and some valid ideas which have been broached in the past are still not acted upon. Too much thought has been given to economy in materials, and not enough to effectiveness in results. The DDT-resistant mosquito is the unfortunate end product. And because of high labor costs, more attention probably needs to be given to the concepts of accessibility, convenience, and the overall time factor in insecticide applications, and in the inspectional services to diret them.

Finally, we have adulticidal methods. Adequate eliminative methods with supplemental larvicidal methods should make adulticidal measures unnecessary. But we all make mistakes, we all have failures of inspection, we all at times experience unusual and unforeseen conditions. We will no doubt continue to need adulticides to cover up our mistakes and our failures, but we should limit, except in special conditions, our adulticidal measures to covering up our mistakes and dificiencies.

Mr. Mulhern: It sounds like Harold has made a good start on keeping those fires out of Alameda County. We've asked Jack Kimball to talk a little on

PROGRESS OF ELIMINATIVE WORK IN TIDEWATER AREAS, ORANGE COUNTY, CALIFORNIA

By Jack H. Kimball

Manager, Orange County Mosquito Abatement District

Introduction

The elimination of unnecessary mosquito breeding sources has a major place in the control program of the Orange County Mosquito Abatement District, especially in the tidewater areas along its fifty miles of ocean shoreline. This District was created late in 1947 and includes some 777 square miles of area within Orange County with a population of 200,000 persons. Eleven incorporated cities are within the boundaries of the District. Although the District has had only two years of operating experience, the pattern of mosquito breeding and possible permanent control measures in the tidewater areas has already become apparent. The District approach to this problem can best be summarized by its three objectives, the first two of which have been attained: (1) Learning the problem; (2) Preparation of data for simplified presentation of the problem; and (3) The determination of the most economical solution.

Learning the Problem

In appraising the tidewater breeding problem a coordinated program of entomological statistics, operational experience, and engineering analysis has been followed. During the past two years Entomologist John G. Shanafelt, Jr. has made constant observations and collections of these mosquitoes, and has coordinated their ecology with physical factors such as temperature, rainfall, storm water runoff, habitat, and tidal floodings. Distinct patterns of breeding habitat have been developed for *Aedes taeniorhynchus* and *Aedes squamiger,* and are shown on the large coastal strip map in green and red respectively. These two species have not been found breeding on the same areas. The *taeniorhynchus* have been found only on salt-marsh areas subject to flooding by extreme high tides. The *squamiger* have been found only on salt-marsh areas isolated from tidal floodings by elevation or by the construction of dykes, dams, roads, or other improvements. The flooding of these particular salt-marsh areas by storm run-off produces the breeding source desired by our *Aedes squamiger.*

Cycles of *Aedes taeniorhynchus* breeding during 1948 and 1949 followed closely the cycles of monthly high tides, with first hatches occurring in May and continuing every month through September. Location of breeding sources was complete, and treatment by larviciding with 2% DDT oil solution by means of hand sprayers and power sprayers mounted on our two weasels was satisfactory.

The breeding sequence of *Aedes squamiger,* on the other hand, has been found to be relatively unpredictable, and constant inspection of these areas is required every month of the year. This conclusion was drawn from sad experience during the spring of 1949. Fourth instar larvae of *Aedes squamiger* were first taken on February 11, 1949, and were collected from time to time until April 25th. Although larviciding treatments were effective on the known breeding spots, many sources were undiscovered, since adult *Aedes squamiger* were collected from Huntington Beach, Costa Mesa, and several other inland communities as late as June 3, 1949. On September 23rd another plague of adult *squamiger* was discovered in Huntington Beach. The source of this flight was traced to a nearby reclaimed salt-marsh area that had been flooded by oil well drilling operations and coincidently by a break in the bank of an irrigation drainage ditch.

Intensive inspections were begun following the first seasonal rains early in November and continued at weekly intervals in order to find and eliminate any new "out of season" hatches of *Aedes squamiger.* The first rains soaked into the ground on the larger known breeding sources; however, first instar larvae were found at the mouth of a small canyon just north of San Clemente on November 6, 1949. Rain water from later rains flooded the larger salt-marsh areas extending from Newport Beach into Los Angeles County, and first instar larvae were found throughout these areas on December 28th. Several plots were selected for untreated controls, and are being inspected and records kept of the development of the larvae. The balance of the breeding areas are being larvicided as rapidly as possible, using two weasels equipped with power sprayers for the larger flooded areas and hand sprayers for the spotted areas. At the present time the *squamiger* at San Clemente have just about reached the pupa stage, three months after hatching.

In the larger salt-marsh areas the larvae vary from second to fourth instar.

Operational experience in the tidewater areas by the field crews under the supervision of our District Foreman Archie Perkins has provided the information needed for the determination of possible methods of control. Detailed knowledge of every square foot of the tidewater area, characteristics of specific breeding sources, methods of access, safety of heavy equipment and of larviciding techniques has made possible evaluation of what can be done with available equipment.

The entomological statistics and the operational experience has been coordinated with the engineering analysis of existing stormwater and irrigation drainage problems, and the use of the tidewater area by industry and recreation to give this District a preliminary appraisal of our tidewater breeding problem.

Presenting the Problem

Before an economic solution to the over-all tidewater breeding problem can be considered the problem must first be presented to all parties interested and economically involved. Besides the District Staff and the District Board of Trustees, other government agencies, property owners, and industry must be informed of any contemplated improvements. To do this, use has been made of a large coastal strip map recently prepared by the Orange County Planning Commission from an aerial photographic map. On this map the limits of the tidewater breeding areas in Orange County have been indicated, with *Aedes taeniorhynchus* and *Aedes squamiger* breeding sources colored green and red respectively. A second map of the entire District has been prepared to show the locations of the tidewater areas and to illustrate the effect of the *Aedes* mosquitoes on the population centers.

Determining the Economic Solution

The economic solution to the mosquito breeding problem in the tidewater areas of Orange County has not been determined as yet. Present methods of control by larviciding have been effective and have not been costly or too time-consuming. Since this District has been operating only two years, it is possible that we have not experienced a breeding season where optimum ecological conditions would require an excessive expenditure of time and materials. At any rate, me feel that the average annual cost of control by larviciding, including capital investment in special equipment, should be compared with the average annual cost of permanent eliminative work over a definite number of years. This period, however, depends on the probable normal improvement of the tidewater areas by recreational interest, industry. and by residential developments.

Since the coast line of Orange County has always been California's most desirable ocean playground, it is to be expected that the existing sloughs and marshes will soon be converted into yacht habors and beach resorts. In fact, detailed studies of Upper Newport Bay are under way by the Orange County Harbor Commission. General plans for all the remaining tidewater areas are under study by the Orange County Planning Commision and by the Orange County Coast Association.

It is our present conclusion that current eliminative control activities will be limited to improved drainage and flushing of the tidewater areas, and that permanent control measures will be coordinated with future development of this area by other interest.

Mr. Mulhern: When I first wrote Ernie Campbell he really took me to task for the way I had the thing set up, and particularly for not demanding a whole day for this permanent control aspect; and I can agree with him as to the importance of the thing, because I really believe that for the future we've got ot get into it more and more, but the Conference of course had to deal very decidedly with the immediate problems, so we had better be satisfied with the short time. We've asked Ernie if he would take about three minutes to tell us about permanent control by ditching to provide free circulation of tidal waters. Ernie?

Mr. Campbell: Well, I don't know that I took him to task for not devoting a day to it, but just pointed out that it could certainly consume a day. And so far we have practiced drainage, of course, since it's the simplest type of control. We had on one occasion about 250 acres, into which we put around 90 feet of hand ditching per acre. We varied that on another area of about 900 acres: we put in 5,500 feet of large canal, about 40 feet per acre, a long hand ditch with a tide flood gate, which we flooded once a month. There were various reasons why we did that, they worked out very nicely. We had another one about 450 acres, where we put in a short large canal, and a weird type of gate, to allow just a minimum of fluctuation, and that's worked very nicely.

