PROCEEDINGS AND PAPERS

OF THE

SEVENTEENTH ANNUAL CONFERENCE

OF THE

California Mosquito Control Association

Held jointly with the

ANNUAL CONFERENCE

OF THE

American Mosquito Control Association

AT

California Hall
University of California
Berkeley, California
AND
Hotel Claremont
Oakland, California

February 7, 8, 9, 1949

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BERKELEY 1, CALIFORNIA

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of the
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of the
California Mosquito Control Association
and of the
Annual Conference
of the
American Mosquito Control Association

DEDICATED IN MEMORY OF

1876 The Late WILLIAM BRODBECK HERMS, Sc.D.* 1949

Professor of Parasitology
University of California

Savant in Malariology
Father of California Mosquito Control
Inspiration to Mosquito Control Workers Everywhere

*Color Reproduction of Portrait of the Late Professor W. B. Herms, Painted by B. Schatz, Presented to the University of California, February 7, 1949, by former Students, Friends, and other Admirers, through the medium of the California Mosquito Control Association

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FIRST SESSION

International Day, Monday, February 7, 1949

California Hall, University of California

Mr. T. G. Raley: The program calls for an opening address by the President of the California Association. However, this will be given tonight at the business session of the California Association at the Claremont. It is a pleasure to introduce to you Mr. H. D. Peters, President of the American Mosquito Control Association who is with the Health Department at Jacksonville, Florida.

Mr. H. D. Peters: Mr. Chairman, Members of the American Mosquito Control Association and of the California Mosquito Control Association. Last year, as you all know, the meeting was held in Florida. The delegation there expressed themselves as having had an enjoyable program in, if I might say so, the sunshine State. We expect this meeting will be equally informative. From the efforts of the Hospitality Committee last night, I am glad I came to California. I have heard a lot of Californians talk and never yet heard one who didn't quite frequently refer to California.

Recently there have been some changes in the organization of the American Mosquito Control Association which will have a permanent bearing on its future operations. These we believe will produce the type of organization which you will want the American Mosquito Control Association to be. Now as to some of the more important events of the past year.

We were able to complete the publication of the bulletin on the use of airplanes in mosquito control. I want to express my thanks for a job well done by those who so generously gave their time and even their financial assistance so that the Association would not become financially involved beyond its resources in producing the bulletin.

It would be hard to even contemplate a more expert or capable group of mosquito control workers than those who participated in the preparation of this brochure. The results justify the efforts for it is a very useful publication.

I also wish to express the thanks of the Association to the Edwin Gould Fund for their financial aid in the preparation of bulletins. The Fund contributed five hundred dollars to a permanent revolving fund for use in future similar projects. We are grateful for this assistance, and I am confident that the future progress of the Association will justify other similar contributions. Our success with the airplane bulletin encourages us to continue with our plans for a similar bulletin on the use of ground equipment in mosquito control operations. This brochure was the basis on which our last year's program was planned. I report that this work is proceeding slowly but steadily and in the not too distant future will be in the hands of the printer. I predict that the final results will be entirely satisfactory and a credit to the Association.

Due to the nation-wide growth of the Association, it became necessary that annual meetings be held in different parts of the country rather than in the east as heretofore. Therefore it was proposed and adopted by the Board of Directors that invitations to meet jointly with various state mosquito control associations would be welcome and that the Board of Directors would have the authority to fix location and dates for annual meetings. This is the second such meeting under this plan.

There were some disturbing times for those invested with the responsibility of producing "Mosquito News" during the past year. This was due largely to the failure of the advertising firm, with whom we had contracted, to produce enough advertising to carry the burden of the expense of the publication. This contract has been rescinded. A Committee of the Association is now hard at work to put our official organ back on a firm financial basis. However, during these trying times the high quality of the publication was not sacrificed. I am glad of the opportunity to tell you of the fine working spirit that has been displayed by those responsible for the success of "Mosquito News." These members of our organization have contributed their time with no thought in mind but to make this publication a credit to the organization it represents. I cannot possibly commend them too highly for the work that they have done.

Now as to some actual changes in the administrative set-up of the Association. The American Mosquito Control Association as you knew it a year ago no longer exists. but has been replaced by the American Mosquito Control Association, Inc. We are now incorporated under the laws of the state of New Jersey. The affairs of the Association are in the hands of a so-called Interim Board whose duties embrace active control of all Association matters until such time as a set of by-laws can be worked out for the actual operation of the business of the Association. In this connection it might be well to mention too that no Constitution is necessary as the Articles of Incorporation supplant the customary Constitution. A Committee is now at work preparing a set of by-laws which they will submit to the Interim Board for their approval and thence to the entire Association for complete ratification.

It is gratifying to me, as the retiring President, to realize that the affairs of the Association are in good order and I certainly appreciate the very active cooperation of all the committee chairmen and members. They have more than done their assigned tasks. They have always been willing to assume additional duties when requested. A more congenial and efficient group would be hard to find. In fact it has been my experience that mosquito workers in general are a group of men who are genuine good fellows and workers. They know both how to work and play and it has been both a privilege and a pleasure to have had the honor to serve as your President during the past year.

To the California Association, I wish to say that we are happy to be your guests and I appreciate all you have done to make our stay here pleasant.

Mr. T. G. Raley: Thank you, Duke. A great many of us here in California are members of the American Mosquito Control Association, Inc.

In California when we speak of mosquito control there is always one group that we have in mind. It has been a guiding group over the years in all phases of mosquito control. That is the University of California. The University of California has been synonymous with mosquito control and we are here today enjoying their wonderful facilities, and on the program, as you will note, Vice-President Hutchinson is scheduled to extend the welcome of the University

Prof. C. B. Hutchinson: Mr. President, Members of the California Mosquito Control Association and Members of the American Mosquito Control Association, Inc. The University of California is happy to welcome you today. The members of the California Mosquito Control Association are friends of ours of long standing since you meet with us frequently and we have had the pleasure of renewing acquaintance every winter since your organization was established. It speaks well for your leadership and vigor that you have persuaded the American Mosquito Control Association to join forces with you in your meeting this year as we celebrate the centennial of the gold rush of 1849. Although the Argonauts of 1949 will find less gold, they will find less malaria than the original pioneers, and this is not due only to our unusually cold weather. I am sure your stay with us will be far more comfortable than was true for those who came to California in 1849.

The University of California is justly proud of its accomplishments in mosquto control. Although New Jersey control work began in 1904, a year before the initial work of Prof. H. J. Quale of this University in 1905, we have consoled ourselves over the years with the thought that New Jersey probably needed mosquito control work more than did we. Although we have many things in California that are bigger and better than elsewhere, every one knows and we do not deny the pre-eminence of New Jersey in mosquito production.

In 1910 we did establish a precedent when Prof W. B. Herms conducted the first specific anti-malaria mosquito control campaign at Penryn in the lower foothills of the Sacramento Valley. The successful results of this demonstration led to the inauguration of a series of campaigns in the malaria-ridden valleys of California, including the first malaria mosquito control program under conditions of irrigated pastures. This too was carried on under Prefessor Herms' direction at Los Molinos in the north central section of the State. Down through the years a continual procession of experts, led by Harold Gray, were all trained in Herms' laboratory and in his company in the field, and have gone forth from this campus to do battle against these vectors. As a result of these years of teaching and research in the University, World War II found Californians in the uniforms of the Army, Navy, and Public Health Service directing essential mosquito control operations on practically every operational front of the various campaigns. In addition to our interest in mosquito control, notable work has been done in this University on insects as vectors of neurotropic viruses, by our Department of Veterinary Science, and particularly through the contributions continually appearing from the laboratories of Drs. Meyer, Hammon, and Reeves of the Hooper Foundation for Medical Research.

On the University's Davis campus, Dr. Bohart has conducted toxicity trials on mosquito larvae and at the same time is finding time to further his studies of mosquito taxonomy.

Aside from the staff members who are actually engaged in mosquito work at the present time, we have a reserve corps of mosquito experts now at work on other fronts. This may perhaps explain the friendly atmosphere that workers in this field always feel at the University of California. For instance, on our inactive list of mosquito experts is Professor Freeborn, who in the recent war was Director of Operations of Malaria Control in War Areas of the Public Health Service; Dr. Usinger, who directed the dengue control campaign in Honolulu; Dr. Bailey, a Navy entomologist, who was the savior of Guam when dengue threatened; Dr. Douglas and other Navy entomologists in charge of malaria control measures on Guadalcanal with the Marines, and who received a citation for a job well done. Dr. Pritchard fought mosquitoes in Puerto Rico. Dr. Middlekauf was head of the entomological section of the Army School of Malariology at Panama. Through these activities and others, we have come a long way since the days of the University's initial efforts. Many important contributions have been made; much remains to be made. We warmly welcome both of your Associations today and express the hope that your stay in our midst may be most pleasant.

Mr. Raley: Thank you. Dean Hutchinson. We indeed are grateful to the University. During the years, that part of the University that we called on probably more than any one part, has been the Division of Entomology and Parasitology. We are fortunate today to have Prof. Essig, the Head of that Division, here to extend his welcome.

Prof. E. O. Essig: Dean Hutchinson has given you such an admirable discussion and historical account of the work of the entomologists in this Division that I will confine my remarks to generalities.

The Division of Entomology and Parasitology is always pleased to welcome all of you who are concerned with the development and administration of mosquito control and of the abatement districts. It is right that you should come to this institution to hold your annual convention because it was here that Professor Herms, Dr. Freeborn, and associates, including many of you in this room who are leaders, conceived and brought into existence the mosqito abatement district act under which you operate. Our chief concern is that this meeting will be most pleasant and profitable and we will do all we can to make it so.

We in the Division of Entomology have much in common with officials of mosquito abatement districts. We are all concerned with the same general problem — the control of pestiferous insects. To this end we may very greatly aid each other in laying out experiments, in testing all the new and promising insecticides, in developing suitable aerosol generators, dusting and spraying machinery, in making insect surveys, in determining all the various species involved and in doing all we can to control the destructive insect pests without upsetting too much the natural balance of beneficial animals that are everywhere needed in the elimination of the ones that we seek to destroy. We share alike in accomplishing these ends with the least possible damage to growing crops. We wish to eliminate the use of insecticides that are likely to leave residues that may cause injury to wild and domestic animals and to human beings. In the determination of insect specimens, and in making recommendations for use of new insecticides and equipment, we may be able to help you. In furthering the progress of our own insect survey, you can assist us very greatly, and I am pleased to announce that during this last year Mr. Dahl of the State Department of Public Health presented us with a very fine collection of mosquitoes which we are adding to our collection which is now well under way and which we hope in time will include all of the mosquitoes in the western states and many others from other parts of the country.

This State, with its varied climate, people, and crops, offers to the investigator of insect problems a cross section of most of the world. Your extremely large and important assignment requires all the knowledge and ingenuity of the combined efforts of every one of us. Let us unite our activities in the cause of public health which is so vital to every one of us and especially to the rural people whom we try to serve. I thank you gentlemen and I hope your stay here and your trip throughout the State will ever be remembered. We are glad to have you here.

Mr. Raley: Thank you, Prof. Essig. As we think of mosquitoes, we usually think of them as a nuisance, but they go beyond that point, for mosquitoes are vectors of certain diseases. On that basis, we will next have a welcome from Dr. Rogers, Dean of the School of Public Health at the University of California.

Dr. E. S. Rogers: My message will be very brief, for you have an interesting program and naturally you are anxious to get on with it. Moreover, I possess no particular cognizance in your field. In this connection, I am reminded a little bit of an account I heard before coming to California. It was an account which would strike terror to the heart of many a young medic. One of the questions asked of a very prominent physician, a man with an outstanding international reputation, was "Identify from specimens twenty-one different mosquitoes and mosquito larvae." Of course he failed miserably in this, as I should have done also. Probably most of you here would have qualified. Therefore, I cannot welcome you as an engineer or an an entomologist, but, as you have surmised from the foregoing story, I welcome you as a fellow physician.

As a specialist in public health, I of course am deeply aware of the importance of mosquito control. It is important to the economic security of the State of California and of the nation and of many parts of the world also. As an administrator, I am thankful that there are experts to whom I may turn for advice and on whom I may depend for the carrying out of most important public health functions.

In regard to the School of Public Health, we view your presence here today with pleasure and your existence with gratitude. May I extend on behalf of the School and its faculty a word of welcome to you and our hope that your stay will be both pleasant and profitable.

Mr. Raley: Thank you, Dean Rogers. The first paper on the program is scheduled to be given by Dr. C. R. Twinn, Chief of the Household and Medical Entomology Unit, Division of Entomology, Department of Agriculture, Ottawa, Ontario, Canada, on "Mosquito Control Problems in Canada." Dr. Twinn was not able to attend, and his paper will be read by Dr. Freeborn.

(This paper is slated to appear in *Mosquito News.*)

Mr. Raley: I now take pleasure in introducing our next speaker, B. V. Travis, of the Bureau of Entomology and Plant Quarantine, USDA, Orlando, Florida, who will speak to us on the subject of "Mosquito Control Problems in Alaska." Dr. Travis.

Dr. B. V. Travis: Florida has unusual weather too, so I won't comment on California. The topic that I have today is concerned with the mosquito or rather the biting insect investigations we have been carrying on in Alaska for the past two seasons — during 1947 and 1948. I get accused of having a fine vacation during the summer in Alaska and during the winter in Florida. They haven't all been vacations, incidentally. Our studies in Alaska have been concerned with the biting Diptera mostly. We have taken a few specimens of fleas, but actually we have been more concerned with mosquitoes than anything else. Also we have been concerned with a problem a bit different from what many of you have. Our problems are the ones that concern the military people and sometimes do not have too much bearing on civilian activities, although most of our studies I think could be used by either group.

(We regret that Dr. Travis did not furnish a prepared paper, and the electrical transcription of his talk was a failure. The remainder of his talk is therefore not presented.)

Mr. Raley: Thank you, Dr. Travis. The next paper on our program is entitled "*Anopheles gambiae* (var. *melas*) Control by Swamp Drainage in a Coastal Area of Africa," which has been prepared by Leonard J. Chwatt, M.D., of the Yellow Fever Research Institute at Lagos in Nigeria, Africa. As Dr. Chwatt is unable to be with us in person, his paper will be presented by Harold F. Gray.

(This paper is to be published in "Mosquito News." An abstract of the salient points of this paper follows.)

ANOPHELES GAMBIAE MELAS CONTROL BY SWAMP DRAINAGE IN A COASTAL ZONE OF NIGERIA, BRITISH WEST AFRICA

(Abstract)

By Leonard Jan Chwatt, M.D., D.T.M.& H.
Medical Department, Nigeria, B.W.A.

The project for the control of *Anopheles gambiae melas* by swamp drainage at Lagos in Nigeria was initiated by

Dr. Alan B. Gilroy in 1942. Lagos was one of the nodal points on the Transcontinental Ferry Service of the Royal Air Force, and an assembly and test base for single-engine aircraft. Malaria control at this large base was essential. Parasite rates in native children were 75% to 90% and spleen indices 60% to 80%. In British military personnel the incidence of malaria per 1,000 strength was 564 in 1941 and 525 in 1942.

The extent of the coastal swamps near Apapa harbor would not permit successful control by piecemeal methods, and it was decided to drain these marshes. A pilot marsh in the vicinity of the airfield was first drained, and the beneficial effects led to extension of drainage to all marsh areas in the harbor where the vector was found breeding.

Tidal range at Lagos is two feet average and three feet maximum at spring tides. There were three zones of swamps, the first being submerged daily, the second being submerged twice monthly by spring tides, and the third being submerged only twice a year. Each zone has a distinctive vegetation. The first zone produced no mosquitoes, and the second zone was responsible for most of the *Anopheles* breeding.

The coastal malaria vector at Lagos is *Anopheles gambiae melas,* which prefers to breed in salt water in coastal lagoons and swamps. About one mile inland from shore *A. gambiae gambiae* replaces it as the dominant vector. Both species tend to leave human habitations at dawn and use outdoor shelters in daytime.

Swamp control was by reclamation, enclosing the low-lying coastal marches by dykes, collecting the water of the swamps into channels and conducting the water to outlet structures, hand operated, which are opened at low tide to permit outflow and closed at high tide to prevent inflow. The dykes and channels were adjusted to the topography. A total of 4195 acres of swamp was drained, by constructing 20.7 miles of dykes, 130.4 miles of drains, and 21 sluice gates.

Control was evaluated by adult captures at 275 selected stations, using the "spray-floor sheet" technique with pyrethrum, and establishing a mean *Anopheles* density index (mean number of female *Anopheles* found in one room per day). In 1942 the mean A.A.D. was 47, and in 1947, after drainage the mean A.A.D. was, by quarters, 0.2, 1.2, 2.2, and 0.5. The reduction in larval counts was indicated by comparison between drained and undrained swamps. In 1947 the figures, for drained and undrained swamps, were respectively 28.4 and 1734.8 larvae collected per acre of water surface per day.

Breeding in the drains was reduced to relatively insignificant numbers, probably because of ecological changes due to drainage, and more effective action of larvivorous fish.

(Abstract prepared by H. F. Gray)

Mr. Raley: Inasmuch as this paper was not given by the author, we will pass up discussion of it. At this time I would like to ask that all of the Trustees from the various districts in California who are present stand so that we can see who is here, and I will ask that they in turn give their names and the district they are from. (This was done.)

Mr. Raley: There is another district trustee present, but from the standpoint of the Association he really isn't a one-district trustee. He is rather the trustee of California mosquito control, and, if he will forgive me for saying this, when we think of him it is a good deal like bread and butter. When we think of Professor Herms we think of Harold Gray. At this time I turn the meeting over to Harold Gray, who will carry on from this point.

Mr. Gray: I ask Vice-President Hutchinson if he will be so good as to come down here, and I ask Duke Peters and Ted Raley to go to the back of the room and conduct Bill Herms down here.

Vice-President Hutchinson, men are honored by their fellow men for various reasons. Some of them are honored for their scientific research. Some are honored because they are great teachers. Some are honored for services to their community and some for various other reasons. Professor William Brodbeck Herms has been honored in many ways by many organizations. As a scientist, he has been elected president of several scientific organizations. I can assure you that he is honored in the hearts and minds of his many students as a great and inspiring teacher. He has been honored for public service, for example, by his own city of Berkeley, which conferred on him the Benjamin Ide Wheeler award for distinguished service to his community. These facts are quite well known and recognized. The purpose of this particular honor that we wish to bestow is not to honor him as a scientist, a teacher, nor as a public servant (you must remember that his public services extend far beyond the city of Berkeley). He was, for example, the "voice crying in the wilderness" in the old days in the field of rural sanitation in California. He is the father of mosquito control work in this State. Those are great and abiding services. But our purpose today is to honor him for something else — as a very lovable human being. His many friends and former students have made possible the presentation to the University of California of a portrait which we hope will remain here always to be an inspiration to future generations of students. We are doing this through the agency of the California Mosquito Control Association, and I now take the greatest pleasure in presenting to the University of California this portrait of Professor Herms.

(The portrait of Professor Herms was then unveiled.)

Prof. Hutchinson: Mr. Gray, ladies and gentlemen, I have a very deep personal feeling of gratitude as well as an official feeling of gratitude to those of you who have made it possible for the University to have a portrait of William Brodbeck Herms. The Chairman has outlined to you briefly a few of the many honors that have come to him. I have always thought of him as one of the most versatile men I have ever known. Not only has he succeeded in his efforts in the scientific world and has made a distinguished contribution through his scientific career, but he has also been a man, a human being, an inspirer of young people. The Chairman overlooked another field in which he has made a great contribution to his community, his state, and his nation, and that is through his efforts with the Boy Scouts of America, where his influence has been brought to bear upon the youth of this community — a good thing in their early, formative years which cannot but be good in its results — good to those individuals and to their communities.

I think it is a fine thing, Mr. Gray, that you and your associates have done. We at the University shall treasure this memento that you have given us in such a generous and splendid way of our good friend Mosquito Bill Herms.

Prof. Herms: My good friends, may I say just a word before they go through the rest of these shinnanigans? I must view this matter objectively, for I do not consider it to be primarily a portrait of Bill Herms but this is a project, The artist and I have worked on this for some five or six weeks together. I have given him lessons in malariology so that the life cycle might be correct and brought right up to date, and I think the exoerythrocytic cycle drawing and the dipper take us out of doors into the field and remind us that after all if you expect to get anywhere in this business of mosquito control that's where your job lies — out where the mosquitoes are. Mr. Schatz, the artist, and I together worked on this as a project. He taught me a great many interesting lessons in art. All I did was to furnish the face, and that doesn't amount to anything. Mr. Gray, aren't you going to introduce him?

Mr. Gray: Won't you come down, Mr. Schatz?

Prof. Herms: That's the man who deserves the credit. As I said before, all I did was furnish the face. Thanks a lot, good friends. You've been awfully kind to me. I'm still alive. It's a very unusual thing to attend your own memorial while you're still alive.

Mr. Raley: Professor Herms remarked about his furnishing the face and that the artist has done the work. As always, there was a lot of work before there was the completed project. I want to introduce Dick Peters, the man who really did a lot of work on this project. Give Dick a very rousing cheer for his efforts.

Mr. Richard Peters: Ladies and gentlemen, I did not come prepared to say anything, but I would like to tell you that the amount of time and some people might say trouble, has been in reality a pleasure because there has been such a genuine response from well over a hundred persons. I personally have been a student of Professor Herms and a good many others have had the same privilege. As far as I am concerned, Professor Herms is to mosquito control and to the field of public health a real leader. I know I reflect Dr. Halverson's attitude in a letter which we received from him, in which he calls attention to the State Department of Public Health bulletin on mosquitoes to which Professor Herms contributed and which has been extremely well thought of. So I am merely confirming the feeling that every one of us has for Professor Herms. I repeat it has been a pleasure and I want to thank every one of you who so generously responded.

Mr. Raley: We started a little late this morning. If you will, I would appreciate your making every effort to have your lunch and return to the hall promptly. We will now adjourn for lunch.

AFTERNOON SESSION

Mr. Raley: We are prepared for a very instructive and enjoyable afternoon, but before we enter into the papers of the afternoon there are one or two announcements that we would like to have made. Mrs. Thurman, do you have an announcement that you wish to make?

Mrs. Thurman: Tomorrow noon is the organizational meeting of the State Chapter of the American Society of Professional Biologists. During this meeting the objectives of the Society will be given by Mr. Roy Fritz, and at the same time a discussion will be had as to the possibilities of organizing a California Chapter. The luncheon tickets are on sale this afternoon at $1.55, and if you will some time during the afternoon come by the registration desk we will have these tickets available for you. The luncheon is to be in the Emerald Room at the Claremont Hotel, which is directly across from the main meeting room. This will not cause any conflict in the schedule, we believe, so we will be expecting you tomorrow noon.

Mr. Raley: I shall ask Mr. Duke Peters to preside at this afternoon's session.

Mr. H. D. Peters: I presume we are a little late, so with that thought in mind we will carry on with the program. The next speaker is an old friend of mine. I am glad to present him. When I went to Florida, one of the first men I met there was Sam Macready. Since that time Sam has changed jobs a time or two. The next speaker will be Mr. S. D. Macready, General Sanitary Inspector, United Fruit Company, San Jose, Costa Rica. His paper* will be on "Observations After Three Years' Use of DDT Residual Spraying of Tropical Labor Camps for *Anopheles albimanus* Control."

Mr. S. D. Macready: Ladies and gentlemen, without too much preamble we will get right to business.

THREE YEARS' OBSERVATIONS IN THE USE OF DDT RESIDUAL SPRAY FOR CONTROL OF *ANOPHELES ALBIMANUS* IN TRPICAL LABOR CAMPS

By SAMUEL D. MACREADY
General Sanitary Inspector, United Fruit Co.

This report is supplementary to those of the two preceding years on the use of DDT as a residual spray for control of *A. Albimanus,* the principal vector of malaria in most of the areas where our operations are conducted.

For the benefit of those not familiar with previous comments, it is advisable to reiterate that, in the past, the preparation and planting of new farms has usually created conditions favorable for increased malaria transmission. When the forest area is first cleared sunhine reaches previously shaded water surfaces and large-scale *A. Albimanus* production occurs. In addition, many of the itinerant laborers and their families have the malaria parasite in their blood when they arrive and, at the beginning, they must of necessity live in temporary quarters until permanent buildings are erected. Consequently, a study of statistics from 1941 to 1945 in those divisions where new farms were planted shows a definite pattern of rising malaria incidence, interpreted in terms of employees hospitalized, which is almost parallel to corresponding rises in employee populations.

DDT residual spraying of labor quarters was first begun early in 1946, and it will be seen by reference to the graphs in the three divisions of Golfito, Punto Armuelles, and Quepos where conditions as outlined existed, that the curves representing malaria case rates reduced sufficiently in each instance to cross the rising population curves. Thus, the pattern was reversed for the first time during this five-year period. Specifically, the Golfito case rate reduced 35% the first year with an estimated 42% increase in employee population; Quepos showed a reduction of 49% with 18% population increase; and Punto Armuelles 63% with a population increase of approximately 29%.

For the three-year period ending in December, 1948, the overall reduction in employees hospitalized for malaria, and it is significant to note that the computations are all on a basis of both primary and secondary diagnosis, is 75.6% in the Golfito Division with 61% greater employee population; Quepos 73% with 56% population increase; and Punto Armuelles 81% with a population increase of 64%. During the period being considered there was considerable new farm activity in these three divisions, which created in varied degrees conditions such as have been described in the second paragraph. Comparable results have never been accomplished under similar circumstances prior to adoption of the DDT residual program.

A different aspect is represented by the Limon and Almirante Divisions. During 1944 and 1945 both of these divisions had become more or less stabilized and a satisfactory degree of control obtained by the usual methods then employed. Actually, the application of DDT residual in 1946 effected little or no change in these two places. However, at the end of 1948 the employee case rate in Limon shows a reduction of 62% for the past two years and that of Almirante an additional 40% during the past year to a low of 19 cases per 1000. With rates of 30, 37, 33, and 19 for the years 1945, 1946, 1947, and 1948 respectively, this division has the distinction of having the lowest incidence of the five divisions being considered. In 1943 the rate was 291.

Based on the thesis that malaria-ridden individuals usually are less resistant to other infection than healthy persons, it follows that control of malaria in any given area should reflect a correspondingly lower incidence of other communicable diseases. In this connection a graph is submitted showing hospital admission rates per 1000 in the Golfito Division for all communicable diseases, including and excluding malaria, for the years 1941 to 1948, inclusive, which is self-explanatory.

It was brought out in last year's report that diesel oil was being used as the vehicle for DDT rather than kerosene, which was employed at the beginning. It is a better solvent, is cheaper, and, if care is used to see that the oil and equipment are clean, disfiguration of wall surfaces is not a problem. Kerosene is used only for selected buildings. 5% mixtures of DDT and these oils are used exclusively, applied to camp walls to an average height of ten feet at a rate of 1 gallon per 1000 square feet, or a dosage of approximately 190 milligrams the square foot. Application is by means of small cylindrical hand-operated pressure sprayers equipped with Army-type flat spray nozzles which provide simple, dependable, and economical service and minimize the delays to be expected when complicated mechanical equipment and unskilled laborers are combined in isolated locations. Two treatments per year have proven entirely satisfactory, not necessarily at exact six-month intervals, but spaced insofar as possible just ahead of the known periods of heaviest production. With the exception of some localized breeding places, all anti-larval procedures have been stopped, as it has been shown that the residual method, if properly conducted and maintained, will provide satisfactory control in the vast majority of cases. Further, in compliance with the general request to conserve diesel fuel as much as possible, an appreciable saving is thus effected.

In 1946 the thought was expressed that a more comprehensive kill of adults was accomplished with DDT as a residual spray in open camp buildings than in those that were screened. Observations over the three-year period still indicate that this is so, and the only possible explanation continues to be that in such open quarters there is nothing to prevent immediate mass contact with the treated surfaces when flights occur. No live mosquitoes have been found in either unscreened rooms or open manaca shacks since the first DDT was applied in 1946. Another significant fact is that very few camp occupants are using mosquito bars.

It has been well established by means of early morning room inspections and mule trap studies that quick, extensive adult kills are accomplished. When conditions are favorable flights occur and heavy adult populations can be demonstrated. The evidence, however, is that flight populations are quickly diminished to harmless proportions. With some few lapses, daily mule trap collections have been made at Puntarenas Farm in the Golfito Division since April, 1947. These data, which are submitted herewith, illustrate the point in question. The highest peak of adult density occurred in January, but declined sharply to negligible proportions almost immediately.

Theoretically, this repeated mass killing of adult females over a period should have a limiting effect upon future production, but trap collection studies will have to be continued much longer before sufficient data are available to warrant definite conclusions in this respect. To date there is nothing to indicate that flights are numerically smaller than before.

During the past several months, it has been shown by various investigators that house flies and some mosquitoes are capable of acquiring some resistance to DDT. In this program, there has been nothing, up to date, to indicate that *A. albimanus* are developing such resistance, although there is some evidence that house flies are. To anticipate this posibility becoming a reality, standby supplies of other residual insecticides are being made available and will be alternated with DDT as necessary.

During the past year's operations an approximation of labor and material costs have been made for the various projects for purposes of study and comparison. These computations were made on a basis of one complete cycle in each division chosen at random during the year, and are as follows:

Division	Estimated Cost Per Employee	Estimated Cost Per 1000 sq. ft.
Golfito	.15	.38
Quepos	.28	.43
Limon	.42	.47
Almirante	.40	.66
Punto Armuelles	.18	.64

These figures indicate an average labor and material cost of .28 per employee per cycle or .56 per employee per year. This is doubly significant when it is considered that the project is providing a degree of control far superior to anything previously obtained.

Mr. Peters: Thank you, Mr. Macready. The next paper on the program was to have been given by Mr. Pedro Galindo. Unfortunately an outbreak of jungle yellow fever in Panama has made it impossible for him to attend. On the other hand, we are most fortunate that Dr. E. S. Horgan, who has been recently in Africa, is now at the Hooper Foundation in San Francisco, and he will present a paper on the vectors of yellow fever in the Sudan.

THE PROBLEM OF INSECT VECTORS OF YELLOW FEVER IN THE ANGLO-EGYPTIAN SUDAN

By E. S. HORGAN, M.D.
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As is well known, until about 28 years ago it was universally believed that the distribution of yellow fever in Africa was confined to a narrow strip of the West Coast territory. The immunity survey of Africa initiated in 1936 by Sawyer and Whitman quickly produced the unexpected result that many of the inhabitants were immune to the disease in a broad band of country extending right across the continent as far east as the River Nile. Further work brought to light the interesting finding that in the area of the Anglo-Egyptian Sudan known as the Nuba Mountains some 400 miles south of Khartoum, a high proportion of the natives — in some villages over 80% — showed antibodies to the yellow fever virus as judged by the mouse protection test. At that time this finding was very hard to correlate with the completely negative evidence of any clinical cases of the disease. No epidemic had ever been reported among the native population and no case had occurred among those Europeans such as government officials and missionaries who had been resident — some for many years — in the area. To these areas the convenient term "silent areas" was given, and such was the situation until 1940. In September of that year cases of an obscure epidemic were reported in some of the hill villages and a research team was immediately dispatched from Khartoum. In spite of delays owing to the unfortunate circumstances that three of the British and three Sudanese went down with the disease — fortunately all recovered — it soon became evident that the epidemic was clinicaly yellow fever, that it had been increasing for 2 or 3 months but that earlier cases had not been reported as the area is well-nigh impassable in the rains. Sections of livers from fatal cases sent to Khartoum for histological examination showed the typical lesions of yellow fever and the virus was isolated from patients by Drs. Mahaffy and Smithburn of the Yellow Fever Research Institute, Entebbe, Uganda. The epidemic has been fully reported and discussed by Kirk (1941).

Before discussing the insect fauna I wish to say a few words on the geography, physiography, and meteorology of the Nuba Mountains area, which is situated between parallels of 10° and 12° N. and longitude 29° and 31° E. This is an area of about 30,000 square miles rising some 3,000 feet above the level of the African plain, which is itself here some 2,000 feet above sea level. It is a country of broken hills in some places rising up as mountain massifs which are riddled with caves and tortuous interstices among colossal boulders and tumbled stones. As in the Northern Sudan generally, rainfall is the important factor in the life of this area. The rains begin in May, ending about October, and the total varies from 650 to 99 mms in different years. During this period the country from being an arid, brown, dried-up area, becomes a veritable garden with mountain brooks and torrents tearing down in cascades to the plain and the dried watercourses ("wadis") becoming considerable streams. Plant life devolops with amazing rapidity, and in 2 or 3 weeks from the onset of the rains the country is carpeted with vegetation and covered with wild flowers. Rock holes and tree holes are filled with water and breed innumerable mosquitoes.

With the cessation of the rains in October the country dries rapidly and by November the dry clear weather has set in. The watercourses and pools quickly dry up, the relative humidity drops from about 80 to 20 per cent and remains at this low till the following May. The meteorological readings show only a slight variation in the temperatures, the average maxima and minima in the rainy months being 96° and 73° F. respectively, and in dry winter months 97° and 68° F.

Wild Fauna — Mammals

These include a few herds of baboons (*Papio anubis*) and red hussar monkeys (*Erythrocebus patas*), while grivet monkeys (*Cercopithecus aethiops centralis*) are more widely distributed. Hyrax is common in the hills, also bush babies (*Galago senegalensis senegalensis*), while a few oribi and gazelle are to be found. Pruner's hedgehog (*Atelerix albiventois*) is common only in the rains, and there are several species of small rodents, shrews, and bats. The only animals in this list which are at all likely to be concerned in the epidemiology of yellow fever are the monkeys, hedgehogs, and possibly the bush babies. Up to date we have no evidence that any of these are incriminated.

Insect Fauna

The Nuba Mountains is a most interesting ecological island for many species not found in the surrounding areas and whose common haunts may be separated several hundred miles, e. g., *Glossina morsitans* and *Anopheles macmahoni.*

As regards the mosquitoes, the genus *Aedes* forms 90 per cent of the total mosquitoes, the chief breeding places being the innumerable small rock pools in the holes, some of which are artificially made in the rocks by grinding down sesame seeds for oil, and judging from the depth of some, representing the work of many generations. Other favorite sites are holes in various trees, especially the baobab (*Adansonia digitata* L.) and to a less extent in the axils of the bowstring hemp (*Sanseviria* Sp.) and the bananas, as these plants are uncommon. The most prolific source of *Aedes aegypti* is the great porous earthenware jars ("zeers") used in the hilltop villages for storing water, all of which has to be dragged up from the plain by the women.

Species of Mosquitoes — Lewis (1943) has discussed these in full, and the following is a short summary based on his paper with some more recent data:

55 species of Culicidae are known, nearly half as many as in the whole Sudan. Swamp breeders as *Taeniorhynchus* are rare, whereas the genus *Aedes* has many species. Of these the commonest are *A. vittatus* Bigot, *furcifer* and *taylori, metallicus* Edw., *luteocephalus* Newst., *unilineatus* Theo. As this paper is concerned essentially with yellow fever I am omitting the other genera of mosquitoes. The most abundant larvae and their breeding places are in order:

A. vittatus, over 90 per cent of the total Aedes, found in rock pools and tree holes with very few in domestic breeding places.

A. furcifer with *taylori,* about 3 per cent, found chiefly in tree holes; very rare in domestic breeding places.

A. aegypti, about 4 per cent, and as usual the majority of larvae are found in domestic breeding places. But it is interesting to note that as regards the number of occasions on which larvae were found, out of 47 examinations they were found 21 times in domestic breeding places and 21 times from tree holes, many of the latter far removed from human habitations. The aedine index of this species is also of some interest: in one area of 300 houses it was found in 25, while in most villages of the epidemic zone of yellow fever the index was nil. The average index for the whole of the Nuba Mountains is under 5. On the other hand, curiously enough, adjacent to the area but outside the endemic zone as judged by the mouse protection tests the Aedic index was very high indeed, in some vollages 100 per cent. In some of the water jars in these villages there are such enormous numbers of larvae such as I have never seen elsewhere.

The most voracious biters of man are *A. furcifer* and *taylori.* These composed more than half a series of evening catches, and next comes *A. vittatus; A. simpsoni* and *A. metallicus* were seen to bite but are uncommon.

By far the most puzzling and unexpected feature of the great epidemic of 1940 — the largest yet recorded in the literature (20,000 cases) was the complete lack of correlation between the occurrence of cases and the presence of *A. aegypti.* Mahaffy (1941) before he arrived in the area and without knowledge of the local mosquitoes expressed the view that owing to the rapid spread and explosive nature of the outbreak, *A. aegypti* with its small range of flight was unlikely to be an important vector, and as has been noted above a subsequent survey fully bore out his views.

Lewis (1943) has compiled a useful table of potential vectors of yellow fever in the area. He estimated their relative importance from a study of their prevalence and their habits. The following is a summary:

Species	*Estimated Role*	*Notes on Adults*
A. vittatus	very important	abundant on or near hills
*A. furcifer** / *A. taylori**	important	common on or near hills
A. luteocephalus	of some importance on or near hills	common on or near hills
A. metallicus / *A. aegypti*	important in a very few villages	common near breeding places
A. simpsoni / *Taeniorhynchus africanus*	very uncommon, of no importance	very uncommon

Direct proof of the vectors: Owing to the explosive nature of the epidemic and its sudden ending it was not possible to inoculate monkeys for isolation of the virus.

*In these lists *A. furcifer* and *taylori* are bracketed together, as according to Lewis it is doubtful if the larvae can be differentiated, and the criterion used by Edwards (1941) viz. the degree of speckling of the abdominal tergites proved far too variable in the Sudan specimens to be of diagnostic value.

Indirect evidence of the vectors: This was based on the capability of the various species to transmit yellow fever to monkeys by biting. Some of the above species had already been shown by laboratory tests to be capable of acting as efficient vectors, namely:

A. luteocephalus	Newst.	Bauer (1928)
A. simpsoni	Theo.	Philip (1929)
A. vittatus	Bigot	Philip (1929)
Taeniorhynchus africanus	Theo.	Philip (1930)

As the capability of some of the others was uncertain, eggs and larvae of *A. furcifer-taylori, metallicus,* and the pale form of *A. aegypti* (*queenslandensis*) were brought by air to the Yellow Fever Research Institute, Entebbe, and adults bred out. The experimental work carried out by Lewis, Hughes, and Mahaffy (1942) showed that the three species were readily capable of transmitting the infection to monkeys (*M. mulatta*) by biting. *A. aegypti* var. *queenslandensis* was included, for although not found in the Nuba Mountains it has a limited distribution along the Red Sea littoral and owing to the volume of shipping between the Sudan's chief port, Port Sudan, and yellow-fever-free countries as Saudi Aribia and India, it was important to know something of its potentialities as an efficient vector.

Cause of Epidemic

Since October, 1940, not a single case of yellow fever has been reported from the area although a small immunity survey carried out in 1945 has shown an increase of immunes of children in some areas adjacent to the epidemic zone. We are frankly unable to say why the epidemic broke out when and where it did, or why it assumed such proportions. There is, however, one suggestive hint in the rainfall of 1940. The total in Talodi, the chief town in the area, was only 664 mms compared to the average of 818 mms for the years 1915-1941. But the rainfall for May, the first month in which rain always falls, was 160 mms, the second highest for 20 years and nearly twice the average of 81 mms; and there is some reason to think that the epidemic may have originated in this month. It is also in May that variations in the rainfall have a greater effect on the breeding of *A. vittatus* than at any other time. "In later months although low rainfall tends to allow rock pools to dry up, heavy rains, by keeping them full, probably favor the development of the dragon fly nymphs which eat the larvae of *A. vittatus*" (Lewis 1943).

Mosquito Control

Control by the standard anti-aedes measures of urban areas is obviously quite impracticable in the large scattered Nuba Mountains area, with many almost inaccessible places. Control of *A. aegypti* in and near the towns is comparatively easy and has been successful. Such control is important for the adjacent areas and the trade routes, but I am very skeptical as to the value of such measures within the zone. In the case of *A. vittatus* control of rock pools by filling them up with sand is possible near some villages of the plain, but would be quite impossible in the case of the many hundreds of hilltop villages 3,000 feet or more above the plain and accessible only by precipitous and difficult paths. Filling up the tree holes near the villages of the plain is theoretically possible, but in practice would encounter grave difficulties as the inhabitants depend on many of these "tree cisterns" for much of their water supply during the dry weather. But socio-cultural changes already on a considerable scale may be of some importance in the future. In recent years many Nubas have left their hill villages to settle on the plain and to cultivate crops as cotton and millet. If this trend continues more of the inhabitants will be living far from the principal haunts of *A. vittatus,* and the clearing of the land and digging of wells may reduce some of the tree-breeding species.

Control of A. aegypti in the Sudan

I do not wish any of my auditors to go away with the impression that we in the Sudan regard *A. aegypti* as of minor importance. The present communication is chiefly concerned with the role played by vectors other than *A. aegypti* in a major epidemic of yellow fever and the peculiar difficulties of their control. No one can have the slightest doubt of the supreme position which *A. aegypti* holds in the pantheon of yellow fever vectors, and much attention is paid to its control by the Public Health Service in the Sudan. The Sudan is in a somewhat curious position, for while the northern provinces are outside the international boundary of endemic yellow fever in Africa, viz. parallel 15° N., the southern provinces — roughly speaking two-thirds of the country — are in the endemic zone. In the non-endemic zone is situated the capital Khartoum with its network of transcontinental air lines, and hence the Sudan Government is under special obligations to neighboring countries as Egypt as laid down by the International Sanitary Convention for Aerial Navigation (1933) amended in 1944. Control measures are specified in articles 38, 47, and 49. Article 38 deals with provisions concerning the endemic zone, the principal features being that aerodromes be situated where water supplies and human dwelling quarters can be made mosquito-proof and that all ground staff be inoculated against yellow fever. These conditions apply to all aerodromes south of Khartoum, the most important being Makakal and Juba on the White Nile, the latter near the Uganda frontier. Article 47 refers to territories or regions in which although the disease does not exist there may be conditions which permit of its development — in other words, the presence of *A. aegypti,* e. g., in Egypt. By arrangement between the governments of Egypt and the Sudan measures which include the disinsectization of aircraft and the isolation for six days of travelers not carrying valid inoculation certification are carried out in the first airports outside the endemic zone, i. e.. in Khartoum. Port Sudan, and Wadi Halfa. Disinsectization of aircraft is by the usual aerosol bombs, and the efficiency of the method is demonstrated by the fact that since the inception of these measures no *Aedes* have yet been found in any planes by the Egyptian Quarantine authorities who inspect all aircraft at the first port of landing in Egypt.

With regard to seaports, measures are detailed by the International Sanitary Convention (1926) amended in 1941. The Sudan has only two seaports on the Red Sea — Port Sudan and Suakin — but in relation to control of yellow fever both are of especial importance. Port Sudan not only has a large volume of steam shipping with Saudi Arabia, Persian Gulf ports, East Africa, and India, but is also a port of call for the hundreds of small local sailing craft of the Arabs, known as "sambuks" which ply up and down the Red Sea and East African ports. In the past the water tanks on these little craft have been fertile breeding places for *A. aegypti,* but now the strictest regulations are enforced that all must have special covered metal tanks as laid down by the Sudan Quarantine authorities. These craft are not allowed to enter the main port, but have to berth in a small harbor some three miles to the north. Suakin is a small, and for the most of the year, a dead port, some 40 miles south of Port Sudan, but during the pilgrim season it assumes particular importance in yellow fever control. Many thousands of Muslims from all parts of Africa pass through the Sudan making the annual pilgrimage to Mecca, and all these must pass through Suakin, where the measures of control are instituted as laid down in the International Sanitary Convention of 1926 (1940). Special attention is paid to these ports and the adjacent littoral, for in the past both *A. aegypti* and its pale form (var. *queenslandensis*) were found. It is only by constant vigilance that these Red Sea ports can be kept clear of *A. aegypti,* and a good example of the contrary was the Italian port of Massowa in Eritrea just after its capture by the British-Indian forces in 1941. This was literally a swarming mass of *A. aegypti,* larvae being found in 100 per cent of houses examined as well as in the water cisterns in the ring of forts which surrounded the town some miles to the west. Dengue was rife, but fortunately no cases of yellow fever were introduced.

Finally a word on mosquito control — specially trained local anti-aedes units under the control of the senior medical entomologist are in all the important towns and adjoining areas, and traveling about is a mobile unit which checks and reports on the work of the local units. Anti-mosquito measures are the direct responsibility of the local Medical Officers of Health assisted by British and Sudanese Public Health Officers. The value of these measures can be assessed by the fact that the aedic index of Khartoum and other important towns on the Blue and White and main Niles has been zero for many years and for several years has been zero in the Red Sea ports.

SUMMARY

(1) A brief account has been given of a major epidemic of yellow fever in the southwestern Sudan in which the part played by the classical vector *A. aegypti* was in all probability negligible.

(2) There were almost certainly several vectors, but strong circumstantial evidence indicated the most important were *A. vittatus* and *A. furcifer* (with *taylori*). These were essentially rural and not domestic mosquitoes, and a brief summery of their ecology and difficulties of their control is given.

(3) Owing to the important geographical position of the Sudan, partly within and partly outside the endemic yellow fever zone of Africa, the control of *A. aegypti* is of especial international importance. The control measures for airports and seaports are briefly discussed.

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Mr. Peters: Thank you very much, Dr. Horgan. The next paper is to be presented by Dr. Luis Vargas of the Institute of Health and Tropical Diseases in Mexico City.

(Note: This paper is to be published in *Mosquito News,* and is not reproduced here. It is a systematic paper entitled "The Subgenera of *Aedes, Downsiomyia* N. Tubgen. (*Diptera, Culicidae*). It was illustrated with slides.)

Mr. Peters: Thank you, Dr. Vargas. The next paper is by Major LaCasse on mosquito control problems in Japan. Major LaCasse was unable to leave Kyoto, and so we have asked Dr. Reeves to present his paper for him.

Dr. Reeves: Major LaCasse presents a problem of magnitude and complexity, and indicates the difficulties inherent in attempts to control mosquitoes on a very large scale.

MOSQUITO CONTROL PROBLEMS IN JAPAN

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At the outset it is emphasized that the contents of the present paper represent the personal opinions of the writer and should not be construed as an expression of official policy with regard to the mosquito control program inaugurated in Japan under Allied occupation.

The limitations imposed by a presentation submitted in writing are well understood by the audience and should be taken into account as this paper is read at the meeting of the American Mosquito Control Association. Among the numerous difficulties encountered in a topic covered in this manner are the inability of the speaker to graphically portray and explain field survey data and the lack of opportunity for clarification of questions which may arise. Contents have, therefore, been limited to narrative form and an attempt has been made to develop the various phases of the problems discussed as fully as limited time allows.

The aspects of the problem of control to be covered in the period allotted include a summary of mosquito-borne diseases in Japan and their incidence, distribution, and relative importance. The species of mosquitoes present, their breeding habits, and their probable relationship to disease transmission will also be dealt with briefly. The control program prior to the occupation and the present program will be elaborated upon and finally conclusions and interpretations will be set forth.

The diseases of man known to occur in Japan which are mosquito-borne include malaria, filariasis, dengue fever, and Japanese B encephalitis. Each of these diseases will be considered separately in the discussion which follows.

Malaria was not a reportable disease in Japan prior to Allied occupation, and the information available on incidence and distribution does not permit accurate evaluation of the problem over a period of years. Statistics compiled by the Public Health and Welfare Section, SCAP, show approximately 11,000 cases of malaria among Japanese in 1947, and 4,752 cases up to 1 December in the year 1948. Cases are reported from all prefectures of the country during both years for which complete records ae available. Approximately one-half of the cases reported during 1948 occurred in Shiga prefecture in south central Honshu and the remaining cases reported showed a rather even distribution throughout the four principal islands. The uniform case distribution exhibited strongly suggests that excepting for Shiga prefecture, a considerable number of malaria patients are probably among repatriates and returned Japanese soldiers who contracted the disease elsewhere. The latter observation is given further support by the fact that the total number of cases reported in 1947 when repatriation was continuing at a high level, was more than double the number reported in 1948. All information at hand supports the contention that malaria does not constitute a significant public health problem in this country.

We have no filariasis surveys conducted among Japanese to date by Allied medical department personnel which are of any real significance. In three separate areas on south central Honshu, Malaria Survey Detachments made a total of approximately 1,000 thick smears on adult persons, and in this series only one positive was found, which on investigation proved to be in a Chinese who had resided most of his life in southern Malaya.

The latest extensive surveys performed by Japanese workers were made in 1926 among soldiers of the Japanese army. Endemicity for filariasis in the latter studies varied from 0% to 2% in prefectures in the southern half of Honshu, while on the southernmost island of Kyushu, infection rates varied from .5% to 2% in the prefectures in which surveys were made. Highest rates recorded were along the western and southern coasts of Kyushu. More up-to-date surveys, carried out under carefully controlled conditions are in order at present and a new appraisal of the problem would be the only basis upon which to properly evaluate the relative threat which the disease imposes from a public health point of view.

According to Japanese informants, dengue fever was unknown in Japan prior to 1942. There is no evidence to back this claim other than a record to this effect contained in an unpublished paper made available to the writer by a member of the teaching staff at Kyoto University. Data enumerated here were obtained from the latter source. In 1942 an epidemic of approximately 13,000 cases of dengue fever occurred in Nagasaki, Kyushu, and in 1943 over 10,000 cases were recorded in the Kobe-Osaka Kyoto area in south central Honshu. In 1944 and 1945 appreciably fewer cases were seen and these were also limited largely to the epidemic area of 1943. No cases have been recorded in Japan since 1945. Dengue outbreaks from 1942 through 1945 were of about seven weeks' duration beginning in late July and terminating shortly after mid-September. The benign nature of this disease and the present lack of evidence of its actual establishment on these islands serve to relegate it to a very secondary position in the over-all mosquito-borne disease problem.

From the standpoint of case incidence, severity, and geographical distribution, Japanese B encephalitis is the most important mosquito-borne disease in Japan. Outbreaks which were probably of this disease date back to 1871, but the first large epidemic of which there is a record occurred in 1924. Over 6,000 cases were recorded in that year; another epidemic of somewhat lesser magniture involving over 5,000 cases occurred in 1935, followed by the largest outbreak on record in 1948 with over 8,000 cases of the disease. In years between these epidemics anywhere from few or no cases to as many as 2,800 cases were recorded, with some almost every season. Approximately 33,000 cases are on record from 1924 through 1948. In the 1948 outbreak there were 2,455 deaths in the 8,023 cases, giving a mortality rate of approximately 30%, while mortality rates in previous epidemics ranged as high as 60%. All figures are quoted per se without taking into account those which may have been misdiagnosed and confused with diseases such as tuberculous meningitis, apoplexy, heat stroke, and others in which the clinical picture may resemble that of Japanese B encephalitis.

In the 1948 outbreak there were 22 cases of the disease among Allied occupation personnel with three deaths. No analysis of case histories of these persons has been seen by the writer and any knowledge gained, particularly with regard to the occurrence of the disease in immunized persons cannot, therefore, be presented here.

The disease appears with most regularity from year to year in the south central portion of Honshu in the Inland Sea area, and while it occurs particularly in epidemic years in all islands of the archipelago, it is very rarely seen in the northernmost island of Hokkaido. Serologically it can be shown that a large proportion of the indigenous population has had experience with the virus. It is estimated that the ratio of clinically recognizable cases to inapparent infections is somewhere between 1:300 and 1:1000. Thus we have a disease which is practically Japan-wide in incidence, a fact which is very important in considering mosquito control as a means of protecting the population.

Consideration will next be given to the mosquito problem as a whole, with particular reference to those species of importance as pests and/or as potential vectors of disease. There are approximately 40 species of mosquitoes known in Japan, and of this number not more than 8 are of any importance from the standpoint of their feeding habits. Among those which feed on man readily there are three species of *Culex,* namely *Culex pipiens pallens, Culex tritaeniorhynchus, Culex bitaeniorhynchus;* three species of Aedes, namely *Aedes albopictus, Aedes flavopictus,* and *Aedes vexans nipponi,* all of the latter being important day-biting mosquitoes. *Anopheles hyrcanus sinensis* is the only *Anopheles* of importance, the four other *Anopheles* known in Japan being rather rare species. In certain sections of the country a representative of the genus *Mansonia* occurs, and in the localities where it is established it is a vicious biter.

Japanese workers claim to have isolated the virus of Japanese B encephalitis from *Culex tritaeniorhynchus* in nature and the evidence at hand points to this species as the principal vector of the disease. *Culex pipiens pallens,* a closely related species, is claimed on the basis of studies carried out by Japanese, to carry the virus in nature, and its habits and seasonal incidence strongly incriminate it as a possible vector. The only anopheline implicated in malaria transmission is the species *Anopheles hyrcanus sinensis* mentioned above. *Aedes albopictus* is the most likely vector of dengue fever; and filariasis may be transmitted by any of the mosquitoes which feed on humans since the entire group has been proven experimentally capable of transmission.

The composite list of breeding sources of mosquitoes which feed on man readily in Japan is a most impressive one and emphasizes the extremely difficult problem of control. For the most part, important species live in close proximity to human habitation and practices associated with agricultural pursuits create a large proportion of mosquito-breeding habitats. An understanding of the basic problem entails a knowledge of local agricultural practices. As a undoubtedly well known to all of you, rice constitutes the principal agricultural crop of the country. The paddies are flooded in June and remain under water throughout the important mosquito-breeding season. In addition to the paddies proper, rice-growing districts are heavily interlaced with a system of drainage and irrigation ditches containing stagnant or slowly moving water. Nightsoil constitutes a large proportion of the fertilizer employed in growing crops and the tanks utilized for storing it dot the landscape wherever crops are grown. In the application of nightsoil as fertilizer quantities of water are used as a diluent, and irrigation tanks often serve as reservoirs for water used for this purpose. Thus we have a large portion of the land under water and productive of some mosquitoes through the summer months, mosquito-producing rice paddy ditches in abundance, and nightsoil storage and garden irrigation tanks scattered throughout serving to further augment the mosquito population. To these can also be added other ground water sources in the form of poorly constructed roadside ditches, and gutters, and occasionally extensive unreclaimed lowland marsh areas. To mention only a portion of other type breeding sources we can add to the above innumerable artificial containers such as drums, bowls, buckets, cans, urinal crocks, flower pots, decorative stone vases, native latrines, cisterns, water-holding rubble still remaining in bombed areas, and the stumps and posts of cut bamboo. Thus we have a very diverse, extensive breeding problem presenting an extremely difficult approach from a control standpoint.

Our attention is directed now from mosquito-producing sources to seasonal variations in breeding intensity and the relationship of the vital factors of temperature and rainfall to mosquito propagation. Daily high temperature normally attains 70 degrees F. about the beginning of May in all areas of Japan south of Tokyo, at or near sea level. There is a gradual increase in daily mean temperatures from May to late June, at which daily high readings of between 80 and 85 degrees F. are attained. Daily temperatures climb another ten degrees to readings of between 90 and 95 degrees F. in early July, and this level of maximum heat is sustained through the end of August. June and September are usually the wettest months, but there is no "wet" or "dry" season in Japan as we commonly understand the term. Seasonally the first heavy impetus to reproduction of mosquitoes is given by the higher temperatures attained in the latter part of June coupled with heavy precipitation occurring during that month. There is a steady upward climb of the density curve of biting species through July, with a rather marked peak attained usually by mid August. Population density decrease is rather marked during the last part of August, and with the onset of cooler weather in September the density curve levels off quickly to points approaching zero. We can demark the control problem as one requiring close attention in the field from about mid-May through mid-September for geographical locations extending from Tokyo and south over Japan.

The point of departure for mosquito control programs is generally the specific diseases present in an area which are mosquito-borne, their relative endemicity or epidemicity serving in large measure to determine the actual time and money expended. In some parts of the world the degree of discomfort occasioned by heavy mosquito biting populations, or economic considerations are prime motivators in the appropriation of funds for abatement projects. In Japan, any one or all of the above factors may enter into the picture depending upon the time of year, seasonal variations in the intensity of mosquito activity, geographical location, or the presence in some seasons of mosquito-borne disease in epidemic proportions.

An attempt will next be made to obtain an objective viewpoint of the size and scope which a mosquito control program would entail, if such a project were to be successfully carried out on a nation-wide basis. Approximately thirty per cent of the land in Japan is arable, and the populated areas coincide closely with areas potentially productive agriculturally. Similarly the requisite control areas coincide closely with arable land, since the remainder of the country is mountainous and for the most part very sparsely populated. The total land area of Japan exclusive of Hokkaido is 113,000 square miles. The approximated 30% which is populated would then represent an area of 34,000 square miles on these islands which would require coverage at roughly ten-day intervals over a period of at least four months each season, if abatement were to be achieved successfully. We can well raise the question at this point, as to whether or not abatement on a nation-wide basis, exclusive of the northernmost island of Hokkaido, is feasible at all when the total cost of such a program is considered. Public health is purchasable, for a price, and the cost of this phase would probably be entirely out of proportion to the returns in terms of better health. In order to stand on a firm basis, the long-term plans for expenditures of public funds for abatement programs in Japan must be on an economically sound scale, and must be capable of successful acomplishment. The answer concerning the scope which the program adopted for the future should cover is probably within these criteria.

I believe it might be worthwhile at this point to analyze briefly certain field survey data obtained over several seasons, since this information may enable an evaluation of the relative success we have met thus far in control operations. The biting collection records set forth below are based upon observations employing humans as bait, and utilizing flashlight and chloroform tubes for capturing adult mosquitoes as they alight to bite. Biting intensity records were made at three to four day intervals from 1900 to 2300 hours from late July through the end of the first week in September, in 1946 and 1947. Two locations were selected for study, one of which was a large city of over a million inhabitants and the other a typical rice-growing district, since these areas afforded an opportunity for comparison of population densities in typical urban and rural localities. During 1946 in the urban area studied biting intensities varied from an average hourly low of six per hour to a high of thirty-five adults per hour, and throughout the month of August the average biting rate never fell below twenty in all hour periods recorded. In the rural area studied biting rates varied from an average low of 20 per hour to a high of over one hundred per single hour period, during 1946. As a follow-up, similar observations were made during the summer of 1947 at points identical to those in which the collections were made the previous year. While the biting rates were slightly lower during the second season, the extent of reduction noted was not sufficient to be of any significance, and the variations lie wholly within the limits of seasonal variations without reference to differences attributable to control.

During the months of July and August in 1938 large numbers of resting adult females were collected in the vicinity of Okayama in southern Honshu, and frequently a single stable yielded several thousand mosquitoes. Stables were usually small and seldom sheltered more than a few animals. Similarly, light trap collections made in the same area yielded anywhere from five hundred to a thousand or more mosquitoes in a single night's catch. The entire time allotted to this topic could easily have been taken up with a presentation of concrete evidence such as that cited above, in support of the contention that whatever the control program may have been, a sufficient mosquito population was still maintained to present a serious pest problem, or mosquito-borne disease problem if mosquito-borne diseases had made their appearance.

The factors, whatever they may be, underlying the largest outbreak of Japanese B encephalitis in the history of Japan during 1948 would make interesting reading indeed. While it is possible that the magnitude of the outbreak could reflect a breakdown in efficiency of control operations as compared with the two previous seasons, it seems very doubtful on the basis of data cited above that the same thing might not have occurred sooner had other requisite factors in the epidemiological picture been adequately met in nature. I bring the question of this particular epidemic up in closing because we cannot fail to take cognizance of the fact that in the third year of experience with mosquito abatement in Japan the inadequacy of control was quite definitely proven. It is the well-considered opinion of the writer based on long close contact with control problems in the field over a large portion of Japan that while considerable effort has been expended we can probably safely conclude that up to the present time only the surface has been touched in what could be termed effective mosquito eradication even in the larger urban centers of population. In smaller communities and rural areas the situation is probably essentially the same as it was prior to the war. The progress made represents a beginning, but the task ahead is a tremendous one if the ultimate goal is mosquito control limited even to the larger population centers, aside from similar progress throughout rural Japan.

Mr. Peters: We will now take a recess and reconvene in ten minutes.

(RECESS)

Mr. Peters: The next paper is to be given by Dr. Hammon, of the Hooper Foundation for Medical Research.

PUBLIC HEALTH PROBLEMS RELATING TO THE VIRAL ENCEPHALITIDES IN THE FAR EAST AND THE PACIFIC ISLANDS*

By W. McD. Hammon, M.D., Dr. P.H.

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

The recognized mosquito-borne diseases of the Far East and the Pacific Islands are: several types each, of malaria, filariasis, and dengue, and one of the arthropod-borne encephalitides, Japanese B encephalitis. Certain groups of Pacific Islands have been recognized as malaria-free, in most cases because they are free of *Anopheles.* Many of the more isolated groups have been either entirely mosquito-free or have had a very limited number of species. Some countries and islands, though having a recognized vector species, have been free of the disease which that species is capable of carrying. Japan, for example, was free of dengue until during the recent war, though *Aedes aegypti* and *Aedes albopictus* are both present in certain areas. During the war and since the war, however. marked changes have occurred in the mosquito-borne disease problem of these areas. These changes have been due, undoubtedly, to both increased travel and to the rapidity of that travel, together with extensive increases in suitable breeding places resulting from bombing, and changes in population densities and habits of living, from the effects of war.

Because of the interest of our Neurotropic Virus Unit in the epidemiology of Japanese B encephalitis and encouragement to pursue the study by the Army Epidemiological Board, several of us have been in a position to make observations directly and to hear of developments regarding the changes taking place. These changes include newly introduced species of mosquitoes on Guam, among which are *Anopheles* and a dengue vector, *Aedes albopictus.* Also on Guam has appeared the previously unsuspected and unrecognized disease, Japanese B encephalitis. On certain islands of the Marshall group, there have been discovered newly introduced species of mosquitoes where a few other species had already been found, and on other islands of the group, one or more species appeared where none existed before. On the very isolated Wake Island, *Aedes aegypti* and *Culex quinquefasciatus,* a filariasis vector, suddenly appeared where no mosquitoes had been found previously.

Such movement and introduction of disease vectors cannot help but lead to health problems. We have already mentioned dengue in Japan. We might also recall to you the now well-known outbreak of dengue on Oahu in 1943, where it had not occurred since 1912 or possibly as late as 1915, and as mentioned earlier, the appearance of Japanese B encephalitis on Guam. Of the latter, more will be said, but for the present let us consider other possible mosquito-borne diseases, as yet unrecognized.

In the last few years a whole series of new mosquito-borne viruses has been isolated from mosquitoes in Africa, where the Rockefeller International Health Division's laboratory has been looking for yellow fever virus. Similarly, in yellow fever studies in South America, at least four other viruses of as yet unknown significance were encountered. Here in this Pacific Coast state of California, we have isolated three times one new virus from mosquitoes of the San Joaquin Valley. We call it the California virus. Antibodies to this virus in man, found in this area only, indicate that man is *one* of the hosts commonly infected.

In the Pacific Islands our troops encountered many febrile diseases, some dengue-like and mostly undiagnosed in respect to etiology. Outbreaks of this nature are still occurring in troops and dependents on these islands under our trust, and a number of these outbreaks have occurred under conditions suggesting mosquito transmision. Natives from these islands, whose blood sera we have received, have been found to have serum antibodies closely related to those of the group of mosquito-borne infections recognized now as composed of St. Louis and Japanese B encephalitis and West Nile fever; yet these antibodies were not due to any one of these three viruses. The evidence for these conclusions and the types of tests performed are of too complicated a nature to discuss in the time available here, but the findings have been mentioned because they indicate that in addition to the now recognized mosquito-borne diseases mentioned earlier, others undoubtedly exist.

The known and suspected distribution of Japanese B encephalitis may be described as covering roughly the Western Pacific coastal areas from Manchuria to Malaya and also many of the Far Eastern islands near the continent, extending from Honshu in Japan to Java, including Okinawa, Formosa and probably the Philippines. However, in January of 1948, cases of fatal encephalitis began to occur in American troops and natives on Guam, almost 2,000 miles further west than Japanese B encephalitis had been suspected to extend previously. This virus was isolated from these patients, nevertheless, and serological diagnoses of Japanese B encephalitis were made. These results were obtained both in our laboratory and in the Army's laboratory in Tokyo.

Culex tritaeniorhynchus and *Culex pipiens* have been considered generally the two most probable vectors in the areas of known previous distribution because of: (1) reported virus isolations from naturally infected mosquitoes, (2) experimental laboratory transmission, and (3) in the case of *C. taeniorhynchus,* a close correlation between the season of mosquito activity and the season of recognized epidemics. Neither of these mosquitoes could be found on Guam, nor had they ever been reported from there, so apparently some other species can act as the vector. Dr. Reeves and I reported several years ago that we had succeeded in transmitting this virus experimentally with seven species of California mosquitoes. These represented three genera and included *Culex tarsalis,* so it appears that potential vectors are not lacking in many places.

Now let us consider some of the potentials in the spread of this and other related mosquito-borne infections in the

*The original investigations reported here were carried out by the Neurotropic Virus Unit of the Hooper Foundation in collaboration with the Commission on Virus and Rickettsial Diseases, Army Epidemiological Board, Office of the Surgeon General, U.S. Army, Washington, D.C.

Pacific. We in the United States are of course primarily interested in spread from west to east, but let us not forget the importance of possibly spreading our Western equine encephalomyelitis virus and St. Louis encephalitis to the west. Fortunately, our seaport cities are free of these infections under normal circumstances and infected mosquitoes are thus unlikely to be carried by ship, but at least one of our international airports is located in the endemic valley area. We feel we know enough about the epidemiology of the types in our Western States to have little concern for infected man serving as a carrier. Wild birds, probably the most important vertebrate carriers, are unlikely to be transported by man-made craft, but horses, mules, and possibly other animals, if transported rapidly, could conceivably arrive in another land at a time when virus was circulating in the blood. Local mosquitoes might then acquire the infection.

Unfortunately, less is known of the epidemiology of Japanese B encephalitis, and nothing known of the other viruses suspected, but not yet isolated or studied. Let us consider, however, the status of present knowledge of Japanese encephalitis. The disease is one which has been endemic in many areas and produces serious epidemics at unpredictable times, but always during seasons of hot weather and large numbers of mosquitoes. The virus was isolated by Japanese workers in 1935 by using the technics learned from Webster's report of the isolation of St. Louis virus in 1933. The Japanese virus was then found to be related immunologically to the St. Louis virus. The Japanese may also have been influenced by the early epidemiological reports from this country stating that all attempts to effect mosquito transmission were negative, and concluding that the disease was probably spread by contact. News of later proof of mosquito transmission of St. Louis virus never got to them because of the war. In any case, official Japanese health department opinion has always held that this disease was probably transmitted by human contact. However, one group of workers in Tokyo accumulated extensive epidemiological and laboratory evidence supporting the mosquito transmission hypothesis. This evidence included demonstration of virus in wild-caught mosquitoes, in their larvae, and in adults from these larvae, demonstration of virus from the blood of infected man, dogs, and other mammals, and experimental transmission to laboratory animals with wild-caught and laboratory-infected mosquitoes. Much of the experimental work, however, was not confirmed by the few other workers who tried to repeat it, and Japanese scientists discarded most of the experiments and the reasoning as unconfirmed and unproved. On several visits to Japan, we have tried to evaluate this work. In the light of findings made here on St. Louis and Western equine virus, all the Japanese work, with the exceptions of congenital transmission in mosquitoes and demonstration of virus in significant amounts circulating regularly in the blood of patients, is parallel to American findings and fits into our expectations. However, the manner in which the experiments were performed and the circumstances under which they were made (using what we call blind mouse passage and done at the time of an epidemic when the mice used might have been infected naturally) lead us to be skeptical of many individual experimental results. Americans, therefore, faced with the problem of controlling this disease, have tried to repeat much of the work, and thus far, working under difficulties, have not been entirely successful.

One difference in epidemiology between the Japanese and American diseases appears quite clear. The most important vertebrate host for the Japanese infection is not avian as for the related viruses in the United States. I, nevertheless, do believe that the disease is in all probability mosquito-transmitted, but consider mammals, possibly man, horses, and dogs, as well as others, as the important sources of viral infection.

In respect to the possibilities of over-water spread to this country, until we have more reliable information, it appears to me that we should consider strongly: (1) the transportation of infected mosquitoes, (2) travel of infected man (with both apparent and inapparent infection) and (3) transportation of man's infected domestic mammals. The proper order of importance cannot be determined at present.

In addition to the appearance of Japanese B encephalitis on Guam, an island far to the east of its previous known haunts, and the repeatedly recognized carriage of mosquitoes by boat and by plane, we know of two human cases of Japanese B encephalitis brought into the United States. Such incidents are worthy of record. The first was a patient arriving in the late, acute stage. In August, 1947, during an outbreak in Okinawa, an American civilian employee left by ship for San Francisco. His ship sailed on August 6th; he became ill just one day later and arrived in San Francisco August 19th (the 12th day of illness). He was diagnosed clinically, soon after arrival, by Dr. Leon Lewis, who had seen many cases on Okinawa, as a case of probable Japanese B encephalitis. The diagnosis was confirmed by serological tests made in our laboratory and at the Army Medical School in Washington. The second case is more significant. An American merchant marine probably beame infected during a one-day stop in Yokohama, at the time of the major epidemic last summer. His ship sailed directly for San Francisco on July 20th. He became ill nine days later and arived in San Francisco on July 30th, only one day after the onset. He died a few days later in the Marine Hospital, San Francisco, diagnosed simply as "encephalitis." The clinical history was similar to that of a severe case of Japanese B encephalitis. At autopsy, heart's blood and fixed brain tissue were submitted to our laboratory. Brain pathology was compatible with any one of the arthropod-borne encephalitides, but the serum had antibodies which were characteristic of those found in most fatal cases of Japanese B encephalitis. There is thus good evidence to support the conclusion that a second case of this disease entered the United States, this one in the very early acute stage.

Reports have come to us of several other cases of Japanese B encephalitis developing in ship's crews after leaving Japan last summer. These landed in other countries. So far, we have no knowledge of the disease developing in *plane* passengers from the Orient, but arrival during the incubation period by this means is quite possible.

Problems of interisland and intercontinent spread throughout the Pacific are not easy to solve while the vectors and the more important vertebrate sources of infection are still unknown. Where concern is great enough, plane and ship mosquito spraying can be made effective. But, what procedures can be applied to the vertebrate hosts? The question as to whether man is likely to be a source of infection is unanswered at present. This at least cannot be ruled out. If so, would vaccine reduce the risk to other countries endangered by travel of infected persons, as in yellow fever? And then, what about dogs, horses, goats? At the moment, all species of mammals must be suspect till further investigation gives many needed answers.

Vaccines for the protection of man are as yet of unproved value for Japanese B virus infection, and serious epidemics are usually too sporadic and unpredictable to warrant recommendation of their routine use except for special groups, where other protective measures cannot be carried out. It appears most reasonable on the basis of present knowledge to prevent large outbreaks of this infection through mosquito abatement, directed at the species in each area which are most suspect on the basis of epidemiological evidence.

Since risks of introducting the virus exist and our knowledge as to how to prevent them is so limited, our next concern and your particular field of interest is to render it difficult for American mosquitoes to become infected.

Let us consider several of the possibilities. If an infected mosquito is imported by ship, it will be in one of our West Coast ports. Man in these ports may be bitten and crew or passengers may have been bitten during the trip. Temperatures in our port cities are usually too low for adequate devolpment of the virus in local mosquitoes which feed on these infected persons (if man is a source of infection, as he may well be), but if these persons have traveled to some of the hotter inland areas, the danger of infection of local mosquitoes and widespread seeding of the virus is a real one. Importation of an infected person from the Pacific by plane or boat presents a similar problem, that is, a danger exists in mosquito-infested, hot inland areas to which he may go. The third possibility is that of importation of an infected mosquito by plane. Landing at a coastal airport would probably lead to a local case or two as in the case of a boat, but otherwise probably present no problem. However, as mentioned earlier, international airports are not all *on* the coast. An imported mosquito in the California Valley may feed on local mammals, man, or his domestic animals, and from this animal large numbers of local mosquitoes may become infected. Our state and U.S. Public Health Service officials are conscious of this danger, and special efforts are made to keep these areas mosquito-free. The danger, therefore, does not appear to be great if landings occur at regular international airports, even though located in high-temperature areas, as long as effective mosquito control is exercised. The greatest danger, therefore, appears to be from the infected person or animal brought in by plane or ship, who then, while virus circulates in his blood, goes into an area with high temperature and a heavy mosquito population. Such areas of danger are where our own encephalitides are now likely to be endemic. Our means of protection against this type of introduction are, therefore, those same measures now employed to control our domestic arthropod-borne virus encephalitides. In our hot valley areas of the West, these consist in intelligent and effective *Culex tarsalis* control, in number one place, and in the position of second importance, abatement of other potential vectors.

Question: I would like to know if there is any danger of introduction of Japanese B encephalitis into the eastern United States.

Dr. Hammon: I think the danger in the eastern United States is less than in the west because of the fact that persons coming from the Orient are going to arrive here first, that a good many of them may remain here for a day or two or longer before they proceed further east. The longer they wait the less chance there is of virus circulating; and again a big "IF"—if virus circulates in the blood of man in large enough quantities to ever infect mosquitoes. *Culex pipiens pallens* of Japan will transmit the virus when experimentaly infected, and yet the season of the disease in Japan does not correlate well with the season of activity of *Culex pipiens pallens*. Japanese B encephalitis has a short season, usually late August and early September, but *Culex pipens pallens* mosquitoes are present in large numbers throughout the summer. We have little epidemiological evidence to suggest that *pipiens* is very important, as some mosquitoes correlate better in the field. *Culex pipiens pipiens* is here perhaps a different mosquito and might behave somewhat differently. I can't answer the question very directly, but I think the further east we go the less the danger simply from the standpoint of distance and time. I think our known vectors of western equine and St. Louis encephalitis are more apt to serve as vectors of Japanese B than some others because the viruses are somewhat related.

Question: Have any of the other animals in Japan been incriminated as vectors? You mentioned certain domestic animals, especially horses.

Dr. Hammon: First as to whether wild animals of the Pacific have been incriminated as vectors. At the moment I can't say that I recall any that have been incriminated. Horses are infected with Japanese B encephalitis just as horses are infected with western and eastern equine. We can as properly call this disease an equine encephalomyelitis as any of the others because horses are affected in large numbers. Practically all of the large domestic mammals do have antibodies. Insofar as the wild ones are concerned, I can't recall any data that the Japanese have made available to us. They have sampled a few rats but I don't remember the result. We tested a few rats from Guam with, as I recall, negative results. The only other wild animal that we caught on Guam (and really they were not at all wild) were cats that came into our rat traps. They also were negative.

Mr. Peters: Any further questions? If not, we will proceed to the last paper, which is by our good friend George Bradley, who unfortunately is not here. However, his paper is here and will be read by Mr. Roy Fritz of the Public Health Service. The subject is "The Present Status and Future Plans of the Public Health Service in the Malaria Control Program." Mr. Fritz.

Mr. Roy Fritz: Members of the Associations. Mr. Bradley sent sincere regrets that he cannot be here with you today. I think probably it is one of the first national meetings he has missed for some time. However, he did assure me that he was unable to come because of other duties and not because of the reports of unusual California weather.

THE PUBLIC HEALTH SERVICE MALARIA PROGRAM

By George H. Bradley

Sanitation Director (R), Federal Security Agency
Public Health Service, Communicable Disease Center
Atlanta, Georgia

The Malaria Control Program of the Public Health Service is being carried on cooperatively with the State Health Departments. It has as its objective the eradication of malaria from the continental United States. Although the idea of malaria eradication has been advanced from time to time in the past, it was not until during the recent war that much attention was given to eradication proponents. Then, at the time the hazard presented by malaria carriers among returned service men was under consideration, the eradication idea was advanced (1) as being possible and (2) as being a logical approach to the returned carrier problem. Dr. L. L. Williams, Jr., whom many of you know from his long association with malaria research and control work, can be credited with being chiefly responsible for guiding the thinking of responsible officials which led up to the unanimous approval of a program for malaria eradication by the members of the National Malaria Society in November, 1943. The strategy proposed by Dr. Williams included first and foremost a concentrated and continuous attack on the anopheline vector in the endemic foci of the disease. Explosive outbreaks occurring outside such foci would be dealt with by mobile units. Those of you who would like to go further into the philosophy of eradication of malaria in this country are referred to the interesting papers by Dr. J. W. Mountin on "A Program for the Eradication of Malaria from Continental United States" (Jour. Nat. Mal. Soc. 3:69-73, 1944), by Dr. S. B. Freeborn entitled "Problems Created by Returning Malaria Carriers" (Public Health Reports, 59:357-363, March, 1944), by Dr. L. L. Williams, Jr., entitled "The Extended Malaria Control Program" (Public Health Reports, 60:464-470, April, 1942), and to the most recent paper in the series by Dr. J. M. Andrews and Mr. W. E. Gilbertson entitled "Blueprint for Malaria Eradication in the United States" (Jour. Nat. Mal. Soc. 7:167-190, 1948).

In those papers the many conditions which tend to render malaria in this country vulnerable to an all-out eradication attack with reasonable hope of victory are discussed. One of the principal predisposing conditions for success was that malaria had been reduced to an all-time low principally by natural causes and apparently was being perpetuated in only a realtively small number of endemic foci. It was reasoned logically, therefore, that if advantage was taken of this situation to make an immediate and concerted attack a minimum of additional effort might well cause the disease to disappear as a public health problem.

Federal, state, and local health agencies generally have accepted the eradication challenge and have given wholehearted support to post-war malaria programs pointed toward that objective. The procedures being followed on these programs are attritional in nature. That is, no attempt is being made to completely eradicate the vector mosquitoes from malarious areas or to eliminate malaria parasites in all affected humans. The first of these approaches, even if practical, would entail prohibitive costs; and for the second no suitable or practical therapeutic or immunologic procedures have yet been developed. The plan of attack, therefore, involves concurrent reduction of the malaria vectors and the malaria parasites in humans to the point where the chances that malaria transmission will occur are nil.

Anti-anopheline activities consist principally of the use of residual insecticides applied within houses in malarious areas for the killing of those anopheline mosquitoes which are most likely to obtain human blood meals and thus become potential malaria transmitters. Larviciding and drainage operations are carried on where necessary around towns of 2,500 population or over, and careful attention is being given to plans for "building malaria out" of reservoirs and other impoundments.

Concerning the work on impounded water I might say that Mr. Nelson Rector has informed me that since the war the Impounded Water Branch of the Communicable Disease Center, in cooperation with state health departments, has surveyed and prepared plans and recommendations for the control of disease carrying mosquitoes on 323 existing or proposed reservoir sites which are under the jurisdiction of the Corps of Engineers, Department of the Army. These sites cover approximately 5⅓ million acres of land in 38 states and affect roughly 3,000,000 people. As a result of this work the recommended malaria-control features are being included in the construction and operating plans for new reservoirs.

I will now review briefly the progress made on the DDT residual spray program, which is, as has been stated, the chief method of malaria control being used.

Figure 1 shows the malaria problem of the South as it existed during the 5-year period 1938-1942. The epidemiological data shown here were used as a basis in making initial operational plans for the eradication program. During that period there were 188 counties in what may be termed the 13 malarious states of the country which had mortality rates of 10 or more per 100,000 population, an additional 181 counties had rates of from 5 to 9.9, and 468 others had lesser rates.

Beginning in 1945, the year in which funds for the Extended Malaria Control Program became available, an attempt was made to include in the spray program all of the 188 counties having the highest death rates from malaria. In addition, work was carried on in several counties or sections of counties where, in the opinion of state and local health authorities, localized problems warranted attention. It was on this basis that counties originally were preapproved for operations. Soon, however, interest in the program became so great that the criterion for preappoval for counties was lowered to include those having mortality rates of 5 or more per 100,000 population during the base period. Funds to permit extension of the operations to include these additional counties were secured by obtaining local participation in the cost of the work. Table 1 shows, for the years 1945-1948, inclusive, the number of counties in which spraying was done and the number included in plans for 1949, the number of spray applications made, and other data concerning application rates, etc. It will be noted that the number of counties included steadily increased up to 1948, when work was carried on in 347 counties and 1,374,766 house spray applications were made.

Figure 2 shows the counties which were included in the

FIGURE 1

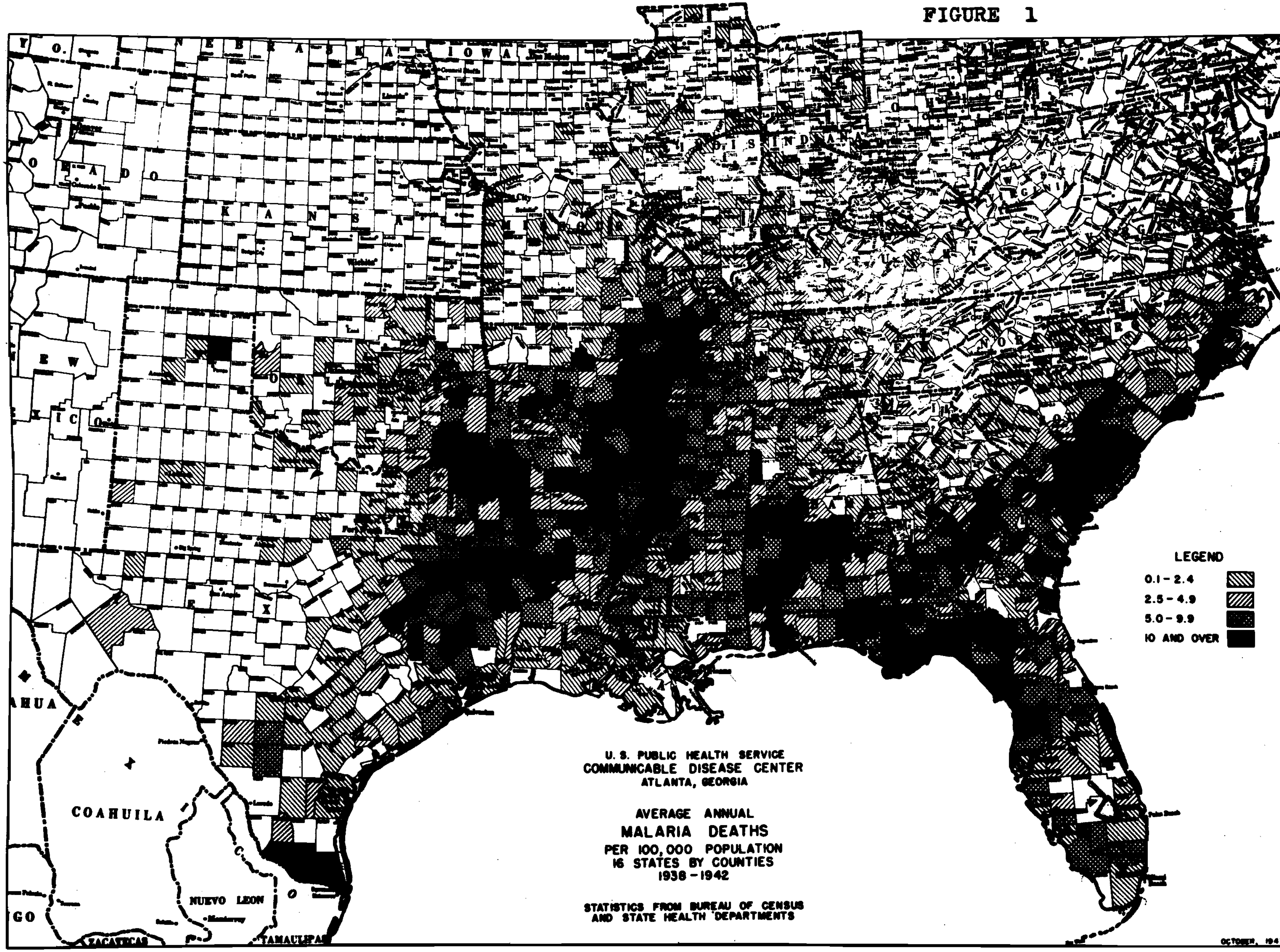

U. S. PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GEORGIA
AVERAGE ANNUAL
MALARIA DEATHS
PER 100,000 POPULATION
16 STATES BY COUNTIES
1938 - 1942
STATISTICS FROM BUREAU OF CENSUS
AND STATE HEALTH DEPARTMENTS
LEGEND
0.1 - 2.4
2.5 - 4.9
5.0 - 9.9
10 AND OVER
OCTOBER, 1947
COAHUILA
NUEVO LEON
TAMAULIPAS
ZACATECAS

FIGURE 2

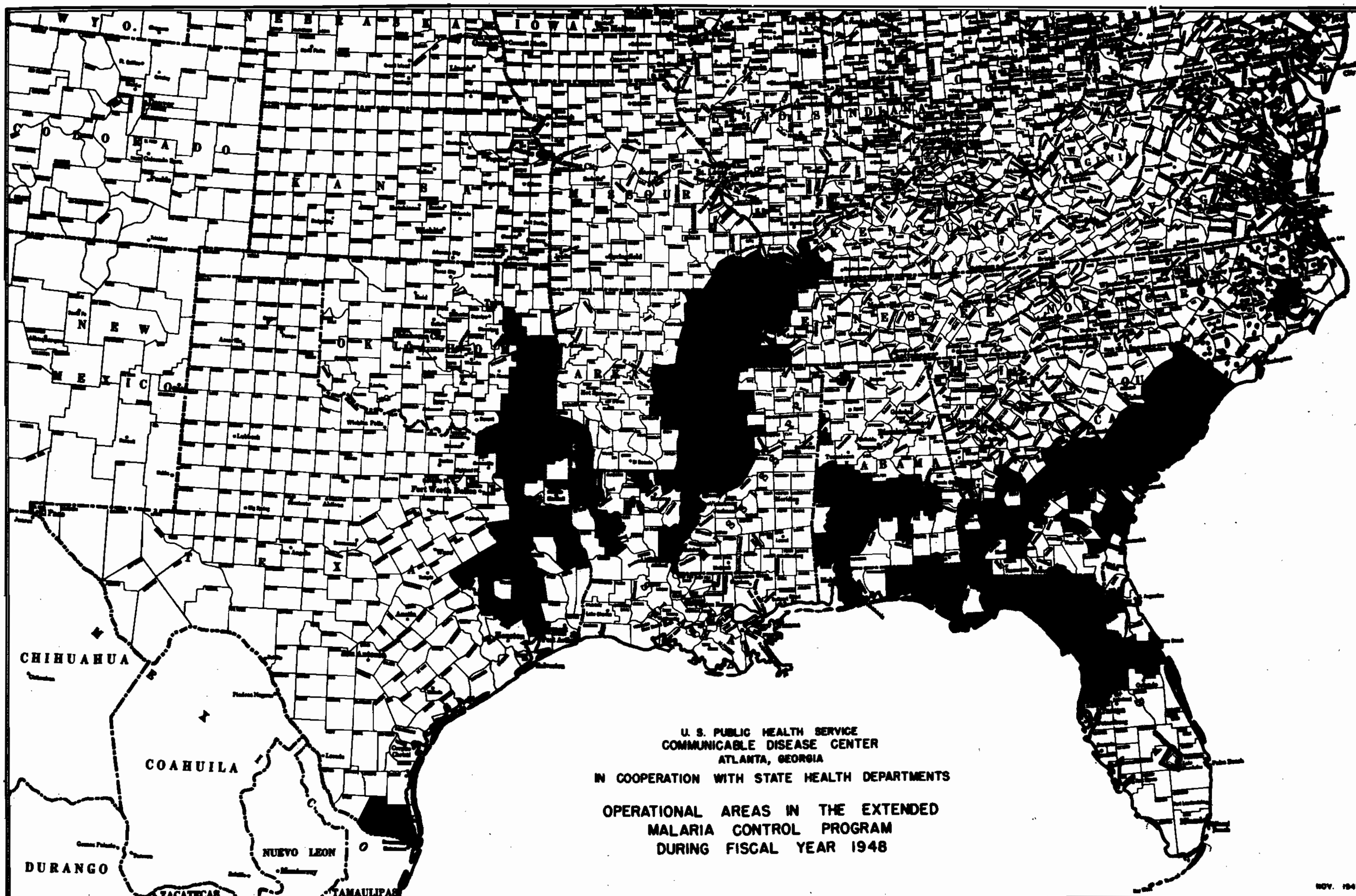

U. S. PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GEORGIA
IN COOPERATION WITH STATE HEALTH DEPARTMENTS
OPERATIONAL AREAS IN THE EXTENDED
MALARIA CONTROL PROGRAM
DURING FISCAL YEAR 1948
NOV. 1947
CHIHUAHUA
COAHUILA
DURANGO
NUEVO LEON
TAMAULIPAS
ZACATECAS
IOWA

FIGURE 3

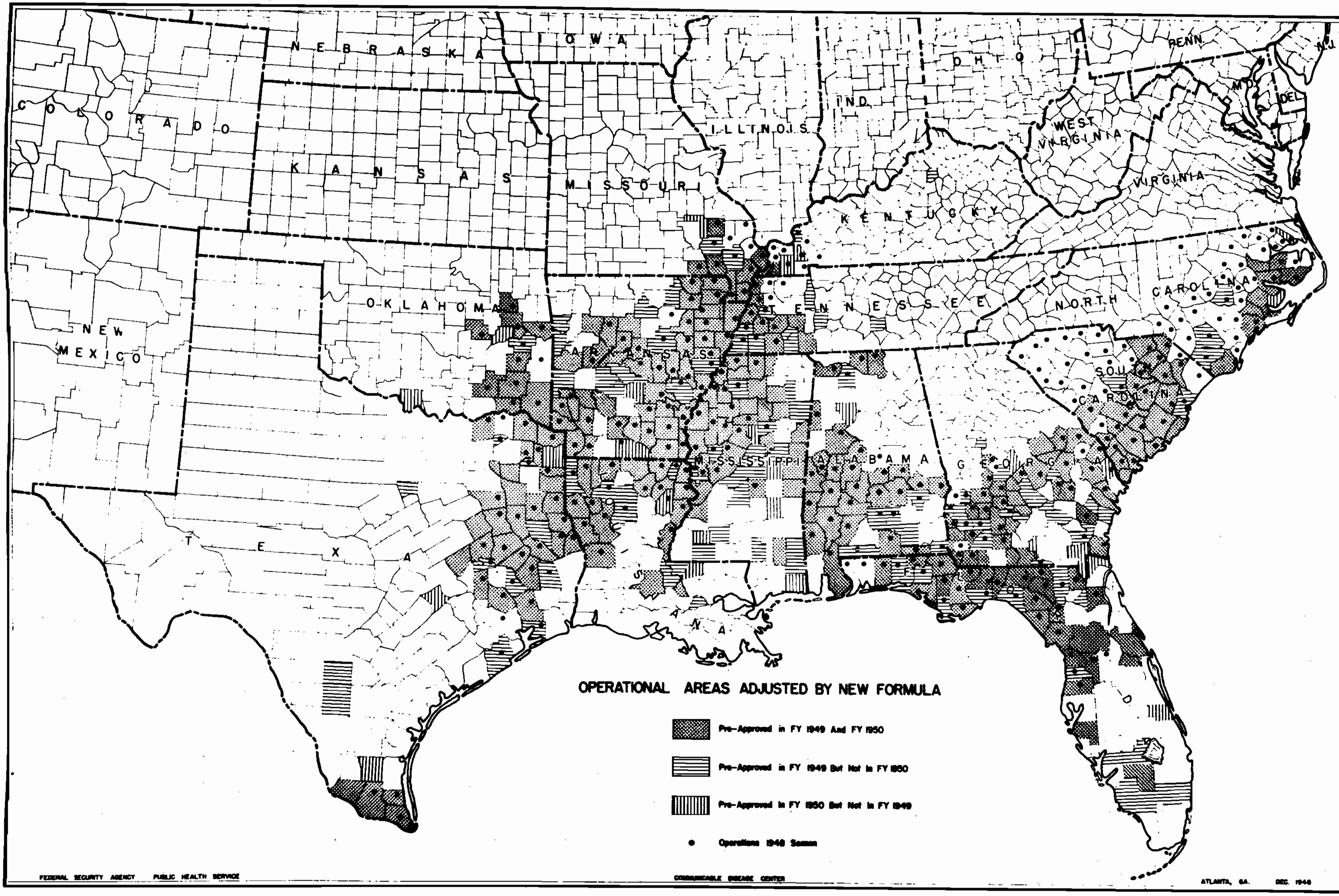
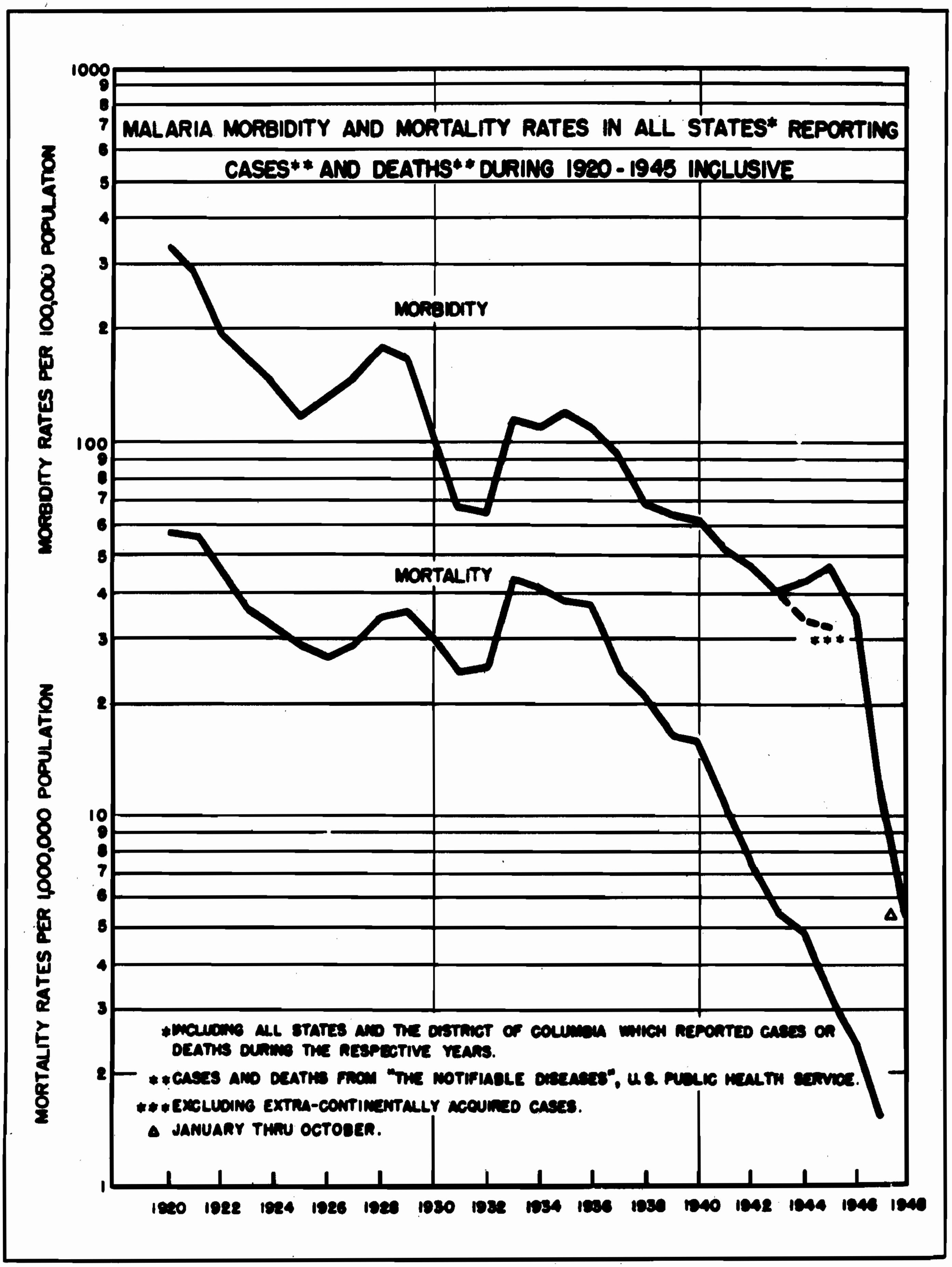

OPERATIONAL AREAS ADJUSTED BY NEW FORMULA
Pre-Approved in FY 1949 And FY 1950
Pre-Approved in FY 1949 But Not in FY 1950
Pre-Approved in FY 1950 But Not in FY 1949
Operations 1948 Season
COLORADO
NEBRASKA
IOWA
KANSAS
MISSOURI
ILLINOIS
IND.
OHIO
PENN.
N.J.
MD.
DEL.
WEST VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
OKLAHOMA
NEW MEXICO
ARKANSAS
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GA. DEC. 1948

FIGURE 4


MALARIA MORBIDITY AND MORTALITY RATES IN ALL STATES* REPORTING CASES** AND DEATHS** DURING 1920-1945 INCLUSIVE
MORBIDITY RATES PER 100,000 POPULATION
MORTALITY RATES PER 1,000,000 POPULATION
MORBIDITY
MORTALITY
1000
9
8
7
6
5
4
3
2
100
10
1
***
1920
1922
1924
1926
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
*INCLUDING ALL STATES AND THE DISTRICT OF COLUMBIA WHICH REPORTED CASES OR DEATHS DURING THE RESPECTIVE YEARS.
**CASES AND DEATHS FROM "THE NOTIFIABLE DISEASES", U.S. PUBLIC HEALTH SERVICE.
***EXCLUDING EXTRA-CONTINENTALLY ACQUIRED CASES.
△ JANUARY THRU OCTOBER.

program for 1948. By comparing these figures with Figure 1 it will be noted that the most malarious counties have just about all been included in the operations program and that there has been a considerable overlapping into counties of lesser importance.