The thing that I think is of a great deal of interest is this area where we had the 250 acres wide open; our soil is a little different from that of the lower bay, where they have more of a silt-type soil. We have what the soil specialists call muck, a peat-like material. We ditched that marsh open and we didn't have any breeding there for years; but it wasn't too long before we discovered that our little random hand-laid ditches were lying on the high ground, and in the intervening spaces there was the low ground. That didn't bother us too much until last fall, when we discovered we were going to have to do something about it. We made arrangements for the trench-hole type of machine that has about two pounds per square foot of bearing surface to come in and ditch it open. The owner had to overhaul his rig, and by the time it was ready his farm customers were calling for his machine, so we told him to forget about it until the spring. It was April when we got in there, and that marsh which before hadn't had any breeding on it at all was very heavily infested with larvae between our little hand ditches; so we then had to spray it, and then we cut it open with these trench-hole ditches, and of course we won't have any more trouble there. That was twenty-two years it took us to do that.

Mr. Mulhern: The larvae apparently eventually developed resistance to ditches. Mr. Jones is going to tell us something about pump systems and the application of controlled re-flooding systems for handling salt-marsh mosquitoes on a permanent basis. Mr. Jones is Superintendent of the Marin County Mosquito Abatement District. Paul?

Mr. Jones: Well I'm not doing much on flooding control over there, I mean flooding certain areas and then getting rid of the water, and trying to get rid of the eggs that way; but I have a little memorandum here of what we've been trying to do over there for I think thirty-five years. I've been at it two years, and after listening to everybody here for the last two days I figure I'm an amateur at it, but I'm trying something.

PERMANENT CONTROL WORK OF MARIN COUNTY MOSQUITO ABATEMENT DISTRICT

By G. PAUL JONES, *Superintendent*

Since its organization the Marin County Mosquito Abatement District has stressed permanent control. This permanent control work has consisted of draining the pot-holes and low places in the open marsh, and encouraging the farming of marsh lands. This latter method has been accomplished by financing one-third of the cost of all culverts and automatic tide gates. After their installation all necessary maintenance work is done by the District. On the replacement of these culverts and tide gates the District furnishes all the labor and part of the cost. Once the open marsh has been reclaimed and planted to hay or grain, the larviciding is done in the drain ditches only. Where open marsh has been reclaimed for pasture, some small ponds may have to be larvicided.

The continued farming of marsh land causes the ground to lose its original moisture, and when this happens, the ground shrinks and settles. The Corps of Engineers have found that some marsh ground in our district has settled as much as 4 or 5 feet. This settling of the ground, in combination wtih the silting of the tidal sloughs and bay flats has made it impossible to completely drain the marsh ground before damage has occurred to grain and pasture. To avoid this damage, pumps of large capacity have had to be installed. In the District there are 14 of these pumps. Two of these pumps are owned by the District and are used to pump flooded pasture land. They are operated when fourth instar larvae and pupae are found. If the land owners want the pumps operated before this time they pay for the power.

One difficulty with the operation of automatic tide gates has been the removing of silt from the gates to the main tidal sloughs. In most cases the ground is soft, too soft for the use of the dragline, and a floating dredger is too expensive. This work has been done by hand labor, and sometimes with the use of a high-pressure portable pump. Recently we have started using ditching dynamite for this job. Our limited use of dynamite has convinced us that we have hit on a solution to the problem.

Then, in connection with our permanent control work, we have encouraged the farmers in the district to apply for financial aid from the U.S. Agriculture Conservation Association. This agency is interested in conservation practices, and they base their help, especially on ditch work and levee recapping, on ten cents per cubic yard for soil that is moved. We find that if the winter rains are allowed to remain in the marshes behind the levees for a long enough time to damage the crops, either pasture or hay land, we get a pretty good source of mosquito breeding. By "encouraging the farmer" I mean going to the extent of drawing maps and writing letters and then getting his signature on them and putting the thing through. I've found that there was a lot of work in our district in the last two years that we got accomplished along permanent control lines that we just didn't have the money to put over in any other way; and this job of trying to talk the farmer into spending money, his money, on something that he can't see much benefit from sometimes is a tough job. We have a few projects over there that I've worked on in the last couple of years, and I tell you I've talked until I'm blue in the face to get them over. Well, that's about the extent of my report.

Mr. Mulhern: Well, it seems to me that Dynamite Dick from Utah who did some successful mosquito work with dynamite reported to us last year, also reported blowing a streamliner passenger train off the tracks some place, and I'm glad to hear that Mr. Jones didn't have any experiences like that.

Well now, only three of our speakers have to do with the salt-marsh aspects of this problem. That is no indication that we think the salt-marsh aspects are any less important than the fresh-water aspects, but probably it is an indication that we all feel that the people working in the salt-marsh areas are a little bit better satisfied that they have the permanent solutions pretty well in mind at least, whereas in the irrigated areas there are a lot of us who feel that there is still plenty of question as to what we can do successfully in the way of permanent control. So, in going into the irrigated areas, it's quite unfortunate that you come pretty well down at the end of the program, because I think Dick Sperbeck feels that probably some of his thunder has been pretty effectively stolen. However, we'll ask Dick to tell us something about the work in the rice areas, the permanent flood areas.

Mr. Sperbeck: I have a paper here entitled "Rice Field Anopheline Control," and for much of this material I am indebted to Mr. Herb Herms, our entomologist, who practically lived in those rice fields all last summer and who has gotten together a lot of good first-hand information. Evidently all these anophelines haven't read all the old books, so they don't live up to all the old ideas. It is of course not the place to read this paper; I'll leave it, and those who are interested in it I think may enjoy it more when you are in your office on a rainy day in a comfortable chair, then you can read about what we have done in the past three years in the Sutter-Yuba Mosquito Abatement District to try to control what I believe is one of our greatest problems. I think it is so serious that the future success of the abatement districts in the Sacramento Valley hinges entirely upon a markedly economical and feasible way of controlling rice field anopheline mosquitoes.

Last year we had no mosquitoes in the area of any consequence up to the fourth of July. We can control the *Aedes* mosquitoes. They are tough. We have plenty of them in the Sacramento Valley too; they are not found only in the San Joaquin Valley. We have plenty of those, but we know what to do about them. It's just a case of a lot of hard work and going out and getting them; but when you do a good job on those you then have all of your work spoiled by a terrific influx of *Culex tarsalis,* starting about the first of July and lasting for a month at least, and then the anophline picking right up where they begin to dwindle and coming in in swarms into the area. As one fellow put it, when one of our men — he evidently wanted to show that he knew something about mosquitoes — when he told them about mosquitoes bothering them out on his ranch, this fellow spoke up and said, "Are they anopheline mosquitoes?", and the other fellow said, "Hell, I don't know, they are the biting kind." So we evidently have been approaching this thing from the wrong angle.

For three years we have been aerosoling by plane. By the way, we have — or the last season we had — approximately 60,000 acres of rice in the two counties, most of it within the boundaries of the District. We have been aerosoling those rice fields by plane at a time when we considered the anopheline larvae — we disregarded the culicine, we just had to take those — were at a peak, because it was too expensive to have to larvicide, which we have found out you would have to do approximately every ten or fourteen days, because re-infestation takes place three or four days after we have killed the larvae. You can kill that generation of larvae, but it's beinning to dawn on us — is that one generation of larvae worth the $7500 or so that it takes us to cover the rice once? We've had the anopheline adults emerging before that, we have them emerging after, and as far as the people are concerned I don't think they notice that one generation is missing in there. So for that reason we are going to approach it from a different angle, and I thought it was something new, and come to find out somebody thought of this angle back in 1907 or somewhere, that if we do more work on that weak link, the link between the overwintering anopheline mosquitoes and the new generation of larvae, that should be the weak link in the whole cycle of the anopheline mosquito. So we are going to concentrate with more intensive inspection to discover where these anopheline larvae are and to spray them and kill that generation as far as we can go. Now, if we have a good wet spring there's going to be an awful lot of water to contend with, but I believe, as some of the speakers have stated this afternoon, that it is the most practical way and we'll get more for our money from it. I think at this time that is all I will say, and as I say there is a lot of good information in here, and I can brag about it because most of it belongs to Herb Herms.