The cost of the program by years is shown in the summarized data given in Table 2. Note that local contributions to the cost of the program increased markedly until 1948, in which year they approximately equaled the funds provided by the Federal government. Also, that for 1949 and 1950 plans call for program support to be provided about equally from Federal and local sources.

That this spray program is resulting in the maintenance of houses practically free from *A. quadrimaculatus* up to 5 months after spraying, is shown by the records of house inspections summarized in Table 3. For the years 1946, 1947, and 1948, respectively, only 1.0, 2.1, and 2.8 per cent of houses inspected contained any live mosquitoes, in comparison with infestation rates of 12.7, 28.0, and 16.7 per cent in unsprayed houses for those same years.

Epidemiological services on the program include the furnishing of current summaries and appraisals of reports of malaria morbidity and mortality which are vital to the intelligent direction of the insecticidal program, as well as the promotion and carrying on within states of intensive drives for the prompt detection and treatment of actual cases. For this work medical officers are given assignments to states which report a considerable amount of malaria (1) to develop better diagnosis and reporting by practicing physicians, (2) to promote the use of the best available anti-malarials, and (3) to follow up reported cases to emphasize the necessity for accuracy in diagnosis. Public Health nurses are furnished to states to supplement the available medical talent in malaria epidemiology. Their work consists in part in stimulating interest in malaria in general public health nursing programs to the end that a larger proportion of sufferers from malaria will be located and encouraged to seek medical attention. By means of these field epidemiological activities, foci of actual or probable malaria transmissions are being delineated. They then are either promptly certified for control operations or subjected to entomological study to obtain affirmative evidence of transmission prior to the initiation of such activities.

Recent data provided by the epidemiologists indicate that malaria mortality virtually has ceased in many of the counties included in the operational program during the 1945-1948 period. Plans are now under way, therefore, to make adjustments in the criteria for county approval, in order that the operational area will conform more precisely to the specific areas of current disease prevalence. Under these revised criteria, approval for participation in the spray program will be limited to:

(1) those counties which had an average annual death rate of 5 or more during the base period 1938-1942, plus an annual death rate of 1 or more per 100,000 population during the period 1943-1946,

(2) those counties which had an average annual death rate of 4 or more per 100,000 population during the period 1936-1946, and

(3) rural homes within 1 mile of a house in which a case of malaria occurred where the case was laboratory confirmed by the respective State Board of Health. This service is to be available in all of the 13 program states.

In 1949 residual spray operations were carried on in a total of 347 counties (Table 1). By applying the first provision of the revised approval plans given above, 268 counties qualify for operations in 1949; by applying the second provision, 26 other counties will be added. Thus, a total of 294 counties will be preapproved for county-wide operations in 1949. It is believed that practically all of these preapproved counties will engage in residual spray operations during the coming season. In addition, a number of counties will be included which carry on operations entirely with local funds, as well as a few others, which because of special conditions will be certified on the recommendation of the state health departments. As shown in Table 1, we expect that operations will be carried on in approximately 325 counties during 1949. These changes in projected operational areas in 1949 compared with those of 1948 are shown in Figure 3. It is planned to periodically appraise the situation with regard to lessening malaria mortality and morbidity and to revise operational areas by some such method as that just discussed, pending the time that the program may safely be guided entirely by current epidemiological findings.

Another feature of the program which should be mentioned is the establishment of a number of "listening posts," or "malaria observation stations," in areas where malaria formerly was hyperendemic, and where under conditions favoring malaria recrudescence, the disease will be most likely to make an early reappearance. Such stations now are located in Helena, Arkansas; Newton, Georgia; and Manning, South Carolina. At these stations intimate studies are being made on the epidemiology of malaria with respect to maintenance of the disease in human populations. It is anticipated that any marked changes in the present downward trend of malaria will be promptly detected in these localities. Surveillance over the program as a whole then can be intensified in order that operational plans can be quickly adjusted wherever necessary. In addition, an ecological appraisal of the vector mosquito species is being undertaken to determine what conditions are associated with active transmission of malaria and those which may have been responsible for its recession. When elucidated, these factors may provide additional means for breaking links in the chain of malaria transmission.

That the goal of the program is being approached is evidenced by the continuing decline in reported mortality and morbidity to the lowest rates on record (Figure 4). Local participation in the program during the past year was at an all-time high, and it is hoped that there will be no lessening of interest during final phases of the program; that this is a possibility, however, must be admitted. One of the features of the residual DDT spray program which, although not concerned with malaria control as such, has made it extremely popular with householders, has been the resulting concurrent fly control. This factor undoubtedly has been responsible for enthusiastic program support in many localities. During 1948 complaints were received that the degree of fly control achieved was not as satisfactory as in previous years. Although this condition may have been due to an increase in numbers of flies which are resistant to DDT, as has been shown in some instances, it is believed that other factors as well were concerned. Included among these seem to have been the climatic conditions in 1948, which in many areas influenced for unusual fly abundance; public faith in DDT which led to the careless handling and disposal of garbage and refuse, thereby creating unusual fly problems; and to the use in a few instances of unsatisfactory commercial DDT concentrates.

Careful attention is being given to this fly control problem in order that it may cause no lessening of interest in the spray program and thereby affect local participation. At present a single seasonal application of DDT at the rate of from 200 to 300 mg per square foot is generally made to wall and ceiling surfaces, and to the backs and undersides of furniture in homes, as well as to porches and privies. It is being recommended that where flies are a problem, the remaining premises structures such as barns, stables, chicken houses, and other buildings be sprayed during the coming year. To insure the use of effective materials, plans are under way to revert to our original practice of purchasing constituent chemicals and preparing the DDT concentrates at strategic points within the program area. Also, for use when outdoor application of DDT residual spray seems desirable, the CDC has developed a modified DDT concentrate which contains a sticking agent. It is believed that this product may solve a part of the fly control difficulty.

It also is being urged that every opportunity be taken to remind the public that the principal purpose of the DDT program is malaria eradication. Where there is concurrent or paramount interest in fly reduction, the necessity for adequate sanitation practices to prevent fly production is to be emphasized.

In conclusion it may be stated that the Malaria Control Program of the Public Health Service appears to be making satisfactory progress toward its goal of malaria eradication from the continental United States by 1952, the date tentatively set for program completion. It must be made clear, however, that program completion will not mean that all malaria prevention work safely may be discontinued. Each state health department in the malaria belt will need to support a minimal program of surveillance and maintenance on a continuous basis to detect and deal with any recrudescence or introductions before they spread. Thus we may look forward to the time when malaria prevention will be accomplished by means similar to those which prevent such mosquito-borne diseases as dengue and yellow fever from becoming problems in this country — quarantine, surveillance, and prompt suppression of outbreaks.

TABLE 1 — SUMMARY OF RESIDUAL HOUSE-SPRAYING OPERATIONS

Fiscal Year	Counties	House Spray Applications	Pounds DDT	Pounds DDT per House	Man-Hrs. per House
1945	111	264,482	103,957	0.39	1.75
1946	266	2,055,397	715,656	0.68	1.55
1947	297	1,236,841	964,449	0.78	1.28
1948	347	1,374,766	1,408,468	1.02	1.36
1949*	325	1,300,000	1,500,000	1.16	1.5

*Estimated FSA, PHS, CDC, November, 1948

TABLE 2 — MALARIA CONTROL PROGRAM

Fiscal Years	Costs	
	Federal	Local
1945	$1,142,210	$ 65,000
1946	$3,988,590	$ 233,000
1947	$3,307,540	$1,138,910
1948	$3,287,993	$3,026,500
1949*	$2,861,400	$3,068,000
1950*	$2,825,000	$3,245,000

*Estimated FSA, PHS, CDC, November, 1948

TABLE 3 — PREVALENCE OF *A. QUADRIMACULATUS* IN HOUSES

	Sprayed Areas				Unsprayed Areas		
	1945 [2]	1946 [3]	1947 [3]	1948 [4]	1946	1947	1948
Number of Houses [1] Inspected	14,129	21,951	9,083	7,479	1,639	1,170	1,021
Number of Houses with **A. quadrimaculatus**	390	220	191	206	208	328	170
Percent of Houses with **A. quadrimaculatus**	2.8	1.0	2.1	2.8	12.7	28.0	16.7

1 — 0 to 5+ months after spraying.
2 — 100 mg. of DDT per sq. ft.
3 — 200 mg. of DDT per sq. ft.
4 — 200 to 300 mg. of DDT per sq. ft., single application per season.

FSA, PHS, CDC, November, 1948

Mr. Peters: Thank you, Mr. Fritz. This evening at 7:30 p.m., at the Claremont Hotel, there will be a business meeting of the Interim Committee of the American Mosquito Control Association. At 8:30 p.m., there will be a business meeting of the California Mosquito Control Association, in the Florentine Room at the Claremont Hotel. I also call your attention to the very fine commercial and non-commercial exhibits which are open this evening and for the next two days in the Florentine Room at the Claremont Hotel. Also, for those of our guests who are interested, there will be a conducted tour of San Francisco's Chinatown this evening, leaving the Claremont Hotel at 8:00 p.m. We will now adjourn until 9:00 a.m. tomorrow in the Florentine Room at the Claremont Hotel.

EVENING SESSION

Monday, February 7

RESOLUTION

Whereas the American Mosquito Control Association, Inc., meeting at Berkeley, California, on February 7, 1949, was privileged to listen to a program of the greatest interest on mosquito control problems in widely separated parts of the world, now therefore,

Be It Resolved, that the Interim Board of this Association, on behalf of the members of the Association, extends its thanks to the participants in this international program, namely, C. R. Twinn (Canada), B. V. Travis (Alaska), L. J. Chwatt, M.D. (Nigeria), S. D. Macready (Costa Rica), E. S. Horgan, M.D. (Sudan), Luis Vargas, M.D. (Mexico), Major W. J. LaCasse (Japan), W. McD. Hammon, M.D. (Pacific Islands) and G. H. Bradley (United States).

Harold F. Gray, President.

ATTEST: Thomas D. Mulhern,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS the Board of Supervisors of the County of Alameda has most courteously assisted the American Mosquito Control Association, Inc., in defraying part of the cost of its convention held in Oakland, California, February 6-9, 1949, jointly with the annual meeting of the California Mosquito Control Association, now therefore be it RESOLVED, that the Interim Board of the American Mosquito Control Association, Inc., on behalf of the Association, extends its thanks to the Board of Supervisors of Alameda County.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS the Tourist and Convention Bureau of the Chamber of Commerce of Oakland, California, has assisted greatly in planning for the annual meeting of the American Mosquito Control Association, Inc., in Oakland and Berkeley, California, February 6-9, 1949, and has performed valuable services in publicity, registration, finance, and other ways, now therefore,

BE IT RESOLVED by the Interim Board of the American Mosquito Control Association, Inc., that we extend our thanks and appreciation to the Tourist and Convention Bureau of the Oakland Chamber of Commerce.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS the Tourist and Convention Bureau of the Chamber of Commerce of Los Angeles, California, has assisted greatly in planning for the motorcade in connection with the annual meeting of the American Mosquito Control Association, Inc., and have performed valuable services in publicity and other ways, now therefore,

BE IT RESOLVED by the Interim Board of the American Mosquito Control Association, Inc., that we extend our thanks and appreciation to the Tourist and Convention Bureau of the Chamber of Commerce of Los Angeles, California.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS for eight years past Dr. Robert D. Glasgow has been Editor of MOSQUITO NEWS, the official publication of the American Mosquito Control Association, and

WHEREAS, under his editorship MOSQUITO NEWS has developed into a unique and outstanding publication of great value to all workers in the field of mosquito control, and

WHEREAS Dr. Glasgow has rendered other services to this Association, on committees and as an officer, in which places his ability, integrity and good judgment have been used to the best interests of this Association, now therefore,

BE IT RESOLVED that the Interim Board of the American Mosquito Control Association, Inc., for itself and on behalf of the membership of the Association, hereby expresses its great appreciation of Dr. Glasgow's services and directs that a suitable expression of its thanks be presented to him at the earliest practicable time.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS the California Mosquito Control Association has been host to the American Mosquito Control Association, Inc., in joint meeting at Berkeley and Oakland, California, February 6-9, 1949, followed by a motorcade through parts of California to observe some of the work of the California mosquito abatement agencies, and

WHEREAS, the officers and members of the California Association have done an outstanding job in organization and management of this joint meeting, now therefore BE IT RESOLVED, that we express our appreciation to the California Mosquito Control Association for a most enjoyable and interesting meeting, and hope that at some appropriate time in the future we may return.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS H. W. Van Hovenburg of the St. Louis Southwestern Railroad has maintained for many years a keen interest in mosquito control work, and has been of particular help to the American Mosquito Control Association, Inc., by assisting to the extent of a five hundred dollar revolving fund the initial financing of the special bulletins on airplane and ground methods and equipment used in mosquito control, now, therefore,

BE IT RESOLVED, that the Interim Board of the American Mosquito Control Association, Inc., on behalf of the members of this Association, extends its special thanks to Mr. H. W. Van Hovenburg for his interest in and assistance to this Association.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

RESOLUTION

WHEREAS M. M. Stallman has given freely of his valued knowledge and experience in the preparation of the necessary documents for the incorporation of the American Mosquito Control Association, and has aided the officers of the Association with wise counsel during the reorganization period, attending both the Florida and California meetings to assist us in the matter, now therefore

BE IT RESOLVED that we extend to M. M. Stallman the sincere thanks of the Interim Board on behalf of the members of the Association for these services so unselfishly given.

HAROLD F. GRAY, President.

ATTEST: THOMAS D. MULHERN,
Secretary-Treasurer.

Done at Oakland, California, February 8, 1949.

TRANSACTIONS
of the
SEVENTEENTH ANNUAL BUSINESS MEETING
of the
CALIFORNIA MOSQUITO CONTROL ASSOCIATION
February 6, 1949

The seventeenth annual business meeting of the California Mosquito Control Association was called to order by President T. G. Raley at 8:00 p.m. on February 6, 1949, in the Florentine Room of Hotel Claremont, Oakland, California.

President Raley reported that he had purposely refrained from making any remarks at the general meeting so that he could give his annual message to the membership of the Association. His paper on the state and accomplishments of the California Mosquito Control Association for the past year, which was read by himself, follows:

The President's Message to the Association

The past year's activities of the Association have been culminated by the Seventeenth Annual Conference now being held jointly with the American Mosquito Control Association. Many hours have been spent in planning and many hours have been spent in actually preparing the many contributions to this affair. While this will perhaps be a highlight of the Association's activities for years to come, we should soberly and with full appreciation keep in mind the sixteen other steps that have been necessary to reach this auspicious occasion. We are what we are, not so much because of our present numbers, but because a few far-seeing people had the courage and tenacity to keep plugging. Those of us who have had the privilege of benefitting from this early work offer heartfelt gratitude and hope that we are worthy.

The year 1948 was important because it was the trial period for a new constitution and by-laws. Under this constitution developed by the first executive committee, the present executive committee has functioned as a guiding body and has met periodically to transact association business. Minutes of these meetings have been sent to all members, and it is the sincere hope of the committee that these minutes have not gone into file "wastebasket." The constitution and by-laws will be discussed later as another part of the business session.

To refresh your memory, a summary of the action taken by the executive committee follows:

FINANCING: To function, any group must have the wherewithal to perform certain acts. During the past year the monetary needs of the association have been raised by a direct assessment of dues against each corporate member. These dues were assessed at a rate of $2.00 for each $1000.00 of the member's local budgeted funds. The very obvious inequality of this method occasioned a general discussion throughout the year seeking a more equitable method of raising these necessary funds. The possibility of outside financing by either commercial firms and other interested groups or by increasing the membership rolls by a change in eligibility, brought only incomplete results. A more concrete approach to adjust at least the matter of assessing dues will be presented later in the meeting. The possibilities of aid through outside financing will be passed on to the succeeding executive body with the blessing of all of us who have kicked it around in the past.

PROCEEDINGS: The proceedings and papers of the annual conference has been through the years the greatest single item of expense. Growing as we have, it is no longer possible to expect one individual to assume this burden as was so ably done for many years by Harold Gray. In more recent years, Dick Peters and the Bureau of Vector Control have gradually taken over parts of this task, but here again there are limits to the amount of effort and time we can expect these able assistants to give. Added to the essential costs of printing, the association must now look forward to the positive requirement of a recording secretary who will not only be responsible for gathering material at the time of the conference, but will be responsible for arranging this material for the printer.

In 1948 the proceedings of the Sixteenth Annual Conference were prepared in printed form. This was done after a survey of all suitable methods for recording this information for future reference and as a record of progress in California mosquito control. The total cost, not of course including the preparation, was $1045.00 for 500 copies. Because of the great demand, districts were asked not to request any more copies than they felt could be used to full advantage. To make these proceedings available for any group or individual outside the association at as reasonable a figure as possible, a price of $2.50 was fixed, based on actual printing costs.

THE "BUZZ": While not too great a drain on the treasury, a certain amount of expense has been charged against the "Buzz," primarily for paper, mailing, etc. Carried on as a joint project of the association and the Bureau of Vector Control, this publication has been a very worthy medium for an exchange of ideas and news. With a mailing list of approximately 850, the "Buzz" has probably reached more individuals than any other single effort of the association. Prepared monthly, interested agencies are kept in close contact with the current news of local, state, and national activities. May I, in behalf of the editor, impress upon all of you the very positive need for monthly contributions.

OPERATIONS MANUAL: This working bible of California mosquito control was unveiled at the last annual conference and was received with great enthusiasm. The demand by individuals and agencies outside of the state was much greater than had been anticipated, and in an effort to achieve a proper balance for financing this demand, a price of $5.00 per copy was set, with the understanding that this charge would be made at the discretion of the executive board. Related agencies offering an exchange of mutual information were, of course, not included in the price discussion. The success of this manual will only be in direct proportion to the contributions that are made. The continuation of this project has been made possible by the able assistance of the Bureau of Vector Control and their very willing acceptance of the chore of preparing and distributing all the material approved for inclusion in the manual.

INSIGNIA: This very colorful identifying emblem of each member's interest in the association cannot, of course, be considered an association expense, but the executive board did take the responsibility for underwriting the initial investment. Purchases from the 3000 decals by individual districts have returned the greatest share of this money to the treasury. Display this with pleasure knowing that you are a part of an enterprising, active group, striving for better service to the people of California.

ANNUAL CONFERENCE: A determined effort has been made to make the activities of this conference self-supporting. A vote of thanks should be extended to the many districts, State Health Department personnel, University of California, the Oakland and Los Angeles Chambers of Commerce, other mosquito control agencies, commercial organizations, and the many individuals who have devoted time, effort, and money to this outstanding event. History alone will reveal the results of this effort.

REGIONAL MEETINGS: Two very instructive regional meetings were held during the year. The spring meeting held in Fresno was a joint effort of Fresno, Consolidated, and Madera Districts. Emphasis was placed on the demonstration of various ground and airplane spray equipment. Many districts and commercial organizations contributed to this effort, showing their specialized equipment and explaining in detail the purpose of each. A worthy suggestion made at the close of this meeting was that in the future an amplifier be available so that everyone would be able to hear the descriptions. This suggestion is passed on with hearty approval for inclusion in future meetings. The fall meeting held in Marysville gave the opportunity to many districts of seeing the tremendous undertaking mosquito control represents in the Sacramento Valley. The business meeting was devoted to a report by all standing committees, and in a sense, was a dress rehearsal for this evening's meeting. Local meetings of adjacent districts do, of course, prove very beneficial at all times and are a common procedure.

Past experience has demonstrated that the annual conference is becoming too technical for the average field operator. With this thought in mind, the executive committee has discussed in great detail the need for making the regional meetings for the field operators. This policy is endorsed by the committee, and the prerogative has been taken of fixing the time and place for the spring regional meeting in 1949. Details will be forwarded to all members well in advance.

RELATIONS OF THE ASSOCIATION WITH THE BUREAU OF VECTOR CONTROL: From an exchange of ideas these relations have progressed to a point where there is general understanding on both sides. A recent letter from Mr. Dahl's office has outlined the Bureau's objectives, and it should be realized by all local agencies that this closer relation will promote better understanding among all concerned. As in the past, the State Health Department is requesting that two representaives from the associaion be appointed to serve on the Advisory Committee to the Bureau of Vector Control. This will be a part of tonight's business session.

STANDING COMMITTEES: As this will be included in other parts of the proceedings, no effort will be made to enumerate the various committees, their chairmen or members. Before proceeding with the reports from these various committees may I express my individual appreciation for the fine work they have done. To me the true indication of any group's progress is the interest shown by each member. Our committees have demonstrated that the California Mosquito Control Association is an active working body.

Following his report, Mr. Raley called upon the standing committees for their annual reports.

Report of the Legislative Committee

Chairman E. C. Robinson stated that a group from Delano had introduced a bill into the State Legislature causing it to be a misdemeanor for mosquitoes to be found breeding on any premises. It was felt that this bill needed further study, and the committee recommended withholding action on it until such study could be made.

The Legislative Committee has prepared a bill which would assist cities within a mosquito abatement district to become annexed to the district. The committee recommended the approval of this bill. Kimball (Orange County) moved, seconded by Bollerud (Durham) that the committee's report by accepted. Motion carried.

Report of the Committee on Association Financing

Chairman Jack Kimball read the report of a committee appointed to study ways and means to change the present system of California Mosquito Control Association dues to a more equitable method. This report had previously been given at the Marysville meeting on November 17, 1948. This report follows:

Final Report of the Budget and Finance Committee

Marysville, California, November 17, 1948

The Budget and Finance Committee met at Santa Ana, California, on October 29, 1948. The objectives of this Committee were to first work out an equitable basis for assessing member Districts for annual contract payments with a maximum of $100.00 per District, and second to prepare a working budget for the fiscal year 1949-50, itemizing anticipated income and expenditures.

The following table of Contract Payments was prepared by the Committee to meet the desired requirements and still insure an income to meet minimum operating expenses. Each member District would make annual payments depending on its total local funds budgeted for that fiscal year.

Annual Contract Payments by Member Districts According to Local Budgeted Funds

Budgeted Funds		Annual Contract
From	To	Payment
$75,000	Over	$100.00
50,000	75,000	90.00
40,000	50,000	75.00
30,000	40,000	60.00
20,000	30,000	40.00
10,000	20,000	25.00
Under	10,000	10.00

The anticipated income from the forty-three districts in California has been estimated on this basis according to their local budgets for the fiscal year 1947-48, and is shown on Exhibit C to be $1710.00. Six districts were not included as paying members.

An itemized Budget for the Fiscal Year 1949-50, showing anticipated Income and Expenditures is presented in Exhibits A and B, respectively. Certain functions of the Association which are now financially carried by the Bureau of Vector Control, State Department of Public Health, are included in the Budget in order to show the entire program. Expenditures for meetings were set up on the basis that these expenditures would be offset by income raised at these meetings, such as registration fees, exhibits, etc. The form of budget was designed to permit a simplified accounting of the principal Association functions in order to secure the information necessary to prepare a useful budget in the future.

Recommendations:

1. That the proposed table of Annual Contract Payments by Member Districts According to Local Budgeted Funds be adopted for the Fiscal Year 1949-50.

2. That a simplified accounting system be set up as suggested in the Proposed Budget and that the Association Treasurer prepare at the end of each fiscal year a financial statement of all income and expenditures, this report to be audited by a proposed Audit Committee and copies sent to each member District by the Secretary at the same time he notifies these Districts that their contract payments for the next fiscal year are due.

Respectfully submitted,
Richard F. Peters
G. Edwin Washburn
Jack H. Kimball, Chairman

Exhibit A

PROPOSED BUDGET
CALIFORNIA MOSQUITO CONTROL ASSOCIATION
FISCAL YEAR 1949-50
Income

Membership		$1760.00
Contract Payments by Districts	$1710.00	
Associate Memberships	50.00	
Conferences and Meetings		$200.00
Fall Meeting, 1949	$ 50.00	
Annual Conference, 1950	100.00	
Spring Meeting, 1950	50.00	
Publications		$100.00
Proceedings and Papers — Sale of Reprints	$100.00	
Mosquito Buzz	0.00	
Manual of Operations	0.00	
Special Services		$150.00
Association Decal Insignia	$150.00	
Total Income		$2210.00
Total Budgeted Expenditures		2060.00
Unbudgeted Reserve		$150.00

Exhibit B

PROPOSED BUDGET
CALIFORNIA MOSQUITO CONTROL ASSOCIATION
FISCAL YEAR 1949-50
Expenditures

General Operation		$460.00
Stationery	$ 50.00	
Post Office Box Rent	16.00	
Postage and Mailing	100.00	
Telephone and Telegraph	0.00	
Miscellaneous Office Supplies	194.00	
Stenographic Assistance	100.00	
Conferences and Meetings		$200.00
Fall Meeting, 1949	$ 50.00	
Annual Conference, 1950	100.00	
Spring Meeting, 1950	50.00	
Publications		$1400.00
Proceedings and Papers — (Editing, printing, and mailing)	$1200.00	
Reprints of Papers	100.00	
Mosquito Buzz — Editing and Printing (Prepared by Bureau of Vector Control, State Health Dept.)	0.00	
Mosquito Buzz — Mailing	100.00	
Manual of Operations (Prepared and transmitted by Bureau of Vector Control, State Health Dept.)	0.00	
Special Services		0.00
Total Budgeted Expenditures		$2060.00

Exhibit C

ESTIMATED INCOME FROM CONTRACT PAYMENTS
BY MEMBER DISTRICTS
California Mosquito Control Association

Local Budget From	Local Budget To	Annual Payment	Est. Number of Districts	Annual Income
75,000	Over	$100.00	7	$700.00
50,000	75,000	90.00	2	180.00
40,000	50,000	75.00	2	150.00
30,000	40,000	60.00	3	180.00
20,000	30,000	40.00	6	240.00
10,000	20,000	25.00	6	150.00
Under	10,000	10.00	11	110.00
Non-member	Districts	——	6	——
TOTALS			43	$1710.00

Sperbeck (Sutter-Yuba) moved, seconded by Murray (Delta) that the report be accepted and that the California Mosquito Control Association adopt the suggested procedure of dues and that the name "District" be changed to read "Agency." The motion carried.

Report of the Committee on Central Valley Canals

Chairman Dahl reported that further studies and evaluations were being made under the direction of Mr. Buchanan on the problems relating to mosquito control along these canals and impounded waters.

Report of the Committee on Irrigation Laws

Your Executive Committee requested a review of the irrigation laws having relation to the operations of mosquito abatement districts.

The State laws regarding irrigation districts are so voluminous that it would require a tremendous amount of time by a competent lawyer to review this legislation. Your Committee feels that it is not justified in expending time and money for this review. In the formation of the many Irrigation Districts in California the requirements of drainage and maintenance of irrigation laterals vary with each district. Therefore, we feel that the local mosquito abatement district and the irrigation district can negotiate their individual problems on a local level better than on a statewide basis.

Respectfully submitted,
E. Chester Robinson, Chairman
G. Edwin Washburn

Report of the Committee on Evaluation and Revision of Reporting Forms

During the past year the Report Forms Committee made a thorough study and revision of the daily operational report form. The revised form together with recommendations on its use was turned over to the Executive Committee and later inserted in the Operations Manual.

A revision of the Monthly Progress Report was also made and is now under consideration by the Bureau of Vector Control.

Studies are being made of the various methods of compiling the data from the daily reports for inclusion in the monthly reports.

Respectfully submitted,
Edgar A. Smith, Chairman

Report of the Publications Committee

The Publications Committee came into being in order that the various functions involving preparation and distribution of literary material could receive the benefit of several persons' perusal. Actually, the activities of this Committee are confined to the three literary functions of the Association, namely, (1) the transcribing, editing, and distribution of the Proceedings and Papers of the Annual Conference; (2) the review of material submitted for the Operations Manual, its preparation, and its release upon receiving approval; (3) the monthly publication of the Mosquito Buzz.

Regarding number one, the Proceedings and Papers— as long as Harold Gray consents to continue with his transcribing and editorial services, there leaves nothing to be desired.

Regarding number two, more material is needed for consideration by this Committee which could be put into the Operations Manual. In short, please read the preface to the Operations Manual again when you return to your individual stations, and then produce!

Regarding number three, The Mosquito Buzz, I feel inclined to request an activity report from the various Buzz reporters, or do you, Jack Kimball, Rolland Henderson, Dick Sperbeck, Gordon Mapes, Pete Pangburn, and Ed Smith, realize that you are Buzz reporters. I feel perfectly justified in submitting to the Association, individually and collectively, that the Buzz requires approximately 2,000 well-chosen words monthly, before it can go to press properly feathered. During the last two months only 200 words have been received. This means that the editor is forced to scratch his noggin most forcibly, and I must confess that his noggin hasn't the attributes of Aladdin's lamp! In other words, some of the articles appearing recently are the products of "forced labor."

It is my hope that some of you will take these remarks to heart and remember the thoughts imparted in this little poem which appeared in the Buzz and has since been reproduced in Mosquito News:

Editor's Lament

Last page, last column
Editor's gettin mity solemn.
Went to the P.O. Found it dry.
Again no contributions! Why?
If you want the BUZZ to buzz,
Better start 'em flowin' cuz
God ain't editing the BUZZ.
Oh how I wish he wuz!

The members of this committee are, aside from the speaker, Harold Gray and G. Edwin Washburn.

Without the existence of a Publications Committee you would be without any form of organized knowledge of local mosquito happenings. It is recommended that the Committee be continued *and supported.*

Respectfully submitted,
Richard F. Peters, Chairman

Report of the Entomology Committee

During the past year each of the three sub-committees of the Entomology Committee met several times, and their accomplishments will be reported by the sub-committee chairmen. During the course of these meetings it became evident that the problems being investigated by the sub-committees were of general interest and were rather broad in scope. This first became obvious in the case of the Sub-Committee on Public Relations and Education, and led to the recommendation that this sub-committee be elevated to full committee status. The Executive Committee approved the recommendation and took appropriate action.

At a meeting of the Entomology Committee in Berkeley on January 21, 1949, it was the unanimous opinion of those present that the Sub-Committee on Mosquito Survey Methods and the Sub-Committee on Insecticidal Testing and Formulation should be continued and should be accorded full committee status, drawing their membership entirely from the Association. This would obviate the necessity for an Entomology Committee as such.

Respectfully submitted,
Edgar A. Smith, Chairman

Report of the Public Relations and Education Committee

The Public Relations and Education Committee evolved into full committee status from a sub-committee of the Entomology Committee because of the breadth of scope of its activities. Originally it was planned that the Sub-Committee should apply itself to matters of entomological significance alone, but it soon became apparent that the general field of public relations and education in mosquito control wants for considerable furtherment, and it would hardly do to develop a single phase disproportionate to the entire need.

First funtion of the then sub-committee, was to sponsor an insignia contest among high schools within local mosquito control agencies. From this contest has come the insignia which today travels California on various district vehicles and is to be found on letterhead and upon the cover of the Proceedings and Papers of the Annual Conferences.

The Committee has analyzed its reasons for being and is working toward two objectives:

1. The furtherment of staffs of local agencies in their own public relations and education, and
2. The development of ways and means of most effectively reaching the public with the individual program of each organization.

In the former, a recommended form for Record of

Service Request and a recommended form for Application for Employment have been prepared by the Committee which have been submitted to the Executive Committee with recommendation that each be put into use by control agencies.

In the latter, the Committee is seeking to gather factual information concerning problems of local mosquito control agencies and to take steps to place such information in the hands of the local agencies and into channels of public information.

The job of this Committee has just begun, and it is recommended that it be continued by the Executive Committee for the current year and ad infinitum.

Members of the committee include: Rolland Henderson; W. Donald Murray; E. Chester Robinson; Edgar A. Smith; Professor W. B. Herms, Honorary.

Respectfully submitted,
Richard F. Peters, Chairman

Report of the Sub-Committee on Insecticide Testing and Formulations of the Entomology Committee

The first meeting of this sub-committee was held at Tulare on February 27, 1948. At this meeting the subject of the standardization of testing techniques in this State was discussed. It was felt by the committee that if this goal could be achieved much would have been accomplished, as only through the use of one test procedure by all agencies could the results be compared, district to district and area to area, with any degree of accuracy. It was also considered advisable that one DDT formulation be set up and designated as "Standard Test Larvicide." This material to be made up in one batch, in order that all of it would be the same, and offered to all districts. This material to be used as a standard against which all others might be tested in the same manner as the O.T.I. is used. The 25% DDT - 10% Triton X-100 in Xylene formula was decided on for this purpose.

In furtherance of these objectives moves were initiated to canvass districts for orders of the Test Larvicide and to request bids for its preparation. The information which it would be desirable to obtain in the field testing of materials was discussed and a tentative test procedure set up. This procedure with discussion has been forwarded to the Executive Committee of the California Mosquito Control Association for inclusion in the Mosquito Control Manual.

The second meeting of the Sub-Committee was held at Selma April 21, 1948, for the purpose of further discussion of the standard test larvicide.

Some of the chemical companies had submitted bids on an or equal basis instead of the formula designated. It was agreed to resubmit the call for bids making it clear that only the stated formula was acceptable. Further it was agreed that the DDT used be a blend of equal parts of the products of four manufacturers and that purchasers of the material be furnished with a complete analysis of the formulation. Bids were again called for and the material made up and delivered to the interested parties.

The final meeting was held in Los Banos on August 6, 1948. Dr. R. M. Bohart of the University of California, College of Agriculture, discussed his work on the testing of the newer insecticides against mosquito larvae.

Tests being carried on in various districts by those present were also discussed.

It is felt that this Sub-Committee should be continued either in its present status or as a standing committee to be available at any time to handle problems which might come before it.

Respectfully submitted,
Gordon F. Smith, Chairman

Report of the Sub-Committee on Survey Methods of the Entomology Committee

I. *Survey Aims and Values*

A. Survey methods, techniques, and equipment should be standardized insofar as is possible, with due consideration for varying mosquito control conditions throughout California. Use of information obtained through survey methods will be a primary objective, as this information is essential in organizing the control program.

B. Standardization of survey methods will act to further stimulate a scientific approach to the problems of mosquito abatement and in this manner aid in contributing to the economic soundness of control operations.

II. *Types of Surveys*

A. *Initial Survey*

1. *Objective:* To determine the most efficient and economical methods that can be employed to achieve control.
2. *Fundamental Information*
   a. Determination of species in the area.
   b. Relative abundance of various species.
   c. Sources of various species.
   d. Distribution of the important pest and vector species.
3. *Procedure:* Conduct a program of sytematic sampling of larvae and adults from all types of sources throughout the survey area. This would include the establishing of a series of resting stations that could be maintained throughout the first full mosquito season. The first records from these stations could be incorporated in the initial survey data. The number of these stations required for a district could be determined on the basis of area as follows: A minimum of ten stations would be required for districts having an area of 500 square miles or less; districts having an area greater than 500 square miles would add one station for each additional 50 square miles.
4. *Description of Terrain*
   a. This will require study of available maps and aerial photographs. A certain amount of gross mapping may be necessary.
   b. Consideration must be given to changing conditions brought about by man-made alterations.
5. Evaluation of the effects of seasonal change in relation to mosquito species.
6. Relative importance of mosquito species.
   a. This must be based on a reasonable knowledge of ecology (relationship of a mosquito to the environment).

7. *Personnel Requirements:* Unless the initial survey is conducted in a thorough manner and the data obtained properly analyzed and interpreted, the end results may be entirely misleading. It was therefore recommended that competent, experienced professional personnel who have a thorough working knowledge of mosquito ecology be employed to render those services. Such services might be obtained either on a permanent or on a consulting basis.

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 larvae and adult inspections. The summary of data could include information from biting records, adult resting stations, light traps, etc. A summary of these data could be made a part of the regular monthly report and recorded as indicated below.

	Number of Inspections	Number of Samples Identified	Species in Order of Abundance
Larvae			
Adults			

By using this procedure the number of permanent collecting stations could be reduced. It is believed to be desirable to reduce the number of permanent collecting stations after the initial survey, in that it is generally recognized that such records do not represent a true statistical sampling and are difficult, if not impossible, to interpret as an index to control accomplishment.

   a. *Collections:* Larvae and adults should be collected by foremen and inspectors as part of their routine work. Specimens should be submitted to the laboratory accompanied by the following information:
      1. Collector's name
      2. Date
      3. Locality
      4. Type of harbor
      5. Approximate density
   3. Mapping.
      a. Section survey maps.

III. *Survey Equipment*

A. Complete field equipment properly carried and ready for use is essential to good survey work.
   1. It is recommended that personnel engaged in field survey work be supplied with the following:
      a. Kit or container for carrying required materials.
      b. Chloroform tube. The chloroform tube is recommended for the following reasons:
         1. Eliminates hazard of coccidioidal granuloma due to inhalation of dust in areas where this disease is endemic.
         2. Chloroform tubes are now in more general use locally and throughout the country.
         3. Chloroform tubes are faster, involve use of less equipment and are generally a more simple device for use by inspectors and operators.
      c. Flashlight.
      d. Pill boxes.
         1. Except for the sliding section type, any small, durable pill box should be satisfactory for storing adult mosquitoes.
         2. In order to prevent mold and the destruction of specimens by ants and dermestids in stored material, the use of paradichlorobenzene or naphthalene is recommended.
      e. Dippers. One half pint, flat bottom, round handle.
      f. Jars for collection of larvae.
         1. One-fourth to one-half pint size — suitable shape and lid.
      g. Pencil.

Respectfully submitted,

Theodore Aarons, Chairman
B. Brookman
Harvey Magy
Jack Walker
Herb Herms

In order that all actions of the Executive Committee might be approved, Elmo Russell (Hanford) moved, seconded by Jones (Marin) that all action taken this year by the Executive Committee be accepted and approved. The motion carried.

A discussion was held concerning the Tentative Constitution and By-Laws. McGowan (Alameda) made a motion, seconded by Henderson (Tulare) that the California Mosquito Control Association continue to operate under this constitution for one more year. The motion carried.

President Raley read a letter from Dr. Halverson asking that two members be appointed to serve on the Advisory Committee to the State Health Department on matters concerning mosquito control problems. Willis (Redding) moved, seconded by Davis (Fresno) that the Executive Committee be given the authority to appoint persons on this committee. Motion carried.

President Raley suggested that we verbally extend the California Mosquito Control Association Exhibit Committee a vote of thanks for their splendid job of organizing and setting up the booths for the Annual Conference.

President Raley suggested to the group that a School of Administration might be offered to certain district personnel this fall. He stated that Fresno State College had signified their willingness to participate and put on such a school. No vote was taken, but most districts seemed to be in accord with the idea.

Trustee Leroy Smith (Delta) stated his views on the Association's responsibility toward the subvention funds, stating that we should all help, especially that each district should get its fair share of the funds and that he felt the California Mosquito Control Association should take a more definite stand and accept its responsibility as a bargaining agent for its members.

One resolution by the Resolutions Committee was read as follows:

RESOLUTION
of the
CALIFORNIA MOSQUITO CONTROL ASSOCIATION

WHEREAS the California Mosquito Control Association, convened for its Seventeenth Annual Conference at Berkeley, California, on this ninth day of February, 1949, does desire to express its appreciation to the Department of Public Health of the State of California, now therefore,

BE IT RESOLVED, that the California Mosquito Control Association does recognize and appreciate the invaluable assistance and many services made available to this Association by the Department of Public Health of the State of California during the past year, without which this Association could not carry out its functions and obligations in the manner so desired and needed by the mosquito abatement districts comprising this Association;

BE IT FURTHER RESOLVED that this Association is in full accord with the Department aims and objectives for mosquito control in general and vector mosquito control in particular, and pledges to do everything within its power to attain these aims and objetives;

BE IT FURTHER RESOLVED that the Secretary of this Association be instructed to transmit a certified copy of this resolution to Wilton L. Halverson, M.D., Director of the Department of Public Health of the State of California, immediately after the adjournment of this conference.

I hereby certify that the above resolution was duly passed by the members of the California Mosquito Control Association attending this Seventeenth Annual Conference on February 9, 1949.

California Mosquito Control Assn.
Edgar Smith, Secretary

Robinson moved, seconded by Gray, that this resolution be adopted. The motion carried.

The Nominating Committee report was called for by President Raley. The report, read by Chairman Robinson, follows:

Report of the Nominating Committee

The Nominating Committee of the California Mosquito Control Association formally present its recommendations for officers and Executive Committee of the California Mosquito Control Association for the year 1949. It has endeavored to conform as near as possible with the By-Laws of the Association, taking into consideration territorial distribution of the officers.

OFFICERS

G. Edwin Washburn, President
Manager, Turlock Mosquito Abatement District
Jack H. Kimball, Vice-President
Manager, Orange County Mosquito Abatement District
Edgar A. Smith, Secretary-Treasurer
Manager, Merced Mosquito Abatement District

EXECUTIVE COMMITTEE

William B. Herms
Trustee, Alameda County Mosquito Abatement District
Thomas M. Sperbeck
Manager, Sutter-Yuba Mosquito Abatement District

The president, vice-president, secretary-treasurer, and past president are, according to the By-Laws, automatically members of the Executive Committee.

Respectfully submitted,
E. Chester Robinson, Chairman
G. Paul Jones
H. C. Pangburn
Rolland Henderson
Joe Willis

Leroy Smith (Delta) moved, seconded by Davis (Fresno), that the Nominating Committee's report be accepted and that the Secretary cast a unanimous ballot. Motion carried.

Smith (Delta) moved, seconded by Smith (Merced), that the action of the Secretary in casting a unanimous ballot be ratified. Motion carried.

President Washburn then called for any further business. There being none, the meeting was declared adjourned at 11:00 p.m.

Respectfully submitted,
G. Edwin Washburn

SECOND SESSION

American Mosquito Control Association Day

TUESDAY, FEBRUARY 8, 1949

Hotel Claremont, Oakland, California

The session convened at 9:30 a.m. President H. D. Peters opened the meeting.

Mr. Peters: Gentlemen, the session for the day is now open. Your retiring President has only one duty to perform this morning, but before doing that I want to express my appreciation for the arrangements that we have here. We from the east are certainly enjoying the hospitality of the California Mosquito Control Association, and it is a great pleasure to meet with you. I have one more duty to perform — that being the introduction of your incoming President. It is rather unusual for a cracker boy from Florida to introduce to a California audience a man you know so much better than I do; however, the occasion demands and merits a satisfactory introduction even to a California audience, and there are those of you here who are not from California. The man who is to succeed me is an old timer, and when I say old timer I mean old timer. For a number of years he has reached national prominence in his work; he is a co-author of *Mosquito Control* with Mosquito Bill Herms, which has been accorded national acclaim. You know him to be a very capable, energetic, enthusiastic worker, and I am sure he will bring that with him when he takes over as President of the American Mosquito Control Association. I think it is fitting that we bring the incoming President to the stage, and if Mr. Harry Stage will help me I would like to escort Harold F. Gray. Harold, there is one feature of this introduction ceremony that must be done, that is, to present you with the symbol of your authority. I am happy to place on you now the President's badge, which is your symbol of authority until you relinquish it to your successor. I am sure you will wear it with honor, and I want to offer you my congratulations and my cooperation and wish you every success in the coming year! (Applause.)

Mr. Gray: I have one very pleasant duty to perform for the retiring President, Duke Peters, before any further activity is undetaken. We have a pleasant custom in the American Mosquito Control Association, of presenting to our retiring presidents gold badges showing that they are past presidents of this organization, and I will now put this past president's badge on Duke Peters. This is a reciprocal proposition. He gives me — I give him. So, Duke, you are now Past President of this Association, with all the assets that go with it, if any, but I want to extend to you the thanks of all of us for the very fine work that you have done as President of this organization during somewhat more than the past year. I believe you have had the honor of having had the longest term of office of any president of the organization. It's a job well done, Duke! We have all admired you for the way you have handled things and we hope to see you at many, many conventions in the future.

Mr. Peters: Thank you, Harold.

Mr. Gray: We are behind our schedule due to various and sundry activities. There are a few announcements to make before we start. It will be necessary to obtain tickets for the Dinner Dance tonight prior to the 10:00 a.m. deadline. There are only about 27 minutes to get the tickets for the Dinner Dance, which can be obtained at the Registration Desk which is outside the door. We also request that those who have not registered please do so at the Registration Desk. Some of you are not members of the American Association. We would like very much to have you who are interested in mosquito control work to become members of this Association, and application blanks may be obtained at the Registration Desk. For those who are interested and do not have copies — there are copies of the last issue, the one that has just come out — of *Mosquito News.* These also are available for free distribution at the Registration Desk. We also call your attention to the fact that there are a few copies of the Aircraft Bulletin — the booklet on the uses of aircraft in mosquito control work — which are available at the Registration Desk. The price of these bulletins is $1.25 for members, $1.50 for non-members. This is a very valuable bulletin which gives a great real of technical and practical information on the use of aircraft. It was assembled by the members of this Association and published by it through the courtesies and financial asistance of Mr. H. W. Van Hovenburg of the St. Louis Southwestern Railroad.

At the meeting of the Interim Board of the Association last night, we elected Lester Smith Vice-President of the Association, and selected Virginia as the place of meeting in 1950.

PRESIDENT'S ADDRESS

About seven years ago it appeared that mosquito control had reached a rather static period in its development, and that until some basically new and different technique was introduced as the result of scientific research the developments to be expected would be along the lines of refinement and perfection of the then available methods.

Then came the war, and the introduction of DDT for military purposes, and finally its release for civilian use. Things moved rapidly in mosquito control, so much so that now it is desirable to pause, take stock, and if possible see where we have gone and whither we are going. If we, like a mariner driven by storm, have been blown off our true course, now is the time to take our bearings and set our course aright again.

The development of new insecticides with larvicidal potencies far greater than any materials heretofore available, plus marked adulticidal potencies either as a surface residual effect or in finely dispersed phase in air, has opened some new and effective avenues of attack upon many insects, especially mosquitoes, flies, fleas, and lice. Of these new materials, DDT is the most publicized, and has had the greatest amount of practical use, so that its limitations and effectiveness are better known, especially as concerns the control of mosquitoes and house flies.

The rather spectacular results which can be obtained with DDT and similar insecticides, and perhaps the fascination which is inherent in a new tool, gadget, or toy, may have led us to the use of these materials beyond the bounds of reasonable long-range economy and effectiveness within temperate climatic zones and in civilized areas. This is particularly noticeable in house fly control and mosquito control.

In this discussion, tropical regions will be omitted from consideration, for the reason that numerous modifications in practice must be made, as compared with temperate climate operations, in order to meet differences in conditions of climate, disease prevalence, economic productivity, and standards of living. The elimination of tropical areas from consideration here does not ignore the great importance of vector control in the tropics; it simply confines the discussion to problems in temperate climate regions and to areas of appreciable economic productivity and reasonably high standards of living.

Before entering into the discussion of the present problems of *mosquito control* as affected by the new techniques afforded by DDT and its analogs, it will be advantageous to consider the problem of house fly control, as a corollary or comparison.

Here the control results which can be obtained immediately, temporarily, and locally by aerosol application, and often over a period of several months by residual applications, are so spectacular that they have tended to obscure, in the minds of many persons, the fact that the presence of appreciable numbers of house flies indicates the accumulation of decaying organic matter, frequently manures, and represents an insanitary condition which should be corrected by appropriate measures.

By any postulates of common decency, common sense, or economics, the mass production of house flies (*Musca domestica*) as a result of careless practices in the disposal of manures, garbage, or other organic wastes cannot be condoned. To an even less degree can we condone the accumulation or accessibility of human excrement or other infective materials from which flies may derive those organisms of communicable disease which they are able to transmit as passive vectors. It therefore is a basic concept of fly control that any manures, garbage, or other decaying organic material in which flies may develop must be removed and disposed of in such manner as to minimize or prevent the production of house flies in large numbers, and that infective materials, particularly human excreta, must be disposed of in such a manner as to be inaccessible to flies. It may not be possible, at reasonable cost, to completely prevent the breeding of all house flies, or to accomplish the complete disposal of all infective materials, but a fairly complete and effective removal and proper disposal of these materials will reduce the total production of flies to relatively small numbers which have little or no public health significance or nuisance capacity.

The use of residual insecticides as the *sole* means of fly control ignores the basically insanitary conditions which permit the production of large numbers of flies, or allow the possibility of their infection. This is neither sensible, decent, nor good practice. The use of residual effect insecticides as an adjunct to basic sanitary measures is defensible and in most cases justifiable, but their *substitution* for sanitation is indefensible, except possibly in emergencies.

With respect to mosquito control, a similar line of reasoning is equally applicable, but with certain added postulates which are of considerable importance.

Over the past forty or more years, both experience and logic have indicated that the basic function of mosquito control is to eliminate or minimize the *production* of mosquitoes. All successful practice in this field, in temperate climates and in civilized areas, has been based on this concept. The introduction of new insecticides of greater toxicity as larvicides or adulticides *has not changed this basic postulate of mosquito control.* It simply gives us *added* techniques which can make our work more effective, and, I expect, ultimately will result in reduced costs of operations if intelligently applied to long-range programs.

However, there are indications that in some abatement agencies this basic postulate of mosquito control either has been lost sight of, or ignored, and that the management of these agencies has become obsessed with the idea that insecticidal vapors can be substituted for elimination, reduction, or modification of production water. It is admitted that clouds of DDT fog in a community are spectacular in appearance, and sometimes (though irregularly and not always predictably) spectacular in the manner in which they will strike down an invasion of mosquitoes. But these mosquitoes developed *somewhere* — that somewhere could have been found while they were yet larvae — those larvae could have been killed before they developed into adults and flew, and, better and more logically, that water in that somewhere could have been prevented from accumulating, by drainage or other appropriate measures.

These clouds of aerosol are spectacular in appearance to the general public. It looks like the mosquito abatement agency is doing something, at any rate doing something the public can see. (*Your effective work they seldom see.*) But actually these clouds of insecticides are *confessions of failure;* you failed to prevent those mosquitoes from emerging on the wing and hungry for blood. The insecticide fog is not only a confession of failure — it is an open *advertisement of failure.* The average citizen and taxpayer hasn't got on to that angle yet, but he will! Just give him time.

But drainage and other measures for the control of mosquito production appear to be expensive, and take a lot of time and work. It may be several years before such measures could become sufficiently effective to produce noticeable results in the redution of mosquito prevalence, and the resident citizen wants results now, not several years later! Admitted, and John Q. Public is entitled to as much protection *now* as is reasonably possible, and is compatible with an economically sound program of abatement. And in a new agency it is both sensible and reasonable that temporary control measures should be used effectively, while the basic *preventive* measures (reduction of production water) are being carried out. The disturbing feature of some programs is that so much effort and expense is being lavished on insecticidal operations of only temporary effect, but there is no long-range plan for the elimination of production water, or else the operations toward the elimination of production water are inadequate.

Some agencies are off the track. Possibly this protest may help them get back on the right track.

But there are other considerations which must be taken into account. These new insecticides, just like most of the insecticides previously available, are toxic agents. Our experience with the new materials is relatively short in time. Most of us have been convinced by experience that if DDT is used in appropriate situations and with reasonable care it is not directly harmful to man. But when it is spread broadcast over the country, what may be its cumulative effects in time? Frankly, we don't know at present. We do not know the ultimate effect that accumulations of these insecticides may have upon the ecology of many of the lower orders of animals which are most affected by them. For example, will soil fertility be reduced if earthworms are killed by accumulations of DDT in large areas as a result of broadcast applications? And if fertility is reduced, will organic cover be so reduced that soil erosion will still further reduce food production? We don't know, but just to raise the question suggests the need for caution in the use of these materials, until our knowledge is more complete and exact.

Furthermore, what effect will broadcasting of these powerful insecticides have upon some useful insects? Some are predators on important parasites of various crops, or domestic animals. Are we doing something to upset the ecological balance? Most of us don't know, and apparently some don't seem to even recognize that this may be a matter of great economic importance.

This isn't a jeremiad. The speaker is confident that DDT, for example, can be used under appropriate conditions with great benefit to man, and with no damage, or at least very minor damage to either man or other animals of economic value to man. He also expects that we will find appropriate uses for other new insecticides, which may possibly be applied to some situations more effectively than DDT. But the reckless and ill-considered broadcast of these insecticides could produce conditions which might result in extreme public disfavor, and possibly restrictive or punitive legislation, which could impede sound mosquito work for many years. No one wants that.

So, let's stick to sound fundamentals. Let's do as much basic control as possible in the prevention of mosquito production. In the long run that is economical and effective. Insecticiding is a continuous, non-reducing expense. With our new insecticides, we do not know, as yet, what the end results, the cumulative effects, may be. Caution and common sense are needed.

Nearly forty years ago Sir Ronald Ross* set forth certain fundamental postulates of malaria control which he called

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*Ross, Ronald. The prevention of malaria. New York, E. P. Dutton & Co., 1910, p. 295.

"GENERAL SANITATION MAXIMS." They are presented in general terms applicable to the prevention of all communicable diseases. These postulates are valid today with little modification despite nearly a half century of progress, indicating the relative permanence of sound basic principles in the midst of changing techniques. The speaker therefore presents for your consideration a dozen basic postulates of sanitary science, which are broadly applicable to the entire field of sanitation, including mosquito control as a phase thereof.

GENERAL SANITATION MAXIMS

1. That sanitation measure is the wisest which causes the public the least inconvenience, and which to the minimum extent runs counter to the customs and beliefs of the community.
2. That sanitation measure is the most practicable which can be carried out by governments without making any demands on the thoughts, efforts, or compliance of the citizens.
3. To the greatest extent possible, sanitation measures should be carried on by the local governments directly responsible to the people concerned; direct operations by the more remote state and particularly federal governments should be at the minimum.
4. That sanitation measure is the most economical which confers, per unit of cost over a period of years, the widest benefits to the public.
5. The cost of sanitation measures must be adjusted not only to the amount of disease or economic loss involved, but also to the economic productivity of the people affected.
6. The unit cost of sanitation measures should be determined over a period of years, say twenty at least, in order to arrive at real costs of various possible measures.
7. In case of doubt, relatively low *cost* measures should be adopted first, in preference to relatively high cost measures; but the true *cost* of each should be determined on a long-term basis.
8. No sanitation measure should be adopted until a careful study has shown both the necessity for it, and the financial ability of the people to pay for it easily.
9. That sanitation measure is the most effective which eliminates or greatly reduces the basic cause of illness or economic loss.
10. Every sanitation measure should be accurately measured as to its results in public benefit (disease prevalence minimized or economic loss reduced) according to its true long-range cost and as to the relation of this cost to the cost of disease or other economic loss sustained.
11. While it takes courage, in a democracy, to tell the public that a sound, economical sanitation program may take several years of planning, organization, and initial work before marked results can appear, nevertheless it is a mark of sanitary statesmanship to adopt a long-range program with ultimate economy, in preference to a short-range program with more immediate apparent results but greater ultimate cost.
12. In a democracy, the public which pays the bill for sanitation measures is entitled to know, and should be regularly, frequently and accurately informed, as to the "why, what, how much, when, where and who" of the work performed for its benefit.

The speaker does not claim that these maxims are original with him. In fact, he would be unable to state definitely the direct sources from which some have been derived, for to a large extent they have developed out of a varied experience in public health work during more than forty years, plus appreciable study of the history of sanitation, plus considerable thought, and discussion with colleagues, as to the reasons for, and the justification of, all forms of public health services by governments. He believes them to be valid, in the past, at present, and in the foreseeable future, though he admits that some persons with a collectivist or socialistic philosophy of government may disagree with them in part.

These general sanitation maxims may be easily translated by anyone into more specific and limited postulates or fundamental principles for mosquito control, by comparatively minor changes in wording. The speaker leaves that for each of you to do, in the best interest of the people who pay you your salaries for the services you render to them.

After a losing football game the coach usually cries "We'll have to go back to fundamentals!" Let's stick to fundamentals in mosquito control and maintain a winning game with the public.

The program this morning is a survey of mosquito control operations throughout the United States, and we have invited representatives from the various areas to present reports of problems and progress. The first speaker will be the Secretary-Treasurer of the American Association, who will present a report from the oldest mosquito control association in the United States, our friend Thomas D. Mulhern from New Jersey.

A REPORT FROM NEW JERSEY, WITH SPECIAL REFERENCE TO THE UTILIZATION OF TEMPORARY vs. PERMANENT CONTROL METHODS

By THOMAS D. MULHERN
New Jersey Agricultural Experiment Station

Introduction

Attending this meeting is to me a rare and satisfying experience, one to which I have been looking forward with great anticipation. I appreciate particularly the incidental opportunity of meeting many of the west coast workers whom I have known before only by the printed records of their varied accomplishments. It is also a pleasure to have the added chance of seeing at first hand some of the problems and the controls established. It was difficult to make the arrangements to come, but well worth while. In this connection, I should like to acknowledge the generous help of the Monmouth and Somerset County Mosquito Extermination Commissions, and the New Jersey Mosquito Extermination Association. These bodies ask that I bring you their sincere greetings, and best wishes for a completely successful meeting. In designating me to speak as its representative, the New Jersey Association also directed that I extend to each of you here its cordial invitation to attend its 36th Annual Meeting at Atlantic City on March 23, 24, 25, 1949. We hope you can come!

We used to think that we had in New Jersey the first organized mosquito work directed against nuisance mosquitoes. But Harold Gray tells me he would argue that point! Then for a long time, we had the largest area in any state under mosquito control, but in the past few years, the tremendous encouraging expansion of your California program has given you the greatest included area, so I guess maybe we haven't any superlatives left except the "meanest and mostest" mosquitoes! Be that as it may, we hope we may here gain more ammunition and more weapons to attack the pest, as well as reporting to you our own progress.

In planning this paper, I talked with the various other workers at the Experiment Station, and in the County Commissions. All would have been happy to be here, but unfortunately only a few of us could come. Dr. Pepper, head of the department, suggested that I bring out the way in which we view the question of "permanent vs. temporary" methods. Many of you are already aware that New Jersey has found it profitable to emphasize the permanent aspects of its program, for reasons which will appear as this paper is presented — but you will also see that in some situations, the principal activities are of a temporary nature, also for good reason. In general, the new developments in temporary control are proving to be an important supplement to the ditching, diking, pumping and filling phases of mosquito elimination.

Let us look for a moment at the organization for mosquito control in New Jersey.

Seventeen of the 21 counties have county mosquito extermination commissions. These commissions are the policy making boards which direct the field work, each having its own chief executive, workmen, and equipment, and its own individual appropriation.

The State Agricultural Experiment Station, located at New Brunswick, New Jersey, near mid-state, has multiple functions: by the legally prescribed examinations of plans, budgets and reports of the County commissions, it is empowered to coordinate the work of all the commissions, but its duties also include the making of mosquito surveys, the execution of a program of research and development, and the conduct of educational activities. All of these phases of its work are performed in collaboration with the several county commissions, in accordance with the mosquito law and as the individual circumstanes seem to warrant. Frequently this means that the laboratory work on an experiment will be done at the Experiment Station, and field testing and proving done by cooperating county mosquito commissions, under actual field conditions.

The New Jersey Mosquito Extermination Association is primarily an educational group, composed of mosquito commissioners and executives, representatives of the Experiment Station, and others. You are all familiar, I suppose, with the "Proceedings" of its annual meetings. Its support comes primarily from the sales of these books to the several mosquito commissions. It is primarily a commissioners' organization, where they gather to hear annually the results of research, and the reports of progress being made in the field of mosquito control. In this respect it differs widely, I think, from your California association, which appears to be mainly a professional workers' association.

In New Jersey, the workers' association is "The Associated Executives of Mosquito Control". This body meets monthly, to discuss in less formal "Round table" fashion the problems of common interest. The importance of this organization may well be lost to a casual visitor because of the informality of the meetings and discussions, but it is rare that any new product, process or equipment finds its way into the control program of the state without first passing the test of discussion by this group. The "Associated Executives" is in fact the workers' educational organization, where the results of research in New Jersey and elsewhere are first passed on to the executives, and where each man retells his experiences for the benefit of the others, reaping in return the benefit of their ideas and knowledge.

The "Associated Executives" requires but little funds to exist, has no formal treasury or obvious means of support, but when any project arises which requires funds, they are raised by "passing the hat" among the members. It has been operating since 1923!

Education

The most permanent thing any of us can do for mosquito control is to educate the people to know what can be done to eliminate mosquitoes, how it can best be done, and how they individually can help. This is a continuous program, and occupies part of the efforts of every one of the previously mentioned groups. All the ordinary propaganda methods are employed. Results are apparent to anyone who has been long connected with the mosquito work. Even 20 years ago many people ridiculed the efforts to control mosquitoes: they believed it could not be done. Now if mosquitoes become numerous, they say "What's the matter with the mosquito commissions!"

Variety of Problems

No two of the 17 counties in New Jersey which are doing mosquito work have identical problems; though there may be considerable similarity, the differences provide a never-ending interest in the work. Perhaps I can sketch in a few words something of the over-all scene:

Originally anopheles mosquitoes were prevalent in most parts of the state, but these have yielded most easily to the general control program, and now are common in relatively few places, where unusually favorable conditions still exist. So the control of malarial mosquitoes is not now a primary problem. The malarial hazard resulting from the war seems to be largely abated, for the number of cases being reported has returned to about the pre-war normal.

A band of salt-marsh, beginning near the north end of the state, along the Hackensack river, extends in an almost unbroken band along the seashore to the southern tip of the state, then along the southern border, and for a short distance up river bordering the Delaware, which separates New Jersey from Pennsylvania, to the west. 300,000 acres of tide marsh are included, the band ranging from a few feet to about five miles in width. The hordes of *A. sollicitans, A. cantator,* and *A. taeniorhynchus* which once came from these meadows are collectively the "Jersey Skeeter" of quip and jest. But with their flight range of 40 miles, and the tremendous numbers which can come from any untreated or neglected marsh, they could again easily make many square miles of New Jersey unusable.

The fresh water swamp mosquito, including several flood water species, is widely distributed, but a great pest mainly along streams or swamps which periodically flood out of their banks. Along one stream in the densely populated north-eastern portion, there are 30,000 acres of low land subject to flood when rainfall is excessive. Here fresh water swamp mosquitoes at times become as great a pest as the salt marsh mosquitoes elsewhere. Similar but smaller breeding sources exist at several places in the state, and these are countless temporary pools and swamps, which hold water continuously during wet periods and thus serve to swell the total of this type of mosquito. However, it is dominant mainly along the flood water areas of North Jersey streams, and in the swamp areas bordering the Delaware River along the western border of the state.

The house mosquito, *Culex pipiens,* finds places in which to breed in all parts of the state, but is commonly most prevalent in the most densely populated and industrialized areas of the north-east, where containers are apt to be present, where industrial wastes may be allowed to accumulate, and in some of the smaller towns where cess-pools are still common. The educational program is directed toward the securing of cooperation of the householders in reducing this problem.

Trap records from many locations, all averaged together, show that nearly ⅓ of the mosquito population awing is from the salt marsh. A similar portion is fresh water swamp and pool mosquitoes (mainly *A. vexans*) and most of the remaining third is *Culex pipiens*. Of the total of about 50 species, all others together represent only about 10% of the total.

Orderly Plan

Disregarding the local variations, and trying to view the progress of the work as a state-wide whole, it is apparent that an orderly procedure has been in effect:

(1) Since the salt marsh problem was so wide-spread and intense, efforts were concentrated on it until a fair measure of success had been obtained.

(2) The house mosquito problem, because of the wide distribution of breeding places, was second only to the salt marsh. Controls were applied in many areas at the same time that the salt marsh program was under way, and the numbers of house mosquitoes is greatly reduced.

(3) The fresh water swamp problem, where favorable breeding conditions exist, may be as great a source of annoyance as any.

(4) The malarial mosquitoes have been attacked vigorously whenever they were found in considerable numbers. But they have never been so numerous or so difficult to eliminate, as the pest species.

Factors Influencing Choice of Methods

The chief factors influencing the choice of methods have been the habits of the mosquitoes, and economic considerations. Perhaps the latter should come first!

The New Jersey work is organized on the basis of counties: hence the protection must be county-wide, even though the population may be unevenly distributed. If the mosquitoes are destroyed at the source, then all the people benefit.

In a county infested by salt-marsh mosquitoes, to attack the mosquito adult would necessitate providing control over the entire upland area. Taking one average county where the salt marsh mosquito is the only mosquito of importance, the area to be treated would be 360,000 acres. To attack the mosquito as a larvae, only the marsh must be treated, in this county a matter of 40,000 acres.

Furthermore, the anti-larval work may be spread over a longer time period than may be taken for an attack against the adult, and less men, materials and equipment need be employed. Economy is essential in the sample county under discussion, for until the past two or three years that unit never had more than $15,000 for a single year. By employing permanent methods, each year adding as much as possible, there was accumulated automatic, continuous operating, drainage facilities which could today be built by hand for not less than an estimated cost of $320,000!

In another similar county, with 50,000 acres of marsh, where no work has been done, a survey was made of the situation, to compare the cost of larval control by spraying, with control by ditching to drain and circulate the tide waters. The comparison showed:

By spraying:

50,000 acres sprayed a minimum of times per season, lowest quoted cost by plane with DDT, 75c per acre, $37,500 each time.

Six times required per season $225,000

By machine ditching:

50,000 acres, 300 feet per acre, 15,000,000 feet.
Cut by machine, 15,000,000 ft.—½c per ft..... $75,000
Work to be done over a 5-year period: per yr. $15,000
Recut every 5th year, 3,000,000 ft. per year
at 1/10c per foot .... per year $ 3,000
Total per year $18,000

On an open salt marsh area, where there is a large amount of routine work to be done, such a comparison can be drawn, but in the more complex upland area, the contrast may not be so striking, but for most of our areas, the principles involved are of the same order.

One great disadvantage of the permanent scheme is that it does not yield immediate relief. Therefore, the three newly-organized county commissions in New Jersey have for the past three years been devoting most of their energies during the summer months to spray, fog and mist work. But in the fall, winter and spring, they have ditching crews at work, getting rid of the swamps and pools which require "repeat" spray treatment—they are gradually reducing their spray requirements, and increasing their proportion of permanent work, as well as improving the degree of control.

Statistics

Seven counties (Sussex, Morris, Passaic, Somerset, Mercer, Camden and Gloucester) have only fresh water control projects, one of these works only in municipalities which will cooperate financially in the program, two are newly organized during the past five years and have so far given most of their attention to spraying, but are now trying to work out means of securing power tools to begin a program of permanent elimination. One has a great many mills and other industrial properties so that it must devote most of its efforts to intensive inspection and elimination of yard violation, two have conventional programs of construction supplemented by inspection and spray progress, and one depends for protection almost entirely upon misting and spraying barrier zones about the breeding marshes and the residential areas. Among this group, each county has conventional power sprayers and there are also two dry fog machines, four venturi or exhaust manifold generators and two mist sprayers or dusters. One of the counties operates a 10-inch hydraulic dredge.

Five counties (Bergen, Hudson, Essex, Union and Middlesex) all in the densely settled north-eastern part of the state have combined salt-marsh and fresh water control areas.

In this section there is the most intensive salt marsh mosquito control program ever undertaken. Most of the marshes are surrounded by dikes and gates to fence out the tides; five permanently installed drainage pumps de-water the most troublesome areas; the rank "foxtail" grass (*Phragmites phragmites*) is regularly crushed down along the ditches, and inspectors go through every week, to spray wherever larvae are present. When full grown (by July 15) this vegetation makes an almost impenetrable thicket. Imagine if you can, a cornfield, with about 40 stalks per square foot, each of which is about as thick as your little finger but about 10 feet high, and you will have some idea of this airless, hot tangle. So dense grows this grass that ordinary air spray treatments are ineffective here. The diked marshes are nearly all shrunken, so that instead of standing at the normal marsh level of four to five feet above low tide, the surface in many sections is only one to three feet above low tide. These marshes, and the streams which drain them, are so polluted with industrial and other wastes that many will not support fish life — hence the commissions must make up for the lack of this natural enemy of the mosquito by artificial means. These commissions have excellent equipment, including in the 5 counties a total of 6 crawler-mounted cranes or shovels, one tractor-operated crane, and 7 crawler tractors. There are 2 fog machines, and an adequate supply of large, small, and portable sprayers, trucks, etc. One commission does a lot of bulkhead and wood tide gate construction, and has a complete set of portable gasoline-powered tools, hammers, saws, drills, etc.

The diked marshes have larger ditches than the small 10" ditch for which New Jersey is known, and the water levels are kept so low that generally one need not wear boots over much of the marsh area. In fact, these areas are so well de-watered, and have been kept from flooding by tide waters so long that when heavy rainfall floods sections, the larvae which appear may be *A. vexans* and *Culex pipiens!* This region remains, however, a potential threat to the metropolitan sections, including such cities as Newark, Jersey City, Elizabeth, Paterson, and Hackensack, for it has been demonsrated (by accident) that the breaking of a dike and the flooding of a marsh at once begin the production of a great brood of salt marsh mosquitoes.

From the Rahway River to the southern tip of the state, the salt marshes are far different — salinity is much higher, the grass is generally a mixture of several low-growing species, and minnows are abundant to attack the larvae if given opportunity to do so. In this group may be included the counties of Monmouth, Ocean, Burlington, Atlantic, and Cape May. Specialized equipment includes 5 salt marsh ditching or ditch-cleaning machines, 2 mole plows, 2 dry fog machines, a mist sprayer, at least 4 venturi fog generators, 2 power boats, 2 scows, and 5 power sprayers. The spray and fog equipment is used in the towns and resort areas, some of which also have spray service furnished by spray or fog contractors. The ditching equipment is of course used only in the marshes. The object of the ditching work is not to drain the marshes dry, but instead to provide circulation of the water in all the low places on the marsh twice daily as tides ebb and flow. So circulating the water exposes the larvae to the predatory fish which inhabit the streams and bays. Here we have an interesting case of the use of engineering means to facilitate biological control, the whole plan being based upon entomological knowledge.

After nearly fifty years of continuous, faithful effort by a corps of efficient workers, New Jersey still has some mosquitoes, and much work remains to be done. But we know that the reduction in mosquitoes which has resulted from the efforts of these men has permitted vast development of the State's resources which could not possibly have taken place had the mosquitoes not been reduced — there are today prosperous summer resorts flourishing in areas where once humans could not live because of the tremendous annoyance, while the scant garb of the summer residents who have made the New Jersey beach area the world's greatest playground gives mute evidence to the present-day lack of need for protection from the sharp bill of the "Jersey Skeeter." And the summer resort business has become one of the state's greatest industries.

Mr. Gray: Thank you very much, Tommy Mulhern. Although our time is limited owing to a late start, I hope that there will be some discussion of these reports. The next report, from the Florida Association, will be presented by Dr. Provost.

Dr. Provost: Before I proceed with the reading of this paper I would like to introduce the Florida delegation here. It includes four men, two of whom are already upon the platform. I am a native son of neither State. However, I have lived a year in California and three or four in Florida, so I think I am an impartial judge, and I can say this, that both of them have plenty of sunshine at the right time of the year.

MOSQUITO CONTROL AND MOSQUITO PROBLEMS IN FLORIDA

By Maurice W. Provost

It was a genuine pleasure for the Florida Anti-Mosquito Association to play host to the National Association last March. Many friends and co-workers visiting us then are now here as guests of the California Mosquito Control Association. It is again a pleasure to meet them here and to exchange views on the mosquito problems of the day. The Florida delegation has come a long ways, but I'm sure I speak for all of us when I say that the value and pleasure of attending these meetings make the journey look small. We are all very, very glad to be here.

I. *Progress in Control Organization*

In the past year, organization for mosquito control in Florida has made some progress. The fact that only two control districts, Manatee County and Anastasia Island, have been added to the previous list often is a little deceiving. We were all very glad to see Manatee and Anastasia join the ranks. But we feel even more elated over the groundwork that has been done towards the setting up of more districts in the near future. We are anxious to see the Aedes coastline of Florida all under control organizations. This strip of coast from Nassau County, above Jacksonville, to Key West and up the Gulf of Mexico coast to Hernando County, above St. Petersburg, is about 800 miles long and includes 20 counties. So far 11 counties are organized for control. Of the 9 left to go, considerable progress toward organization has been made in four. When our goal is reached, *Aedes taeniorhynchus* and *Aedes sollicitans,* the two major pest mosquitoes of Florida, will face hard times indeed.

This past summer the interior cities of peninsular Florida have shown more interest in mosquito control than ever before. Some have made an attempt at control already, and several have been surveyed by the Division of Entomology of the State Board of Health. There is every reason to believe that before many years organizations for combating the inland mosquito swarms will be formed. Their problems will be quite diffetent from those of districts now operating, which are all coastal. But the fast developing and improving techniques in mosquito control will make it possible for them to reduce their annoyance as well.

A few years back CDC personnel attached to the then Bureau of Malaria of the Florida State Board of Health began circulating a news pamphlet covering their activities. This paper was named the "Centerfield," and many of you receive copies. Since then a Division of Entomology has been set up within the State Board of Health, which not only assumes the duties of the Bureau of Malaria but branches out into various fields of arthropod control, including the coordination and advancement of mosquito control in the State. The "Centerfield" has never attempted to serve as the reporting agency for all mosquito control carried on in Florida — it more or less stuck by its old function of reporting goings on within the "family" of the Division of Entomology. It is now felt that Florida needs a news-sheet on mosquito control which will more adequately fill the demands for dispersing mosquito control information among all parties involved in this work in the State. The Florida Anti-Mosquito Association is taking the matter under advisement, and at its forthcoming meeting at Mt. Dora in April the question of its taking over the publication of such a news letter will be considered. Something along the line of your "Mosquito Buzz" is what we have in mind.

II. *The 1948 Mosquito Problems*

From year to year the abundance of mosquitoes in Florida changes, like it does anywhere else. The weather, of course, is the important factor in this respect. The early spring of 1948 found many coastal areas of Florida besieged by high and enduring wind tides. The rainy season was slow in coming and slow in ending. Two hurricanes in extreme southern Florida, one in late September and the other in early October, brought torrential rains to the lower glades and adjacent coasts. Fall temperatures were much above average, right up to Christmas. The season of mosquito annoyance was accordingly prolonged in the fall, and large emergences of salt-marsh mosquitoes and Mansonias were noted clear into December. So between abnormally high wind tides in the spring, heavy rains in the summer, two hurricanes at the equinox, and high temperatures in the fall, our control districts had a long and arduous time in 1948. Inland areas not in control districts were severely plagued with mosquitoes. Record-breaking spring floods in north Florida put out terrific numbers of flood-water *Aedes*. The malaria vector, *Anopheles quadrimaculatus,* was more abundant than it had been for many years. The glades mosquito, *Psorophora confinnis,* had one of its best years on record. The Mansonia pest in central Florida was at least as bad as we have ever seen it. Weather always makes the news, and it certainly does make mosquito news.

All this paints a pretty dismal picture for the 1948 mosquito situation in Florida. It was so in actuality. There probably has never been in the State such an opportunity to contrast areas under control and areas without control. Whereas in the districts, light-trap collections exceeding 100 biting females per trap-night were very rare, it was not at all uncommon to collect way over 1000 per trap-night in uncontrolled areas — whether in Aedes areas, Psorophora areas, Anopheles areas, or Mansonia areas. Some salt-marsh regions outside controlled areas turned up collections of over 2000 females per trap-night quite consistently. One such area reached the dizzy height of 35,000 biting females in a single night's collection from one trap. It's too bad more people from control districts couldn't spend a few days a year in such a place.

III. *Two 1948 Mosquito Phenomena*

As you know, we have two salt-marsh Aedes in Florida, *taeniorhynchus* and *sollicitans. A. taeniorhynchus* has been all along the more abundant and wide-spread of the two. *A. sollicitans* has, in everybody's memory, always been rare in the southern coastal counties while in the northern counties it has been a spring and fall species, giving way almost altogether to *taeniorhynchus* during the summer months. This year, for some strange reason, *sollicitans* practicaly overshadowed *taeniorhynchus,* or at least ran it a close race, on much of the Atlantic coast. The northern counties had about as much of one species as the other — clear through the summer. The southern counties had a virtual abundance of the once rare *sollicitans*. Mr. Stutz here will vouch for their numbers in Dade County. I have been thoroughly covered with biting *sollicitans* on the third southernmost of the Florida Keys. . . . Something has certainly upset the balance of the species in 1948. The strangest thing about it is that to our knoweldge this upsurge in *sollicitans* numbers has occurred only in coastal areas under control. In our extensive survey of the lower Gulf coast, which is almost entirely without control, no such unbalance was noted. Here, then, is a problem for the experts to chew on. I might clarify one point. The increase in *Aedes sollicitans* numbers was not merely relative to *A. taeniorhynchus,* it was an increase in actual numbers.

Another 1948 mosquito phenomenon occurred on the lower Gulf coast. The coastal anopheline here, *Anopheles atropos,* has apparently done here what *Aedes sollicitans* did on the Atlantic coast. Old residents tell us they never before saw the mosquito which they describe as "black, stinging, standing on its head, and biting anywhere any time of day or night." Or else they saw it but rarely. Now they say it's all over the place. In one area we were told that in 1948 it was more of a pest than the common "bandy-legged" mosquito — *Aedes taeniorhynchus* to us. Our light traps substantiated these reports. In one town a light trap brought in hundreds of *atropos* every night, the maximum single night's collection being 1100 females. This fall, this same town, in what was supposed to be outside Florida's malaria belt, had the first demonstrated case of malaria transmission in Florida for several years. A survey showed *Anopheles quadrimaculatus* present, but in numbers far smaller than expected from the amount of transmission. This incident raised several questions, and their answers are still conjectural.

III. *Complexity of the Mosquito Problem*

The motorcade which many of us are looking forward to is a splendid idea. It's really unfortunate that something of the kind wasn't done last year in Florida.

You know, Florida to the eye of a tourist and Florida to the eye of a naturalist are virtually two different states. The tourist sees monotony of landscape, chiefly because he judges scenery by contours only — of which Florida is indeed poor. The naturalist, on the contrary, sees diversity, because to him contours are only one item in a landscape. To a person even only a little versed in the physical and biological sciences, Florida is, as Barbour has so often put it in his books, a Naturalist's Paradise. Few states in the union can hold a candle to Florida in the matter of floristic and faunistic diversity — this in spite of what many misinterpret as monotony. This diversity is found also in the mosquito fauna. The State's list stands at 70 species now. And there is variey even in diversity. One light-trap collection may yield only 200 mosquitoes, but these representing 20 species. Another single collection somewhere else may yield but four species, but one of these to the tune of 85,000 individuals. It is always a little mysterious to set up a light trap in an area that superficially looks absolutely undifferentiated and then in the morning to pick up a jar and find in it 15 to 20 species of mosquito. Dr. Small, the famous botanist, must have felt the same kind of bafflement when he walked into a tropical hummock in the glades that looked at first like any other forest, made a tally of hardwood tree species, and came out with a list of 45 species.

Light traps operated in Florida will average about 20 species and 6 genera in a year of operation. Offshore islands normally have a poorer fauna, except for those in the subtropical region. Inland areas very seldom have less than 20 species in their local fauna. At Belle Glade, in the Everglades, a trap has been in operation semi-weekly for four years and has never been moved. This trap has captured 16 species of mosquito, representing 7 genera. Another trap in Gainesville, between April and October this past year, captured 24 species representing 8 genera. These, of course, are not all species affecting man. A clear majority are, however. In Leesburg this year, 19 human-biting species were collected between April and October. This list excluded species which normally do not annoy people: *Megarhynus, Orthopodomyia, Uranotaenia, Culiseta,* and *Culex* (Melanoconion). These figures are given to show that the variety of mosquitoes in Florida is great not only on a state-wide basis, but on a local basis as well.

All this is by way of explaining that mosquito control in the State of Florida must be essentially a judicious combination of many techniques and operations, so that the director of a district may have to know and utilize a considerable variety of mechanical equipment in a considerable variety of ways, besides deploying his personnel efficiently. If the district is coastal, the main efforts may be directed against salt-marsh mosquitoes. Some he may kill in the water, others he may have to attack on the wing. Downpours on the back country may produce invading hordes of *Psorophora confinnis,* which must be fought on the wing. The cities may have a yellow-fever mosquito problem thrown in. Canals and other fresh waters may produce swarms of Mansonias, calling for space spraying or weed eradication. Certain areas of the district may be foci of the malaria mosquito, calling for other control methods. And so it goes, it's not a fight against a group of minor mosquito pests, or a fight against one terrific species and a group of lesser species, but more often than not it's a war against a *group of major pest species,* each one very much of a nuisance or health hazard in itself, each one with very individual production and dispersal characteristics, and each one calling for special control methods. In interior Florida, the mosquito problems in one area are equally diverse. One city, Leesburg, surveyed in 1948, showed large numbers of *Mansonia perturbans,* from April to early June, when *Mansonia indubitans* took over in even larger numbers; by late July the latter species, still numerous, was surpassed by hordes of *Psorophora confinnis;* in September and October a final combination of the latter two species with *Anopheles quadrimaculatus* plagued the citizens. These were the major pest species; fiften other human-biting species of mosquito did their best to magnify the situation. It is easy to understand why the people are calling for mosquito control. And it is easy to understand that a control program here, to be efficient and effective, must be a well-integrated combination of techniques.

It is this compelxity in the mosquito problems of Florida which makes it so urgent for all of us in the battle against what may be called the State's No. 1 pest enemy, to exchange whatever information we have individually, so that each may learn to the benefit of all. The Florida Anti-Mosquito Association is determined to fill this need with a news letter or some such medium of idea exchange. The State Board of Health will continue its research into the production and dispersal characteristics of our important mosquito species and its search for better evaluation techniques. The districts and other organized groups will continue their ever-improving camaigns for health and relief from obnoxious pests. And in a few years — we hope — more of Florida will be memorable to its residents and tourists for sunshine and less for mosquitoes.

Mr. Gray: Are there any comments?

Mr. Mulhern: Superlatives are piling up in this meeting one after another, and now we have superlatives in mosquito trap catches in Florida. In fifteen years of trapping in New Jersey we were never able to get over 10,000 mosquitoes in a single night, but I don't want to give the plum to Florida, because I happen to know that somebody in Delaware once caught 176,000 mosquitoes in one night. As to the relative prevalence of *taeniorhynchus* and *sollicitans,* we have had in New Jersey the same thing in reverse on several occasions, and we have never yet been able to account for it. *Sollicitans* is of course our common mosquito, but occasionally we will have a particular marsh or section of marsh which will turn off a whopping big brood of *taeniorhynchus.* We do not know why this difference — it will happen one year and then the next year, with similar weather and tide conditions, we don't get anything like that. We hope Dr. Provost will be able to work it out from his end. Maybe it will give us some help for working it out from our end.

Prof. Herms: I didn't hear Dr. Provost mention *albimanus.*

Dr. Provost: Well, as you know, *albimanus* on the Florida Keys has presented somewhat of a problem. Way back in 1908 or 1905 — I believe it is 1908 — some of them were found on Key West and within a few days they were apparently exterminated.

During the war a few specimens were picked up in Boca Raton and Palm Beach on the lower Atlantic Coast.

In 1945 Dr. Richards of the University, Mr. Seabrook of Palm Beach, and myself were collecting in the Keys and we picked a fourth instar larva. We immediately began a survey and sent a man there consistently working with the problem, and he made as thorough a survey as can possibly be made on a small area. The way *albimanus* has behaved in the Keys is very difficult to interpret. Maybe it will pop up here one year and then over there the next year. The way it behaves is so erratic that we are led to the conclusion that it is probably present all the time, but in relatively small numbers. At the perimeter of its range it behaves very, very erratically. We are going to collect all the data we have on the problem and decide what to do about it, whether to proceed with eradication, or to continue studies of its ecology.

Mr. Gray: We will now have a report from the Virginia Association. Perry Ruth is unable to be with us, and he has given his report to Mr. Stallman of New Jersey to present.

Mr. Stallman: I would like to assure you all that the selection of a New Jersey man to read the Virginia report is entirely without any significance.

MOSQUITO CONTROL IN VIRGINIA

By PERRY W. RUTH, *President,* and
ROLAND E. DORER, *Secretary*
Virginia Mosquito Control Association

The season just past has been one of the most successful seasons yet experienced in Virginia mosquito control. This is a fact substantiated by trap collections and by the general public's opinion of a job well done. Because there are fewer mosquitoes in the control areas was not an act of God. The season was warmer and wetter than usual. The results obtained were due to the effective control measures practiced by Federal, State, and local agencies cooperating in complete harmony.

Virginia is shaped like a triangle, one leg of which extends five hundred miles west from the sea along the North Carolina line, another leg running in a northeasterly direction for about three hundred miles, and the third leg bounded mostly by the Chesapeake Bay, its tributaries, and the Atlantic Ocean for about two hundred and fifty miles. The easterly and southeasterly section of the state is a low coastal plain. The topography of the middle section of the state is hilly, and the west and southwest are mountainous, containing the fertile and prosperous Shenandoah Valley. It is in the eastern section of the state where the mosquito problem is most acute. Here can be found large salt marshes and great fresh water swamps. The topography is flat and the water table is close to the ground. The railfall average is 42-plus inches per year. It is in this section, generally, that there is too much water, and drainage is to agriculture here what soil erosion or irrigation is to agriculture in other sections of the country.

Malaria used to be the number one health problem in Virginia; but for the past twenty-five years the incidence of the disease has been falling, until now locally transmitted malaria is rare.

The first mosquito control work done in Virginia was directed against the malaria mosquito. Because this disease is a rural disease, most of the work was done in the towns and villages. However, larger communities and resorts have been concerned with pestiferous mosquitoes for many years. It is not uncommon to see in the "Forty Years Ago Column" of the local newspaper an item where a committee had been formed to do something about the terrible scourge of mosquitoes visiting the city at that time.

In 1930, the Norfolk Association of Commerce was successful in having a survey made of the salt-marsh mosquito problem in the Hampton Roads area of the state by the U.S. Public Health Service. It can be recalled that there was a depression in the 1930's; and in 1933, the CWA was born, primarily designed to give work to those who needed it. One of the first projects started in Virginia was for malaria control and salt-marsh mosquito control as outlined in the Public Health Service survey made several years before. Almost overnight three thousand men were employed in this program, but hardly before a start had been made the program ended. Then followed the other relief agencies including the ERA and the WPA, all having a part in accomplishing the initial work but not always fitting the most economical plan. For example, not always was there a supply of men on relief available where work was most needed.

With the gathering of war clouds in 1940, the U.S. Public Health Service realized that the southern states would be used as a war training ground for large numbers of men and that this importation could be very disastrous from a malaria standpoint as it had been in previous wars. Based on this sound reasoning, the Malaria Control In War Areas program was developed. The plan, generally, was that the armed services would conduct malaria control within their own boundaries and the U.S. Public Health Service and the State Health Department would conduct malaria control activities in the area extending one mile surrounding such war establishments. Malaria control activities were carried on around forty-eight major war establishments in Virginia. Because a great many of these were so close, the mile zones overlapped, making the control areas quite large, in some instances being as large as a hundred square miles. In controlling malaria mosquitoes in these control areas, a great many of the pestiferous mosquitoes were also controlled. Of course, with the end of the war came the end of malaria control in war areas.

During the first world war, a similar expansion of war activity had been developed in Virginia, and a similar attack against the mosquito had been made as a war measure. Unfortunately, the end of World War I ended control measures. No local efforts were made to keep up the work, and soon conditions became as bad as and even worse than, those that existed before control was attempted. Having this experience as a background, it was determined that this should not happen again, and from the beginning of the Malaria Control in War Areas program the local governing authorities were consulted and included in the plans with the idea that they would be familiar and ready to take over control when the end of the Federal program came.

The General Assembly in 1940 passed a law providing for the creation of mosquito control districts in the southeastern section of the state. This law was modeled after similar laws in other states with the aded feature that the State Health Department was empowered to contribute twenty-five per cent of the funds collected locally.

The Virginia Beach - Princess Anne County Mosquito Control District was created in 1940, and there would have been more created at that time except for the uncertain conditions due to the ensuing war. With the end of World War II, a special effort was put forth to create mosquito control districts in the areas where Malaria Control in War Areas Program had been most active. To date, ten additional districts have been created and approximately $200,000 of local money is being expended for mosquito control activities. In addition, many thousands of dollars are being expended by the various Federal agencies, such as Army, Navy, Public Housing Authority.

Norfolk City was one of the first regions to appreciate the value of mosquito control. By as early as 1938, the City had taken over the program and made it a function of the Department of Public Welfare. The excellent job accomplished in Norfolk has served as an example of what can be done to the rest of the state.

Through the years, a great deal of effort has been put forth to educate the general public on mosquito control matters. Moving pictures, radio talks, talks before practically every civic club of any description in the entire area (some on an annual basis) have been made. Many contacts have been made to enlist influential citizens of the state in the fight.

In February of 1947 the Virginia Mosquito Control Association was created, primarily designed to promote better public relations. A very successful first annual meeting of the Association was held in Norfolk on January 16, 1948.

By the time this paper is read the second annual convention of the Vrginia Mosquito Control Association will have been held at the Chamberlain Hotel, Old Point Comfort, Virginia, on January 28th.

At this meeting the following speakers have accepted invitations to participate in the meeting: William M. Tuck, Governor of the Commonwealth of Virginia: Alvin Massenburg, Speaker of the House of Representatives. Rear Admiral Ralph O. Davis, Commandant of the Fifth Naval District; Rear Admiral J. C. Adams, Medical Director of the Fifth Naval District; Col. J. T. Swann, U.S. Army, Mrs. Jesse A. White, President of the Federation of Garden Clubs of Norfolk and Vicinity; and Floyd E. Kellam, of the 28th Judicial Court of Virginia. Several other dignitaries will be contacted to round out the program.

Mosquito control in Virginia has been built on a solid foundation. The progress thus far is sound and will not go backward. In the future lies the organizing of more districts in those places where mosquito control is economicaly sound. With the continuing cooperation of the Federal, State, and local Governments, the many civic organizations, and prominent citizens, this work must expand.

In the words of Lieutenant-Governor Lewis Preston Collins, spoken at the 1948 meeting of the Virginia Mosquito Control Association, we should like to conclude: "It is unfortunate that human beings cannot work jointly on an international scale for peace as effectively as they do against insect enemies."

Mr. Gray: Our nearest group of friends and co-workers, to us at least, is the Utah group, and for many years we have had the pleasure of having Don Rees of the University of Utah and the Salt Lake City Mosquito Abatement District.

Dr. Rees: On behalf of all our Utah mosquito control workers who are unable to attend these meetings, I have been asked to extend greetings and best wishes, and for those of us who are here, our appreciation for the fine California hospitality that we have received.