RICE FIELD ANOPHELINE CONTROL — WHEN IS THE BEST TIME?

By Thomas M. Sperbeck

Manager, Sutter-Yuba Mosquito Abatement District

Introduction

One of the biggest problems, if not the biggest, in the Sutter-Yuba area is the control of the rice field mosquitoes, *Anopheles freeborni* and *Culex tarsalis*. Our control operations, using a plane, begin in the fall when adult *A. freeborni* appear most bothersome and when the larval population seems to be at a peak. Because of the expense we can use a plane only once over a field, applying a DDT thermal exhaust aerosol. The work is expensive, and although we have reduced the cost to less than 20 cents an acre, we can afford to do only a limited amount of control on the 60,000 acres of rice in the two counties.

Therefore, we are seeking a more economical and effective method of control. The one treatment of rice fields by plane cannot prevent the escape of some adults before the work begins. Since first instar larvae recur within a few days, the adults that later emerge must be aerosoled with truck equipment, adding to the expense.

Some Questions on the Local Problem

Perhaps there is a "weak link" in the life cycle of the rice field mosquito. Control directed at that point could conceivably prevent the establishment of larvae in rice fields.

Spring larval control has been suggested and tried by us on a limited scale, at which time the adult anopheline population is at its lowest. This would seem to be a logical time. At that time of year, however, there is a considerable amount of flood water, seepage, and rain water. Control, then, would necessarily be over an extensive area. We hope to find out more about this phase of the problem this coming spring.

Several questions have puzzled us concerning the larval habits and development of *A. freeborni* in our particular area. Where do larvae develop when rice fields are not under water? Where are *A. freeborni* larvae until the apparent build-up in rice fields in August and September? And when does *A. freeborni* invade rice fields — is it in August or is it earlier?

With these questions in mind, our entomologist, Herbert Herms, set out to gather information on specific larval locations in the spring and summer, the approximate time when larvae appear in rice fields, and the vegetative appearance of rice fields at the time larvae were found. We believe that we have at least partial answers that will help us in the future in the control of rice field mosquitoes.

Natural and Miscellaneous Larval Habitats

The main source of *A. freeborni* larvae in the fall is rice fields; but the fields are under water only for part of the year, from about the middle of April until they are drained in September or October. Since adults are active in the early spring, there remains a period of egg-laying and larval development excluding rice fields.

By frequent dipping in the early spring, we found anopheline larvae in river bottom borrow pits adjacent to the levees on both sides of the Feather River, road ditches, and seepage and floodwater areas. In some places the concentration was heavier than we find larvae in the fall. The first anopheline larvae were found in the river bottoms in late March and early April. Scattered anopheline larvae can be found earlier in rain water pools, but this was the first concentration of any consequence.

The Rice Field Habitat

The first anopheline larvae were not found in rice fields until after the first of June — six weeks to two months after the fields were first flooded. In an occasional rice field, *A. freeborni* larvae appeared within a few days after flooding (May 1). One larval source in particular was an old field in which very little ground preparation had been done after last year's harvest. Larvae were hidden under tules and weed growth along the edges of the checks.

For at least a month after the first flooding most rice fields have very little weed growth on top of the contoured checks. The checks are usually bare, unless last year's checks remain, and the water surface is clear until rice shoots penetrate through.

After rice fields are completely flooded so that excess water overflows into drains, larvae soon appear in the tule-clogged, slow-moving drains. Many drains are difficult to spray. Since they are drains, they adjoin the low check of a field, where larvae next seem to become established. Other parts of the field are then affected.

The appearance of *A. freeborni* larvae in rice fields seems to be dependent upon whether there is enough vegetative growth along the checks to hide and protect the egg-laying females. From our observations, *A. freeborni* larvae cannot be found readily in a rice field until there is this heavy, protective growth of overhanging weeds, tules, and rice on the contoured check. To find anopheline larvae it is usually necessary to dip under this growth and up against the bank of the check. The overhang may be two or three feet wide over the water surface and several feet high.

Some fields planted late remained free of larvae into the midle of July, a month or more after the earlier fields had been infected. When weeds or rice became thick upon the check, then larvae could be found.

The Adult Problem

Generally speaking, the adult anopheline mosquito is most noticeable to the public in the fall — August and September — and then during the first warm days of January or February as the hibernating females leave their winter shelters. For the remainder of the year, the adults do not present a problem. But from larval collections during the spring and summer, *A. freeborni* adults are apparently active then although they are not bothersome. According to Dr. W. C. Reeves,[1] adult anophelines acquire most of their blood meals from non-human sources. He found by precipitin tests of adult anophelines tested, that only a small percentage contained human blood, while about two-thirds had fed upon horses and cows.

Culex tarsalis larvae can be found much earlier than anopheline larvae in rice fields, and as a consequence this mosquito is a continual summer problem although not as intense as the anopheline problem.

Control Problems

Since the fall rice field control work was started here in 1946, it has always been possible to find anopheline larvae in a field within a few days after the airplane spraying had apparently done a 100% control job. The State Bureau of Vector Control, in experiments conducted by Mr. Harvey Magy here in 1947, demonstrated that a pint of 5% DDT solution per acre applied by plane as a thermal exhaust aerosol achieved practically a 100% kill. Yet within five days after treatment, larvae recurred. We tried various materials and methods of application this year in an attempt to find an explanation. After checking about 35 fields from one to ten 10 and dipping from 10 to 250 dips each time, we can only offer some of our results together with what we believe to be the reasons.

At first this summer we believed that after control operations there remained a residual of surviving larvae protected from the spray by heavy growth and almost impossible to find by dipping. With this in mind we tried spreaders — B-1956 and an Ortho spreader — so that the material would penetrate to the shallow edges of each check. But results remained the same. When Emulsible DDT was tried results were still just about the same. Larvae could be found again within a few days. Although only one or two larvae and sometimes none per 100 dips could be picked up after the plane work, there is still the possibility that a residual fringe of surviving larvae may be responsible for the larval recurrence within 4 or 5 days after control work.

Also, after control operations this summer and fall, we discovered that many adult anopheline and culicine mosquitoes remained in the field. From 1 to 6 or more adults per lineal foot of check could be found hidden at the shaded, cool, protected base of weeds and rice near the water's edge. The aerosol material seems to be able to penetrate this growth and kill larvae but apparently adults are unaffected.

No doubt some of the adults are those that emerge shortly before the plane's work, but others were gravid females. Therefore, it seems logical that anopheline females resumed egg-laying after the plane work and that recurring larvae were those that hatched a day or two after the plane treatment. If this is the case, then rice field control work, to be effective in the fall, must also kill adult mosquitoes as well as larvae.

Tried as tests to control adults as well as larvae were various percentages of DDT aerosol-spray, emulsible DDT, a mixture of DDT and DDD, and Lethane and Pyrethrum were added to DDT. In all cases, larvae appeared again within a few days. As an adulticide and a larvicide, an 8⅓% DDT with a 2% Pyrethrum and a 2% Lethane mixture was applied at the rate of a quart to an acre or .167 pounds of DDT per acre. Still larvae returned and numerous adults remained behind.

Early spraying of a field was also tried, and this same field received several applications with no clear-cut success in the prevention of a larval build-up.

It would seem that further work is necessary to find whether the adition of some insecticide as an adulticide or as both an larvicide and an adulticide would be economically and financially practical so that fall rice field control work by plane could be achieved with one application. Spring larval control work seems to be the other alternative.

Mr. Mulhern: Thanks a lot, Dick. Bob Portman has some definite ideas to contribute on the same subject of Mosquito Control by Permanent Means, or by any means, in the rice field areas or the more or less flooded areas. Bob?

Mr. Robert Portman: Several of the gentlemen who have been up here yesterday and today have complained about losing their thunder. Well, we're at the end of the program and have lost a lot; and when you have to talk after a man like Sperbeck and think almost the same way he does about the problem, you don't have very much to say, I believe, but there are certain things in regard to the rice fields that I feel are very important.