REPORT FROM THE UTAH MOSQUITO ABATEMENT ASSOCIATION

By Don M. Rees

President, Salt Lake City (Utah) Mosquito Abatement Dist.

The Utah Mosquito Abatement Association was organized on March 20, 1948. The Constitution and By-Laws of this organization, patterned after the New Jersey and California Associations, have been approved by the Executive Committee and will be presented for adoption at the next annual meeting of the Utah Association to be held in Salt Lake City, March 18th and 19th.

The membership of the Utah Mosquito Abatement Association consists of the four organized districts in the state and Salt Lake County. According to the Constitution of the Utah Association it is possible for any county, city or town government to beome members of the Utah Association, although they may not be organized as abatement districts. This provision was made to increase the membership and include within the association all local mosquito abatement agencies in the state.

Organized mosquito abatement work began in Utah in 1922 when Dr. T. B. Beatty, then state Health Commissioner, called upon the United States Public Health Service for assistance to combat the mosquito nuisance in the state. The Public Health Service sent J. A. LePrince to assist with the problem. Major LePrince made a preliminary survey of the mosquito situation and with Dr. Beatty held a number of public meetings to discuss the problem. As a result a mosquito abatement law was drafted with the able assistance of Major LePrince and passed by the State Legislature in 1923, becoming effective on May 8th of that year. This law has been cited by Herms and Gray and others, as one of the best and simplest state laws on the subject. In spite of this fact, or perhaps we had better say, because of this fact, H.B.136 is now under consideration by the Utah State Legislature. This bill is an attempt to amend the law and place all taxing powers for mosquito abatement purposes, in the hands of the County Commissioners, rather than in a non-political, independent board of trustees as the law now provides. This bill was instigated by a few County Commissioners who are reported as being more interested in controlling the funds than in abating mosquitoes.

The Salt Lake City Mosquito Abatement District was organized in 1924 and began field operations in 1925. This district is officially confined to the legal limits of Salt Lake City, but of necessity much of the control work is conducted outside of the city limits. The Salt Lake City District continued to function for 20 years as the only organized district in the state. However, during this period numerous mosquito control projects were conducted in various parts of the state under Federal Government, E.R.A., C.W.A., and W.P.A. funds. As a result of these federal mosquito control projects, the obvious success of the Salt Lake City mosquito abatement work, and finally the return of mosquito indoctrinated military personnel from World War II, the moquito abatement program in Utah has been stimulated to more rapid development within the last few years.

In 1945 the Box Elder Fly and Mosquito Abatement District was organized. This district includes one of the largest counties in the state, covering some 5,594 sq. miles. Fortunately, from the standpoint of mosquito control, most of this vast area is semi desert country with no significant mosquito control problems and few human inhabitants. However, the Box Elder District is confronted with a tremendous problem of mosquito abatement in the Bear River marshes, and other fresh water marshes, along the shores of the Great Salt Lake.

This district is also engaged in an active fly campaign, in which buildings and fly breeding material are sprayed with D.D.T. This service is conducted on private property only at the request and partial expense of the owner. This part of the program has been very successful and has been an important factor in selling the idea to the public of supporting a mosquito and fly abatement district. However, requests from private property owners for the treatment of their property for fly control have become so great that it is difficult to provide this service and at the same time develop necessary mosquito abatement work. The tax levy of the Box Elder District was raised this year from .25 to .75 of a mill on the assessed valuation of the County in order to provide funds for both mosquito and fly abatement work.

The Magna Mosquito Control District was organized in 1946. This district is located in the west part of Salt Lake County, adjacent to the Salt Lake City District. The Magna district operates on a one mill levy and a $10,000 annual contribution from the Utah Copper and American Smelting and Refining Companies. To date the Magna District has been concentrating on, and recently completed an extensive drainage system. Most of the drainage work was constructed by the use of ditching dynamite. During last December some of the blasts were of such magnitude they caused distinct earth tremors which were reported by inhabitants in the west part of Salt Lake City some eight miles from their source. These so-called earth tremors received front page publicity for several days in Salt Lake newspapers until it was discovered that it was only Magna shooting at the lowly mosquito at the rate of a ton or more of dynamite per shot. This is one way to publicize mosquito abatement work although we do not recommend the practice as standard procedure. It is too startling for public nerves.

The Weber County Mosquito Abatement District was organized in 1947. This district includes a large county surrounding the city of Ogden. Organized abatement work was started last year with very satisfactory results. The tax levy for 1949 was set at .3 of a mill.

The Salt Lake City Mosquito Abatement District has previously reported on its progress at California and New Jersey Association meetings. This district has never exceeded .3 of a mill tax levy, which now provides about $50,000 annually. In addition the district has succeeded in forming a cooperative agreement between the district, Salt Lake City and Salt Lake County; each to contribute $10,000 a year to a fund to be used for maintenance of the installed drainage system. The burden of this maintance work in the past has been assumed by the mosquito abatement district.

The total area now included in mosquito abatement districts in Utah covers some 6,251 square miles. A fifth district comprising the remainder of Salt Lake County, not included in existing districts, has practically completed organization. This new distrit will cover approximately 130 square miles. Two other counties are also considering the organization of abatement districts. It is highly improbable that Utah will ever have state-wide coverage by mosquito abatement districts as mosquito control problems are more or less localized due to the arid conditions that extend over the greater part of the state. Another factor that limits the state-wide expansion of this work is the fact that the population of the state, less than three-quarters of a million inhabitants, are all confined to available permanent water supplies which are also the principal areas where mosquitoes are produced.

The expansion and progress that has been made in mosquito abatement work in Utah during the past three years has been very satisfactory and gratifying to those of us who have been interested in this work for many years. We realize and here wish to publicly recognize that much of our success in Utah has been made possible through the advice and encouragement we have received from the U.S. Public Health Service and the New Jersey and California Associations. Representatives from Utah have been attending New Jersey and California Association meetings since the early beginning of our abatement program and we are convinced it has produced far more profitable returns than any similar amount of money expended in any other phase of our abatement program. We realized in starting this work that we were isolated by distance from other agencies of its kind. Our nearest neighbors engaged in this kind of work were, and still are, some 750 miles to the west and 1,200 miles to the east. We also realized that with our limited funds we could not afford to conduct extensive experiments, nor carelessly expend the small amount of money available for mosquito abatement work. Therefore, we have borrowed freely from the experience and practice of others and have tried to adapt them to our own particular problems. The results have been extremely satisfactory.

I mention these facts at these meetings of the American Mosquito Control Association as I am convinced this national organization can, and will play an important role in assisting mosquito control work throughout the nation, especially in isolated areas where such work is necessary but where it would be virtually impossible without the guiding influence of a strong parent organization. Utah is sold on the principles of mosquito control and we hope as members of this national organization to be able to obtain continued assistance and guidance and at the same time help in passing on this public service of mosquito abatement to others who do not at present enjoy this comfort of modern health insurance.

Mr. Gray: Is there any discussion or questions anyone of you would like to ask Dr. Rees? Apparently he covered it so thoroughly there is little left to the imagination. I won't say anything about his dynamiting, because I was kidding Tommy Mulhern about shooting a rock through a house a while back. At this moment I would like to call on Norman Ehmann of the Los Angeles City Health Department to make an announcement in regard to the caravan.

Mr. Ehmann: It is indeed to be the privilege and honor of the people of Los Angeles to be able to extend their hospitality to the motorcade that is traveling south. You will arrive in Los Angeles in the afternoon of the 14th, that is, Valentine's Day. You will stay at the Mayfair Hotel on 7th Street. You will arrive in time to eat and prepare for a trip to the Columbia Broadcasting Studio where you will see a major broadcast. After the broadcast there will be a trip around the studio. You will find yourself then in the middle of Hollywood and the rest of the evening will be free for whatever each individual wishes to do. On the following morning at 9:00 o'clock you will be picked up at the Hotel by Tanner buses and taken on a tour around Los Angeles, San Fernando Valley, Hollywood and there will be a banquet that evening at the Mayfair Hotel. Then we will adjourn to spend the evening at one of the night spots called *The Drunkard. The Drunkard* is not as the name sounds. It is an old time melodrama. You sit very close together at tables and drink beer and listen to the melodrama for the evening and everyone that has been there has said that it is one of the nicest entertainments in Los Angeles. Now there are certain presumptions I will have to make for this trip. First of all, I know that it will cost the people $19.12 for their stay in Los Angeles and that will include one breakfast and one dinner. There has already been deposited $10 on that so that will leave a balance of $9.12. Now of that $10 that has been deposited I must assume that everyone that has made that deposit wants to take in the CBS broadcast, the banquet, the Tanner tour and the trip to *The Drunkard.* In order that I can make the reservations, we must know the exact number of people by this coming Friday. Anyone who doesn't wish to include any one of these events in their agenda, should notify me before this Wednesday evening. If there is anyone who hasn't made the deposit, because they are going to stay with relatives in the Los Angeles area should also notify me so that I can make reservations for the different events.

Mr. Gray: Thank you very much, Mr. Ehmann. I am sure we are going to have a good time in Los Angeles. They have really spread themselves to give us some entertainment to wind this meeting up in a blaze of glory.

Mr. Wilson: I'm one of the Board of Trustees of the Orange County Mosquito Abatement District. At the last meeting of the Orange County Board we passed a resolution that an invitation be extended to the group that is going on this motorcade to take a trip to Orange County. Orange County is located some thirty to fifty miles southeast of Los Angeles. According to this schedule it will be the 16th, that is Wednesday I believe. Those that would like to take the trip to Orange County will please see Mr. Ehmann or Mr. C. E. Robinson and make their reservations. The Orange County District will furnish transporta tion and we will furnish you a free dinner on that day. A trip through the Orange Belt is really a sight to see, and we especially would like to have the Florida crowd come down. Please make reservations with the motorcade committee so we will know how many cars to provide for this trip.

Mr. Gray: Thank you very much, Mr. Wilson. Norman Ehmann, stand up, please. You are one we contact for this trip. Chester Robinson, stand up. Where is Jack Kimball? There is another one you can contact in regard to the trip. I know they will give you a good time. You will see some very interesting problems indeed.

Ordinarily we would take a recess at this time. In the interest of the conservation of time I am going to cancel the recess. I wish we had time for the recess because we have some tremendously interesting exhibits around the hall here. I am anxious myself to take a look at some of them. I think we can learn a good deal from these exhibits. The commercial firms have been very fine in cooperating with us, and they are helping substantially in financing this conference.

Now we come to the man who has the best nose for mosquito publicity of any man in the Nation. I think he has done better on publicizing mosquito control than anyone of us, J. Lyell Clarke of the Saturday Evening Post and the Desplaines Valley District in Illinois near Chicago. Lyell, will you tell us what your District is doing?

Mr. Clarke: Mr. Chairman, as a present from the State of Illinois to the mosquito workers of California, I have here three hundred long-lived mosquitoes. I had no trouble at all in collecting these mosquitoes in the Chicago area, as we had a very mild winter — sunshiny. We just went around and picked them up everywhere. My idea in bringing these to you is that I thought perhaps this cold weather may have killed all your mosquitoes, so I bring these to you as a brood colony, so your big district won't go out of business. Incidentally, these are *Culex pipiens.*

Mr. Gray: These are our friends, the source of our income. Thank you, Lyell.

REPORT FROM ILLINOIS — DDT FOGGING OF TWENTY-SEVEN VILLAGES

Illinois State-Wide Mosquito Control Activities

By J. Lyell Clarke

DesPlaines Valley Mosquito Abatement District, Lyons, Ill.

Since the passage of the mosquito abatement act in Illinois, in 1927, ten mosquito abatement districts have been organized. Five of these districts were organized within several years after passage of the act, and five were the result of increased interest in health measures during World War II. The total population served by the ten districts in Illinois is 493,000, persons. The total annual tax levied is $200,500 resulting in a cost of 41 cents per person per year.

In addition to the intensive control work cerried on in the ten districts, the State of Illinois, through its Chief Sanitary Engineer, Clarence W. Klassen, maintains a very active educational campaign. The staff of two mobile units demonstrates methods of fly and mosquito control, new types of sprayers, and approved insecticides. Demonstrations are made to interested groups throughout the State with the thought that these groups will organize mosquito abatement districts or hire the work done.

ORGANIZED MOSQUITO ABATEMENT DISTRICTS IN ILLINOIS

	Area in sq. mi.	Population	Annual Appropriation
1. Carbondale Mosquito Abatement District, Carbondale, Illinois	4	9,000	$ 3,000
2. DesPlaines Valley Mosquito Abatement District, Lyons, Illinois	76	200,000	70,000
3. North Shore Mosquito Abatement District	75	130,000	68,000
4. Lake Forest Mosquito Abatement District, Lake Forest, Illinois	14	7,000	8,000
5. Highland Park Mosquito Abatement District, Highland Park, Illinois	13	15,000	10,000
6. Cairo Mosquito Abatement District, Cairo, Illinois	8	20,000	5,000
7. Herrin Mosquito Abatement District, Herrin, Illinois	3	10,000	4,500
8. East St. Louis Mosquito Abatement District, East St. Louis, Illinois	25	76,000	20,000
9. Dupo Mosquito Abatement District, Dupo, Illinois	8	3,000	1,000
10. Freeport Mosquito Abatement District, Freeport, Illinois	91	23,000	11,000
Totals	317	493,000	$200,500

In discussing the thermal fog generator, be it a Tifa, Bes-Kill, or the California Plumber's nightmare, do you, who have used these flamboyant thermal aerosols, believe that they give a 100% kill as is indicated by public acclaim; or do they merely provide a cushion of contentment in the minds of the public and the abatement officials?

Factually we can show only a 70% kill of caged mosquitoes in an area where the public claim 100% satisfaction. Do the remaining 30% become alarmed and fly out of the area?

In 1947 all tests with the Tifa fog generator were made in a large open field with the grass two feet high and scattered high willow and cottonwood occupying one-quarter of the area. In each of these 36 day and night tests 15 gallons of a 5% DDT-oil solution were released from a 500-foot front, averaging over the test area .3 pounds of DDT per acre. The three cardinal points learned from these open-field tests are as follows:

1. That the average kill over a distance of 1,500 feet downwind was 90% for the night tests and 66% for the day tests.
2. That wind velocity of over eight miles per hour is not conducive to good results, for a release of 3 gallons of 5% DDT-oil per 100-foot front.
3. That an average of 400 DDT-oil droplets are required to obtain a 95% kill.

In 1948 all tests with the Tifa fog generator were made in built-up residential areas, heavily wooded with high shade trees and low shrubbery. Twenty-seven villages were fogged twice during the season. The fog machine traveled along each street at an average speed of 6 mph, emitting as a fog 1½ pints of 8% DDT-oil per 100-foot front, resulting in an application of .1 pound DDT per acre.

A brief summary of results obtained is as follows: An average of 70% of the caged mosquitoes were killed; 72% of the caged flies were killed. Forty-six per cent of the mosquito larvae in cups were killed; and an average of 191 droplets of DDT-oil was recovered on the magnesium oxide slides. All test materials were placed in the middle of city blocks.

Theoretically, in the wooded village tests of 1948, where .1 pound per acre was applied, the slides should have registered 400 drops, and a 98% kill should have been obtained. Actually the results at 150 feet in wooded villages were as poor as last year's at 1,500 feet in open field tests. Therefore it is suggested that .1 pounds may be used for lightly wooded village fogging with light winds, and .3 pounds per acre for a heavily wooded village fogging with strong winds.

A point worthy of mention is the surprisingly low percentage of recovery obtained on the glass slides placed horizontally on the ground. For instance, the amount applied in villages was .1 pounds DDT per acre; and the amount recovered was .003 pounds per acre, or about .3% of the amount applied. The remaining 99.7% apparently at first blush was lost, but actually it was not lost. Deposition of DDT-oil particles was accounted for by lateral and vertical contact with leaf surfaces. Much experimental work is needed to determine the true pattern of deposition; however, the following pattern based upon field observation in 1947 and 1948 is as least suggestive:

(1) Screening out of DDT-oil droplets by lateral passage or vertical fall upon leaf surfaces of trees, shrubs, flowers may multiply the horizontal plane surface more than 100-fold in densely wooded areas. An estimate of 100 times the land area, or horizontal surface, for a heavily timbered area may be visualized as a conservative estimate in the light of the findings of Stanley, who reported that by actual measurement the leaf area of full-grown tobacco was found to be ten times that of the surface area on which it was planted. This screening out is thought to be the principal factor in requirement of seemingly high output demand of DDT in villages to obtain a 90% kill of adult mosquitoes and flies.

(2) Large particles falling close to the generator like rain. A heavy deposit is suggested by the large number of particles recovered at 300 feet in 1947.

(3) The fine particles are scattered over an area of several miles by strong winds.

(4) Uprising air currents carry ten microns diameter particles aloft.

Comparative Effectiveness of DDT, Chlordane, and Pyrenone

Now we shall discuss an entirely different experiment, one having to do with the comparative effectiveness of DDT, chlordane, and pyrenone used outdoors as a space spray in the form of a thermal aerosol for the control of flies and mosquitoes.

Much loose talk has been indulged in concerning the immunity of flies to DDT. Skepticism came about through the valuable observations made at the Orlando Laboratories, where it was shown that 10% of the regular run of house flies survived a mild concentration for a short-time exposure (a 1% DDT aerosol for 2 minutes), giving the public the impression that DDT was not effective under normal field practice, where an aerosol mist of DDT-oil aerosol of 5% to 10% is held in contact with mosquitoes in flight for a period of 15 to 30 minutes. It is unfortunate that the exception to the rule was publicized unnecessarily.

Arguments as to the ineffectiveness of DDT as a fly spray were so rife during the latter part of the season that the DesPlaines Valley Mosquito Abatement District was prompted to determine by experimentation the relative merits of the three most highly advertized space sprays. The insecticides chosen were DDT, chlordane, and pyrenone. These three materials were tested during the same night over built-up suburban villages in order that the same conditions would prevail as to wind direction, humidity, surface inversion, and temperature. In the test of these three different materials the amount of each material was determined on a cost basis of an equal amount of DDT (resulting in 8% DDT, 2% chlordane, and 2% pyrenone). Twenty gallons of No. 3 furnace oil was used as a solvent for each insecticide.

In the test to determine the comparative toxicity of the three insecticides 16 cages of flies, 16 cages of mosquitoes, 16 cups of mosquito larvae, and 16 glass slides were placed in one city block. Percentage of kill was determined 24 hours after fogging.

Per Cent of Kill Within One Block

Test Materials	*DDT*	*Pyrenone*	*Chlordane*
Flies in Cages	68	37	23
Larvae in Cups	5	21	14
Mosquitoes in Cages	31	14	7

A wind velocity of seven miles per hour lowered the kill far below the average for the season; the effect of the high wind was also reflected in the number of drops of oil recorded on the slides, an average of 65 drops, which is far below the determined 400 drops needed to give a 95% kill.

In conclusion, reference is made to Figure 7, which shows that 400 droplets per square inch of DDT-oil aerosol of 20 microns diameter are required to obtain a 95% kill of caged mosquitoes under favorable wind conditions, less than eight miles per hour, with DDT solutions of 5% and 8% in oil.

These studies suggest that perhaps a 2% DDT oil solution applied as an aerosol at the rate of one quart per 100-foot front in wooded villages may be as effective as an equal amount of 20% DDT-oil solution. This quantity, one quart, would produce 400 drops per square inch in either instance, yet a 2% solution would give a rate of application of .05 pounds per acre, while a 20% would give a rate of .5 pounds per acre. Hence is the rate per acre of a highly concentrated solution of greater economic consequence than an equal number of drops of a lesser concentration?

If it can be shown that a 20% DDT-oil solution is as effective as a 2% DDT-oil solution, the rate of application remaining the same, the running time to fog a square mile would be reduced from nine hours to one hour.

We ask this question in this manner not merely to induce discussion, but to provoke it — if we must!

Mr. Gray: The next paper was to be a report from the New York area by Dr. Glasgow and Dr. Collins, but unfortunately neither of them are able to be here. At their request, Mr. A. L. Fornhoff of the Bell Aircraft Corporation will show some movies which have been prepared to illustrate some work done under Dr. Glasgow's supervision.

Mr. Fornhoff: In the absence of Dr. Glasgow I will present a 16-mm film in color to show the work Dr. Glasgow has done in the Adirondack section of New York State, on black fly control. I thought it would be particularly interesting to you in view of the fact that after we had run these tests and done the job, a complete absence of mosquitoes was very definitely noticed. The work has been so well received now that it is a service which has been contracted for by the Adirondack Hotel Association which is comprised of 117 hotels in that area.

In the Adirondacks they only enjoy about six weeks of business in those hotels per year. Since this service has been done the hotel business has multiplied at least 150 percent and has lengthened the season.

These tests were conducted by Dr. Glasgow and Dr. Collins in the New York Science Service, and the Combustion Engineering Department of the Todd Shipyards. I believe they have a representative here, if you care to talk to him afterwards. While Dr. Glasgow had spent probably twenty years or more on the black fly in that area he felt that in the last year he had achieved what he had been looking for in a life time. It was a combination of DDT, a method of dispersing the DDT, and a method of getting the DDT where he wanted it.

This picture will show you the work being done over four or five thousand acres. The machine that you will see will be carrying approximately forty gallons of fluid, flying at a speed of about fifteen miles per hour. We have found we can lay a swath of approximately three hundred feet and in a half hour's time we can cover a swath seven and a half miles long.

What does the public think about it? Absolutely no flies could be found; the housewives continued hanging up their wash, the children playing in the streets. Everything went on as normal. Bird life, fish life, was not affected, as was proved afterwards by those who were testing.

(Mr. Fornhoff then projected the film.)

Mr. Gray: Thank you very much, Mr. Fornhoff. We have run appreciably overtime and I will postpone certain papers until this afternoon. However. we have several announcements to be made. I will ask Dick Peters if he will make these announcements.

Mr. Peters: My anouncements all pertain to the thing that everyone is interested in — Food! Luncheon for today has not been slated for the group as a whole. The Garden Room of the Claremont is open to anyone who wishes to dine there. Special arrangements have been made there to increase the service of waitresses.

The American Society of Professional Biologists is having a section meeting in the Emerald Room. Anyone who is interested in this meeting who has not purchased tickets may do so at $1.65 per luncheon. You may contact Mrs. Thurman at the Registration Desk outside the door. The luncheon is going to begin promptly at 12:00 o'clock.

The Dinner Dance is scheduled at 8:00 o'clock on your program, and on your tickets you will notice it says 7:00 o'clock. Please heed the tickets. The Dinner Dance is set for 7:00 o'clock. We want to get started as close to 7:00 o'clock as possible, because the orchestra arrives at 9:00 o'clock. We have a talk by Mr. Knowland which is going to be given between the eating and the dance, so it will be a squeeze to get everything in.

Mr. Gray: Thank you, Dick. Please make note of that change and particularly as to the Dinner Dance this evening at 7:00 o'clock instead of 8:00 o'clock. We will now adjourn to meet at 1:15 p.m., and please let us get started on time.

NOON RECESS

The session reconvened at 1:15 p.m.

Mr Gray: We have two symposia scheduled for this afternoon, with one paper sandwiched in between. The first symposium will be on the subject of ground pretreatment for the control, primarily, of *Aedes* species. This symposium will be conducted by B. V. Travis of the Bureau of Entomology and Plant Quarantine, assisted by Mr. A. W. Lindquist and Mr. Basil Markos. Dr. Travis will also summarize some of the Canadian pretreatment work which was to have been presented by Dr. Twinn, but who is unable to be present. I hope that there will be time for discussion of the points brought out in this discussion. Dr. Travis, will you please take over.

Dr. Travis: The program designates this is a symposium on ground pretreatment. Some people have preferred to call this pre-flood treatment, or pre-hatch treatment, and other names too. We prefer to think of it as a pre-hatch treatment, especially when we start to apply chemicals to snow in the arctic regions. You can't call that a pre-flood treatment. It is a pre-hatch treatment. This method is only made possible by the new chemicals which are persistent and can be applied several weeks or months in advance of the mosquito hatching period.

I want to make it clear that we consider this method just another method for mosquito control. We call it a useful adjunct to mother nature, but we still think that there is a place for permanent control measures. There may come a time when the continuous application of chemicals for the control of bugs won't work for you.

This is one of the topics in entomology where there is not much in the literature. There are very few references. Most of the work has been carried on in Arkansas, Florida, Washington, and Oregon, and some in New Jersey, by various workers. During the past two years there has been considerable work done also in the Arctic. Today we will have a report on the use of this method in California.

I will first summarize for you the work done by Dr. Twinn of Canada and his co-workers, with Mr. McDuffie of our Bureau, and representatives from the Surgeon General's office.

In all of the applications at Churchill, the work was done on snow. The first tests were performed in 1947 on a large series of hand-treated plots, and this past year some more plots were treated plus enlarged airplane plots.

The major insecticides have been tested by hand treatment. Most of the materials were applied as oil solutions and some applied as dusts. DDT was applied with four formulations, two oil solutions, emulsions, dusts, and powders. For hand equipment they used three-gallon pressure sprayers, and rotary hand dusters. They also used a spray boom on a weasel, and some of the plots were sprayed in this manner.

The rate of application in the Churchill area was from .05 to 1.0 pound per acre. The solutions were applied at the rate of 1 and 2½ gallons per acre. The dusts were used undiluted.

Perhaps it is best to present the results according to methods of application. The results of hand application, to make a general statement, showed that DDT was superior to the other materials tested. With DDT 100% control was obtained with .10 of a pound per acre in both wettable powder form and emulsion form. The dust showed 95% control with .40 pound per acre but less than 70% with .25 pound. Dust was considerably inferior to the wettable powder and emulsion. Fuel oil solutions were rather intermediate — 97% to 99% control at .25 pound and dropping off after that. With chlordane they obtained 100% control with .50 pound in fuel oil, but it required a pound in wettable powder for 100% control. Toxaphene in fuel oil gave 100% control at 1.0 pound, and with wettable powder at the rate of .50 pound per acre. Benzene hexachloride in fuel oil gave only 78% control with .50 pound. Special comparisons were made with DDT, TDE, etc., at .05 pound per acre, and the results showed that DDT, TDE, and heptachlor were about equal. Methoxychlor was considerably less effective and, as with our Alaskan tests, parathion was not effective as a pre-hatching treatment. Mr. McDuffie tells me they had about the same experience we had in Alaska. They actually had more larvae in the parathion plot than in a test control plot.

In the airplane tests which were conducted this year, the spray used was the ordinary airplane 20% concentrate diluted with fuel oil to various percentages and dosages. They made several types of comparisons. In one set of tests, they tried concentrations of 5%, 10%, and 20% DDT with various volumes ranging from a pint to 6.7 pints. very nearly from about .50 pint to 7 pints per acre and dosages that varied from .05 to .35 pounds per acre. All the airplane work was with DDT. The tests were in two major types of areas — the open tundras and the forested areas — and there were some intermediate types. The results were very interesting. With a 5%, 10%, and 20% spray applied at the same volume, 1.1 pint per acre, there was very little difference in results. The difference was in favor of the lower concentrations, say 5%. When they applied a heavy treatment, using 6.7 pints in a 5% solution, instead of the 1.1, control was not increased. This was very interesting too because they increased not only their amount of DDT but the total volume of liquid over six times and yet they did not increase their control. In the forested areas, there is another comparison — dosages of

.05 pound per acre provided 85% or better control. This was in contrast to what the results were that they obtained in open tundra areas or the lightly forested areas. In the open tundra or lightly forested areas, considerably higher dosages were required and they did not determine the upper limits, but with at least at .3 pound per acre or six times what was effective in forested areas, this dosage failed to control larvae effectively in the tundra or lightly forested sections. The difference seems to be a matter of run-off. In the forested areas there was not much run-off when the snow melted, whereas in the open tundra and in the lightly forested areas there was considerable run-off. No doubt an appreciable amount of the material was washed away as the snow melted. They also had another complication. In the open areas there was a very marked recession of season which extended the period in which there were larvae present in the pools. The forested areas did not have this. Hatching came abruptly and emergence ended rather abruptly.

Conclusions which might be drawn from the Churchill test are that the method does not appear to be superior to conventional larvicide methods. However, the data indicate that effective control can be obtained under certain conditions, and in some areas pre-hatching treatment may be a more convenient method to use — convenient because we can apply the material during the period of the year when other mosquito control activities will not be operative.

I may be able to answer a limited number of questions on the Churchill work, but I think we should move on to the others and have our questions and discussion come later.

The next discussant will be Mr. Lindquist, who will tell you something about the usefulness of this particular method. He is located at our Corvallis station in Oregon.

Mr. Lindquist: I do not know who first thought of putting insecticides on the ground or snow for control of mosquitoes hatching several months afterwards, but I do know that Mr. Stage and Mr. Gjullin and Dr. Freeborn proposed that idea many, many years ago in regard to control of snow water mosquitoes. I believe they actually tried to carry out some work on it. In those days they didn't have any residually effective insecticides, so they carried oil up the mountains and applied it in various forms to the ground in the fall of the year. At any rate we didn't have much of a chance to use this type of control until the arrival of DDT and other residual-effect insecticides. I have prepared with Mr. Roth and Mr. Yates a paper on this subject called "Ground Pre-Hatching Treatment for Mosquito Control." Part of it is general and part of it is somewhat specific on our work.

GROUND PRE-HATCHING TREATMENT FOR MOSQUITO CONTROL

By Arthur W. Lindquist, A. R. Roth, and W. W. Yates

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

Application of insecticides on ground or snow-covered areas containing *Aedes* eggs a few weeks or months before they hatch has been receiving considerable attention in the last 2 or 3 years. The method may have widespread use in many areas on many types of mosquitoes, such as flood-water, salt-water, and Alaskan *Aedes*, and snow-water mosquitoes. However, much research needs to be performed to determine the real usefulness of this type of control. The Corvallis, Oregon, laboratory of the Bureau of Entomology and Plant Quarantine has worked on the control of snow-water mosquitoes in Washington and Oregon during the last 3 years. Some of the results of this work are reviewed in this paper.

One reason this type of treatment has created interest may be that mosquito control personnel could be used more efficiently. The use of control crews for application of insecticides before the active mosquito season begins could well eliminate hurried and often ineffective treatment against sudden outbreaks. Usually the mosquitoes hatch and are on the wing in a few days, and with the usual method of applying larvicides the crews are always faced with the tremendous job of applying treatments within a short time. Frequently they fail in this work because of bad weather, breakdown of equipment, and other causes. It has always been difficult to apply regular larvicide applications at the correct time, particularly in small villages or farming areas where there is no established mosquito-control district and no trained personnel are available. Even in organized districts scouts must be in the field a week or two before the active season, and they must determine just when the mosquito hatch will occur. Frequently they cannot cover the area in such a short time.

Perhaps the insecticides could be applied over a period of several weeks before the larvae become active. Even though the dosage of insecticide required for pre-hatching treatments might be somewhat greater than that which is used now, the increased cost might be offset by savings in labor. Control crews would have more time to do a thorough job, and yearly scouting to determine hatching would be eliminated. Certainly the crews would welcome a change from the present frantic scramble to cover the areas in the few days required.

Obviously the answers to all questions concerning pre-hatching treatments are not available. The treatments may be completely ineffective or impractical in many cases.

There is at least one place where pre-hatching treatments seem to have definite possibilities. I am referring to the treatment of swales in the mountain areas for the control of snow-water mosquitoes.

Snow-water mosquitoes are present in many mountain areas in the West. They are vicious biters and create a serious problem to many people. It is exceedingly difficult, and sometimes impossible, to treat swales or ponds in the mountain areas in the spring when larvae are present, because roads and trails are not passable. The treatment of these areas in late summer or early fall appears to have promise.

In preliminary work Roth *et al.* (1947) showed that DDT applied at the rate of 0.9 pound per acre, 6½ months before mosquitoes hatched, was completely effective in mountain areas. The results of more recent work with DDT are presented in Table 1. In September and October, 1947, more than 30 swales in the vicinities of Twin Butte, Washington, and Santiam, Oregon, were treated with two formulations of DDT — a wettable powder and an oil solution. Dipping records in June and July, 1948, showed complete control in all plots treated at rates from 0.5 to 5 pounds of DDT per acre. The wettable powder, which was broadcast over the plots, gave as good results as the oil solution, and was much easier to apply. Larvae were found in five of the eight plots treated with 0.15 pound of DDT per acre, an indication that the dosage was too light.

TABLE 1

Results of tests on swales treated with DDT in September and October, 1947. Examinations for larvae made in June and July, 1948.

Formulation	Dosage of DDT (Pounds per Acre)	Size of Swale (Sq. Ft.)	Average Number of Larvae per Dip In Washington	Oregon
Wettable powder, 50%	0.15	5,400	10.4	–
		7,200	0.5[1]	–
		7,560	10[1]	–
		500[2]	–	3.1[1]
		6,000	–	0
		5,400	–	0
In diesel oil, 5%	0.15	1,800[2]	–	0
		10,800	0.6	–
Wettable powder, 50%	0.5	64,800	0[1]	–
		54,000	1[1]	–
		10,800	–	0[1]
		1,500	–	0[1]
		1,000	–	0
		25,200[2]	–	0[1]
In diesel oil, 5%	0.5	3,000	–	0
		19,800	0	–
		43,000	0[1]	–
Wettable powder, 50%	1.0	2,000	0[1]	–
		9,000	0[1]	–
		135,000	0[1]	–
		22,000	–	0
		1,500	–	0
		450	–	0
In diesel oil, 5%	1.0	900	–	0
Wettable powder, 50%	2.0	1,400	–	0[1]
		11,000	–	0[1]
		66,000	0[1]	–
		522,700	0	–
Wettable powder, 50%	3.0	7,200	–	0
Wettable powder, 50%	5.0	20,000	–	0[1]
Checks (no treatment)				3
				10
			20	
			10	
			32	

[1]Eggs or egg fragments found in soil samples taken at spraying.

[2]Covered with snow when treated.

In the vicinity of the test plots in Oregon, 90% of the larvae were *Aedes communis* Deg. and 10% *A. hexodontus* Dyar. Larvae from several check plots in the Washington area were determined as follows: *A. nearcticus* Dyar, *A. communis*, *A. fitchii* F. and Y., *A. hexodontus*, and *Aedes* sp.

Of course there are numerous problems connected with the possible use of this method. It might not be feasible where mosquitoes are breeding in slow-running water, such as are found in certain floodwater areas. In further research on this phase of the work, mosquito-control districts may find that parts of their territories can be given the pre-hatching treatment and that other parts must be treated with the usual methods.

For control of snow-water mosquitoes, the best insecticide or formulation to use has not been determined. Most of our work has been done with DDT, but in a few tests both TDE and parathion at 0.5 pound per acre were found satisfactory. However, samples taken from a plot 8 months after it was treated with parathion were practically nontoxic, while samples from a plot treated with TDE were toxic to first and second instars of floodwater *Aedes*. Some compounds that do not have such long-lasting qualities may prove more effective under certain conditions than those that we refer to as having a long-time residual action. This result may come about through solubility of the insecticides in water, which will be referred to later. In our work, oil solutions, emulsions, and wettable powders were effective at 0.5 pound per acre, but a dust or other formulation may prove to be more effective at lower dosages and may be easier to apply.

The locating and marking of the mosquito-breeding areas so that treatment can be applied by unskilled crews is of great importance. Obviously these areas canont be located with certainty in late summer, since usually there is not enough water to guide the investigators. Complete surveys must be made during the spring, when larvae are found. Trained personnel must locate and treat every depression or swale in the area. How large an area must be treated to insure protection from mosquitoes is still to be determined. Little is known of the flight range of snow-water mosquitoes, but it is likely that control must extend over several miles.

Another problem in connection with pre-hatching treatments is whether ground or aerial application should be used. Aerial treatment might not be practical where small swales are scattered over several square miles but might be used successfully on swales covering one or two hundred acres. If an airplane is to be used, many questions arise. Is it necessary to spray 6 to 8 months before the mosquito season? Would a regular larvicide treatment at a lower dosage be preferable, or should a low-dosage treatment be applied on the snow and ice 2 or 3 weeks before the eggs hatch? Information on this phase of the work in the mountain areas of the West is not yet availavble.

The question of how dry deposits of DDT applied on soil can later kill mosquito larvae is most interesting. We have had a theory that some of the chemical dissolves when water covers the area, but this concept may be entirely wrong. It is certainly open to conjecture at present. It has been stated that DDT will actually dissolve at the rate of 1 part in 80 million parts of water. This concentration is more than enough to kill most young mosquito larvae. It is possible that enough of the DDT goes into a colloidal suspension rather than a true solution so that the larvae are killed. In our laboratory, attempts have been made to filter aqueous mixtures of DDT and other toxicants through filter papers and Berkefeld filters. The filtrates have been tested against *Aedes* mosquito larvae. Simultaneously, comparative biological tests were made with known concentrations of insecticides to determine the amount of toxic agent present in the filtrates. On the basis of these tests the filtrates contained the following parts per million of toxicants: DDT 0.0115, TDE 0.033, chlordane 0.0025, toxaphene 0.0234, and benzene hexachloride 0.6. All these tests were made with double filter papers No. 2, and a few were made through a Berkefeld filter. Whether the filtrate contained a true solution or a colloidal suspension of the toxicant is not known. At any rate more benzene hexachloride passed through the filter papers than the other chemicals.

We have been impressed with the fact that poor coverage of an area gives perfect kills of mosquitoes when the insecticide is applied as a pre-hatching treatment but not when it is applied in the regular larvicide operation. This seems to indicate that the toxicants may go into solution. Water samples taken from field plots one year after they were treated with DDT in oil solutions and a dust mixture at dosages of 0.9 to 2 pounds per acre killed all second- and third-stage *Culex* larvae in the laboratory. Samples taken 21 months after treatment failed to kill young larvae. Apparently the DDT was available in either a colloidal suspension or a true solution.

The good results we have obtained with pre-hatching treatments are probably due to the ease with which newly hatched larvae are killed. We have found that a concentration of 1 part of DDT to 1 or 2 billion parts of water will kill young larvae. Since the insecticide is present at the moment the larvae hatch from the eggs, it appears that a low concentration will be highly effective under practical conditions.

It is probably true that more insecticide will be required for this new type of treatment than for the regular application of larvicides. Apparently more insecticide will be necessary if there is a long interval rather than a short one between the treatment and hatching. The problems of terrain, whether snow or ice is present, and the extent to which the area is covered with vegetation are all important. Much needs to be done before this method of treatment can be proved.

Literature Cited

Roth, A. R., W. W. Yates, and Arthur W. Lindquist. 1947. Preliminary studies of larvicides on snow-water mosquitoes. Mosquito News 7 (4): 154-156.

Dr. Travis: The next paper on this symposium will be presented by Dr. Basil Markos of the U.S. Public Health Service.

Dr. Markos: Before presenting this paper I must apologize to the group because I am not prepared to present slides to illustrate some of the results that we obtained last year. I have been away for two months and have only recently returned to California.

The title of this paper is "Pre-Application of Larvicide for Control of *Aedes* Mosquitoes." It is a paper by the speaker, Howard Greenfield, and Carl Spencer. The project was sponsored by the California State Department of Public Health, Bureau of Vector Control, with the cooperation of Merced County Mosquito Abatement District and the Public Health Service.

(Editor's Note: This paper was not available for publication in January, 1950, but will ultimately be published elsewhere.)

Dr. Travis: I would like now to summarize very quickly the meat of the Alaska work last year.

We found the fuel oil solution and emulsions, speaking in terms of DDT, were more effective than dust or wettable powder. There was no statistical difference in the applications that were put on the ground in August of 1947 and the applications that were put on the snow in April of 1948. There has been considerable discussion as to whether or not there is delayed kill. Some of the results indicate that the larvae continue to be killed by these applications as they grow. Our results in Alaska indicate that the larvae were killed very shortly after hatching and we saw practically no evidence of delayed kill. That might not be true in areas where mosquitoes grow at a much more rapid rate than they do when they are bathed in ice water. Into treated plots where we found no larvae (and we had quite a number, especially with the higher dosages) we transferred larvae from untreated areas and, with very few exceptions, we were able to show that the material in treated plots was still effective. In one or two instances we saw very, very young first stage larvae in the plot and never any fourth stage larvae. Evidently they were killed shortly after they hatched.

We may draw certain conclusions from the Alaska work. One of them would be that the method is useful under some conditions, and we should experiment further to determine the various conditions where the method is really effective. We believe that dosages of .50 pound or greater will be required to be reasonably sure of success even in the areas where we know that the pre-hatching treatment is useful. The method may be limited in effect by the total area to be treated. For instance, in the Anchorage area breeding locations are somewhat limited in size and there we believe pre-hatching treatment to be quite useful. But in the Fairbanks area breeding terrain runs for very many square miles, so we have to apply very large total dosages and we are not too sure how it will fit in the economy of mosquito control. Due to the very great flight range of mosquitoes in Alaska, we are inclined to control mosquitoes with conventional larvicidal methods, or adult control, because there we are able to control larvae and adults with .10 per pound of insecticide an acre. If we have to go to .50 per pound per acre for pre-hatching treatment it is an important item, for we can treat many more acres with .10 of a pound than we could with .50. But I am not too certain that we may not have to reverse our ideas on this point because we have some indication that plots treated year before last, for the control of larvae, were at least partly effective as a pre-hatching treatment the following season. If this is so, we will expect to find in 1949 in some of the very large areas we treated last year a considerable over-all reduction in larvae. In the Fairbanks area, where we sprayed two areas of thirty square miles and twenty-four square miles in size, one of which received a total of .50 pound DDT per acre and the other .40 pound per acre, it won't surprise me a bit if we find considerable reduction in the over-all breeding.

Now I know some of you people have some comments to make so for a period let's see if someone will volunteer.

Mr. Gray: Mr. Chairman, I would like to make one or two remarks on the subject of ground pre-treatment based on some of the experience we have had. We have found from analysis of our costs that the cost of materials is 15%

to 20% of the total cost of the spraying operation; in other words, the machine time, labor, transportation, and supervision is about four times the cost of the chemicals that you use, and therefore a little difference in chemicals will make slight difference in the total cost of operations. Therefore, I think our job should be to see not how little chemicals we can get by with, but to put enough on to do a thoroughly satisfactory job and not have to go back and do it over again. The results that we have had presented in the symposium, particularly by Basil Markos, on conditions in California, indicate that somewhere around 1 pound of DDT per acre is about the lowest dosage that is consistently dependable for what we consider reasonably good results — that is, 99% effectiveness. In our work for prehatching treatment on areas which are to be flooded by duck clubs, we have used as high as 2 pounds per acre and have gotten practically 100% results as judged by preliminary and subsequent checks by Mr. Aarons, our entomologist. We haven't used airplanes or aerosols. We have come right to grips wih the enemy. We get right on the ground and we sock it to them right there. We have been using either jeeps or weasels, depending upon the type of terrain. If it is a little soft we use weasels with a spray boom. We spray swath after swath with the weasel. I am not too sure, except on a very large acreage, that attempting to apply ground treatment with airplanes is in the long run as successful as applying it with ground equipment. If you have the right equipment, you can put your DDT right where you want it.

Member: We use a jeep to make our applications, with an air power sprayer feeding two nozzles directed downward. With 1.2 pound of DDT or TDE per acre we get control from one to approximately three months, averaging about one month to six weeks. By using ground equipment we can go into dry pasture and run through the pasture without doing any damage whatsoever, but if we go in there on wet ground, the ground gets torn up, the dykes are destroyed, and the farmers don't care for this one bit. With pre-hatching treatment we increase the efficiency of the whole operation while working on dry ground.

Mr. Dahl: Mr. Markos did not have an opportunity to present all of his data here. When the published paper comes out it will be of much more value. I would like to bring out two facts. The period between the initial ground treatment and the beginning of the irrigation cycle may or may not be of significance. It is the number of irrigations that we can control with pre-treatment that is the important thing. The second point I would like to make is that if we use heavier dosages of DDT on agricultural crops we must get as much of the DDT or other insecticide as possible onto the ground, and as little as possible onto the foliage of the crops. We have a responsibility in this particular matter. The timing factor in pre-treatment needs to be given due consideration by the manager. Certainly major treatments should be applied immediately after cutting of the crops, or after a crop has been foraged heavily, so that most of the DDT or other insecticide will get down on the ground and not be on the crop that is fed upon by the cattle.

Dr. Travis: I have several comments that I would like to get in here. In the Arctic we didn't see any difference between airplane and ground applications in the matter of effectiveness. I think it may come down to a matter of the size of the areas you are treating as to which way you will put the material on. The other comment I would like to make is one that has not application to agricultural conditions. In Alaska, the DDT was plastered on the vegetation, and the grass and vegetation was packed down later by the snow, and so became readily available to the larvae in the Spring after hatching. Of course that would be the reverse of what you want in an agricultural situation.

Mr. Elmo Russell: If farmers would irrigate more often with less water they would get a better crop and nearly half of the mosquito risk would be eliminated. That at least applies down our way and I think in most other places too.

Dr. Travis: I wish to thank the gentlemen who have contributed to his symposium, and will now turn the meeting back to the President.

Mr. Gray: During the war many of us had something to do, either directly or indirectly, with the Malaria Survey Detachments or the Malaria Control Detachments. Operations in the Pacific area would have been much more difficult, or even impossible, if the services of the units had not been available. Out of the experience of the war the Army has developed plans for improvements in vector control methods and organization, and Major Ralph Bunn is here to tel us about certain phases of them.

THE PLACE OF ENTOMOLOGISTS IN THE MEDICAL SERVICE CORPS, MEDICAL DEPARTMENT, UNITED STATES ARMY

By Ralph W. Bunn

Major, Medical Service Corps, United States Army

Before trying to delineate the place of the entomologist in the Army, it may be well first to examine the record to see why entomologists have a place in the Army.

Many pages have been written concerning the effect of diseases transmitted by insects upon armies and military campaigns. We need not look back into history beyond World War II to find conclusive evidence that the insect is a significant factor that must be considered in planning and conducting a military operation.

Hospital admission rates of four insect-borne diseases, malaria, dengue, filariasis, and sandfly fever, in the overseas forces of the United States Army for the years 1942 to 1047, inclusive, are listed in Table 1. The combined rates for these four diseases are shown in Figure 1. Hospital admissions of battle wounded for the years 1942 to 1945, inclusive, are included in both the table and the chart for comparative purposes.

These data show that insect-borne diseases reached their highest incidence in the summer of 1943. Then, as the necessity for preventive measures became obvious to even the least insect-conscious, trained personnel with supplies and equipment were moved overeas to initiate control operations. Their efforts resulted in the beginning of a downward trend in the incidence of insect-borne diseases that has continued through 1947.

TABLE I

Hospital admission rates for insect-borne diseases (dengue, malaria, filariasis, sandfly fever) and for battle-wounded, total overseas forces, U.S. Army, 1942 to 1947 inclusive.