Dick mentioned that we have *Aedes* resulting from the initial flooding of the rice fields, and they can be controlled, and it has proven quite satisfactory in many instances. But we have this problem of a few anopheline larvae showing up in the rice fields, going along for a period of time and then suddenly the reproductive potential of these mosquitoes is greatly accentuated. In fact, I have some slides to show you, and you may be surprised to see how rapidly they rise.

Now, to date all we have been able to do in the rice fields is to use repetitive methods of control, that is larviciding. It would be possible that a ground aerosol could be used if you could get to the rice fields to help control some of these adults, but we can't get to the rice fields. It has to be by plane treatment, and plane treatment is costly, because instead of a few thousand acres we have a lot of thousands of acres. We have a backlog of information as to the life-cycle of the anopheline mosquitoes, but we still have a lot of information to find out yet. There's anopheline all up in that rice country, and just about the time you think the anopheline are gone your collecting stations will start building up on the first warm day. Where they come from —

[1] Reeves, W. C. Preliminary studies on the feeding habits of Pacific coast anophelines. J. Nat. Mal. Soc., Vol. III, No. 4, 1944.

well, that's a question that we don't know. We do know that they move, and how they can move in a few days from a distance that's been aparently clean of them before for several months and where they come from is a problem we have to solve. A lot of the work that has been done on the rice fields, to the control of the rice field mosquito, has been done as regards trial and error from the best information we have, and some of it has been done on some wishful thinking because we didn't have facts.

Ed, would you show those slides? [Slides shown.]

Now, Dr. Markos carried out some extensive experiments or research work in the rice fields in the upper Sacramento Valley this past season, and I've obtained this information from him. We know this information in a general way, but until you get it down on a piece of paper and draw a chart you don't really know what you have at hand. The left-hand side of the scale represents the number of anopheline larvae and pupae per twenty dips; the right-hand side represents the height of rice in inches. You notice that at the first of June we have a few larvae in the rice fields, then suddenly toward the end of July they start increasing, so that from practically nothing — one or two in the field — you will find that by the middle of August there are close to two hundred in twenty dips. Now, that may not sound like very many mosquitoes compared to a pasture, but when you have 50,000 acres of rice fields and if you can figure out how many dippersful there are in each rice field you can get an idea of how many mosquitoes we have. Then for some unknown reason these mosquitoes drop down in reproductive potential toward the end of August and then shoot up again. Their reproductive potential apparently follows the growth of the rice, as you notice by the curve of the rice line. The dots here represent first and second instar anopheline larvae, because the curve up here representing a total of larvae and pupae may not give you a true picture.

The larvae increase from about ninety per twenty dips to over two hundred in the short space of around ten days. Then when the rice fields are drained that puts an end to them. How high that would go nobody knows because nobody lets the rice run that long. (Next slide, please.)

In cooperation with Dr. Markos we took several selected fields which he kept a record on all season long and plane-sprayed them, trying to catch the final peak of anopheline larvae as close as we could to the draining time, so that we killed off the larvae, and before they could build up and come off as adults the fields would be drained. Now that is close timing. You only have in the neighborhood of approximately two weeks, and if you can imagine, like Dick has up there, and up in our area there may be some 20, 30, or 50 thousand acres of rice that you might want to spray, and to contemplate spraying that in a two-week period is a job, if you can get it done.

Here you notice the larvae come up and have a peak in this one plot, fall off and come up to another peak. This was plane-sprayed on this rise up here, and when the reproductive potential was quite great it dropped down to practically nothing, and except for a few late instar larvae and pupae — I think, if I remember the data correctly, it was only pupae — rise up again. The only thing that stopped these anophelines from building up again immediately within ten days or less and coming off within less than two weeks as adults, is the fact that the rice field was drained. The increase of the height of the rice is paralleled also by the increased production of the anopheline mosquito.

(Next slide, please.) Here we have a similar situation, similar to the other slide, but this is just another plot. We have the same results; plane-spraying accompilshes the result, but in a short period of time they build right up again. (Next one, please.) Now, in this particular field, different from the other two, was the fact that we had drainage soon after or immediately after the spraying so that we got an excellent kill, and then the field was in the process of being drained so that we didn't have any build-up again. (Next slide, please.) These plots were two plots in each rice field so that as near as possible they represent the same area. It's more or less of a check, and they do parallel closely; you notice here in this case we don't necessarily have a peak, but we have a leveling off and then a rapid peak. When it was plane-sprayed we got reduction to a great degree to practically nothing, and then the draining of the field prevented any more breeding.

I believe that you will be able to see from these slides that we do have a problem, and the problem is comparable to spraying *Aedes* in the pasture — you get a good larval kill, then it's flooded again and you have *Aedes* once more within a short period of time. We have the same thing in rice. The question is when to plane-spray and whether you can afford to plane-spray enough times during the year to keep those larvae down when the reproduction potential is as great as it is, because if there are some adults left in the field, even though you do get a complete kill within ten days you have the same story over again. Another factor is our seasonal weather. Dick mentioned the fact that we had *Culex tarsalis* coming off the rice fields in July. I'll say we did. Mr. Slusser, who is here today, can readily verify that. They moved in town. Another thing is, we had a peculiar season for a period of time in August when we had cool weather, and it fooled the anophelines and they thought it was fall and the fields were ready to be drained, and they started moving out. Normally they stay in the fields more close to draining, but they started moving out ahead of time. So I would like to say that we still have a lot of information that will have to be gained in regard to rice field mosquitoes and their ecology so that we'll be better able to control them.

Mr. Mulhern: We'll push right along without taking any discussion time, even though we are now going to swing from the irrigated lands that are pretty much continuously flooded during the summers to the general subject of control on lands which are only intermittenly flooded during the summer. Mr. Portman has indicated to you something of how the problem is delineated on the one type, and Don Murray will give you the orderly fashon in which at least his district is attempting to determine where it is worthwhile to go to the expense of permanent control in the intermittently flooded land.

Dr. Murray: We have our district fairly well mapped in sections (one square mile), and we show in pencil or in lines the different fields, indicating them by solid black lines or in some other way. Each field, of maybe only five, ten, or twenty acres, has its own irrigation cycle. We indicate in red the exact areas where we have found breeding of *Aedes nigromaculis,* or perhaps *Culex tarsalis,* during the season. Now, we also have records, which we follow through each season, of each irrigation cycle, which tell us how much time we spent in controlling and how much DDT we used, and that gives us a figure of how much it cost us to control all the fields in this one section. I have it here more or less itemized at about $81.15 to control *Aedes nigromaculis* alone, that's the field part of it. *Culex quinquefasciatus* has to be considered too, but that's a little different problem. Then we find out how much money we get out of that particular section.

I'm especially interested in the *nigromaculis* fields. This area colored yellow represents one farm, and we find that we get $165.00 in taxes off that one farm. When we combine the two we find that expense may be greater or may be less than the revenue. Now, my procedure has been to go out to the individual rancher and discuss these fields with him find out the reason for the low areas or the excess water and attempt to get him to do something about it. In one case the person went right out and re-leveled the field. Leveling fields in this way may cost as much as $100.00 an acre — rather expensive. Some of them are willing to do that. Maybe it's a matter of firing an irrigator. Well, is that permanent control? It might be. Things like that enter our work.

Mr. Mulhern: Now Ed Smith follows along in the same principles, and he will tell you of the ultimate development of that same idea as it is carried out in Merced County.

Mr. Smith: I'm afraid I can't lay any claims for Merced County as a resort area — too many of you have been there. However, I think I can say without any fear of contradiction that Merced County is the favorite playground in California for *Aedes nigromaculis*, and the *Aedes nigromaculis* problem in our irrigated pastures is one of our major problems, if not the major problem.