Month	Year	Battle Wounded	Dengue	Malaria	Filariasis	Sandfly Fever	Total Insect-borne Disease
Jan.	1942	T*	3	39	0	0	42
Feb.		2	T	27	0	0	27
Mar.		T	6	23	0	0	29
Apr.		1	25	19	0	0	44
May		1	14	26	0	0	40
June		2	10	48	0	T	58
July		T	6	42	0	T	48
Aug.		1	4	30	0	1	35
Sept.		1	5	22	0	2	29
Oct.		1	8	28	T	2	38
Nov.		30	6	29	0	T	35
Dec.		25	11	57	0	T	68
Jan.	1943	20	8	78	T	T	86
Feb.		14	14	83	T	T	97
Mar.		16	23	76	0	T	99
Apr.		42	36	80	T	T	116
May		22	29	79	0	2	110
June		6	18	118	0	3	139
July		45	9	124	T	6	139
Aug.		43	6	156	T	5	167
Sept.		21	4	124	T	6	134
Oct.		17	3	105	T	2	110
Nov.		28	4	81	1	T	86
Dec:		27	8	51	1	T	60
Jan.	1944	28	18	45	1	T	64
Feb.		52	18	41	1	T	60
Mar.		25	12	43	T	T	55
Apr.		16	10	43	T	T	53
May		38	10	42	T	1	53
June		136	9	44	T	2	55
July		170	14	50	T	4	69
Aug.		110	23	47	T	5	75
Sept.		130	24	37	T	6	67
Oct.		122	7	33	T	1	41
Nov.		168	6	23	T	T	24
Dec.		133	6	18	T	T	24
Jan.	1945	136	5	14	T	T	19
Feb.		106	5	14	T	T	19
Mar.		133	5	18	T	T	23
Apr.		149	4	23	T	T	27
May		54	4	23	T	T	27
June		21	4	20	T	1	25
July		2	5	16	T	3	24
Aug.		1	5	12	T	1	18
Sept.		T	3	11	T	1	14
Oct.		T	2	11	T	T	13
Nov.		0	1	16	0	T	17
Dec.		0	1	22	T	0	23
Jan.	1946		1	19	0	T	20
Feb.			1	17	T	T	18
Mar.			1	20	0	T	21
Apr.			T	20	0	T	20
May			T	17	T	T	17
June			T	18	0	T	18
July			T	21	T	T	21
Aug.			T	22	0	T	22
Sept.			T	17	0	T	17
Oct.			T	11	0	T	11
Nov.			T	11	T	0	11
Dec.			T	11	T	0	11
Jan.	1947		T	10	0	0	10
Feb.			T	8	T	0	8
Mar.			T	7	0	0	7
Apr.			0	7	0	0	7
May			T	8	0	0	8
June			T	11	0	T	11
July			T	10	0	T	10
Aug.			T	15	T	T	15
Sept.			T	14	0	T	14
Oct.			0	8	0	0	8
Nov.			0	6	0	0	6
Dec.			0	4	0	0	4

*T is used to indicate the occurrence of a few cases producing a rate of from 0.01 to 0.50. Rates are expressed as cases per thousand mean strength per year.

Malaria was responsible for the majority of hospital admissions, with dengue contributing some fairly high admision rates in certain areas. Local outbreaks of filariasis and sandfly fever occurred, but the overall incidence of these diseases was consistently low.

The peak incidence of insect-borne diseases and of battle wounded was of about the same order of magnitude, and the Medical Department was called upon to provide hospitalization for about as many soldiers knocked out by bugs as by bullets.

The sinister role that insects play is not completely revealed by these data. The fly has long been incriminated in the spread of diarrhea and dysentery. Recent work reported by Watts and Lindsay[1] has shown conclusively that the incidence of diarrheal diseases may be reduced by controlling flies. No one has yet determined the proportion of cases transmitted by flies. Such a figure would vary tremendously with geographical area and season. However, there can be but little doubt that a significant number of those soldiers sent to the hospital with diarrhea and dysentery could trace the origin of their illness to food or drink contaminated by flies.

Similarly, a large number of soldiers were hospitalized with "fever of undetermined origin." In all probability some of these cases were actually malaria, dengue, or some other insect-borne disease.

If, in view of this evidence, it may be conceded that insects are of importance to an army, then perhaps we may deduce that entomologists are also of importance and can serve a useful purpose in an army.

The United States Army has arrived at that conclusion and currently is utilizing entomologists in the Medical Department in the following capacities:

1. As staff officers at major headquarters.
2. As part of the scientific team at Army Area and major overseas laboratories.
3. In conducting research and teaching at Army medical installations.
4. As officer personnel of preventive medicine units.
5. As liaison representatives of the Surgeon General at civilian research institutions.

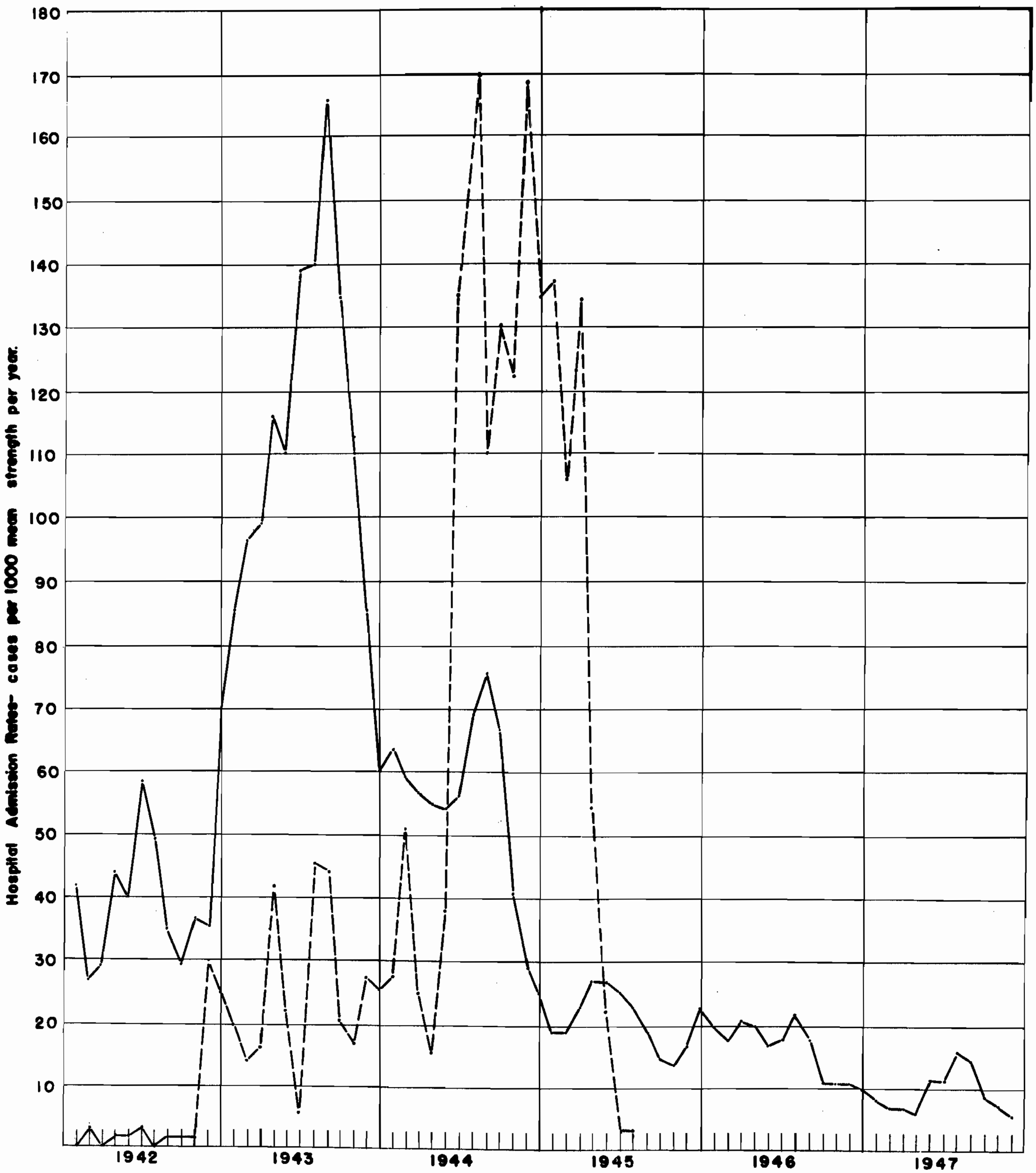

Figure I. Hospital admission rates for insect-borne diseases (dengue, malaria, filariasis, sandfly fever) and for battle-wounded, total overseas forces, U.S. Army, 1942 to 1947, inclusive.

·——·——· Battle Wounded.
·————· Insect- borne Disease.

The Army has adopted the policy of assigning responsibility for insect and rodent control operations to the Corps of Engineers at fixed installations in time of peace, since under these conditions, the control of pests of economic importance is a necessity, and is outside the primary sphere of interest of the Medical Department. The Corps of Engineers employs a group of entomologists under civil service regulations to supervise this work.

When an army is in the field, however, its entomological concern is with those insects serving as disease vectors, and the Medical Department retains responsibility for their control. For this purpose it plans to reorganize the Malaria Control and Malaria Survey Units of World War II, forming preventive medicine units. These will be trained and equipped so that they may be utilized for the control of any disease vector encountered. Plans call for combining two Malaria Control Units with one Malaria Survey Unit and adding enough motor maintenance and mess personnel to make the unit self-sufficient. Officer personnel would include one administrative officer to carry the burden of administrative detail and two scientifically trained officers who may be entomologists, sanitary engineers, or parasitologists, the choice depending upon the nature of the problem encountered. The total strength of the unit will be approximately forty men.

What does the Army have to offer the entomologist considering a career in the service?

Most basically, it offers the entomologist an excellent opportunity for constructive work. Many of our unsolved medical problems today are highly complex, and their solution calls for the concerted attack of a variety of specialists. As a part of the medical team, the entomologist has an enviable chance to take part in solving some of these problems. The tasks the Medical Department entomologist will be called upon to do in following the Army policy of rotation of duty, are perhaps more varied than his civilian counterpart may meet. However, all possible consideration is given to the individual's particular training capabilities, and desires in making assignments. At least, if variety is the spice of life, the entomologist in the Army will not suffer from lack of seasoning.

The entomologist whose interests extend beyond the confines of the United States will enjoy the prospect of serving in one or more of the interesting parts of the world where the Medical Department is active. Assignments in this country are mostly at Medical Department centers located near larger cities. The Army has not escaped the housing shortage, but good progress has been made in providing housing, and every effort is made to provide a favorable background for family life. Sports and recreation facilities are excellent, and the Army has a liberal leave policy of 30 days per year.

Although there may be some better-paying positions available to entomologists in non-government work, entomologists serving as officers in the Military Services are as well paid on the whole as are their counterparts in other agencies of the government. There are other features which also benefit entomologists in the Military Services today. For instance, base pay rates are increased by five per cent for each three years of service. Overseas pay is 10 per cent above base pay. Allowances for food and rent are exempt from Federal income tax. Retirement is provided after completing about 30 years of service, or at the time of incurring a medical disability, at three-quarters of base pay. Medical and dental care are provided. A maximum time period in each grade has been established by law, and officers with superior ability can expect to be promoted more rapidly.

The Army encourages the officer to continue his education after entering service. Special study for advanced degrees is offered on government time at leading civilian institutions. Refresher courses are given to officers at various times in their careers.

The Medical Department needs a strong, well-trained group of officers in the Organized Reserves as well as in the Regular Army. The outlook for the reserve officer is constantly improving. President Truman recently issued an executive order directing the Secretary of Defense to establish a vigorous and progressing reserve training program. Public Law 810 now provides retirement pay for reserve officers after the age of 60.

Reserve commissions in the grade of first lieutenant may be obtained by entomologists without prior military experience who:

1. Possess a doctor's degree from an accredited school, or
2. Possess a master's degree from an accredited school and have at least two years of professional experience, or
3. Possess a bachelor's degree from an accredited school and have at least three years of professional experience.

Entomologists not meeting these minimum requirements may be commissioned as second lieutenants in the Pharmacy, Supply and Administration Section of the Medical Corps, and may be transferred to the Medical Allied Sciences Section of the Medical Service Corps when qualified for promotion to first lieutenant.

Entomologists possessing more than the minimum requirements may be commissioned in the grades of captain through colonel, commensurate witth their training and experience. However, appointments in grades of major and above will not be made except in cases of highly qualified men of recognized ability, such as individuals with professorial rank or those having outstanding scientific research accomplishments.

Application forms may be obtained from any Army post, camp, or station, and should be submitted to the commanding general of the Army area in which the applicant resides.

Permanent commissions are available only to reserve officers who have satisfactorily completed a competitive tour of duty for one year. Candidates must be between the ages of 20 and 30 years at the time the competitive tour begins.

For further information write to the Chief, Procurement Branch, Personnel Division, Office of The Surgeon General, Department of the Army, Washington 25, D.C.

Literature Cited

1. Watts, J., and Lindsay, D. R. Diarrheal disease control studies. I. Effect of fly control in a high morbidity area. Publ. Health Rep., 63, No. 4. 1948.

Mr. Gray: Thank you, Major Bunn. For the finale of this afternoon's program, we will have a symposium on the uses and limitations of the new insecticides. We have had similar symposia before, and we will undoubtedly have them again in the future, as this is a perennial subject of interest and importance to us all. I expect this symposium to be as valuable to us as any which have preceded it.

It was to have been conducted by Dr. F. C. Bishopp, but he has been detained in Washington by urgent Bureau business, and Harry Stage will preside in his stead.

Mr. Stage: The following people are going to take part in this symposium and I would appreciate it if they would come up on the platform at this time: Dr. Travis, Mr. Lynch, Mr. Mulhern, Mr. Fritz, Mr. Cope and Mr. Lemmon. Dr. Bishopp has divided this symposium into several talks. "The Uses and Limitations of Insecticides for the Mosquito Control by the Military" is to be given by Dr. Travis. "Insecticides Used in Salt Marsh Mosquito Control" is to be presented by Mr. Lynch of Delaware and Tom Mulhern of New Jersey. George Bradley was asked by Dr. Bishopp to prepare a paper on "The Use of New Insecticides in Residual Sprays", and Mr. Fritz will handle that. Mr. Cope of the Fish and Wildlife Service has been asked to discuss "The Effect of Insecticides on Wild Life" and Dr. Lemmon of the California State Department of Agriculture has been asked to discuss the toxicities of these insecticides to man and domestic animals. At the conclusion of these discussions I am asking Harold Gray to summarize the several discussions given.

We might first review the use of insecticides in the control of mosquitoes. The record certainly is a long one, probably beginning in 1890 when Dr. L. O. Howard of the Bureau of Entomology used kerosene as a larvicide; then in 1920 came Paris green, and later pyrethrum: then there was a long lapse before other insecticides were developed which were of much use in mosquito control. It was not until 1942 that DDT came into the picture and made a reputation for itself almost over night. In the last three or four years several related compounds have shown great promise in the control of mosquitoes and other insects. We know a little about their composition; we know too little about their uses, about their limitations, and about their toxicity to man and animals. I hope after we discuss these various factors that you will feel free, of course, to ask questions and add to this sympoium. Dr. Travis, will you start your paper, please?

Dr. Travis: Many of our projects at Orlando are financed by the military. Many of the projects have direct application only to the military. The Armed Forces are using very little other than DDT, but the other insecticides are being investigated to see how they will fit in the military problems. I think the most urgent mosquito problem encountered during World War II resulted in unusual awareness among the Armed Forces of the need of an efficient mosquito control program.

Many of you know that DDT dust is not particularly effective against culicine larvae. The use of dust is also limited by wind, therefore dusts are not too useful to the military, because the dusts don't have general enough application. Wettable powders haven't been used much either, because equipment suitable for the handling of the material is not available. The three gallon pressure type sprayers do not provide sufficient agitation and there is too much trouble with plugging the nozzles. About the only type of equipment with which the wettable powder can be of particular use by the military would be a skid-mounted pressure sprayer that furnishes agitation. Agitation is necessary if wettable powder is to be used effectively. In the final analysis, the limitations and uses of the newer insecticides for military purposes may be considered to be the uses and limitations of DDT because other insecticides are not being used at present in routine operations by military personnel, and DDT is being used either as an emulsifier or as an oil solution.

Mr. Stage: Now, Mr. Lynch of Delaware, will you please tell us about your extended experiences in the use of DDT in controlling the salt marsh mosquitoes in your state?

TWO-YEAR SUMMARY OF AIRSPRAYING IN DELAWARE

By E. Elwood Lynch

Mosquito Control Engineer, State Highway Dept., Lewes, Delaware

Mr. Lynch: The use of aircraft for distributing DDT to mosquito-breeding areas has provided a means of meeting public demand for an immediate reduction in mosquito annoyance at populated centers. This method of control has been practiced in Delaware over the past two years since funds for drainage work have never been sufficient to keep the original 2300 miles of C.C.C. drainage ditches maintained. Regardless of the protection made possible by drainage work in our state, experience has shown that airspraying will supply the *missing link* in our control program. Many times in the past we have been confronted with wide spread breeding brought about by storms, periodic tides or other causes, and this has provided a means of curbing such since the *time factor* is always highly important.

The basic information necessary to start such a spray program was secured through literature available on the subject, and such other detail problems as concerned us were worked out on a cooperative basis with the Delaware Agricultural Experiment Station.* Also the advice of Wild Life Authorities was obtained previous to any large scale operation.

The first airspraying for mosquito work in our state was begun during the summer of 1947 with a total of 35,134 acres of marsh being treated. The spray was applied at the rate of two quarts of No. 2 fuel oil per acre containing two-tenths pound of DDT. The first year's work meeting with success and receiving wide support from the public, plans were then formulated for expansion during 1948. The second season's work totaled 93,319 acres at the same rate of application as previously mentioned. The periods of treatment were regulated according to existing field conditions so as to curb larvae development or adult migration. Due to the large amount of rainfall during the 1948 season nine spray applications were required over a hundred-day period to provide relief for about twenty miles of coast line, including the towns of Lewes, Rehoboth, Bethany Beach and intermediate points, the treated area totaling 76,000 acres.

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* Subject: *Resort Protection by Restricting the Migration of Aedes Mosquitoes*—Stearns, McCreary, Lynch, and others —4-12-48. *The Use of DDT and Paris Green on Muskrat Marshes* — Stearns, Lynch, and others — 1947.

The town of Rehoboth received greater benefits from the spray work since it was the largest resort of the group receiving our attention and has more than 5,000 acres of marsh within a five mile radius or about 20,000 acres within a fifteen mile radius. Most of the marsh and swamp land within the five mile limit received regular treatments with DDT. Miscellaneous summer residents around the bay and river shores including boys camps not included in our regular program received benefits from the work as well. This was accomplished by treating with plane any concentrated breeding located by our group of field inspectors. These points of concentrated breeding could be covered by plane in a few minutes, otherwise by ground equipment many days of work would have been involved.

The Delaware City section located in the northern part of our state received nine applications of DDT totaling 17,319 acres. The conditions in this section were different from those in the southern part of the state in that most of the marshland was kept flooded in the interest of the muskrat industry, and no drainage work of significance had ever been accomplished. Our program of spraying provided ample relief for the town residents as well as those at the Governor Walter Bacon Health Center formerly known as Fort DuPont.

The principal species encountered in lower Delaware on this project were *Aedes sollicitans* and *Culex salinarius*. Those affecting Delaware City were the Anopheline group including *Anopheles quadrimaculatus, Aedes sollicitans, Aedes vexans,* and *Culex salinarius*. Although our spray work was very satisfactory in both sections of the state, *Culex salinarius* were more numerous among our trap collections. One of the reasons for this no doubt was due to a 33.95 inch rainfall in the four month breeding period, the normal being 17.36 inches. There is also a probability that the spray may be less toxic to this species, and the conditions under which they breed may provide shelter from the spray as well. A better understanding of the life habits of this species and effects of the spray materials upon them will be obtained through research in the future.

Test plots were measured and arranged for checking output of planes and glass slides revealed how the material was distributed. This system of checking was continued through the season to insure proper application and distribution. The use of slides was also employed at various points to insure coverage in the sections to be treated. To further improve the system each pilot was provided with U. S. Coast and Geodetic Survey maps containing marked plots of 200 to 300 acres each, using natural boundaries such as streams, drainage ditches, or roads to mark their outer extremities. In this way we eliminated the necessity of using markers for each swath. These maps were folded in such a manner as to fit in 5" x 12" plastic cases for protection and convenience of handling.

The spray material was prepared at our headquarters from 100% DDT powder, the No. 2 fuel oil and DDT being brought into solution by a combination of heating and agitation process with the resulting mixture containing .4 pounds of DDT per gallon of solution. The plant is largely of mechanical nature having an output of approximately 2,000 gallons of spray material per eight-hour day, and can be operated by one individual.

Our delivery truck for transporting oil from plant to plane has a tank capacity of 1,100 gallons, and is equipped with 2" Brodie meter, delivery hose, agitation facilities, and 2" suction hose for loading. The rate of delivery from truck to plane averages approximately 60 gallons per minute or about 1½ minutes for each plane load. The truck is a regular 1½-ton stake body with four cellar oil tanks which are fastened to the floor of the truck body; the entire unit was planned and assembled at our shop at a reasonable cost.

The cost of oil, DDT, mixing, loading and delivery to plane tank averaged 31 cents per gallon and the *contract rate for spraying was 24 cents* per acre. At the rate of two quarts per acre this brought the average cost to approximately *40 cents per acre,* including all phases of the operation.

In closing I wish to add that the program was well supported by the public which added to the success of the work. We obtained this aid by keeping the public informed when spraying was to take place over the towns through the use of mobile address systems. The few complaints experienced were unimportant from the standpoint of damage. Also through constant inspection in the sprayed parts we were unable to observe any damages to the various forms of life concerned.

Mr. Stage: Mr. Mulhern, will you continue the discussion of uses of new insecticides on salt marsh mosquitoes.

Mr. Mulhern: I was greatly pleased when Mr. Lynch agreed to come out here and present his experiences with DDT on the salt marsh. He has for three years been doing a large scale job under conditions where there is no other efficient protection from salt marsh mosquitoes, and where there were plenty of salt marsh mosquitoes to begin with. The greatest limitation of the use of airplane spraying for mosquito control in the Northeast has been first of all, costs, and Mr. Lynch and his people secured a much smaller figure than any of us previously have believed possible. He has shown you a total cost of 40c an acre. The other limitation which he did not mention, but which has been up for discussion many times in the Northeast has been the question of damage to salt water fish. We know from laboratory studies and carefully measured field studies that we sometimes damage fish with dosages of anything over .10 of a pound of DDT per acre. Now, under ordinary field conditions Mr. Lynch has used .20 of a lb. per acre and he has not had any damage whatsoever. That checks well with some other observations which have been made under ordinary field application. I refer in this connection to a paper presented by Dr. E. N. Cory to the American Association of Economic Entomologists in which it was shown that under field conditions you can use even much larger dosages without damage to the wildlife of the marshes and the adjacent water. So I think that Mr. Lynch has given us a very great contribution with respect to the conditions which prevail along the Atlantic Coast.

The fear of damage to wildlife has been for a long time one of the limitations to the use of insecticides for salt marsh mosquito control. This dates back to the time when we were using ordinary fuel oil for salt marsh spraying. To get adequate control of the salt marsh species, we had to us upwards of 50 to 75 gallons of oil per acre. That was enough to cause trouble with the salt marsh minnows. The wildlife people were much concerned about it and so, too, were the mosquito people, because the salt water minnows are the natural enemy of the mosquito and a very great friend indeed of mosquito control men. There are few places where ordinary fuel oil is applied in large doses at present.

Where there is a great deal of sewage pollution in the water, the small dosage applications of DDT and similar insecticides do not perform too well. We find that we get better results in those limited circumstances by applying plain fuel oil and using lots of it. As the sewage pollution kills fish and drives out other wildlife, the use of oil is permissible.

You are aware that some years ago, in order to avoid damage by fuel oil to desirable wildlife, Dr. Ginsburg of the New Jersey Experiment Station developed the pyrethrum larvicide, and we still find it to be a useful material in the places where we absolutely must not take chances on damaging desirable fish life or plants. This material is still being used to a limited degree by a number of New Jersey Commissions. You are much more concerned with DDT and the other new insecticides, and Dr. Ginsburg in our station has been doing quite a lot of work, some of it on a laboratory scale and some in cooperation with the various county commissions, with DDT, DDD, Methoxychlor, BHC, Toxaphene, Chlordane and Parathion. He has reported in considerable detail on these materials.

When Dr. Bishopp asked me to speak he probably wanted me to present such information as I could from the standpoint of the practical mosquito control man, rather than as a scientific investigator, and I can summarize to a degree what Dr. Ginsburg has to say in his more learned presentations by indicating that of all these materials none has shown any particular superiority over DDT from the practical standpoint, except possibly TDE or Rhothane, which apparently is a little less toxic to fish; however, DDT is the material being used on a practical scale in New Jersey.

On vast areas of salt marsh in New Jersey no spray materials are being used. They are used only on comparatively limited areas, diked marshes for example, and to a lesser extent on some of the open marshes along the seashore where drainage has been cut off by railroads, highways, etc. Under such conditions DDT has been used as a larvicide in an oil solution or emulsion, and to a very much smaller extent in water suspension. Application has been primarily by power equipment, with some airplane work, although not very much. We use small dosages to kill the larvae, without expecting any lasting or residual effect.

To protect the populated areas subject to infestation by flights of adult mosquitoes from the marshes, applications of DDT aerosols have been made by fog and mist machines primarily, a little by airplane, and some by hand equipment. In areas subject to floods the attack against the larvae by use of ground pre-treatment has been favored wherever it can be accomplished economically, for if we can destroy the mosquito in the aquatic stages then a much larger area inluded in its flight range need not be treated as in the adult control program. The limitation is cost. But the reports that have filtered back from the field workers who have been trying to use DDT on pre-treatment applications are very confusing, and we think this may be due to the widely variable conditions under which the materials are applied. For example, a marsh may be flooded by an extremely high tide a few hours after an application was made, or it may go for months without tide coming on the marsh. This variable may be partly responsible for the difference in the results which have been reported under field conditions. Some of our people report very excellent results; the same treatment applied elsewhere will be reported as disappointing.

We have had some experience with 5% DDT solution with .50 of B-1956 spreader added, and with applications up to one quart per acre applied with a pin stream oiler. (A small oiler such as the garage man uses to spray the springs of your automobile.) On clear waters on the salt marsh a very minute treatment appears to give quite good results. On the uplands on clear waters they give *very* good results. The spreader apparently is an essential part of this treatment; without it the small dosage does not do the work at all. However, on polluted salt marshes the small dosage is not at all satisfactory for mosquito larviciding. And there you have another limitation. The type of water will very often determine the results.

A much more useful type of application on the salt marsh has been worked out, an intermediate type used in several of the counties of northern New Jersey where the marsh conditions are such that DDT might be expected to not operate too well. In those areas the dosage is about 7 gallons per acre of 3% DDT which is about a pound per acre, applied with an ordinary compressed air hand sprayer or at times by a light weight power pump. This dosage overcomes another objection to the very small dosage in that the field man who makes the application can very readily see whether or not he has a complete film on the water treated The workmen like to use the larger dosage for this reason. The larger dosage also has a considerable lasting effect on the cleaner waters. We believe also that larger dosages tend to kill a number of the adult mosquitoes which come to the water to lay eggs. Another advantage is that it offers a possible opportunity to incorporate a weed killer in the spraying materials so that the banks of ditches may ultimately be kept reasonably free of objectionable vegetation.

For residual treatment for adults we had one significant experience back in 1945 at a plant producing powder for the Navy. Mosquitoes had gotten so bad that the night shift could no longer operate. There were so many mosquitoes all over that 1,000 acre tract that we estimated about 500 to a circle 5 ft. in diameter. It was impossible because of local conditions to treat that area in any way except by air. This area included salt marsh and fresh water swamps, and had a wide variety of species of mosquitoes. The treatment was made in three sections; a hundred acres was treated with a 5% oil solution at the rate of 5 gals. per acre. The balance of the area — 900 acres, was treated in two blocks. One was treated with an emulsion applied by air, again 5 gals. per acre with the concentration adjusted to give a dosage of 1.2 lbs. of DDT per acre. Another section was treated at the rate of 1.8 lbs. per acre. The 5 gals. of oil very seriously burned the upland foliage. The emulsion caused far less damage. We had no noticeable damage to two bee-hives. Two fish ponds in the area were stocked with perch and carp. They received a dosage of 1.2 lbs. per acre. We killed some perch but not all. We did not kill any of the carp. The area was searched by our local wildlife people and we killed no birds, no animals, although there were plenty in the area. The residual effects of that application was such that there was no necessity to re-treat the area until the end of the season although the original treatment was made on July 21. During a period of about one month after spraying, the area that surrounded this 1,000 acres was badly infested with salt marsh mosquitoes, at the rate of at least 20 to a five-foot circle, but within the treated area the mosquitoes were almost completely absent. We are convinced that the mosquitoes were continuously coming in to reinfest the tract and being destroyed by the residual DDT deposit. However during the period of night flight there was no protection noted, and that has been repeatedly noted on other field applications of DDT where treatment was adequate for daytime protection. The protection failed at dusk when the night flight began.

Mr. Stage: Thank you, Tommy Mulhern. The next discussion is by Mr. Roy Fritz of the Public Health Service and he will discuss the uses of new insecticides as residual sprays for larvae control.

Mr. Fritz: Mr. Chairman and members of the Association. I wish that Mr. Bradley were here to present this paper himself since he's much more familiar with the paper than I am.

MALARIAL CONTROL THROUGH THE USE OF NEW INSECTICIDES AS RESIDUAL SPRAYS AGAINST ADULT MOSQUITOES

By G. H. Bradley, *Sanitary Director* (R)

and L. W. Saylor, *Entomologist*

Communicable Diseases Center, U.S. Public Health Service Atlanta, Georgia

The literature on the use of the new insecticides as residual sprays against adult mosquitoes for malaria control purposes is already so great that to properly summarize it all would go beyond the scope of this discussion. Nevertheless, it is possible to give some information on such use of residuals from all of the zoo-geographical regions of the world in which malaria is a problem. Almost all of this information concerns the use of DDT. In general, authors have reported effective results with this material, although specific supporting data are not too numerous. Also, in many cases house residual sprays have been used in conjunction with anti-larval measures and malaria therapy — so that it frequently is impossible to determine the exact contribution that each has made to the general result. In the present discussion we have included mention of instances in which residual sprays against adult mosquitoes have been the only, or principal, malaria control measure used, and for which some epidemiological evaluation data are available.

Nearctic Region

In the Southeastern United States, where *Anopheles quadrimaculatus* is the vector, the degree of malaria control attributable to the large scale DDT residual spray program of the U.S. Public Health Service is difficult to ascertain because of the general recession of the disease in all parts of this country. Nevertheless, on the basis of the maintenance of houses free from *quadrimaculatus* and the destruction of mosquitoes which have fed on humans, the hazard of transmission has been greatly reduced. (Bradley and Fritz, 1947). For the year 1946, for instance, approximately 99% of sprayed houses were kept free of *quadrimaculatus,* and precipitin tests of blood from 25,798 specimens of this mosquito from sprayed areas indicated that only 0.2% of them had fed on humans and survived, whereas in unsprayed areas 1.1% of the specimens showed human feedings, an indicated reduction of 82%. Reports of work in succeeding years have been in agreement generally with that for 1946. Also, in controlled experiments conducted by Quarterman (1948) it was shown that of the *quadrimaculatus* mosquitoes which entered a treated house and obtained a blood meal, only 15.5% escaped and survived for as long as 24 hours — results which are in close agreement with those obtained for the over-all program evaluation. In addition to the foregoing entomological evaluations, epidemiological data from a carefully controlled experiment in South Carolina in 1945, where malaria rates averaged around 5%, showed that a significantly greater decline in malaria, as measured by positive blood films, occurred in sprayed as compared to unsprayed sections of the study area (Link, 1947).

Neotropical Region

Several authors working with DDT residuals in Central America and the West Indies, primarily against the important carrier *A. albimanus,* reported effective malaria control based on blood smear or spleen surveys. Macready (1947) in Panama and Costa Rica lowered the malarial hospitalization rate of 44, 50, and 66% respectively in three different areas through spray techniques. Trapido (1946) in Panama reported a decrease of parasite rates from 45.5% before spraying to 14.8% within 18 months after spraying. In Puerto Rico Stephens and Pratt (1947) reported the parasite rate reduced within one year from 5.8% to 0.9% in sprayed areas. In South America authors in Peru, Bolivia, and British Guiana have reported effective use of DDT residuals for malaria control in areas where *A. darlingi* is the main vector. In Peru, for example, Corradetti (1947) reports that a positive smear rate ranging from 11 to 28% among 8,300 persons decreased to less than 1% after DDT residual spray applications.

Oriental Region

A number of writers in India have reported excellent malaria control as a result of residual spray work. Senior-White (1946) has stated that in one treated area where *fluviatilis* and *culicifacies* are the main vectors, the spleen rate was reduced by ½ in 2 years and in another such area by ⅓ in 10 months. Viswanathan (1947), also dealing with these same two vector mosquitoes, cites several instances of parasite rate reduction due to DDT sprays; in one case a parasite rate of only 3.3% occurred in a treated area while in a comparable unsprayed area the rate was 32.3%. Comparable spleen rate decreases also were demonstrated.

Australian Region

Investigators dealing with *A. farauti* (*p. moluccensis* of authors) reported effective control. Bang (1947) in New Guinea found that in treated villages the parasite rate was lowered and the spleen rate unchanged, whereas in the control both spleen and parasite indices increased, with an average increase of 17%. Yust (1947) in New Hebrides reported 400 primary malaria cases per month early in 1943 among troops previous to the use of DDT; early in 1944 after DDT was used in all troop housing (and this was later extended to native huts and plantation buildings and some larviciding was done) no single new case of malaria among some 40,000 troops was found during the rest of the year.

Ethiopian Region

Control results have varied in this region. In Africa Davidson (1947) reported *ineffective* control from the use of benzene hexachloride (gammexane) against *gambiae* and *melas* during a five-month period. On the Island of Mauritius, Tonking (1947) used DDT against the vectors *funestus* and *gambiae,* and was very successful; he was able to lower the parasite rate in a general population of 2,600 persons by ⅔, and in this same area the parasite rate in children was lowered by ½.

Palearctic Region

Considerable work has been done here. In Italy Aitken (1946), Soper (1947) and others working primarily with *A. m. labranchiae* secured very effective control as measured by reduced spleen and parasite rates. Aitken reported a parasite index reduction from 21% pre-DDT to 1% post-DDT, and a spleen reduction from 43% to 25% respectively. Missiroli (1947) reported "striking declines in reported cases of malaria, in positive blood films and in malaria deaths." In Greece where the species primarily concerned with malaria transmission were *superpictus* and *elutus,* Lividas (1946) and Mandekos (1948) reported a "conspicuous decline in both spleen and parasite indices," and the Salonika Malaria Laboratory reported a parasite rate decline from an original 40.4% to 5.0% within 18 months after the spray program was initiated. Foy, et al (1948), reporting on accomplishments in the same area in Greece, however, disagree with the conclusions of these authors and state that in their opinion the "effects of DDT were minimal"; they credit much of the apparent malaria reduction in the area to a general downward trend in incidence of the disease then in progress and to atabrine therapy. In Palestine, Berberian (1948) using residual sprays plus larviciding against the vectors *sacharovi* and *superpictus* reported a "reduction in the spleen sizes — within eight months."

Chemicals

Little information is available on the effectiveness in malaria prevention of chemicals other than DDT which possess residual insecticidal properties. However, tests to determine the residual effectiveness against mosquitoes of the principal chemicals in this group (benzene hexachloride, chlordane, chlorinated camphene, and DDD) as compared with that of DDT have been made by several authors, and their general conclusions are embodied in the statements below. For further information on this subject reference should be made to the comprehensive reviews of literature on the use of the new inscticides against insects of public health importance published by Bishopp (1946) and Andrews and Simmons (1948).

Benzene hexachloride (gammexane, BHC, etc.) has been reported especially by British authors, but results in controlling anophelines cannot compare with those resulting from DDT residual spraying. The residual effect of benzene hexachloride compares favorably with that of DDT during the first 8 weeks after application, after which there is a much more rapid decline of effectiveness. The strong fumigant and therefore repellent effect, as well as the disagreeable penetrating odor, further limit the usefulness of this chemical for residual spray purposes in houses.

Chlordane (1068, chlordan, etc.) when applied as a residual spray is practically as effective as DDT against *A. quadrimaculatus* for the first few weeks, but rapidly declines thereafter. For this reason it is considered generally inferior to DDT. It is, however, a very promising insecticide for use against some other insects of public health importance, such as roaches, lice, and others.

Chlorinated camphene (Toxaphene, etc.) possesses a slower knockdown than DDT and its residual effectiveness against anophelines is limited to a period of about 8 weeks. Like benzene hexachloride, this chemical has an objectionable odor which limits its use for house treatment purposes.

DDD (preferred name TDE) as a residual spray does not quite compare with DDT, though but little detailed specific information is yet available; it has evidenced considerable promise for larviciding due to its low toxicity for wildlife.

In conclusion it may be stated that malaria control has been reported as a result of the use of DDT as a residual spray for all malarious regions of the world. In many instances conclusions are not supported by adequate data and in certain cases they have been challenged. Nevertheless, the weight of evidence supports the contention that residual DDT treatment of houses can be relied on to reduce the hazard of malaria transmission with most of our vectors. The extent to which the hazard may be reduced by this measure will depend on the habits of the specific anopheline involved. Careful evaluation of effects of residual sprays on each anopheline species therefore should be made in order to determine the applicability of the measure in malaria control in any region.

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Mr. Stage: Thank you Mr. Fritz. I think that it might be well to point out the fact that Chlordane is one of the few new insecticides that has a fumigation action, and for that reason may or may not be an extremely useful material. The next discussion is going to be on the effect of the new insecticides on wildlife, by Dr. Cope of the Fish and Wildlife Service.

Dr. Cope: Before plunging into the prepared paper I would like to inject just a word of caution about the use of "threshhold toxicity" in relation to fish and game species. The little work that has been done along this line has been done by different people in different parts of the world, using different methods and under different ecological situations. It isn't always possible to draw a direct comparison between the different work. If you consider using these figures let me recommend that you proceed with caution because they may not apply in your particular situation.

THE EFFECT OF MOSQUITO INSECTICIDES ON WILDLIFE

By Oliver B. Cope

Fish and Wildlife Service, Department of the Interior

Introduction

A year has passed since these societies last heard reports dealing with the susceptibilities of game and fish animals to the actions of mosquito toxicants. In that period of time, additional advances have occurred in the development of promising insecticides. Two years ago, there were at hand four prominent new insecticides awaiting investigation by wildlife biologists. During 1948, no less than eight important wartime and postwar chemicals were the subject of detailed studies in relation to their effects on game species and their foods. 1949 will undoubtedly see the emergence of still more chemicals worthy of investigation, and I feel certain that wildlife and fishery biologists will make a creditable showing in keeping apace of the demands for testing.

The technical journals of 1948 reflected the acceleration of activity in this branch of insecticide testing that began in 1947. The cooperation between federal, state, and other conservation agencies has resulted in the completion of several research projects in laboratory and field. Through the use of the results of these studies, entomologists and wildlife biologists are better able to plan control projects based on sound conservation principles. We have today a clearer concept of the importance of the various factors contributing to the final consequences of field treatments with highly toxic chemicals. Investigators are, more than ever before, aware of the importance of water volume, of proper synchronization of control procedures with seasonal changes, of applying the proper formulation in the right way, of frequency of application, and of the size of the area treated. As these factors come to be better understood and are substantiated by repetition in reliable experiments, the principles thus established will be passed on to the abatement supervisor, who can then plan his campaign with the knowledge that optimum effectiveness will be the result of his efforts.

The tendency to apply results derived from laboratory testing directly to field operations is giving way to a more cautious approach. Experience in the field has repeatedly shown that such matters as the interruption of food cycles the chemical nature of waters, and mechanical problems of application often present difficulties not anticipated in the laboratory. It is heartening to note that more and more investigators are planning their work with this in mind, and are coordinating aquarium and cage tests with parallel field tests under a variety of natural conditions.

Needs for Study

To date, certain phases of the toxicology problem involving fish and game have been investigated less completely than have others. People concerned with the control of salt marsh mosquitoes have been curious for some time as to possible damage to beneficial salt water and brackish water animals through the use of DDT and related preparations. Investigation in this important field has lagged somewhat behind that concerning fresh water situations.

Additional careful work on birds is necessary to determine their reactions to widespread treatments on a commercial scale. Although there is much in print regarding changes in bird populations after treatments, it has not been demonstrated always that insecticides were the cause.

The interpretation of reports on insecticide testing has been rendered difficult for wildlife biologist and entomologist alike by discrepancies between the results of different workers and by the various styles used in presenting data. Too often have we read papers reporting only the name of the toxicant and its concentration, without mention of the formulation or any of the associated physical and chemical circumstances. Indeed, there is need for a set of basic standards for the guidance of researchers during the planning and execution of their work and in the presentation of their findings.

Recent Advances

The recognition by wildlife people of the needs enumerated above is reflected by the results of certain recent investigations. I shall emphasize these particular findings this afternoon, because they seem pertinent.

One of the possible hazards to marine organisms in relation to salt marsh spraying in some areas concerns oysters. Piles of oyster shells awaiting use as substrata for the setting of oyster spat are often purposely sprayed with DDT to control flies. Salt marsh mosquito spraying frequently leaves a deposit of chemical on the shells. Loosanoff, Nomejko, and Tommers (1948) conducted tests at Milford, Connecticut, to determine whether DDT on substrata interferes with the reception of oyster spat. These men, using DDT and kerosene, found that neither substance by itself inhibited the rate of oyster setting. However, when the shells were dipped into a 5% DDT solution in kerosene for 30 seconds, the setting on the shells was reduced somewhat. This reduction was not appreciably changed when the treated shells were kept in air for several weeks before planting. DDT in xylene-Triton emulsion was found to be more toxic than its solution in kerosene. When oyster shell piles were sprayed with 5% DDT in kerosene at the rate of one pound per acre, the rate of setting was not affected. The spraying at three and five pounds per acre showed that the intensity of setting was somewhat affected.

Observations on the setting of oysters on concrete collectors painted with a 5% DDT solution, with kerosene alone, and on untreated controls showed that somewhat fewer oysters set on the DDT-painted collectors than on either of the others. The untreated control collected the largest number of spat. Established oyster beds were sprayed with DDT in kerosene and in emulsion form, at the rate of 1.5 pounds per acre, causing no unusual kill among young or adult oysters. The beds receiving the emulsion treatment did not exhibit a lighter set than either the control beds or those sprayed with DDT in kerosene.

Dipping adult oysters into a 5% solution of DDT in kerosene did not significantly affect their rate of growth or increase in weight.

Oysters in water treated with one and two ppm of DDT emulsion survived exposure up to 8½ days. It is not likely, therefore, that mosquito control treatments would seriously affect adult oysters. However, the possibility of indirect effects through destruction of food organisms or oyster larvae should not be overlooked.

Patuxent Research Refuge in Maryland was the scene of some 1947 work dealing with the toxicity of new insecticides to quail. (Linduska and Surber, 1948.) Fish and Wildlife Service biologists sprayed the vegetation in identical floorless brooder coops, each with one of the following chemicals at the rate of five pounds per acre: wettable DDT, TDE, benzene hexachloride, and chlorinated camphene. Ten male and ten female quail were then introduced into each pen. A normal diet of food and water was provided the birds. Within two or three days, all vegetation in the pens was eaten by the quail, and on the tenth day, when the test was concluded, no ill effects or loss of weight were recognized.

The second phase of this experiment entailed feeding the same quail a diet containing 0.025% of the same chemicals used previously. At an earlier date, 0.025% DDT in the diet of young quail had been found lethal to 50% of the birds in two months.

Extreme excitability was noted among the DDT-fed quail on the eighth day; three individuals died on the eleventh day. Two females in the TDE group were found dead on the fourteenth day. On the thirty-second day a female in the chlorinated camphene pen succumbed, but it is suspected that this bird may have been more susceptible than the average, due to her light weight at the beginning of the test. A male fed benzene hexachloride died on the thirty-fourth day, and the test terminated on the forty-fourth day. The toll was: DDT — three deaths; TDE — one death; benzene hexachloride — one death; chlorinated camphene — one questionable death. The birds fed DDT showed the least gain in weight.

Evidence of a trend toward standardization of testing methods is seen in a recent paper by Prevost, Lanouette, and Grenier (1944). These workers pointed out the necessity of using adequate volumes of water in toxicity experiments on fish. Fish in DDT-treated water absorb quantities of the chemical and lower the concentration of the toxicant. If the volume of water per fish is particularly low, a relatively high reduction occurs, yielding misleading results. The same starting concentration of toxicant in a larger volume of water is affected to a lesser extent by the activities of the fish, and the experiment proceeds to its termination with the toxicant at or practically at full strength. As the authors pointed out, many toxicity experiments exhibit discrepancies which can be accounted for on this basis.

The adoption of principles of this kind by all investigators of fish toxicology promises to help bring into agreement the results of workers from different regions. The growing tendency to report essentials of methods and water conditions will also contribute in no small measure to an understanding of the full indications of results.

Other Studies

While the studies discussed above were in progress, a great deal of routine testing was being done in connection with fish. Researchers have been building onto our previous knowledge by testing new chemicals, new formulations, hitherto untested animals, and by repeating older work in new situations. All this has aimed toward the establishment of thresholds of tolerance for as many combinations as possible, and has extended much further our bases for management.

Much of what is known about the effects of insecticides is based upon observations made in connection with forest insect and orchard insect control operations, involving amounts of toxicant far exceeding those used in mosquito control work. Nevertheless, it seems advantageous to summarize some of these results in order to appreciate the relative toxicities of the various chemicals.

DDT

Hoffman and Surger (1945) reported on an aerial application of wettable DDT at one pound per acre made at Back Creek, West Virginia, in 1946. The actual deposition on the streams in the area was 0.49 pounds per acre. Of the warm water fish confined in live cars, 10% were lost. The stream bottom insects on riffles showed a 70% reduction, with the Coleoptera and Hemiptera proving very resistant. In 1947, when the insect bottom fauna was seen to have recovered completely, the same area was again sprayed. The 1947 treatment was with DDT in oil, and the rate of deposition was 0.27 pounds per acre. This treatment reduced the stream bottom insects by 90%, and affected the Coleoptera and Hemiptera as drastically as other groups. Fish mortality was somewhat heavier in 1947, and larger fish were killed.

In the laboratory, Everhart and Hassler (1948) tested 1½-inch hatchery brown trout against DDT at one ppm. The wettable formulation produced 50% mortality in 34¾ hours, the xylene-Triton emulsion did the same in 2½ hours, and DDT dust killed no fish in 100 hours.

Benzene Hexachloride

Surber (1948) tested the beta, gamma, and delta isomers of benezene hexachloride in acetone solution against rainbow and brown trout at Leetown, West Virginia. Strengths of 0.05, 0.2, and 0.5 ppm were used, with the following results:

The beta isomer showed no effect.

The delta isomer affected locomotion at the higher strengths, but all fish recovered.

The gamma isomer killed all fish at all strengths.

An experiment on daphnia with a field formulation of benezene hexachloride at one pound per acre (0.18 ppm) showed no mortality to bluegill sunfish, goldfish, sculpins, creek chubs, and several other minnows.