Any discussion of eliminative control in Merced County must start with Harold Lilley. Harold Lilley was the Superintendent of the district from 1934 until 1945. During that period of time he started from the first doing eliminative control work. He was an early disciple of Harold Gray, I think, as soon as he got into the field of mosquito control. He looked up Harold Gray and got his slant on things. From the time of about 1935 to about 1940 his principal instrument for doing drainage ditching was what he called his trusty muck stick, his shovel. In 1940 he was able to purchase a Fordson tractor and a small ditching tool. His first experience in using that in irrigated pastures to reduce the water areas that were standing were rather rough. The farmers didn't want any part of it. They wouldn't even let him on the land. He had to talk like a blue streak — and he could do that very well — to persuade them to let him go in there and do that work at no charge. He was trying to persuade them that by eliminating that standing water they would not only be getting rid of the mosquitoes but they would be getting better pasture grass, that they were drowning out the pasture grass at the time and that he would help them to bring that into better production for their cattle and eliminate mosquitoes at the same time. Well, that program of his was eminently successful, as was attested by the fact that the Crocker-Huffman Land and Cattle Company, which was one of the first properties he started on, within a few years began to pay him to do that work and in the last few years have bought their own tractor and ditcher of a similar design and are paying their own men to go out and do the same work. They are convinced that it is well worth while not only from the point of view of making life bearable for their irrigators and also being a little easier on their cattle, but also that it helps to improve their pasture grass.

In the past, say, five years, further developments with the advent of DDT and with the expansion of the District from 17 square miles to 2000 square miles, the District has undergone — shall we say — growing pains, and for a period of two or three years with the beginning of the use of DDT, a lot of that maintenance of the original drainage work was neglected. I think we have as good an illustration, or as good a proof of the benefit of that work in our records from the results of the relaxing of maintenance of that drainage work. Our district also uses the section survey concept which Don Murray mentioned. We started using the section survey maps in 1946; we differ somewhat in detail, but the idea is the same. We make inspection treatment cards which give a complete record of every single larvicidal or adulticidal treatment on the individual plot of land, and we use that as a basis for planning eliminative work.

Now, in the particular case of the Crocker-Huffman land just north of Merced, in fact, practically continuous to the city limits of Merced, that work was neglected for a period of a couple of years. In 1946, when that work was still effective, we did not have to do any aerial spraying in that field, I think, with the exception of the last two weeks of the season. We did have to spray one or two of those fields. We did not maintain the drainage work in those fields in 1946 or 1947, and in the summer of 1948 we had to send our airplanes out into those fields to spray them on virtually every irrigation throughout the season.

We figured out the cost of some individual fields, of about 100 acres, and it ran up to six and seven hundred dollars for that hundred acres for the season. Eliminative work was a lot cheaper. This last winter before this we did get back and re-do the original work at a very low cost with the same Fordson and ditcher, and this last season, 1949, the picture is again as it was several years ago, that we have not had to send our airplane out to spray those fields except in a few individual cases.

In the last year we have purchased additional drainage equipment; we have purchased an Allis-Chalmers HD-7 with a ditcher, and we are offering that equipment to farmers for cooperative drainage projects at cost. This last winter is the first time that we have attempted that, and we have got an excellent response. We have much more work lined up for that tractor and ditcher than we can handle. We are attempting to make that program self-sustaining.

Mr. Mulhern: "The eliminative work was a lot cheaper." That was a statement which Mr. Smith made which impressed me very much. He was speaking, of course, about one section; we have other sections where that might not be the case. Now, Elmo Russell wasn't able to stay, but he left a statement, "Why and How the Hanford Mosquito Abatement District Believes in Permanent Mosquito Control." It deals with cooperative elimination of sloughs in his area. With your permission and because of the shortage of time, we'll place the paper in the record rather than reading it here. I think many of you have seen or heard of Elmo's slough elimination work in any event.

WHY AND HOW THE HANFORD MOSQUITO ABATEMENT DISTRICT BELIEVES IN PERMANENT MOSQUITO CONTROL

By Elmo Russell

Manager, Hanford Mosquito Abatement District

It is agreed that while the methods of mosquito control are essentially the same wherever mosquitoes are found, the approach and methods of practical and permanent control differ according to the topography and vegetation of the several districts.

The Hanford Mosquito Abatement District is just to the north and east of a large area known as the Tulare Lake region. This lake, which is now dry, when full covered an area of some 40 miles long and 30 miles wide, yet only reached a depth of around 12 feet. Under extremely wet conditions this lake is fed by all the rivers and creeks flowing from the east side of the valley, from the San Joaquin River in the north as far as the Kern River 135 miles to the south.

This background is important, because the Hanford Mosquito Abatement District is so located that the Kings River flows a few miles north of the district, then turns and flows a few miles west of the district, with Cross Creek flowing east of the district.

This portion of the valley is so level that until a few years ago this river and creek, in time of high water, flowed over the whole area, with the result that there is a large network of sloughs and ponds. Hardly a ranch does not have a slough or low place in it. The city of Hanford, one mile wide and two miles long, had several ponds and two sloughs.

Many of the ponds and all the sloughs were lined and filled with such a dense growth of willow trees, tules, hyacinths, blackberries, wild grapes and roses, rye and marsh grasses, to a width ranging from 50 to 300 feet, which made hand or power spraying impossible and airplane spraying impractical, even if finances would permit such spraying.

As these sloughs twisted and turned through the fields, much good land was lost to farming and cultivation was made difficult. Much irrigation water was lost, washing large holes in the sides of the fields and the soil into the sloughs. The vegetation was host to such arthropods as red spider, vine hoppers, grasshoppers, etc., and housed squirrels, rabbits, rats, skunks, opossums weasels, crows, and sparrow hawks, all detrimental to the farmer.

It seemed that the proper approach to good mosquito control was indirect, to first approach the owner from the standpoint of more profit to himself through eliminating these hazards, especially since adjoining ranches which had been leveled were selling at from $350 to $450 per acre or raising a good crop, while many of the places with sloughs were so unlevel that dry farming was practiced, returning from one-quarter to one-third crop values.

From a good business standpoint, when prices are up, every one feels good, and because of income tax exemptions, capital investment, etc., is the time business firms make improvements and expand — so why not the farmer, especially since the government is giving aid for improving farms and supports prices on crops.

Then again, when such aid is no longer given, those places which were so improved can then be more economically farmed, and even if prices are low, will still be able to make a profit.

Then there is the other side, the psychological side. All men want to be successful in good citizenship, as well as in business. So it was suggested that by improving his place he would not only make more money, but that the people in the district so wanted to enjoy their homes and themselves in the long summer evenings, that they had formed a district to rid themselves of mosquitoes. That with such hazards, spraying was expensive and a makeshift at best, with no assurance of successful control, but even if the owner was liable for raising mosquitoes, the district was willing to cooperate by putting one year's cost of spraying each place into helping to eliminate these hazards, and that the people of the district would be grateful to him for his cooperation in making his community a better place to live.

It usually developed that getting rid of the trees on the sloughs was their mental hazard, and when the district assumed one-half of the dozing and guaranteed to burn them up, work was soon under way.

Pictures were taken of before and after, and were displayed at the fairs and other places, with owners named. Publicity was given in clubs and other meetings, that if all were cooperating like Mr. John in helping rid the community of mosquitoes, shortly our problem would be solved.

The results are some twelve miles of slough cleaned, with several miles completely filled and ponds leveled, at a cost to the Hanford Mosquito Abatement District of less than one man's yearly spraying cost, with all these hazards permanently removed, with everybody happy and friendly towards each other. Taxes have been reduced 4 cents, reserves have been built for a depot and for replacement of equipment, with enough funds to carry through the dry tax period and keep our men the year round. And further, if a rancher is troubled with a slough, he now comes to us for advice and aid. We in Hanford believe it has paid us many returns not only in control but in friendship.

Mr. Mulhern: Dick DeWitt has just handed me the memorandum on his paper, which is entitled "Program of Eliminative Work on Lands Flooded Intermittently During the Summer Months," and it has to do, I think, principally with eliminative work in cotton areas where the district has cooperated with cotton farmers to provide for drainage of tail-end water, and in many cases the reclaiming of that water by pumping it again to the head-ends of the cotton fields. The thing has been done on a basis where it has been economically sound and feasible. We will place this in the record also by Dick's request rather than reading it in detail.

PROGRAM OF ELIMINATIVE WORK ON LANDS FLOODED INTERMITTENTLY DURING THE SUMMER MONTHS

By Richard (Dick) DeWitt

Kern Mosquito Abatement District

It is estimated that in the Kern District 90% of the mosquito breeding sources are created by man, with 70% a consequence of agricultural practices. With an increase in irrigation each year because of newly tilled lands, the job of control becomes progressively more difficult. Numerous breeding sources are continually being added, many of which can be eliminated or reduced in the mosquito breeding potential.

To minimize the repetitive larviciding required under these conditions we have developed a public relations program to try and obtain the farmers' cooperation in eliminating the cause of the mosquito breeding sources. This is done through direct contact with the farmer by a public relations representative. Our experience in this work during the past 1½ years has shown a very difinite value in having one man make all contacts and stay with each specific problem until completion.

Any problem of consequence in the field is called to the attention of the public relations man, and he goes over it very thoroughly with the district operator in that area. When a complete study has been made as to the possibilities of elimination, then contact is made with the farmer. It has proven very important to have a definite plan to be able to put to the farmer even though it may be a detailed drawing and include a cost estimate when materials are needed.

In all cases the district's activities are pointed out to the farmer and he is asked to cooperate rather than ordering him to make the necessary corrections.

The district owns and operates a bulldozer and grader that is made available to farmers who do not have heavy equipment of their own for the correction of mosquito breeding sources on their lands. The district furnishes the equipment and does the work at a cost to the farmer of $7.12 per hour. This method of eliminating a problem has proven very successful and a benefit to the district in that the job is done properly from the standpoint of mosquito control. When the farmer chooses to use his own equipment and men, all too often a considerable expenditure may not correct the problem in respect to mosquito control.

By direct contact with the farmer the district is building up a good district-farmer relationship, and to date it is realizing big dividends because of the farmers' cooperation and understanding of the part he will have to play in making good control possible.

Although the public relations program has been in effect for two seasons the nearest thing to legal action taken has been the case where a farmer was reprimanded by the local Justice of the Peace for not fulfilling his promise to keep his irrigation tail water from scattering on alkali flats.

Our experiences with this program show a very definite value in public relations and the elimination of many major mosquito-breeding sources throughout the district. On the other hand, it also emphasizes that repetitive larviciding is a must when carrying on a mosquito control program where irrigation is a major source of mosquito breeding. All too often it is economically prohibitive for the farmer to eliminate mosquito breeding sources created by his farming practices.

Mr. Dahl: Mr. Chairman, may I comment just briefly? There is one important thing in the Kern Mosquito Abatement District — Mr. DeWitt. One of his main jobs — in fact, his principal job — is to go out and talk with farmers and to sell drainage and this type of eliminative program. Isn't that your main job in the district?

Mr. DeWitt: Yes, that's right.

Mr. Dahl: And I feel that that's something that each of you districts might take to heart in case you don't know about it. Art Geib has Mr. DeWitt working for him on this particular activity alone during the major portion of the year.

Mr. Mulhern: Rolland Henderson will speak on "Lightening the Load of Temporary Work by Specifically Decreasing the Area Requiring Treatment."

Mr. Henderson: I think the subject has been very adequately covered several times, even starting back yesterday when the pictures of the equipment of the several districts were shown on the screen and from the words that have been spoken there seems to be no reason to believe that any of you are against permanent control, using tractors, or anything like that, and I'm certainly not against it.

We have, as you saw in the picture yesterday, the small orange tractor, not one of the big jobs, a little one; this is our first year of owning our own equipment and going in to doing that type of work. We have borrowed equipment on several occasions in years before and done some, but we have the small Case tractor. We have a large disc. a two-wing V, and the adjustable scraper that you saw on that tractor yesterday which can be used as a scraper blade or as a dozer blade.

We are in the process right now of building access roads, drainage ditches, and things similar to that which I won't go into.

BENEFITS OF SMALL EARTH-MOVING EQUIPMENT

By ROLLAND L. HENDERSON

Manager, Tulare Mosquito Abatement District

There is a definite place in mosquito control for the use of small earth-moving equipment. We have a small Case tractor, disc, 2-wing V, and an adjustable scraper which can be used as a scraper or dozer blade, whichever the situation calls for.

There are numerous areas in any mosquito control district where access roads, tail-end ditches, and drainage ditches may be installed by this type of equipment, that will greatly cut the cost of operations. We are completing, among others, a five-mile access road along Packwood Slough in order to facilitate control in and along this slough, which otherwise could not be accomplished.

We ditched and re-channeled tail-end water in one instance that eliminated 20 acres of breeding area which had taken 1½ days a week to spray because of the inaccessibility of the field.

There are some breeding areas which caused us trouble last season. These can be and have been drained after each irrigation into nearby sloughs which must be sprayed anyway, and in some of these instances, control may be accomplished by use of fish. In other cases, we have thrown up levees along the low ends of fields. These levees have a controlled outlet into a tail-end ditch, and we expect to install a drip system to get the needed mosquito control in the surplus water.

With this equipment we have cleaned numerous miles of slough of stumps, trees, and overgrowth in order to facilitate spray operations.

Some of the work that we have done and some that we intend to do has been in cooperation with the land owners on an equal basis and some has been done on our own expense. In one small place alone, we expect to save approximately $150.00 per season in spray time and insecticide. Multiply this by numerous other places and we feel that it really pays off to use this type of equipment in our program.

Unquestionably, there is a place in mosquito cnotrol for all types of equipment similar to this, both large and small, but in a district of our circumstances, small equipment, at least as a beginning, is all I feel is practical.

Mr. Mulhern: Mr. Ed Washburn is going to tell us something about agricultural practices which are susceptible of modification which would result in mutual benefit to agriculture and to the mosquito control agencies.

Mr. Washburn: Talk about stealing thunder — I think all of mine has been stolen already. I'm going to make this very brief. The particular emphasis Tommy wanted was on the cultural practices; however, I will relate two or three other things. I have ten points which I will just briefly enumerate and not try to elaborate on at all.

The first point is one which ahs alrealy been discussed to some extent, and that is the possibility of the ranchers doing a better job of grading or leveling their lands. That, of course, applies not only to new land coming into cultivation, which we heard about this morning under the Central Valley Project and other irrigation projects, but it applies equally and perhaps more especially to land which is already under cultivation, where we do find problems. Many of the districts have been able to get cooperative effort in that respect. There is a whole day's discussion on that particular problem, so we don't need to discuss that one further.

Second, better control of the water to permit quicker irrigation. Better control of the water sometimes is out of the hands of the individual farmer, to some extent, in that the type of personnel that he must hire to do the irrigation has no real interest in the job at hand. Other things that can be used to better this particular situation are concrete pipes and concrete-lined ditches. In this particular instance it is a problem of the prevention of seepage. Many irrigation distritcs have now gone through the plan, or are following the plan, of lining all of the irrigation canals and laterals, not only to prevent seepage but also to conserve water.

Third, change of the irrigation cycle of the particular crop to permit drying between flooding periods. Now, that will only help, as I see it, in the solution of the *Culex* or *Anopheles* problem. I can't see that that is of any particular value in the control of *Aedes,* which of course is our big problem. Someone suggested that we might use continuous, flooding, which might help also, but of course that brings the possibility of secondary crops of mosquitoes, which many of us have run across in the last two or three years.

The fourth point is, cultivation, principally for weed destruction. I don't think we can plan that it will eliminate mosquito breeding, but it may lesen it to some extent. At least it does do away with the places of harborage for mosquito larvae. It would apply to certain crops but not to others.

Fifth, tail water drainage and re-use. In the Kern Mosquito Abatement District, their re-use of tail water drainage in the potato-growing area is an outstanding example. Too many irrigation districts make no re-use of the tail water at the ends of the checks or at the lower ends of the fields. In many instances it can be re-used for a useful purpose and thus prevent mosquito development.