Chlorinated Camphene

Tests at Leetown in 1948 further emphasized the extreme toxicity of chlorinated camphene. In outdoor ponds, a treatment at 0.125 pounds per acre (0.02 ppm) killed silverling minnows, creek chubs, and some other minnow species, only goldfish surviving. Trout were killed at the 0.005 ppm level, and bluegill sunfish demonstrated a threshold at 0.01 ppm.

Chlordane

At Leetown, one pound per acre of chlordane in fuel oil killed 87% of the bluegills tested. At 0.5 pounds per acre, most of the fish survived, while at 0.25 pounds per acre, practically all the fish survived.

Tetraethyl-pyrophosphate

Tetraethyl-pyrophosphate has been tested by Surber for initial toxicity thresholds and for decrease in toxicity after periods of time. The results indicate that tetraethyl-pyrophosphate is about as toxic to fish as is DDT, exhibiting mortality at 0.25 ppm and above.

Parathion

Preliminary studies on parathion showed that rainbow and brown trout withstood up to 0.378 ppm, and that the threshold for bluegill sunfish lies somewhere near 0.2 ppm.

TDE

Surber's tests on bluegills with TDE involved strengths from 0.125 to 0.2 ppm. No kill occurred at the low strength, 40% of the fish died at 0.05 ppm, and the highest strength was lethal to all the test fish.

Methoxychlor

Methoxychlor in acetone solution killed all fish tested at 0.15, 0.10, and 0.05 ppm. At 0.025, the average survival of the fish was 75%.

Summary Statement

It is still too soon to list the relative toxicities of these chemicals to fish. It is true that certain of the group have properties that are easily recognizable, such as the extremely poisonous nature of chlorinated camphene and the relatively mild toxicity of benzene hexachloride. Between these two lies the remainder of the toxicants, whose strengths in relation to DDT is known for some formulations, but which await results of current studies for clarification.

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Mr. Stage: I think Dr. Bishopp rightfully left a most interesting paper to the last of the program; this is to be by Dr. A. B. Lemmon of the California State Department of Agriculture, and he is going to discuss the toxicity of the new insecticides.

THE TOXICITY OF INSECTICIDES TO MAN AND DOMESTIC ANIMALS

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Handling an insecticide is somewhat like handling a mule — one has to make it work, but must never forget that there may be kick-backs. The past few years have brought a deluge of new chemicals for control of mosquitoes. Many of these compounds are more powerful than any of those formerly available and, being more powerful, may be more dangerous to use. This is by no means always the case, but some of the new chemicals present dangers with which we are not yet completely familiar.

There are many types of hazards, and all must be considered if accidents and damage are to be avoided. There may be dangers during application. For example, a material may be flammable or it may produce vapors or mists that are toxic to the operator. There may be dangers to the area treated. For example, it may injure valuable plants, or livestock, or wildlife. Danger is still possible after the material is applied. Residues on forage crops or food crops may be deleterious, or water supplies may be contaminated. Furthermore, danger may still lurk long after the job has been done. Disposition of empty containers presents a very serious danger in the case of some distinctly poisonous chemicals such as sodium fluoroacetate, sodium arsenite solution, and lead arsenate. Particular care is necessary in disposing of empty containers which have held 2,4-D herbicides to avoid damage to valuable plants. Fortunately not all the chemicals used in control of mosquitoes generally present such a serious problem as do some of these others, but care is needed to make certain that left-over portions of material are not set aside in improperly labeled containers or stored where they may cause injury years later. An unlabeled container of a hazardous chemical is like a loaded gun — or worse, it is like a gun that isn't known to be loaded.

We in the Bureau of Chemistry are probably more conscious of labeling than anyone else. Being in the middle, between the manufacturers and the users, naturally we hear more than anyone about the thousand-and-one things that can go wrong or be misunderstood. Adequate labeling is a matter of primary importance in the handling and use of agricultural chemicals. To a certain extent, it is perhaps of lesser importance in mosquito abatement, because the chemicals are handled only by individuals who have had some training in their use, and who have some knowledge of their dangers.

The hazards involved in use of some of the older chemicals, such as Paris green and petroleum oil larvicides, became generally known and the chemicals were used with knowledge of how they might cause injury or damage. Similarly, common knowledge has served fairly well as a guide in handling poisonous chemicals such as nicotine, sodium arsenite, and hydrogen cyanide. Sometimes common knowledge is not common enough. It was not known fully enough that sodium fluoride was a distinctly dangerous chemical until it had caused several mass-poisonings and dozens of individual tragedies. This is an expensive way to gain an education.

In California, each insecticide, fungicide, or other pest control product must be registered with the Bureau of Chemistry as an economic poison before being offered for sale. It is our responsibility to refuse registration for a product that is of little or no value for the purpose intended, or which, when properly used, is detrimental to vegetation, except weeds, to domestic animels, or to the public health and safety. A specimen of the proposed label for each product is carefully examined before the product is registered. In order to be in a position to judge the acceptability of an applicant's label claims, it has been necessary to accumulate available information concerning toxicity of economic poisons. We have not been able to carry on original toxicity studies in our own laboratories, but have relied on the data supplied by public agencies such as the Federal Food and Drug Administration and the Insecticide Division of the Production and Marketing Administration of the United States Department of Agriculture. Also considerable data have been secured from some of the large private laboratories operated by industry. We have tried to summarize some of this technical information in common terms that show the relative toxicities of the different chemicals.

When DDT first appeared on the scene in the Fall of 1945, it was probably the first agricultural chemical to be marketed extensively before adequate information was available with regard to its possible hazards. The armed services had used it for about two years and had developed considerable information. Civilians did not know whether it was as innocuous as dusting sulphur or as poisonous as strychnine, but everyone wanted it. Since then, of course, much scientific information has become available. We know that DDT is definitely toxic to human beings, but not alarmingly so. At least we know that it is less dangerous than many other chemicals now in common use.

Accurate toxicity data are necessary in considering the potential usefulness of new agricultural chemials, but adequate information of this kind can be obtained only by long and costly investigation. The chronic toxicity of a chemical can be estimated only after prolonged tests on many laboratory animals extended over at least one or two years. Also it must be kept in mind that the toxicity of a chemical differs with different species of animals, and a figure obtained with white mice may not agree with one obtained with rabbits, and neither may be directly indicative of the toxicity to human beings. Nevertheless such experimental data do give us some idea of the probable relative toxicities of various chemicals and what precautions should be taken in their use.

Our present information indicates that one of the most poisonous of the new insecticidal chemicals is TETRAETHYL PYROPHOSPHATE, also called "hexaethyl tetraphosphate, "Bladan", "TEP", "TEPP", or "HETP". It is estimated that a lethal dose of this chemical to warm-blooded animals is only two milligrams per kilogram body-weight. That means that about three drops of the pure liquid might kill a man. Roughly, this is about 125 times as toxic as DDT. The material is not only poisonous when swallowed, but it may be absorbed through the skin or inhaled as a mist. It has one fortunate characteristic, however, and that is its unstability. It may be applied to edible crops because in the presence of moisture it breaks down rapidly into non-injurious compounds. In fact, special precautions are necessary to see that it does not break down before it is used. Manufacturers prepare dusts containing the ingredient just before it is to be applied, and the dust is immediately delivered to the user for prompt application. This chemical is largely used for control of aphids and spider mites on plants. It does not seem to have been used for control of mosquitoes. One case of its misuse for control of mosquitoes came to our attention last year. A man in an experimental mood sprayed it beneath his house. Several hours later his son stood next to the house for some time firing a target rifle. The son was seized with convulsions and hospitalized for several days.

Each manufacturer of economic poisons has his own series of brand names which are usually some variation of a single key-term. Some of the brand name key-terms associated with tetraethyl pyrophosphate follow:

Agrifume, Bladex, Fosvex, Hexate, Hexatone, Hexcide, Hexidust, Killex, Nifos, Phosphofume, Tetra-chem, Tetra-cide, Tetra-tone, Tetron, Vapotone.

Next in order of toxicity is PARATHION, and it is almost as dangerous as tetraethyl pyrophosphate. One could probably stand up to five drops of the pure chemical — but more than that and he wouldn't stand. Roughly, this is about 70 times as toxic as DDT. This material is also readily absorbed through the skin. It is sometimes said that if you keep your mouth shut, you will stay out of trouble, but this isn't true with all of the new chemicals. Some of them can enter through skin and cause more injury than when swallowed. This is an important point that all of us should keep in mind. Half of one teaspoonful of parathion spilled on the skin of a man may cause his death if not removed.

We have made analyses of some vegetable food crops dusted with parathion dust and found that the material decomposes upon exposure. It does not decompose nearly so fast as tetraethyl pyrophosphate, but most of it disappears over a period of several weeks. It is being widely used on agricultural crops, and labels bear the warning not to use it on edible crops within thirty days of harvest. We understand that parathion has shown some promise for control of mosquito larvae, but the hazards of such use are not fully known. We do not have any specific data on how long the poisonous material may persist in water supplies, and this, of course, would be of primary importance in your work.

Technical parathion containing about 95% of the chemical is sold to manufacturers, but due to the extreme hazard of handling the concentrated material, it is available to users only in powders containing 15% or 25% of the pure chemical. Dusts containing 1% or 2% are in fairly common use in agriculture. Some brand name key-terms associated with parathion follow:

Alkron, Aphamite, Durathion, Genithion, Niran, PAR, Paradust, Parakill, Penphos, Phos Kil, Planthion, Thiondust, Thiophos 3422, Vapophos.

Next in order is CHLORINATED CAMPHENE. The lethal dose for a man is estimated to be about a teaspoonful if swallowed, or about one and a half ounces absorbed through the skin. Roughly, chlorinated camphene is considered four times as toxic as DDT. It has been used as an insecticide on cotton, but so far its high toxicity has discouraged use on edible crops until more is known with regard to the persistence of deleterious residues. Some of the brand name key-terms associated with chlorinated camphene follow:

Alltox, Penphene, Phenatox, Toxaphene (which has now been adopted as the common name of the material).

The chemical may have some use as a surface spray for control of adult mosquitoes, and preliminary work suggests that it may be of value as a larvicide.

Next is the GAMMA ISOMER OF BENZENE HEXACHLORIDE. As far as the figures on laboratory animals indicate, a man might die from swallowing about two teaspoonfuls of this chemical. Roughly, this is considered twice as toxic as DDT. Like the others, this chemical is also dangerously absorbable through the skin.

The chemists call it benzene hexachloride or hexachlorocyclohexane interchangeably, and the initials HCCH and BHC are commonly used. The British use Gammexane, but this is a trade name for the gamma isomer. When first discovered, the chemical was commonly referred to as "666" from its formula $C_6H_6Cl_6$, but since "666" is the patented name of a cold remedy, the manufacturer threatened to take action against the improper use of its brand name. Some investigations indicate that the compound by any name smells just the same. Other investigations indicate that the purified isomer has a less obnoxious odor in actual use than the mixed isomers. The facts are still somewhat obscure.

The objectionable odor of some preparations containing this compound has limited use of the materials as space sprays for control of adult mosquitoes, but the chemical appears to have considerable promise as a larvicide. Minute traces of the chemical absorbed by plants, particularly root rops, have rendered them inedible by imparting a distinctive musty odor. It is believed that the contaminated food is not dangerous from a health standpoint, but some of it is definitely and permanently unfit to eat. This is a rather new type of damage and serves to emphasize the fact that we learn something new every day concerning economic poisons — sometimes to our advantage and sometimes to our chagrin

Economic poisons containing this chemical are being widely used for control of a number of pests of agricultural crops and livestock. Some of the brand name key-terms associated with it are:

Bentox	Gamtox
Chem-Hex	G-Tox
Gammacide	Isotox
Gammaloid	Lexone
Gammoxo	

Next we come to DICHLORO DIPHENYL TRICHLOROETHANE or DDT. This has been so widely used that it has become a sort of yardstick or baseline by means of which both the values and the hazards of other compounds may be compared. Unless we differ greatly from the laboratory animals used to investigate the toxicity of this chemical, a man might be killed by swallowing about one-half of an ounce of the chemical, or about one tablespoonful. It may also be absorbed through the skin, particularly from oil solution. One of the peculiar hazards connected with use of DDT involves its absorption by animals and its storage in the fatty tissues. Small amounts do not seem to injure livestock feeding on contaminated forage, but appreciable amounts of the unchanged chemical appear to be retained in the fat of the animal and excreted in the milk of dairy cattle. Whether these amounts present a serious danger to the animals or to human beings who eat the meat or drink the milk from affected animals has not been established, but there is no question that the matter is serious enough to warrant extensive investigation. Hundreds of economic poison products containing DDT for one purpose or another are registered for sale in California, but most investigators are so famiilar with them that there seems no purpose in listing representative key-terms, as we have done for other chemicals.

Next in order we come to compounds less toxic than DDT. The first ones are the ORGANIC THIOCYANATES commonly marketed as a series of different "Lethanes." They are approximately half as toxic as DDT when swallowed, but more toxic when absorbed through the skin. That means that about two tablespoonfuls taken orally might kill a man. They have been used both as a space spray for adult mosquitoes and as larvicides.

CHLORDANE is in the same order of toxicity — about half as poisonous to animals as DDT. In other words, the experimental data on the acute oral toxicity of chlordane to laboratory animals indicate that a man might be killed by swallowing one ounce of this chemical. This material is more toxic than DDT when absorbed through the skin. Chlordane is being widely used as a household surface spray for control of adult mosquitoes but seems not to be promising a a larvicide. Brand name key-terms associated with the chemical follow:

Budane	Dowklor
Chlor-Dust	Octaklor
Chlorotox	Velsicol 1068
Chlor-Spra	

ISOBORNYL THIOCYANOACETATE is about one-quarter as toxic as DDT. Probably about two ounces would be needed to kill a man. It might seems that we are getting up in the beverage class now, but these high figures don't mean that caution is unnecessary. These are the lethal doses. Smaller amounts may still be distinctly injurious, and a man can get deathly sick without dying. This chemical has been widely used in household sprays and in livestock sprays, but seems not to be used a a moquito larvicide. The most common brand name product is Thanite.

Next is DICHLORO DIPHENYL DICHLOROETHANE, commonly called DDD or TDE. It seems to be about one-tenth as toxic as DDT. It must be remembered that we have been estimating the acute oral toxicities of these chemicals. There is little or no relationship between the acute toxicity of a chemical and its chronic toxicity. A compound may present no signifiant danger of acute poisoning and yet very small amounts absorbed over a period of time may be injurious. Data on the chronic toxicities of many of the new chemicals are incomplete. However, the preliminary information indicates that this particular compound does not have a significantly high chronic toxicity. The trade name key-term most commonly associated with the chemical is Rothane D-3. The chemical has been used for control of adult mosquitoes and also as a larvicide.

The last chemical in this short representative list is METHOXYCHLOR. It is also called dianisyl trichloroethane and methoxy DDT. It is believed to be only about one thirty fifth as toxic as DDT to human beings. By way of comparison with the other chemicals, this would indicate that a man would have to eat nearly a pound of the pure material to demonstrate that it was lethal. Methoxychlor has a more rapid action than DDT on some insects, but it is not as long-lasting nor as potent to many of them, so larger dosages are needed to obtain an equivalent kill. It has been effectively used both for control of adult mosquitoes and for their larvae. Brand name key-terms associated with the chemical are Marlate, Anisate, and Orthotox.

To recapitulate the rough approximations given for these chemicals, the lethal doses for an adult man are probably somewhat as follows:

Methoxychlor	One pound
DDD	One-half pound
Isobornyl thiocyanoacetate	Two ounces
Chlordane	One ounce
Organic thiocyanates	One ounce
DDT	One tablespoonful
Gamma benzene hexachloride	Two teaspoonfuls
Chlorinated camphene	One teaspoonful
Parathion	Five drops
Tetraethyl pyrophosphate	Three drops

We might call this a suicide's menu. Perhaps some of the figures are too large and some too small, but they seem the best estimates that can be made with the available data.

It should be noted that straight materials are used by manufacturers to prepare ready-to-use formulations containing only a portion of the toxic chemical. These formulations are the products sold to the general public.

The toxic action of any chemical depends upon a number of factors such as the individual's susceptibility to that particular type of poison and his condition at the time of exposure, the other compounds present, the physical form of of the material, and the nature of any previous exposure. Anything that favors absorption usually accentuates the toxicity; for example, some of these compounds are much more toxic in the form of oil solutions than they are as dry dusts. In other words, there is no guarantee that the amounts just listed will kill every man who swallows them. On the other hand, much smaller amounts than those given might in some cases end all interest in mosquito control.

Mr. Stage: Before throwing this symposium open to general discussion, I shall ask President Gray to summarize the symposium.

Mr. Gray: Chairman Stage, I have been listening here for some little time with a congested and buzzing head. I am impressed and completely overwhelmed with the details that have been given to us. I cannot digest them. I have not the wit nor the receptive capacity to adequately summarize this remarkably excellent symposium. If we had the time to study the literature that is coming out now on various insecticides, we would not have time to do any work, and by the time we studied what we now have we would have a whole lot more and we would still be behind the eight ball.

One thing I noticed about what Dr. Travis had to say was that the limits of military uses of DDT are the limits of DDT itself. After a certain amount of experience with the Military myself I wonder if it is not the limits of the military mind that we are up against, remembering that the commanding officer always has the last say, not the medical officer nor the technical officer.

I was very much impressed with Mr. Lynch's results at a very reasonable cost. I think that is a distinctly interesting and valuable contribution he has made to you. I shall not attempt to analyze all that he had to say, but shall merely point out the skill with which he has combined economy and effectiveness.

Mr. Mulhern, as usual, has presented a considerable amount of information from which I can only pick out one or two points that we can summarize within the limitations of time we have. He called attention to one problem all of us have had to face and will face in the future. That is the problem of polluted water or water of very high organic content, which makes an appreciable difference in the effectiveness of the materials used, whether they are oils or the chlorinated hydrocarbons. This is not an ecological problem, but is a chemical-physical problem which very definitely affects and puts a limitation upon the effectiveness of any of these materials. One thing also that we might mention in connection with what he has said is that the pyrethrum larvicide and pyrethrum itself is not obsolete. There are places where it is valuable, and I do not believe it will ever be entirely substituted for by any other materials. Where you need kill with no toxicity it is still excellent and still usable.

He mentioned the matter of bee-hives. In California we have had some experience with the bee problem in connection with mosquito control work. Chester Robinson in particular and others have had it and our reports have always been to the effect that there is no material increase in mortality among the bees. But just recently I had a letter from India which indicates that careless use of DDT has caused severe mortality among silkworms and a very appreciable economic loss.

In Dr. Bradley's paper it was most interesting to compare the residual spraying results in last year's CDC program with the reports presented for 1947, and with the reports by Mr. Macready for the United Fruit Co. But there is one thing that must always be kept in mind, however. The usefulness and ultimate effects of these insecticides cannot be judged safely on the basis of only a season's use; we must carry out observations probably for several years. I think that is particularly true in regard to the problem of malaria reduction. One season's application may so affect the balance of malaria transmision that it may carry on without any further use for several years.

We cannot disregard the ecology and habits of mosquito species we are attacking with residual sprays. With certain vector species it would be a waste of time, effort, and materials to spray the interior of houses and expect to have any effect upon transmision of malaria. But with other vector species DDT residual has a very direct, positive, and definite effect upon malaria transmision. Know the *habits* of your mosquitoes!

I am particularly pleased to see Dr. Cope here. I want to emphasize the fact that the mosquito people are asking the wildlife professional personnel, the conservation people, to sit in with us. This is good proof that we are not trying to do a destructive job. Mosquito people have a conscience so far as conservation is concerned. We have had some wildlife "yahoos" among conservationists who have been guilty of reckless and irresponsible attacks upon mosquito abatement people, but they have not been trained conservationists. We definitely call the attention of everybody to the fact that the mosquito people desire and solicit the guidance and assistance of the conservationists. We expect cooperation from them and we expect to give cooperation.

Dr. Cope calls attention to one matter that is frequently overlooked and is important, that is formulation of insecticides. In relation to the results obtained, solvent and emulsifier may be as important as the active insecticide itself and the method of application.

Dr. Lemmon impressed me with his presentation of the precautions necessary in handling these materials. If you understand their toxicities they are less dangerous than if you are proceeding ignorantly. Many of them, particularly DDT, are safe if you know what you are doing and operate on a sane and sensible basis. But if there is less danger in the use of these toxicants by mosquito abatement personnel because they can be presumed to have some knowledge of them, a very definite responsibility is placed on us, which we must fulfill competently and with good judgment.

I wish particularly to compliment Dr. Lemmon on his interesting presentation of comparative toxicities of these chemicals in terms of what dosage may kill a man. I cannot readily visualize toxicity in terms of milligrams per kilogram; I can visualize toxicity in terms of teaspoonfuls per man.

We have learned a great deal in this symposium; we can now proceed with greater confidence, but still with caution, for there is still much to be learned as to the effectiveness and limitations of these new insecticides.

Mr. Stage: Thank you, Harold. That was a masterful summary of a complicated subject. I think it is a very good example of a brilliant mind working under pressure against time. Now then, with the exception of your chairman, we have a battery of experts up here, and if you will fire questions quickly we will try to answer them. We have a few minutes left for discussion.

Dr. Sears: Is there any cumulative positive effect of DDT upon mosquito control workers?

Dr. Cope: As far as we know there hasn't been any proof of accumulation of DDT in field workers. I did see one report recently of an individual who had been using DDT in spray operations for a couple of years, and he had a fatty growth removed from his neck. The fat contained DDT. This indicates that human beings are not different from cows, and absorbed DDT will accumulate in the body fat of humans.

Mr. Stage: I will now turn the meeting back to the President.

Mr. Gray: Thank you, Mr. Stage, and thank you, members of the panel. It has been a very stimulating discussion. We will now adjourn until the banquet in this same room at 7:00 p.m.

(At the dinner dance, the convention was addressed by Hon. Joseph R. Knowland, Chairman, California Centennials Commission, who gave a very interesting talk on the early history of California and the centennial celebrations being held during 1948, 1949, and 1950.)

Wednesday, February 9, 1949

California Mosquito Control Association Day

Hotel Claremont, Oakland, California

The meeting convened at 9:35 a.m., with President Theodore G. Raley of the California Mosquito Control Association presiding.

Mr. Raley: Looking at your very alert smiling faces I have the pleasure of bidding you goodbye. I am retiring, and have the honor and pleasure this morning of introducing to you your new president, who is manager of the Turlock Mosquito Abatement District, Edwin Washburn, who will guide this association during the coming year.

Mr. Washburn: Thank you, Ted! It says on the program that there are to be remarks by the incoming president. I will make those remarks very brief, merely saying that I thank the California group for their vote of confidence in putting me into this responsible office. I trust that I can carry it out to your wishes. I can't do it all myself. Someone has to head an organization, but it takes the entire organization to really make the thing swing. Ted, on behalf of the California Mosquito Control Assocation I would like to present to you a small gift. We certainly appreciate your untiring efforts on behalf of the Association. You've done a big job.

Mr. Raley: This doesn't call for words. I am going to look. (He exhibited a fitted traveling case.) I do really thank all of you. This has been one of the nicest things I've ever received.

Mr. Washburn: The men handling the projection equipment would like to have any information in regard to film or slides to be shown this morning. Please see Dick Maynard by the machine ahead of time. Mr. Robinson, would you care to make any announcements in regard to the motorcade that starts tomorrow?

Mr. Robinson: Not at this time, but later in the day.

Mr. Washburn: We have a resolution to present, which I will read.

RESOLUTION
of the
California Mosquito Control Association

Whereas the California Mosquito Control Association, convened for its Seventeenth Annual Conference at Berkeley, California, on this ninth day of February, 1949, does desire to express its appreciation to the Department of Public Health of the State of California, now therefore,

Be It Resolved, that the California Mosquito Control Association does recognize and appreciate the invaluable assistance and many services made available to this Association by the Department of Public Health of the State of California during the past year, without which this Association could not carry out its functions and obligations in the manner so desired and needed by the mosquito abatement districts comprising this Association;

Be It Further Resolved that this Association is in full accord with the Department aims and objectives for mosquito control in general and vector mosquito control in particular, and pledges to do everything within its power to attain these aims and objetives;

Be It Further Resolved that the Secretary of this Association be instructed to transmit a certified copy of this resolution to Wilton L. Halverson, M.D., Director of the Department of Public Health of the State of California, immediately after the adjournment of this conference.

I would like to urge the adoption of this resolution at this time. Will someone take care of that?

Mr. Raley: Mr. President, I would like to move the adoption of this resolution.

Mr. Washburn: Do I hear a second?

Mr. Gray: Mr. President!

Mr. Washburn: Yes, sir.

Mr. Gray: With pleasure I second this resolution.

Mr. Washburn: Obviously it does not need discussion. I'll call for a vote. All in favor of passing this resolution indicate by the raising of your right hand. Any opposed? Carried.

Our first speaker this morning is our good friend. He has been a friend of mosquito abatement and mosquito control for a long time. I introduce to you Dr. Wilton L. Halverson, Director of the State Department of Public Health.

Dr. Halverson: Mr. Chairman, Ladies and Gentlemen. It's a great pleasure to be with you here today in a working conference. I would like to talk to you just a little bit about the World Health Organization. Some of you may think that is the only thing I know by this time. Dorothy Nyswander just told me that she has listened to me for four times and I'm a little concerned as to whether she is going to walk out on me, so I will be very brief.

The World Health Organization is one of these specialized agencies of the United Nations set up with the United Nations Educational, Social and Cultural Organization, the Food and Agricultural Organization, the International Civil Aviation Organization, the International Labor Organization, and another half dozen other specialized agencies that do a part of the work that the United Nations considered when it wrote its charter here in San Francisco in 1945. Following that meeting an International Health Congress was held in New York City in 1946 which was attended by representatives of 62 nations of the world, who considered and adopted a constitution for the World Health Organization. The stipulations of this constitution called for an all-out effort by the nations of the world to improve health conditions. It further stated that when 26 of the members of the United Nations had ratified this Constitution that there should be the first meeting of the World Health Assembly. Everyone presumed that this would happen about six months after the New York Conference, but actually it didn't take place for about two years. That was because many of the nations did not feel free to adopt the constitution because of unsettled conditions and other problems that occupied their attention and which they felt were more important. Some of them didn't want to join. At the Teheran conference, Mr. Stalin is supposed to have told an anecdote about a man in Araby who asked his neighbor if he could borrow his rope, and the neighbor who had the rope said, "I can't let you use the rope. I have to tie my milk up with it." Whereupon, the man who wanted to borrow the rope said, "I didn't know that you could tie milk up in a rope." The reply was, "Well, brother, if you don't want to loan your rope, one reason is as good as another."

When our Senate and House of Representatives were considering the constitution of the World Health Organization, they didn't do anything about it and didn't give much reason either, so we were one of the Nations who took the longest time to ratify the Constitution, in fact we got to it only about two weeks before the Conference was held in Geneva on June the 24th, last year. So that when the invitations went out to the various delegates of the Conference it became something like this — if the United States joins the World Health Organization, and if the President asks you to be a member of the delegation to this organization, will you accept? And that was the basis on which we worked until about two or three days before it was time to go. At any rate we all got there and carried on the very interesting program at the first meeting of the first World Health Assembly on June 24, 1948. There were actually 54 nations represented at that meeting. We met in the old home of the League of Nations, but it looks like a new home, because it is a magnificent building. We held our sessions in the Assembly Hall, that beautiful assembly hall that some of you have seen. There are four seats on the floor assigned to each delegation, although some nations did not have four members in their delegation. The United States had about eighteen.

One of the important projects is to make scientific and medical literature available to the countries of the world which have been starved for this information during the past ten years, and who now have so few dollars available to buy this literature that it is almost impossible for them to get it. One of the first bulletins of WHO to be issued will be a bulletin on malaria control, and one of the early projects is collaboration with the Rockefeller Foundation, and the Italian Government, in the Sardinian Anopheles eradication project. Dr. Aitken had hoped too be here to talk to you about this and present a paper, but the Rockefeller Foundation has indicated that it is not ready to present a formal paper at this time. I had the opportunity of visiting Sardinia just a few days after the meeting of the WHO, and I'll give you about 5 minutes worth of my impressions.

(NOTE: Dr. Halverson's discussion of the malaria control program in Sardinia is not reproduced, pending official publication of results and methods by the Rockefeller Foundation.)

Mr. Washbburn: Thank you, Dr. Halverson. That was certainly an interesting discussion of world problems.

One of the things that most abatement agencies have trouble with, and the thing we are always looking for new ideas on, is education. Our next speaker will give us some new ideas on methods and techniques of education to be used in our mosquito abatement work. Dorothy Nyswander, Professor of Public Health Education in the University of California, will speak on the "Uses of Modern Techniques of Public Health Education as Applied to the Work of Mosquito Abatement Districts." Dr. Nyswander.

Dr. Nyswander: Mr. President and Chairman, Members and Guests. By the predominance of the male of the human species here this morning it seems that the female human doesn't play as important a part in mosquito abatement as does the female Anopheles.

THE PLACE OF EDUCATION IN A MOSQUITO ABATEMENT PROGRAM

By DOROTHY B. NYSWANDER, PH.D.

Professor of Public Health Education
School of Public Health
University of California, Berkeley

I am either a very courageous person or else a complete fool in appearing before you today. I leave it to you to make the diagnosis at the conclusion of this paper. My experience as an educator in the field of mosquito control is limited. It is slanted toward the prevention of malaria in some work which I did with teacher-training institutions in Central and South America. Being thus limited, in an attempt to broaden my horizon, I have read a prodigious amount of material during the past weeks.

Some excellent reports are available in malaria control education. Not so prevalent, however, are documents showing the educational techniques that are being used when malaria is not the number one enemy. It is my opinion that we could well afford to borrow heavily from the educators who are fighting malaria to teach people *other* reasons for the war against mosquitoes, namely that the mosquito is an economic liability, a potential carrier of disease, and a "pesky" nuisance.

To many state departments of health, to the Army, to the published proceedings of meetings of various mosquito control associations, to certain individuals here in this conference, I extend my thanks for helping me understand some of your problems and operating procedures.

All of this help, however, is no safeguard that I will not miss the boat entirely. I can only say that the responsibility is mine alone. If I miss the boat, I will welcome a lifeline from any of you.

During the past years my task as a health educator has been to develop sound educational practices to improve the output of a group of professional workers. Fundamentally, then, there should be little difference between the educational principles basic to improving the work of public health nurses, clinic physicians, elementary school teachers, girl scout leaders, and those principles pertinent to improving the work of the staff of a mosquito abatement agency. All groups are giving services to the public; all require support for their programs by the public. Our educational objectives, then, in every instance are (1) to improve our services, and (2) to develop in the citizenry a type of support based on informed opinion.

If I had not your own words in writing to contradict me, I might well have thought, prior to my reading, that since a large part of a mosquito abatement program depends on activities such as spraying and drainage which cannot be the responsibility of any *one* citizen, you would have little interest in what the average person knew or felt about the program. Mosquito control, so I thought, like water purification or milk pasteurization or sewage disposal, is a large-scale operation. It calls for measures which, when once established, demand a minimum of participation by the individual in protecting himself.

I found that I was very wrong. True enough, a mosquito control program *does* entail assumption of responsibility for the overall protective operations, but it differs uniquely from the other broad public health measures in that its successful operation makes continuous demands on the cooperation of individual home owners, farmers, and industries. A department of public works which administers the water supply system of a town does not have to gain entrance to premises each time a hydrant is turned on, nor does it need to ask a householder to move the furniture or cover the foodstuffs whenever waste materials go down the sewer. Little help is needed from persons in the daily operating procedures.

There is still another difference between the overall sanitation program and that of mosquito control. Nearly every citizen in an urban area with a modicum of education knows that his government is giving him protection against impure water and milk and that he has a sewerage system. He knows, moreover, that he is paying for such services. Not so true is it that the same citizen knows he has the services of a mosquito control agency or that part of his taxes are going for its support. I ask you to verify this statement by an informal check among people who do not know you or your job. The situation might be different with rural people — but, are you sure you *know* what it is? Do you know how many citizens understand the services you are giving or what part of the tax dollar is taken out to finance these services?

This need for personal cooperation on the part of people receiving services and for year-to-year financial support by the taxpaying public brings us back to the educational objectives of the program, namely, *how to improve our services* and *how to educate the public.*

Any sound educational effort is based on the following principles. First, education is a part of a program of sound administrative planning. Second, administrative planning must be based on data provided by research. Third, administrative planning, operating programs, and education of staff and the public can only be kept alive and vigorous through continuous evaluation. Data which tell us what the specific problems are, planning based on these problems, operations which carry the planning into action, and periodic evaluation of both changing needs and operating practices — these are the cornerstones upon which education must rest.

There is no type of education which can strengthen a program that has been developed on false or weak premises. And the educator who would seek to improve the work of an operating staff or to interpret a program to the public where the basic data are not known or where systematic evaluation is not part of administartive direction would be rendering a third-rate service.

Because I accept these principles for education in a mosquito control program just as I accept them in any field of education, be it the teaching of arithmetic or the prevention of tuberculosis — it is not clear to me how an educational program both for the staff or the public can be effective without the services of a person qualified to determine the specific problems, conduct the necessary research, and evaluate the success of the operating program. I would judge that the active or consultative services of an entomologist were imperative for these phases of the program.

I have elaborated on the foregoing in order to make the point that it is a waste of money, time, and effort to introduce educational techniques into a vacuum. A sound administrative set-up is the first prerequisite.

Assuming we have an administrative program that stands on its four square bases of research, planning, operation, and evaluation, let us look at the different kinds of educational work we could be doing. It seems to me that there are four major areas. These are:

1. Education of the staff to do a better job.
2. Cooperative work with other agencies.
1. A *long-range* program of public education.
4. Informational services on current problems.

I would like to discuss each of these briefly.

1. *Staff Education*

Every member of the staff has potentialities for growing on the job. Where the administrator makes conscientious efforts to plan for such growth, he creates what is called "staff morale." Staff members need to feel that their work is important. They need, too, to know that they can make suggestions to improve the work of the organization. These are accepted principles in public administration. But they are principles often ignored by the "busy" director or by the director who "runs" his show with authoritarian efficiency. If the director wants the clerks, inspectors, and field crews to develop better performance in their work and respect for themselves and the agency, he must take time out to think *how* he is going to do it.

A program to help staff members become an integral part of the organization and to improve their work is called "in-service" education. Many approaches to staff must be used in such a program.

First is the *orientation of the new worker,* no matter in what capacity he is hired. The new worker needs to know what the purpose of the agency is; what are the problems that are being worked on; what different methods are being used; where his particular unit fits into the overall program; what important niche he personally will fill.

A second method is that of holding *regular staff meetings.* These meetings may be of two kinds. Some may be for all workers; some for only members of one division; some for top staff members. Each type of staff meeting has its own purposes. The best staff meetings are those which staff members have planned and carry out. The administrator who calls his staff together only when he wants to interpret a directive or to do all the talking himself is the fellow responsible for making staff members dread staff meetings.

A third method is that of holding *short institutes* periodically for certain staff members. Such institutes in public health, education, and agriculture are now accepted procedures. Staffs from several counties join together to study and discuss problems for periods of time varying from one day to one week. In these institutes good educational procedures are replacing the formal lecture and question-answer discussion periods. Some of these institutes might well be focused on the many problems of human relations.

Every inspector has an opportunity to educate in each of his contacts. If inspectors are like the rest of us who work with people, I suspect that they need a lot of help in this area of human relationships. I would think that some of the criteria by which successful public health nurses are judged when they visit homes might apply to the inspector who visits families and industrial sites. It is not sufficient to gain access to premises and do the needed task; the citizen has a tight to know why it is necessary and receive a report on the findings.

Obtaining trained personnel is becoming increasingly difficult in every agency. Training on the job becomes the only answer. It is significant that the Communicable Disease Center in Atlanta, Georgia, has recognized this problem and has developed films and film strips on all phases of operational techniques. In-service education is part of administrative planning.

2. *Cooperative Work with Other Agencies*

"Everyone talks about going to heaven" — but we're not too sure how many will actually get through the pearly gates. Everyone talks about cooperation; but the word often calls forth a cynical smile. Why is this? Primarily, I think, because the basic principles of cooperation have been violated so often in the past that we are getting tired of it. For example, asking for cooperation from the schools, to some administrators, means that the administrator and his staff decide they need a Mosquito Control Day or Week as the case may be. They figure out what they want the schools to do; they print some pamphlets; they even attempt to develop some teaching materials to be used in the classroom. If the superintendent of schools is a nice fellow he says that he will take it up with the school principals and teachers. But very little happens except that hundreds of children take home pamphlets which their parents don't read. Neither teachers, nor parents nor children really learn anything.

A true cooperative program would have been developed along radically different lines. The administrator would have met with the school superintendent and several of his staff to lay his problem before them. He would have asked how they, the schools, could help. And as a result, there would have been one or two teacher committees working with the agency staff to develop programs in the school and in the home in which children and their parents would participate. Cooperative programs imply joint thinking between agencies in the *planning stage; assumption of responsibility* for appropriate parts of the program; *active, not passive participation* by a maximum number of members of the other agency.

Certainly many public agencies should know about the mosquito control program of their area. Stubbs has pointed out the necessity of administrative and supervisory staff who work in housing developments, agriculture, industry and commerce, conservation and wildlife, and highway construction being aware of the hazards which, through ignorance, they create. This type of coordination again demands that the administrator possess insight into the techniques of working with other people.

There is still another reason why cooperation with other agencies is imperative. The best way to learn about mosquito control is through participation in a mosquito control program. McCauley in an article, "Malaria Education in Arkansas," tells how the Agricultural Adjustment Agency distributed form letters; Agricultural Extension Service workers and Home Demonstration Agents arranged meetings and the Farm Bureau gave help. In reading this account, I was struck by the kind and amount of education which the agricultural leadership had obtained and how far-reaching their influence could be.

Cooperating with other agencies, then, is an administrative and educational technique which not only provides sound bases for program planning in a community, but also develops informed personnel to spread the gospel through diverse channels not open to the staff of the mosquito abatement agency.

3. *A Long-Range Program of Public Education*

To teach people new facts, new ideas, and new practices takes a long time. The impatient man has no business in education. Human nature doesn't change quickly, and the impatient soul is only deluding himself when he believes that he has some high-powered publicity stunt that will bring results next week.

For this reason, society is placing more and more responsibility on the schools for initiating the kinds of education that are important for adult life. Education must start with the young. New ideas must be introduced before attitudes become fixed, values set, and practices hardened into habits. Whether we are interested in the democratic process, mental health, dental health, or learning to speak the English language — we know that the beginnings of these learnings are in early childhood. It is primarily to the schools then that we turn when we think of a long-range educational program in mosquito abatement.

Directed toward educating teachers to understand the reasons for the mosquito abatement program, its operation, and why every child and his parents should be aware that a mosquito abatement program is in operation — we find the beginnings of a plan which will bear fruit as the youngsters taught by the teachers grow into adulthood.

The efforts of the T.V.A., Mississippi, Tennessee, Georgia, and other states to teach teachers about malaria give us clues as to good procedures to use. In Tennessee during the summer of 1944 three workshops were held. To one of them came five teachers and a sanitarian from each of the eight counties near the college where the workshop was held. These forty teachers and eight sanitarians studied together for two weeks. Technical information was given them during certain periods of the day, but the greater part of the time was spent by the teachers in developing the materials which they would use in their own classrooms.

Previous to this, in 1942, Tennessee tried out another experiment. Twenty-six teachers were carefully selected from twenty-six counties and brought to Memphis, where, for a few weeks, they studied the principles of malaria control. Those teachers then returned to work during the summer as health educators for the county health departments. Later they incorporated in their classrooms what they had learned about malaria. The account of what this group of twenty-six teachers did in their communities makes interesting reading.

There are other excellent examples. Suffice it to say that what has been done in educating teachers, and through teachers, the children, can be done in any mosquito abatement program. In each community the problem is different. Education must be based on the facts as they exist in the local district and the local program. It should not be difficult for any district administrator or the education assistant on his staff to gain access to the teaching profession through their annual institutes, faculty meetings, and other in-service education programs carried on in every school district.

4. Informational Service on Current Problems

The district administrator has many ways of sensitizing the public to the importance of the agency's work. He may use these same publicity channels to give the public a better understanding of what each person's responsibilities are in the program. Unfortunately, it appears that often these channels of press, radio, poster, pamphlet, bulletin, and annual report are employed in ways that reveal little imagination or insight into educational techniques. They learned in Arkansas that not everyone can do an educational job; they learned:

> "That effective performance of this type of work required the application of exacting techniques in public relations. The educators must have the ability to influence people and conduct the work with imagination and initiative. Accomplishments of personnel assigned to the counties were in direct proportion to their possession of these abilities."

Let us take a brief look at what might be done with some of these media.

A talk over the radio by a professional person is usually a deadly affair. Why not have a high school class work up a round-table discussion of the work going on in the district? You tell your stories to the boys and girls. Let them tell it the public over the air.

The usual press release giving details of a meeting or an election of officers will be read by the people who were present at the meeting. Who else reads it? Why not give a feature story writer an opportunity to spend a day with your operating staff. Let him talk with your research man. Tell him some of your problems. Bring your work to life so that the public can get insight into the battles you are waging. Your stories are just as dramatic as any Dr. De Kruif has ever described.

When it comes to pamphlets I can only ask the question —*for whom* did you write it; *why* did you prepare it; how much consultant help did you get in writing it? Far too many pamphlets look as though they were attempting to answer questions which the writer had in *his* mind, not the questions of the reader. How many of you have undertaken a study to find out what the consumer really wants to know?

A few posters made by school children are worth more than all you can produce by the silk-screen process—that is if you want people to pay attention to them.

Then we have the bulletins and annual reports—a lot of work goes into these publications. Are you making the best use of them? When I read some of them, it seems to me that they were written only for the Board of Directors. Yet within their pages are facts of interest to every civic and professional group in the district. But it is hard work finding these facts in the rather dull writing which *is* the annual report. Only a few people, if they had the opportunity, would think it worth the effort to try to find them.

Many other agencies are streamlining their annual reports—a few pages; good photographs; captions that catch your eye; needs for the future clearly portrayed. Such annual reports are used in high school civics classes and teacher-training institutions. They have wide circulation and tell a good story.

Not enough use has been made of "conducted tours." Groups of all types—Boy Scouts, teachers, committees from the Parent-Teacher Associations and the Business and Professional Womens Club will get from "seeing with their own eyes" what no amount of publicity will provide.

Exhibits at county fairs are good. When staffed by volunteers from the community, the exhibit takes on a "participation" flavor that people like. And the agency achieves its purpose of being regarded as part of community life.

In summarizing the points I have tried to make in this paper, I want to ask a few questions.

1. When you hire a new employee, do you merely tell him when and where he is to report for work?
2. Do you think staff meetings are a waste of time?
3. Do you think that your staff have no need to get together with staffs from other districts to discuss techniques of work?
4. Is it your opinion that if the health department, the school department and the department of agriculture all tend to their jobs and let you tend to yours, you are on the right road?
5. Do you think that it would be worse than useless to work with the teacher-training institution in your district?
6. Do you think it of no importance that children and their parents should understand what your program is trying to accomplish?
7. Are you satisfied with your own efforts to tell the public about your work and get their cooperation?

If your answers to each of these questions is *YES*, then an educational assistant can either give you a tremendous amount of help or you are beyond all help!

To take a more serious vein, however, we see that educational techniques comprise an important part of the administrator's program. Techniques to help the staff do a more competent job and one that is more satisfactory to the public with whom they deal; techniques of working with other agencies; techniques of introducing your program to teachers; techniques of telling your story to the public; these are the skills which an educator brings to the program.

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Mr. Gray: If the program chairman had done nothing but to bring this one paper to you, I think that the entire Conference was well worth while. I knew Dorothy Nyswander was good. I didn't know she was that good. (Applause.) I would like to ask her one question. She is right here in the University of California amidst the Alameda County Mosquito Abatement District. Would it be possible for our district to make use of a graduate student on a research project covering the educational program of mosquito abatement districts, if the districts provide part of the funds on a scholarship basis?

Prof. Nyswander: I think that's possible—with some planning. Some of my students worked with the Mental Hygiene Association last year and we gathered data I think which were helpful to the Association. There are various things that can be done. One, for instance, is this knowledge inventory first of all. Then the second thing would be to construct some of the kinds of materials, and map the avenues to use for the program.

Mr. Washburn: We will proceed with the next paper on the program. Our friend, counselor and advisor, Dr. Freeborn, is going to discuss the relationship of mosquito abatement agencies with some of the other agencies of our government.

Dr. Freeborn: I was supposed to give this paper last year and I started out on it and completely bogged down on it, but I have been thinking about it for a year and I got so enthusiastic about it that I've got to read this paper in order to get inside my time limit.

THE RELATIONSHIP OF MOSQUITO ABATEMENT AGENCIES TO OTHER AGENCIES OF GOVERNMENT

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Public health ventures are divided very distinctly into two separate categories: those that are dependent on community action and those that may be administered by the head of the family — generally the mother.

In the great majority of cases those that require community action have, without exception, been based on convenience, comfort, and aesthetics rather than any deep-seated yearning for decreased morbidity statistics. The problems of water supplies, sewage systems, garbage disposal, and stream pollution fall within this category.

The phases of immunization, food contamination, public health education, prenatal care, public health nursing, and a myriad of other modern ancillaries of public health fall within the category of services which are much more adequately and effectively administered by public agencies, but which have been and could be covered within the individual family unit.

Mosquito control programs fall squarely athwart both of these categories. By carefully screening the premises, utilizing residual sprays within the household and regimenting the forays of the family to the out-of-doors, it is probable that family control would prove successful in protecting the health of the inhabitants. This procedure would, however, be a strictly palliative measure with little prognosis for improvement in the major problem. On the other hand, mosquito control undoubtedly falls in the category of public health problems that have had their genesis in increased convenience and comfort, although we have rationalized the expenditures on the basis of disease control.

The initial legislation in California for the formation of mosquito abatement districts was inspired by an attempt to supplant free-will offerings for mosquito control campaigns directed against salt-marsh mosquitoes by an equalization by means of a tax levy distributed over all the property owners who enjoyed the results. The earliest tax-supported campaigns in California were all directed against salt-marsh mosquitoes, which were violent disturbers of civilian comfort but in no way involved as vectors of disease.

Obviously, adequate mosquito control is a community enterprise. The individual property owner may control his own source of the plague but he is powerless to protect his premises from foreign sources. We often used to say in connection with *aegypti* control, however, that if every property owner in a community would abate all the mosquito nuisances on his own city lot on any given date that the city would make up the next morning to find that when the last adult awing had expired, the problem for that community had ceased to exist. Unfortunately, this is not true with the ordinary culicines, the anophelines, and the salt-marsh mosquitoes, which are not limited to man-made receptacles and the environs of human habitations.

In other words, mosquito control is a community project like water supply and sewage disposal, yet with opportunity for the individual owner's responsibility and cooperation to ameliorate the community load. Consequently, it would seem obvious that a different approach was indicated.

The early programs attempted to meet the issue by holding "Tag" days, community plays or festivals to raise sufficient funds to employ directors and laborers and purchase equipment for season to season campaigns which were extremely localized and almost as unpredictable as the source and magnitude of the funds. Of these early ventures in California, one of the most stable was to be found in a lumber town with a strictly supervised city saloon, the proceeds of which constituted the support of the mosquito abatement district. It was a "spirited" campaign.