Sixth, limitation of the use of water according to crop needs. Some irrigation districts are now coming to the point of limiting through their own actions, through law, the amount of water which may be aplied to crops. Most crops require a specific amount of water in order to mature a satisfactory crop, say from four to six acre feet for clover. This must be modified, of course, according to soil and climatic conditions, but ordinarily I think it is something that can be heeded more than it is. If clover takes from four to six acre feet of water in order to produce a satisfactory crop, and as you well know many farmers put on from ten to twelve acre feet on that very same crop, it does not produce the satisfactory crop that four to six acre feet would do. As I suggested earlier, some irrigation districts, including our own at Turlock, now are limiting the total use of water through the year.

Seventh is the engineering problem of cleaning ditches and laterals. That can be done, of course, through the use of herbicides and manual labor as well as machinery.

Eighth, repair of structures to make them water-tight and to prevent seepage. We saw pictures this morning of that sort of situation in connection with Federal irrigation projects. Many ranchers have only wooden structures which cannot be made water-tight; even some of our beautiful concrete structures still leak around the edges.

Number nine is the emphasis on changes to new crops, more valuable crops, or varieties of crops which can be cultivated or controlled to eliminate mosquitoes. There may be a possibility in some instances of changing from pasture crops to other crops of more value. It's pretty hard, though, in the Central Valley, I think, to do that. We find our pasture crop is a very valuable crop to us, and in most instances it can be grown on — shall we say — marginal land, where some other crops would not produce satisfactory results.

And lastly, but certainly not the least, is farmer education on all these above and other practices relating to the use and misuse of irrigation water.

Mr. Mulhern: Ed has shown that we need farmer education, and I think he has also shown, although he didn't say it directly, that we need mosquito men educated in farm practices so that we will know a little better what to try to educate the farmers in.

Chet Robinson has had some pretty good practical demonstrations of cooperative drainage between property owners, irrigation districts, and mosquito abatement groups, and we'll ask him to say something about it.

Mr. Robinson: Thank you, Tommy. There's only one thing, Toommy, you know I live right next door to that guy Washburn, and then you put me on the program with him, right alongside of him.

COOPERATIVE DRAINAGE BETWEEN PROPERTY OWNERS, IRRIGATION DISTRICTS, AND MOSQUITO CONTROL

By E. Chester Robinson

Manager, East Side Mosquito Abatement District

The East Side Mosquito Abatement District is a rather small district in comparison with our county-wide and two-county districts. We have about two hundred and eighty square miles. We were formed in 1940, and at that time started out with the conception of the elimination of water.

Through cooperative efforts over 15 miles of drainage ditches have been constructed and approximately 5 miles of concrete pipe drains have been installed, and six pumps.

These pumps have returned to the irrigation districts over 30 second feet of usable irrigation water. The Modesto Irrigation District from 1940 through 1949 has expended a total of $109,000 on construction and installation of drainage projects. This long-term drainage policy and cooperation of the irrigation district has been a large factor in the elimination of mosquito-breeding sources. This drainage work has returned to the farmers over 800 acres of land for crop use.

The plan of operation, generally speaking, follows this policy:

1. Where small lateral ditches are to be constructed that will empty into an existing drain they are constructed by this district without cost to the land owner.

2. Any permanent structures, such as valves or gates, on the property owner's land, are paid for by the property owner.

3. Where large ditches are required the land owner gives to the distict the right of way or easement of 20 to 40 feet for the purpose of constructing a drainage ditch. This work is done by county equipment under a cooperative agreement with the Board of Supervisors.

4. Where a large area, consisting of a number of farms, is to be drained, any expenditures for pipe lines or other materials to get the water to an irrigation lateral is paid for by the property owners within the area.

5. The Modesto and Oakdale Irrigation Districts have installed the pumps to reclaim this water after it has been brought adjacent to their canals.

These cooperative projects have benefited all concerned by eliminating standing water for the property owner and returning water to the irrigation district at a low cost for irrigation purposes. The county roads are kept drained both fom excess irrigation water and rain water, thereby reducing cost of maintenance to county roads. The mosquito abatement district benefits are quite well known to you because of the elimination of standing water in which mosquitoes may breed in great numbers.

Mr. Mulhern: Bob Peters will tell us a little bit about control in the river bottom land.

Mr. Robert Peters: Mr. Chairman, ladies and gentlemen: As a relative new-comer in this field of mosquito control I'm inclined to agree with Harold Gray that the use of the terms "mosquito breeding" has been somewhat confusing. Particularly when the public talks in terms of mosquito breeding in relation to trees and shrubs and grasses, and then we ourselves talk in terms of all the way from water to Stanford University. I think that perhaps something in the line of suggestions is in order. I'd like to perhaps suggest that we ask Dr. Kinsey to write his next book on the sex life of the mosquito.

Secondly, I would like to acknowledge one thing in this particular subject which I am to discuss, and that is that the program was begun by the previous manager of the district, Mr. Campbell, who deserves the credit for the work that has actually been done there. I am not here to defend the work we're doing, I'm here to praise it. I believe we have actually done a job through the permanent control aspects that would never be able to be done economically over any period of years under any other circumstances. As was previously mentioned by our entomologist, we have areas within our district adjacent to the Mokelumne River, which flows through the attractive center of the district, that have such cover on them that penetration by us mere humans is something which is almost impossible. *Aedes vexans* primarily, and a certain smattering of *A. lateralis,* now it's *A. sticticus,* I understand, are the objects of our attention in this particular area.

In the work which we are doing here we are working entirely on a cooperative basis. Primarily the work consists of clearing land for agricultural purposes. It is recognized by our district that we will have a continuous problem unless this particular vein of work is followed, and in that light we have, I believe, for a period of over three years now, been carrying on this form of work to a successful culmination. This particular area, I might say, in answer to one of the questons that was raised, has a little different — shall we say — topographical feature or just general variation from what might have occurred there ten, twenty, thirty, forty, fifty or so years ago when the area first began its jungle growth. Now we have a condition where the water above is at least partially controlled by a dam, I should say a series of dams, and the same picture is not present now insofar as the land goes from the standpoint of causing the damage which would have been done if there were not something in the way of water regulation on this particular stream. The snow-melt causes a rise in the water in this particular river channel. We have two conditions; one is to a certain extent still a direct overflow, however, I believe the majority of the area which is affected is rather seepage into those channels, shales, those eddies which previously were developed by extreme overflow conditions.

The work which our district has done, as I mentioned, has been cooperative in nature. It has been a land reclamation which has resulted primarily in agricultural benefits. It is something which could only be feasible if the property owner himself were the one who footed the bill; it would not be fair by any manner of means for the district to go and clear what is now good river bottom land and have the general taxpayer within our district support that man's enterprise as far as the future is concerned, and based on that reasoning this activity was begun and has continued. I think that we have got to cite other useful purposes than just agricultural pursuits as results of the work that has been done. We have constructed levees to a certain extent. We have constructed wine and waste sumps which have definitely and materially aided us in the actual cost of control in this river bottom area. Future plans appear to include such things as construction — or should I say the possible construction — of the effluent disposal fields of one of the sanitation districts which is forming. One of the things which is of interest, I believe, is the possible collaboration of Lodi, which is the main city within our district, to establish a very large municipal park. This will be done on a cooperative basis provided the city of Lodi is able financially to see their way clear, over a considerable area of this river bottom which borders the edge of the city itself. We hope that the consequence will be that we can do the work and still be able to do it economically so that both results may be the objective, mosquito control and recreation. I think that the consequence may be that regardless of which State or country has the most satisfactory recreational area that we in Lodi will at least be the city with the most desirable area for recreational activities. My formal paper is submitted to do with as you wish.

RIVER BOTTOM MOSQUITO CONTROL

• By Robert H. Peters, *Manager*
Northern San Joaquin County Mosquito Abatement District

Of particular concern in the mosquito control program of the Northern San Joaquin County Mosquito Abatement District is the Mokelumne River, which rises to flood stage in the late spring owing to the snow melt. At that time the bottom land area, ranging in width from a few yards upwards to a half mile in places, is covered by overflow or seepage water which pockets in the lower levels for a time sufficient to allow the *Aedes* mosquitoes (*vexans* and *lateralis*) to emerge in countless swarms.

Our Board of Trustees, realizing the futility of attempting to penetrate the jungle foliage covering this river bottom, initiated a program of clearing, which was begun under the direction of the previous manager of the District, Mr. Ernest Campbell. This program has consisted in the use of heavy equipment (two D-7 Caterpillars) which have been operated on a cost basis in a cooperative arrangement between the District and the land owner (usually a farmer). As such this plan has been highly successful, since it has resulted both in effective elimination of many points of origin of mosquitoes as well as to reclaim land for beneficial agricultural purposes. Rather than to interfere with private enterprise in the soil moving business, this program has acted as a boost to this field of activity, since it has rendered considerable land into a condition from which it can be finished by contractors for agriultural or other useful purposes.

In addition to conversion of these lands to farm uses, the District has constructed waste and wine sumps and retainer levees. At present the City of Lodi is contemplating the enlarging of their city park, which will include a large area of this densely overgrown river bottom. It is anticipated that the District will cooperate with the city in this endeavor and consequently eliminate or provide easy access to numerous points of heavy mosquito infestation.

This form of land clearing consists of the following steps:

1. Brushing—in which the tractors, equipped with 13½-foot blades, open up the areas between the larger trees, piling the brush as the work proceeds.

2. Digging around trees — this is preliminary to felling the larger trees.

3. Tree felling — this is done in either of two ways, by the tractors pushing the smaller trees down or by the use of cables in which two tractors pull down the larger trees aided by a crew of three men who handle the cable.

4. Piling of trees—this step consists of pushing the fallen trees to spots convenient for burning.

5. Filling and rough leveling — this is done both by blade and with the bucket scrapers, which move 10 to 12 cubic yards of soil for redistribution.

Needless to say, real progress is being made in this field of permanent control of some of our worst areas along the river, and considerable credit for the feasibility of this program goes to the efficiency of our operators in this work.

Mr. Mulhern: All of our speakers, Bob included, have indicated, I think, that our best deal whenever possible is to get voluntary cooperation. Harold Gray here again will speak to you and show you that although we do like to walk softly we do still carry that big stick which we can swing if it's absolutely necessary. Harold.

Mr. Gray: I'll make it snappy, the hour is getting late; it's short anyway.

ELIMINATIVE MOSQUITO CONTROL MEASURES IN RELATION TO INDUSTRIAL OPERATIONS

By Harold F. Gray, *Engineer-Manager*
Alameda County Mosquito Abatement District

There are a number of industries which use large volumes of water in their processes, and which produce liquid wastes which may be very productive of mosquitoes. To suggest just a few, we have logging and lumber mills, canneries, sugar refineries, paper mills, wineries. slaughter houses, milk processing plants, etc.

If these are located in cities, the wastes are discharged to the sewer system and in themselves do not then present a mosquito breeding problem. But many such industries may be located in rural unsewered areas. Direct discharge of such wastes to streams is prohibited by laws against pollution, and the wastes are usually discharged onto land, almost invariably presenting a serious mosquito control problem.

In some cases the liquid wastes may be subjected to a treatment process, to remove coarse solids (screening) or fine solids (sedimentation), but the end product is still water, containing appreciable amount of dissolved, colloidal, or finely divided suspended organic solids which are usually nourishing pabulum to mosquito larvae. The result is large numbers of foul-water breeding mosquitoes such a *Culex pipiens, C. tarsalis,* and similar species.

Land disposal is generally the only available method of disposal of these wastes. The nature of the soil, whether relatively porous or relatively impervious, will determine the scheme of disposal, by intermittent percolation into the soil, or by ponding. In either case, the important point in mosquito control operations is accessibility for vehicles and equipment used in inspections and control work. Circumferential dykes with roadways should be provided, plus interior dykes at close enough intervals for effective spraying operations. Vegetation must be controlled on the dykes, and emergent vegetation controlled in the ponds. With intermittent application, the soil must be worked frequently with discs or harrows.

Since the cost of disposal of these wastes is a part of the cost of the manufacturing process, there should be an established policy requiring the company to install whatever facilities are necessary to make mosquito control effective and reasonably convenient, and to defray the control costs, such as labor, materials, and transportation. If strong opposition is met, there should be no hesitancy in applying the procedures for the abatement of public nuisances.

In some wastes, the organic insecticides are relatively ineffective owing to absorption or neutralization of the chemicals, and Diesel oil will be more effective. In others, oil may be ineffective because the organic matter in the waste may lower the surface tension of the water so much that the oil will not spread. In others, *Gambusia* may be used effectively, but some wastes are toxic to fish. No fixed rule is applicable, but each case must be handled individually.

In some cases, minor changes in manufacturing processes may greatly reduce the actual use of water, and in many cases it may be possible to reduce drastically the use of water by curtailing its careless waste. A water waste survey may be profitable to the industrial plant and an appreciable help to mosquito control.

To some extent it may be possible to obtain help in mosquito control in industrial wastes through the new Regional Pollution Boards, but these are only being organized at present and the scope and nature of their work is not clearly defined in actual practice. But it would appear to be desirable for the Association to try to work out a general policy on mosquito control in industrial wastes in cooperation with the State and the Regional Pollution Boards.

Mr. Mulhern: Ted Raley is going to give us some word about the strengthening of the position of the mosquito abatement district by a local ordinance. Ted. Ted Raley?

Comment: Ted had to leave.

Mr. Mulhern: If Ted had to leave that winds up our speakers. We saved a few minutes of the time which was originally allotted to us, but we are still far behind schedule, and unless someone has some discussion which he particularly wants to offer I would like to turn this meeting back to the Chairman with just one comment of my own. The things which I have just heard here encourage me tremendously to feel that there is a fine opportunity for advancing our cause of mosquito control by giving more and more careful attention to the possibilities in permanent control. I do hope our program committee for next year will see fit to devote a little bit more time to this, what I think, important subject.

Mr. Kimball: Thank you very much, Tommy, for all the time you've put into preparing this symposium and all tne members of your symposium. We certainly wouldn't want to end the technical session of this Conference without at least acknowledging and expressing the appreciation of the amount of time that all the individuals have gone in to make this program that was designed by Art Geib and his program committee. The amount of time to prepare this data and present it is tremendous, and I know that I've appreciated sitting here and listening to it and will also look forward to the Proceedings for a constant reference.

Before we adjourn I'd like to call on Dick Peters for one last anouncement.

Mr. Peters: Those agencies which have not yet picked up the Proceedings for last year, that is, those who are entitled to them, I have a supply of them over here at this corner of the desk; if you will stop by and see me before you leave I will issue some to you. One other mention, Chet Robinson, are you going to be with us this evening at the night meeting? (No.) Thanks is due Chet, Robinson for a special treat we are going to receive after we have arrived at the Town and Gown and during dinner. Gallo Wines are going to introduce us to a new wine that they have recently developed. He is on our legislative committee for that reason, so I think Chet ought to get a hand.

Mr. Gray: I have just one announcement, Jack, just before we close. I regret very much that through an oversight I didn't know that he was only going to be here yesterday. Lester W. Smith, the Vice President of The American Mosquito Control Association, was here, and we should have called on him, and I expected to work him in today some time, but he had other business and so off he went, but I do think it should be in the record that he was here. He will be the next President of The American Mosquito Control Association.

Mr. Kimball: Just one more reminder to everyone who has forgotten to leave their paper off. Paul Jones, be sure and leave your paper at the desk. You know that seven-thirty is the time for the real highlight and we count on Dick Peters and his gang of cohorts for the program that they have cooked up, so in adjourning it has been suggested that we adjourn in memory of Professor Herms and Mr. Lilley.

The meeting is adjourned.

THE NINETEENTH ANNUAL CONFERENCE OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION WILL BE HELD IN RIVERSIDE, CALIFORNIA, MARCH 12, 13, 14, 1951.