In 1915, when legislation was enacted authorizing the establishment of tax districts for the purpose of creating a continuing source of funds for organized mosquito control, the thinking behind the legislation was far different from that which is in the ascendancy now. For years we had attempted to control mosquitoes through the enforcement of anti-nuisance ordinances. The owner who allowed mosquitoes to breed on his property was guilty of maintaining a nuisance. He could be forced to abate the nuisance or be brought to court to defend his negligence. The very name of the act under which we operate today, The Mosquito *Abatement* Act, is a tacit reminder of the function that the legislators had in mind when the act was framed. Our early meetings and professional literature were largely concerned with model nuisance ordinances and how best to enforce them.

The language of the act itself is largely concerned with the powers of the newly created districts and their boards to enforce cooperation and cause nuisances to be abated by recalcitrant property owners. The original legislation and with no fundamental changes, the legislation under which California districts are operating today, was designed to establish a legal body whose primary function it was to prevent the establishment or maintenance of mosquito breeding nuisances. For this purpose the legislature contemplated the employment of a trained superintendent, inspectors to find the breeding places and workmen to control emergency outbreaks and cooperate with landowners in establishing and maintaining permanent control measures. There was no idea of the personalized, valet-type of service that present districts are expected to render their clients no matter how negligent, careless or asocial their acts may be.

I would hesitate to defend the thesis that a mosquito control agency should be constituted as a police authority established for the sole purpose of compelling property owners to abate mosquito-breeding nuisances. However, I would have no hesitancy whatever in asserting that our present programs have far exceeded the expectancies of any reasonable demands. Why, I ask you, should a public-supported agency be expected to expend forty to fifty dollars every ten days to treat a low check in a farmer's alfalfa field because he refuses to construct adequate drainage facilities or negligently overirrigates. As a matter of fact, it is a disservice to the farmer to allow him to continue the malpractice, which is costing him substantial losses in crop values in addition to the expenditures that he is creating for his community.

One of the ablest mosquito control men that California ever produced was entomologically-trained engineer named Noble Stover. He was the superintendent of the first two Mosquito Abatement Districts in California — the Marin District and the Three Cities District — both primarily salt-marsh problems. He entered the "game" when it was primarily supported by voluntary contributions and was a leader in the inauguration of the police-power districts. He was a wise man, however, and although he had adequate police authority he was an ardent believer in education and cooperation. One of his first moves was to interest the owners of large areas of salt-marsh land in the possibilities of reclaiming them for agricultural use and incidentally remove them from their sole existing function of producing mosquitoes. He proposed to use his tax funds for strengthening levees and constructing tide gates if the owners would put in the major drainage canals and cultivate the land that had been released from overflow on the high tides. I don't believe he ever had a refusal from a landowner, and the results were miraculous. Communities that used to blow a "No School" whistle when mosquitoes were so bad that children could not be allowed out-of-doors, began to pester the mosquito control office if a lone mosquito was heard to buzz of a night.

Typical of his activities was an incident that occurred when it became rumored that the State was to build a superhighway skirting the marshes in his area along the foothills whose drainage led down into the marshes. Stover, who by that time had the complete confidence of every citizen in his district, visited each landowner whose property would be traversed by the new highway and exacted the promise that the owner would sell a right-of-way only provided that he had the privilege of approving the position, capacity, and adequacy of all drainage culverts on his property. The State Highway engineers who met this united front at every contact finally asked Stover to indicate the position, grade, and dimensions of all the culverts he wanted for the entire reach of his district. Today this stretch of highway is a model as far as perfect drainage is concerned, with no borrow pits, no culverts above grade, adequate run-off without flooding: in short — everything that most highways lack. I am sure that Noble Stover, who died many years ago, would ask for no more fitting memorial.

Perhaps you can guess from what I have said already that my thesis really is for progressive mosquito control. It is an integrated combination of sound biological procedure with all the existing agencies — private or public — that impinge on the problem.

Frankly, I don't think we have reached the point nationally when we can say that complete mosquito protection is the inalienable right of every freeborn American citizen. While 1½ million homes have no source of water within 50 feet of the house and almost a million domiciles lack even an outside privy, certainly we are not in a position to advocate a national "Fifth Freedom" — "Freedom from Mosquitoes." However, some areas have progressed faster than others in approaching the satisfaction of human wants and necessities. If a community is ready and willing to pay for the health protection and comfort that comes from adequate mosquito control, they should certainly be given the opportunity to obtain it both for their own protection and as an object lesson to other communities who may have similar aspirations. Even here, however, I can't reconcile my thinking to the belief that the public should condone the negligence and arrogance of the careless malefactor by assuming control of situations that are caused by uncooperative individuals.

From a social and public health standpoint, however, we must face the fact that there exist many areas with vector problems of high magnitude that lack the financial possibility of meeting the challenge of adequate control. It is very evident that in these areas, from the standpoint of wider social aspects, that subsidies or subventions which spread the cost over areas where the ability to pay is greater, should be inaugurated for the ultimate welfare of the whole. A very potent example of this idea is expressed in the residual spraying program of rural homes in the most malarial counties of the South inaugurated in 1945 by the U.S. Public Health Service. Neither the individual home owners nor the states concerned could have borne the cost of this program, which bids fair to be the final effort to eliminate from this nation the possibility of the recrudescence of a disease which at one time was a leading cause of morbidity and mortality in over half the states of the country.

However, the administration of subventions, whether they be federal funds allotted to the states or state funds subvented to organized districts, is most difficult and fraught with dangers of misunderstanding and mismanagement. Basically, the difficulties stem from two sources. In the first place, the dispensing agency is acutely aware of its responsibility to its Congress or Legislature for the effective and proper use of the funds. It consequently damands reports, establishes standards, audits accounts, and, when it is convinced that ineffective work or faulty management is responsible for uneconomical expenditures of funds, demands changes in the local procedures.

This thoroughly justified control is immediately responsible for the second basic cause of trouble. Any autonomous agency that is forced to depend for any considerable part of its support on a separate and superior agency of government, which attempts in any material way to control the expenditures, immediately seems to fall victim of an inferiority complex (if agencies have psychological reactions). Almost without exception they become supercritical of the dispensing agency, its personnel, and its established policy. It is illogical and foolish that such a condition should exist, but after working on "both ides of the fence" for many years, I am convinced that we are confronted with something basic in human nature that no amount of experience or education will overcome.

The solution of the difficulty may be in establishing a different method of subsidy. Once standards of methods, personnel, and equipment are established for different sized districts, the administration of subsidies could be accomplished much more easily by underwriting the expense of specific salaries or non-recurrent items of equipment on a line item budget basis. Fiscal accounting would be reduced to a minimum and there would be considerable reduction of the hazards that accompany expansions based on subsidies. An annual budget built on subsidies is only slightly more secure than those of our early efforts when public donations and local entertainments served as a source of revenue. For this reason, subventions should be governed by basic premises. (1) They should be temporary aids to perfect the personnel and equipment and should be allotted only while the emergency of "growing up" is real. (2) They should be granted to agencies with sound financial and biological programs. And (3) they should be allocated in proportion to the willingness to pay on the part of the recipient rather than the total amounts of offsets. Area and population numbers have little real significance in the assessment of a problem. I have seen more mosquito problems in terms of dollars and cents needed for control in four square miles in Arkansas than there are in the biggest districts in California.

The logical distribution formula could be based on the size of the problems at hand. This would not be an impossible job by any means, but it would be an extremely complicated one broken down into major drainage, maintenance, and larviciding. It is possible to designate areas through experience on a basis of the dollars per season per square mile and have the summation of the square mile costs closely approximate the annual expenditures.

However, I have a much easier and less complicated formula for determining need. Long experience as an administrator has taught me that the surest way to determine how badly an individual or an agency needs a particular piece of equipment, some new staff members, or more assistance, is to inquire as to how much they plan to spend from their own budgets toward defraying the expense of this new innovation. When they give until it hurts, I know they really need it.

The same principle applies exactly to agencies of government. When a community is realy anxious to tax itself up to forty cents for mosquito control, the need is far greater than in one which is perfectly content with the results obtained from a tax rate of less than five cents. It is obvious tha the latter group lacks either need or desire for better control.

In conclusion, may I bring up one more facet of the problem of the relationship of mosquito abatement agencies to other agencies of government.

As pointed out earlier, the mosquito abatement districts were organized in California as independent agencies answerable only to the people of their communities through a board of directors and the county supervisors. While their independence has enabled them to function with a minimum of red tape, this same independence has made lone wolves of them with the incident lack of cooperation. I realize full well that forced cooperation is an impossibility, and I would also be the last to accuse the mosquito abatement agencies of failing to cooperate. I think that any criticism would be of an attitude of mind rather than of fact. In other words, the mosquito control agencies have assumed their mandate to control mosquitoes a bit too literally. They have assumed that they were the sole agency responsible for mosquito control and have taken on the responsibility single-handedly to do, not only their own legitimate work, but that which is created for them by other agencies of government and by individuals.

I have seen a city district where fully 50 per cent of the mosquito control expenditures were created by the city water department. You have all been plagued with faulty or neglected sewage disposal systems and superintendents of streets who built tricky culverts and catch basins for the special entertainment of mosquitoes. City planning commissions through their zoning prerogatives have seldom thought far enough ahead to avoid mosquito-breeding pitfalls. Agencies in charge of impounded water projects have, in general, been most cooperative, but even here we have some glaring examples of ignorance and stupidity.

Apparently without question, the mosquito control agencies blithely take over the problems created by other agencies of government. In addition, they have adopted an attitude of either despair or resignation about the individual or corporate property owners who willfully create mosquito-breeding nuisances and meekly expend public money in periodic control, rather than create strained relations with a client who should be in court.

The mosquito control superintendent should be a party to the planning that precedes practically every development in his community in order that he may forestall unfortunate and costly mistakes. In addition, he should utilize his staff, particularly his entomologist, for the education of the public concerning their share in the cooperative venture.

To summarize this rather rambling presentation, I would like to leave the recommendation that public mosquito control agencies should become far more intimately concerned with the activities of other governmental agencies and far more aggressive in their demands that both public agencies and private ownership assume their rightful responsibility for avoiding the creation of nuisances and the correction of those that have been created already.

Mr. Washburn: I am glad we waited two years to hear that paper. It's really worth it.

So that you may know some of the other officers of the coming year, I'd like to turn the rest of the program this morning over to Jack Kimball, the incoming Vice-President of the California Association. Jack — take over.

Mr. Kimball: Thanks, Ed. The next paper on this morning's session is of vital interest to the various districts and to mosquito abatement agencies in California. The paper, "Progress of Mosquito Control Operations in 1948 in California," will be presented by Arve H. Dahl, Chief, Bureau of Vector Control, State Department of Public Health.

Mr. Dahl: This has really been a wonderful convention and I am not ashamed to say that I have enjoyed it. I have now been in California about two years. The first year I gave a staid old paper that really took you to task for what you hadn't been doing and bragged about what we had been doing. I was as serious as a staid old guy can be in his first year among fellows with whom he was not well acquainted. Last year I wrote a paper which I didn't give because I got the flu. I thought Sunday night I was going to be laid up with hospitality, but fortunately wasn't. I was given the title of this paper and I think it was an excellent one. It gives me a chance to deliver a bit of original thinking and a bit of analysis without getting down to specific detail on the state of our relationships, which I think are on the mend and which I have every confidence are going to lead to many, many years of excellent relationship.

PROGRESS OF MOSQUITO CONTROL IN CALIFORNIA

By Arve H. Dahl, M.S.

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I. Introduction

Progress — as defined by Webster — means movement forward toward a goal, gradual development or advancement toward maturity or completion. The ramifications of the word "progress" are manifold. Therefore, to be of value not only to mosquito control organizations within the State, but to present our California mosquito control porgram clearly to people from out of the State, I am taking the liberty of presenting this paper as a project proposal which can serve as a report to the world and a guide for us in the coming year.

A project proposal for mosquito control in California requires that the objectives, the problems, the knowledge available regarding control, what has and is being done to control mosquitoes, be clearly discussed before there can be an analysis of the progress that has been made. I shall not attempt to critically analyze that progress but shall present only some of the immediate challenges to our current program, followed by brief recommendations that I feel are appropriate.

II. Objectives

The objectives of carrying on mosquito control in California are threefold: public health, economic, and the enjoyment of living.

A. *Public Health*

Public health deals in the most valuable commodity, the human being. It is a field of activity which strives to prevent transmission of communicable diseases and to create a sanitary environment.

Malaria has been a relatively unimportant disease in California in recent years even though it once was common in parts of the Central Valley. Only once since 1924 has the malaria rate exceeded five per hundred thousand civilian inhabitants. During World War II intensive measures against *Anopheles freeborni* were conducted around military establishments and airfields because it appeared possible that the advent of large numbers of troops might set the stage for explosive outbreaks. However, neither during the war nor afterward did such outbreaks occur.

Another mosquito-borne diseasse of greater current significance in California is encephalitis. This disease has been reported from many parts of the State, but is considered to be highly endemic, insofar as the human population is concerned, only within the great Central Valley. Several species of mosquitoes have been demonstrated to be potentian vectors of the disease in the laboratory, and extensive field collections have found naturally infected mosquitoes, primarily *Culex tarsalis,* throughout the Central Valley. The epidemiologists advise the mosquito control worker that only through area-wide mosquito control effort over an entire season can he hope to protect the human population from encephalitis.

B. *Economics*

The economic benefits of mosquito control are likewise manifold. Prevention of loss of livestock due to encephalitis, greater butterfat production, and more egg production reported, etc., are common testimonials. Specifically, farmers have reported increased production by agricultural workers when mosquitoes have been controlled.

C. *Enjoyment of Living*

It is often the case that mosquito control is prompted by the desire of citizens in the community to obtain an environment free of mosquitoes to permit them to enjoy the out-of-doors in the warm summer evenings. Frequently real estate expansion has been prevented by the presence of a tremendous number of mosquitoes.

III. The Problem

The enumerated objectives to which we should strive indicate that practically all mosquitoes in California are of interest and a problem for the control worker. We can classify our problem under four general categories, which may or may not be complete: namely, irrigation and attendant problems; natural problems involving river overflow, etc.; domestic and municipal problems; and salt marsh mosquito control. All individual types of breeding sources fall within these groups. They are also the major general fields of activity with which the mosquito control worker in California has to work.

Irrigation and attendant problems include the tremendous problems associated with flood water mosquitoes. The most highly endemic mosquito-borne disease area of the State is the irrigated Central Valley. There are, annually, approximately 3,500,000 acres of cultivated land under irrigation in the Central Valley at present, and completion of the Central Valley Project will add 3 million more acres. In the summer months *Aedes* flood water mosquitoes are often on the wing three days after the field from which they emerge was flooded for irrigation purposes. Good irrigation practices limit the mosquito population. However, such problems as created by emergent crops such as rice are continuous throughout the season and they have, in addition, peak seasons of mosquito production.

A great majority of California is arid, and were it not for irrigation a considerable portion of the natural breeding areas which are maintained by waste irrigation waters would be dry and produce no mosquitoes. Natural problems involving river overflow, etc., are obvious to the mosquito control worker. Every spring there are heavy run-offs from the mountain areas, which overflow the banks of creeks, fill all small lagoons and ponds, affording tremendous areas which produce mosquitoes. In addition there are the natural areas which are flooded by spring rains, and the duck clubs and wildlife refuges on which man maintains standing water during a good portion of the mosquito-breeding season.

Domestic and municipal problems involve the inevitable sewer farm in California, as well as many other common mosquito-breeding places such as industrial wastes, cemetery flower vases, lawn irrigation, utility vaults, etc. These need no further explanation.

Salt marshes are listed as a separate item because they are the largest single problem in the coastal areas. They are handled largely by permanent control methods, using dikes, tide gates, controlled flooding, although considerable larval repetitive treatment is utilized. This specific problem can be handled under pretty uniform recommendations.

V. Knowledge Available Regardidg Control

California has a rich heritage in mosquito control. We have the best-known experts in mosquito control, including Prof. William B. Herms, Harold F. Gray, Dr. Stanley B. Freeborn. Their experience has proven the feasibility of controlling mosquitoes anywhere in California.

Certain sound principles have been set down to guide mosquito control agencies in the over-all planning and operation of their projects. These minimum principles were fourfold: I shall now make them fivefold after Dr. Nyswander's stirring paper on education in our work and enter a new principle as number one:

1. Education both in-service and of the community shall be continuously carried on.
2. A primary program on the incorporation of eliminative measures aimed at progressive reduction of known larval breeding sources and such supplemental larviciding measures as are required.
3. Adult mosquito control measures are presently recognized in California as a supplement to larval control and are included as a secondary type of control.
4. Entomological services to determine sources and species and effectiveness of control operations shall be continuously carried on.
5. Methods, equipment, and material should be reliable, efficient, and used with precision.

Since the war, and we can say, since DDT became available, the trend has been toward repetitive treatment. Other newer insecticides similar to DDT are also available, such as rothane, toxaphene, chlordane, and BHC. DDT permits the rural areas of California to be covered by larval control methods using light mobile equipment. No longer are heavy vehicles with tremendous loads of oil necessary. The greatest progress has been made in the science of larval and adult mosquito control by repetitive methods. While effort has been expended on incorporating eliminative measures aimed at the progressive reduction of known larval breeding sources, the least effort has been expended in this direction. Tremendous opportunities exist for advancement of permanent corrective measures, even in these irrigated areas where almost continuous water usage is essential during the major breeding season.

Operational techniques involving pre- and post-treatment inspection, section survey methods, education of agricultural groups to utilize good irrigational practices, etc., all are employed by the progressive mosquito control agency to evaluate and minimize control requirements.

V. What Is Being Done to Control Mosquitoes in California?

Local, State, and Federal agencies have combined to efficiently work together in attacking the mosquito control problem in the State.

A. *Local Agencies*

It is the policy of the State of California to support local agencies in attacking local problems. The Health and Safety Code of the State of California provides for the establishment of mosquito and pest abatement districts. These districts are local taxing, self-administered governmental units governed by a board of trustees appointed from the tax-payers of the District, who hire a manager or superintendent to direct the activities of the District.

During World War II the armed forces demonstrated the feasibility of mosquito control, and the advent of DDT made it economical for large areas to immediately institute mosquito control without primary dependence on permanent eliminative measures. In California there was an immediate expansion of mosquito abatement districts in the State, as is shown in the attached chart.

In addition to the local mosquito and pest abatement districts, some local health departments and other municipal bodies carry on mosquito control on their own. Only two of these agencies, Monterey County Health Department and the Los Angeles City Health Department, have active control programs which simulate the work in the districts.

At the present time there are 44 local mosquito control agencies operating in the State of California, of which 21 are operating under contracts with the State Health Department for doing mosquito vector control in addition to their general program. It is significant to note a few of the statistics on the districts in the State.

Those districts which were under contract with the State Health Department expended a total of $1,281,125.71 during the fiscal year ending June 30, 1948. I have selected one of the analysis charts which we have prepared on each of the contracting agencies to show how their activities are distributed through the year.

In addition, we have summarized the entire subvention operations for the fiscal year ending June 30, 1948, for the 19 contracting agencies. Collectively they reported 11,559 square miles of area under surveillance or control, 5,981 service requests handled, 1,702,770 miles of vehicular travel and the following operational details:

1. *Larviciding:* 69.95 tons of DDT and TDE (140,012 pounds DDT and 3,696 pounds TDE) and 27,000 gallons of oil were expended in the treatment of 743½ square miles (477,821 acres) of water surface; 10,605 cesspools, 43,252 catch basins; and 30,333 miscellaneous containers in both rural and urban areas. To accomplish this 89,580 man hours and 1,513¾ hours of airplane operation were necessary (18.6% of total man hours).

2. *Adulticiding:* 21 tons of DDT and TDE (42,458 pounds DDT and 52 pounds TDE) were used in treating 7,785 acres of building surface and 8,877 miscellaneous buildings in addition to 506½ square miles (325,886 acres) of area space treatment. All of this in both rural and urban areas with an expenditure of 25,191 man hours and 63 airplane hours (5.2% of total man hours).

3. *Drainage Construction and Maintenance:* About 50 miles (265,080 lineal feet) of ditches and drains, and 60¼ miles (318,433 lineal feet) of access roads were constructed. 98 cubic yards of dirt were moved in filling low areas. In adition, 198½ miles (1,048,192 lineal feet) of ditches required maintenance and 11,216½ acres of vegetation were removed. A total of 40,772 man hours were expended on these operations (8.5% of total man hours).

4. *Entomological Inspections and Surveys:* 147,326 man hours were expended on these operations (30.6% of total man hours.

5. *General Supervision and Engineering Surveys:* 54,466 man hours were expended on these operations (11.3% of total man hours).

6. *Clerical Assistance:* 30,012 man hours were expended on this operation (6.2% of total man hours).

7. *Public Relations:* 6,004 man hours were expended on these operations (1.2% of total man hours).

8. *All Other Operations:* Such as distribution of Gambusia, repair and maintenance of equipment, depot maintenance and construction, etc. required 88,273 man hours (18.4% of total man hours).

Of the total of 481,624 man hours expended during the year, 61.4% were chargeable to rural operations; 13.1% to urban operations; and 25.5% were unclassified operations.

All of the local agencies have made tremendous strides in the past few years and are constantly striving to improve the degree of control that they are giving in their areas. They are constantly prompted by their boards of trustees to work as effectively and economically as is possible. When taxing board members govern their own affairs they constantly desire to reduce their own tax rate. It is a good safety valve.

B. *State Agencies*

1. *State Department of Public Health, Bureau of Vector Control:* The State Department of Public Health has developed the Bureau of Vector Control to handle all field problems in connection with arthropods of medical importance. Last year at the conference we reported on the total field of responsibility of the Bureau, and at this meeting we merely wish to outline the activities of the Bureau with reference to mosquito control. The Bureau of Vector Control engages in endemic surveys, control demonstrations, and a control program in its mosquito program.

In the way of endemic surveys the Bureau has a responsibility for evaluating the mosquito-borne disease hazard and has carried out intensive encephalitis virus vector surveys throughout the State. In 1948 continuing surveys were made in the Central Valley by mosquito abatement districts with specimens submitted to the State Health Department for virus recovery. The Bureau of Vector Control concentrated its virus recovery work in the peripheral aeas of the State outside of the Central Valley. No recoveries of virus were made in these activities in 1948.

The control demonstrations carried on by the Bureau are largely tied in with the subvention program, which is also administered by the Bureau for supporting vector mosquito control operations of local mosquito control agencies. During the past years the Bureau has assigned personnel to the following studies: airplane evaluations, *Aedes* pre-treatment, rice field studies, ground aerosol studies, sewer farm studies, entomological survey methods, toxicity studies on new insecticides, and DDT residual studies. The purpose of each of these studies was to develop better techniques or secure knowledge to permit the local mosquito control agencies in the State to obtain a better degree of mosquito control. Many of these studies were carried on in direct cooperation with the local control agencies.

In the way of control programs perhaps the most significant factor which has aided in the development of mosquito control in California since World War II has been the State subvention for vector mosquito control. We are now in the third subvention program and the State has encumbered or expended some $1,260,000 during this period for assisting local mosquito control agencies. The legislation provides that the State Department of Public Health may enter into contracts with local mosquito control agencies and may cooperate on any programs under such terms and conditions as the State Board of Health may prescribe, except that under no condition could the State pay for more than 50 per cent of the total cost of a project.

The Department, to guide itself, created an advisory committee of recognized leaders in mosquito control from the University and local agencies. This advisory committee, together with the Department, developed principles which were used in awarding subvention monies. Experience now available will permit more formal awarding of subvention monies.

In addition to the administration of the subvention program, the Bureau of Vector Control acts in an advisory capacity to new areas desiring mosquito abatement. The Bureau contains a staff of professional engineers and entomologists experienced in mosquito control to assist in advising on local mosquito control problems. The Bureau maintains a technical information service which edits and prepares the monthly "Mosquito Buzz," which contains comments on control techniques and any information of value either to State or local interested groups. The technical information service also assists in identifying any insects that are sent to the Department. It assists in editing and distributing to the local agencies brochures for insertion in the California Mosquito Control Association Operations

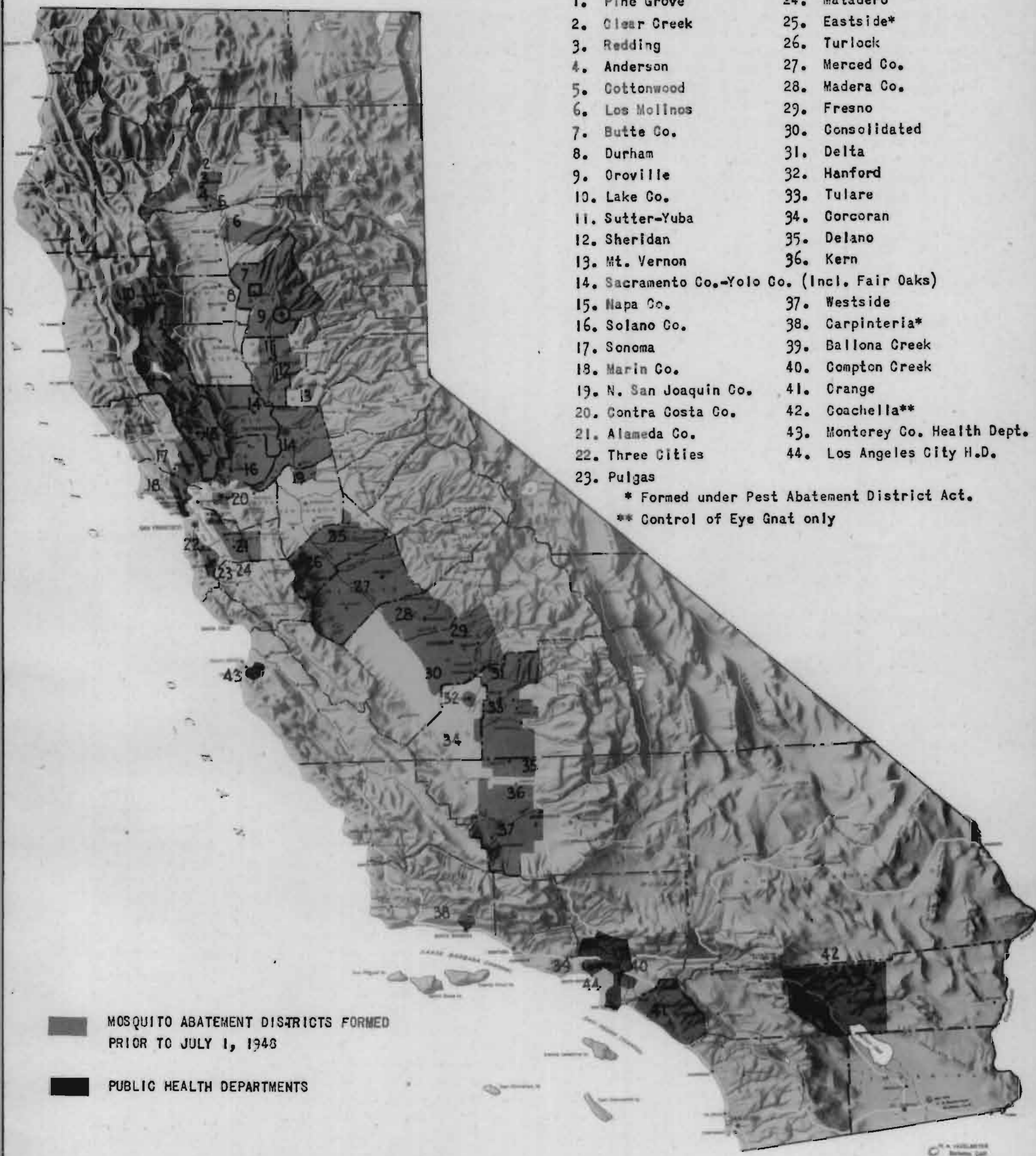
YEAR ROUND MOSQUITO CONTROL AGENCIES

LEGEND

1. Pine Grove
2. Clear Creek
3. Redding
4. Anderson
5. Cottonwood
6. Los Molinos
7. Butte Co.
8. Durham
9. Oroville
10. Lake Co.
11. Sutter-Yuba
12. Sheridan
13. Mt. Vernon
14. Sacramento Co.-Yolo Co. (Incl. Fair Oaks)
15. Napa Co.
16. Solano Co.
17. Sonoma
18. Marin Co.
19. N. San Joaquin Co.
20. Contra Costa Co.
21. Alameda Co.
22. Three Cities
23. Pulgas
24. Matadero
25. Eastside*
26. Turlock
27. Merced Co.
28. Madera Co.
29. Fresno
30. Consolidated
31. Delta
32. Hanford
33. Tulare
34. Corcoran
35. Delano
36. Kern
37. Westside
38. Carpinteria*
39. Ballona Creek
40. Compton Creek
41. Orange
42. Coachella**
43. Monterey Co. Health Dept.
44. Los Angeles City H.D.

* Formed under Pest Abatement District Act.

** Control of Eye Gnat only



MOSQUITO ABATEMENT DISTRICTS FORMED PRIOR TO JULY 1, 1948

PUBLIC HEALTH DEPARTMENTS

Manual. An abstracting service of all mosquito journals provides latest information to mosquito control agencies. During the past two years the Bureau has conducted a training program for local mosquito control workers. The latest operational activity of the Bureau involves the investigational unit which is to work on the Central Valley Project.

The Bureau of Vector Control is wholly in sympathy with the problems of mosquito control in the State and endeavors at every opportunity to develop and improve the control work done for the protection of the public health.

2. *The University of California:* Several units within the University of California have contributed considerably to the knowledge of mosquito-borne diseases and mosquito control in California. The University continues to carry on special studies and investigations on mosquitoes.

3. *The Hooper Foundation for Medical Research of the University of California* has done the most original research of any institution in the world in the field of mosquito-borne encephalitides. For a number of years they have maintained the special research investigation in Kern County studying human encephalitis. Practically all basic epidemiology has been completed by the Hooper Foundation and it was on the basis of their original work that the endemic conditions in the State were first made known.

C. *Federal Agencies*

U.S. Public Health Service Communicable Disease Center: The Communicable Disease Center activities of the U.S. Public Health Service in California are conducted under the direction of the Bureau of Vector Control. CDC had the responsibility for carrying on mosquito control activities during the war years around military establishments and airfields to guard against outbreaks of malaria. Surveillance of anopheline populations was carried on from the fiscal year 1943 to 1944 to detect the possibility of outbreaks. In 1947 the principal work was done around the international airports of entry because of fear of Japanese-B encephalitis being introduced. In 1948 these airports of entry were contained within local mosquito control agencies receiving assistance from the State for doing mosquito vector control, and the personnel assigned to the Bureau of Vector Control by the CDC became an active part of the total program of the Bureau.

In addition to the activities performed by CDC personnel within the State, the CDC has supplied through its Technical Development Division many techniques which have been adopted by mosquito control workers. They have provided supplies and equipment and many training aids, which have been invaluable in developing mosquito control.

From the foregoing comments it can easily be seen that the activities of local, State, and Federal agencies are complementing each other in the total mosquito control effort in California.

VI. Major Challenges to the Current Program

In looking over the total project proposal as developed there appear to be perhaps two major challenges that the mosquito control worker should concentrate on. These are: the economics of mosquito control, and the relationship of the Central Valley Project and irrigation to mosquito control.

First, with reference to the economics, there has to be more tangible evaluation of the value and cost of intermittent versus permanent mosquito control measures. In connection with the economics of control work today we must recognize that a good portion of the monies expended for mosquito control are provided by State subvention. The duration of such aid is a questionable quantity, and every effort should be made so that operations can be continued should such State aid cease. Accordingly, it is necessary to evaluate closely the costs of various types of operations so that in the near future the most effective and economical techniques can be employed.

The second major challenge to the State will be the effect of the Central Valley Project and increased irrigation on the long-range program of the mosquito control agencies. To date irrigation has developed slowly and the total effect has been felt gradually. Now in a relatively short period of time will be imposed a tremenodus water load upon the agricultural areas, and it is doubtful whether we can expect all areas to utilize proper irrigation practices.

VII. Recommendations for the Future Program in California

In conclusion, before opening this paper for discussion, it is the desire of the Bureau of Vector Control to present a few general recommendations which apply to the program wherever it exists in the State. These are:

A. That there be a real appreciation of the problems as outlined by this project proposal by all concerned. It is necessary that every mosquito control worker endeavor to do a better job accordingly.

B. That we resolve at this meeting to realize all local, State, and Federal agencies are working on the same problem toward the same objectives.

C. Finally, it is recommended that the California Mosquito Control Association accept the challenges which I have presented as major problems which the Association can materially aid in solving. I again assure you of the support of the Bureau of Vector Control in attacking these challenges.

Mr. Kimball: Before going on to the next paper, I would like ot ask Mr. Robinson if he has an announcement to make on the motorcade tour tomorrow?

Mr. Robinson: Thank you, Jack. Here are a few announcements regarding the motorcade tour. First is that this afternoon we will have baggage tags available. We want all of you to have your baggage marked so that we will know who it belongs to. Baggage tags will be on the desk this afternoon right outside the door. We would like to have all the baggage out at the front door of this hotel by 8:30 tomorrow morning, so that we can get the baggage truck and the cars loaded and get on our way, for we have a long and interesting trip. Before closing tonight we will have a list of passengers and car drivers which will be given to each one of you who are going on the motorcade. This list is a flexible list, and it is listed only from here to Marysville. If afterwards some of you wish to switch from one car to another to get better acquainted with other people, it can be arranged very readily. Complete maps and directions will be provided for each car. The motorcade will be ready to leave at 8:30 tomorrow morning if you are ready. Please be on time.

Mr. Kimball: Dick Peters. Do you have an announcement?

Mr. Peters: I would like to report on the California Executive Committee Meeting of this morning. Some of us brave souls arose at an early hour despite the evening before. I am harking back to the first day of our Conference, at which time we presented to the University a portrait of a very outstanding gentleman. I have chosen a time when he is not here—at least I hope he is not here—to make this announcement. We feel that portrait is significant, and should be preserved by mosquito control workers throughout the world. If it's held in the University of California alone, it will be shared only by the students coming there. We would like to have that portrait reproduced; we would like to have it go to far places and honor our father of mosquito control in California and a notable mosquito control worker of the world. The CMCA is about to make itself available as a medium to receive contributions for a color reproduction of the Herms portrait.

Mr. Kimball: The next paper will be given by Mr. Harry Stage, of the Bureau of Entomology and Plant Quarantine.

Mr. Stage: Mr. Chairman, Ladies and Gentlemen. This might be an appropriate time for me to tender my thanks and appreciation of the wonderful meetings that you have held here, of the fine hospitality you've shown us all from the east and elsewhere. We thoroughly appreciate it, and I think this has been a splendid meeting in many respects.

RESEARCH ON MOSQUITO CONTROL BY THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE DURING 1948

By H. H. Stage

Division of Insects Affecting Man and Animals
Bureau of Entomology and Plant Quarantine
U.S. Department of Agriculture

Since 1942 the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture has conducted considerable research on mosquito-control problems with funds allotted to it first by the Office of Scientific Research and Development of the National Emergency Council and later by the Army and Navy. Although this research was designed to give answers to questions involving the military, much of the information obained has been adapted to civilian needs. The Bureau has also conducted work on some of these problems with funds appropriated directly to it by Congress. This paper is a report of the work done in 1948.

Research in the Pacific Northwest

Studies in the Pacific Northwest have been continued under the direction of A. W. Lindquist at Corvallis, Oregon. Although most of the mosquitoes involved there are *Aedes* spp., the investigations have also included such species as *Culex tarsalis* Coq., *C. stigmatosoma* Dyar., *C. pipiens* L., *C. apicalis* Adams, *Culiseta incidens* Thom., *C. inornata* Will., and *Anopheles punctipennis* Say.

The main problems in controlling *Aedes* in this region relate to temporary waters, such as irrigation water in deserts, snow water in mountains, salt water in tide flats, flood water adjacent to large rivers, and rain water in the Coast Range. For example, many tests have been made in which toxicants have been introduced into irrigation ditches with an assortment of drip cans. In fields up to 10 acres in size DDT and TDE emulsions applied at the rate of 0.1 ppm gave good results for 3 or 4 days. Water samples taken 1½ miles below the point of application were still toxic to mosquito larvae after 4 days. However, because the drip cans available for this purpose are not fully automatic their use cannot be generally recommended until a more efficient dispersing applicator is designed.

Recent increases in lumber production have indirectly accelerated mosquito breeding in log ponds adjacent to the mills. These mills vary in size from 1/6 to 20 acres and are usually teeming with *Culex tarsalis* and *Culiseta incidens*. Several other species are found, but they are of minor importance. Our research in such situations has been stimulated by owners who need information on how to control mosquitoes around their sawmills. Several experiments were made to determine the best larvicidal formulation for both immediate control and residual protection. Oil larvicides gave good initial kill but little residual protection. Wettable powders of the new insecticides were ineffective, and in no instance were all the wrigglers killed when the toxicant was applied at the rate of 0.2 ppm. TDE and DDT emulsions killed all the larvae at 0.04 to 0.2 ppm, and gave residual protection for at least 30 days at 0.1 to 0.2 ppm.

In southeastern Oregon, where *Aedes dorsalis* Meig., *Culex tarsalis*, and *Culiseta inornata* are severe pests, several tests were conducted in alkaline water. Oil solutions of TDE and DDT gave about 96 per cent kill when applied at the rate of 0.2 pound per acre. However, since this kill was not obtained until after 48 hours, it appears that the concentration of these insecticides will have to be increased to secure complete kill in a shorter time.

The application of insecticides on dry or snow-covered areas where *Aedes* mosquitoes breed is a novel and practical method for controlling larvae, especially in mountainous areas where access is difficult in the season. The details of this research were given you yesterday by Mr. Lindquist.

Research in Florida

The Bureau's Orlando, Florida, laboratory, about which all of you have heard and many have visited, is headed by W. V. King.

Of the several new compounds tested as anopheline larvicides at this laboratory, parathion was the most toxic, and only one other, a compound related to chlordane, was as toxic as DDT. The effectiveness of several insecticides on mosquito pupae in the Southeast is also being investigated.

Larvicide investigations in the field were concerned largely with prehatching treatments over large areas of salt marsh. Airplane applications of DDT dusts and suspensions at dosages of 0.5 to 2 pounds of DDT per acre were tested against *Aedes sollicitans* Walk. and *A. taeniorhynchus* Wied. The two types of treatment were about equally toxic, but neither was consistently effective on all types of marshes. Even the heaviest dosages were not effective in small ponds. The danger to fish was limited to those present at the time of treatment; many species of fish were unharmed by a 2-pound dosage, but other species were affected by a 1-pound dosage.

The flight habits of salt-marsh mosquitoes were studied to determine their rate of infiltration into large treated areas from surrounding untreated marshes. The mosquito populations were rarely constant, and infiltration usually occurred within a few days. When small areas were treated, however, satisfactory control was not obtained for more than 24 hours.

Progress was made in the development of constant flow in gravity-feed dispersing equipment for airplanes. This type of equipment is preferred because it eliminates the pump and other moving parts of spray units, which are subject to wear and mechanical failures.

New compounds and new formulations that had shown high toxicity to the body louse and mosquito larvae were tested for their effectiveness as residual and as space sprays against *Aedes aegypti* L. Similar tests were made with other chemicals and formulations and with new synergists for pyrethrum.

Of approximately 600 new chemicals tested for residual effectiveness, none were equal to DDT, chlordane, or parathion. Tests with benzene hexachloride showed that the alpha, beta, and delta isomers were much less effective than the gamma isomer, and that the gamma isomer was extremely toxic for only short periods.

The residual effectiveness of whitewashes made with skim milk or casein and DDT was not so great when wettable powder was used as when the DDT was in the form of an emulsion. Residues from neutral or alkaline emulsions were toxic longer than those from acid emulsions. None of the emulsions, suspensions, or kerosene solutions provided a durable residue on clay surfaces. All formulations tested were about equally effective on straw, but the suspensions were far superior to the others on palm thatch.

Of almost 200 compounds tested as space sprays, none proved equal to DDT. In tests conducted to find synergists for pyrethrum, several chemicals were equal to or better than piperonyl butoxide in causing knockdown, but none gave a higher mortality after 24 hours. Only gamma benzene hexachloride was highly effective as a space spray, and it was about eight times as toxic as technical benzene hexachloride (12 per cent gamma).

Females of *Anopheles pseudopunctipennis* Theob. were collected in a Mexican village where DDT residual sprays had been applied to all buildings for three successive years. The tolerance of these mosquitoes to DDT was compared with that of similar mosquitoes collected from an untreated village. As far as could be determined, the residual treatments had not caused a resistant strain of this species to develop.

Most of the chemicals received at the Orlando laboratory are routinely tested as mosquito repellents. Cotton stockings impregnated with acetone solutions of the chemicals are placed on the arms and legs of test subjects and exposed at intervals in cages containing hungry *Aedes aegypti* mosquitoes. Materials that are effective as repellents after two weeks of aging are studied further. A few chemicals have been found which are good repellents for one year, and many have been found effective for 100 days. Stockings treated with the best chemicals are washed and then tested in the field against *Aedes taeniorhynchus* and *A. sollicitans*. During the year 688 chemicals were tested in the laboratory and 134 in the field. The following were found to be outstanding repellents under field conditions and have been indicated by the U.S. Food and Drug Administration as safe for use as clothing impregnants: Butyl ester of 3,4-dihydro-2,2-dimethyl-4-oxo-1,2-pyran-6-carboxylic acid (Indalone); 2-butyl-2-ethyl-1,3-propanediol; N-hexyl mandelate; N-butyl-1,2,3,6-tetrahydrophthalimide; and alpha-(2-butoxyethoxy)-N-cyclohexylacetamide.

Research Under Arctic Conditions

The research on mosquito control under arctic conditions is under the general direction of the Orlando laboratory. B. V. Travis is in charge of the investigations in Alaska and W. C. McDuffie headed the work at Churchill, Canada. The investigations at Churchill, which were made in cooperation with the Canadian Department of Agriculture, have now been terminated.

The tests in the Churchill area were conducted principally on small plots in typical tundra and muskeg country to compare the effectiveness of DDT, TDE, methoxychlor, heptachlor, and parathion both as pre-hatching and as conventional larvicide treatments. As a pre-hatching treatment DDT was the most effective, a dosage of 0.25 pound per acre in oil solution giving at least 90 per cent control. TDE and heptachlor were almost as effective, but parathion was unsatisfactory at a dosage of 0.05 pound per acre.

Pre-hatching treatments applied by a C-47 ariplane to 300 one-acre plots demonstrated the practicability of aerial dispersal of insecticides in that region. The dosage necessary for control depended largely upon the type of terrain. In forested areas (muskeg) 0.05 pound of DDT per acre gave excellent control, whereas in open areas (tundra) at least 0.33 pound per acre was required. Ten- and 20-percent solutions gave comparable results, and in general were more effective than a 5-percent solution.

When used as a conventional larvicide treatment, DDT and parathion suspensions applied at 0.05 pound per acre gave satisfactory control of mature larvae. Parathion was slightly more effective than DDT. In oil solution DDT was slightly more effective than TDE, methoxychlor, or heptachlor, when applied at dosages of 0.1 to 0.2 pound per acre.

The standard mosquito repellents — dimethyl phthalate, Indalone, Rutgers 612, and a 6-2-2 mixture of these materials — and 27 other materials were tested on the skin and as clothing impregnants at Churchill. The standard repellents gave protection for 5 to 5½ hours on the skin. Several of the other materials were equal to or slightly better than the standard materials when tested on the skin, but none were sufficiently outstanding to warrant their recommendation. Most of the repellent materials were effective for 5 to 7 days when impregnated in clothing.

In Alaska at least 17 species of *Aedes* and *Culiseta* were identified and many individuals were reared so that the immature forms could be associated with the mature forms. A number of mosquito-breeding environments were studied and the relative effectiveness of a number of the new insecticides was determined in each. In addition, large plots, up to 30 square miles, were treated by aircraft to control adults and larvae. Ten repellents were tested as skin treatments and 35 as clothing impregnants. Of particular importance was the development by C. N. Husman of a spray boom for a C-47, in which electric fuel-transfer pumps were used for the pressure system. This equipment gave droplets having a mass median diameter of 136 microns and an effective swath of 800 feet. I have given only a very brief résumé of the investigations in Alaska, because Dr. Travis gave you the details on Monday.

Last summer C. C. Deonier and I made a rather hurried survey of mosquitoes and other blood-sucking insects in a small area on Queen Victoria Island in the central Arctic Zone. Unfortunately we reached there too late in the season (August 7-27) to collect a large number of mosquitoes. In fact, we saw mosquitoes on two days only, and as far as we could determine we collected only one species. Undoubtedly it was *Aedes nigripes* Zett. or *A. nearcticus* Dyar., but because larvae and males were not available a specific determination could not be made. In an effort to obtain larvae we tried to force an abnormal hatch by draining a lake and using the water to flood a depression that appeared to be a breeding place for mosquitoes. However, we were unable to find any larvae in the newly flooded depression. The breeding areas on the island appear to be unlimited, for there were innumerable large and small ponds and depressions. According to local observers, mosquitoes are extremely annoying for about 3 weeks in July, but their numbers vary year to year.

Afternoon Session

Mr. Washburn: Edgar Smith, Manager of the Merced County Mosquito Abatement District, wishes to make an announcement.

Mr. Smith: Most of you by now have been blinded by flash bulbs. We have had a good many inquiries about the possibility of getting copies of some of those pictures, so we have arranged to make up a dozen or so of the best pictures taken by Tommy Mulhern, myself, and the photographer from the Merced Mosquito Abatement District. There will be about a dozen of the best pictures that we can select, and they will cost $1.50. There will be somebody at the registration desk outside to take orders.

Mr. Washburn: To get right in to the program I want to call on Tommy Mulhern to take over for the symposium on "New Equipment and Recent Improvements in Methods of Drainage and Application of Insecticides by Ground Equipment."

Mr. Mulhern: I would like to have all the participants in this symposium come forward if they will and take places up here. Mr. J. Lyell Clarke, Harold F. Gray, Arve Dahl, Ted Raley, and Mr. Stallman. In attempting to present this subject there was a great deal of information which might have been brought in. We have attempted to eliminate a good deal which has already been publicized. However, there never was a time when good equipment has been so much needed in mosquito control as at present. Labor costs have reached an all-time high peak and in a great many areas a rapid turn-over in labor prevents the establishment of large well-trained crews. Even in the regions where labor can be had, men do not take kindly to doing work by hand which might be done more easily and efficiently by machine. We are in a machine age and must try to keep up with modern developments. Contractors today are spending more for their equipment, and the manufacturing concerns are sparing no pains to increase the productive capacity of equipment. The development of pneumatic and hydraulic controls, better cabs, quieter and more powerful engines and drives, has done a lot to take the drudgery out of machine operation, and to add to the comfort of the operators. This consideration for the workmen has paid off very well indeed, particularly with the larger machines, in consistently higher production. Mosquito workers have been giving much attention to more and better chemical control, better spraying equipment and methods, and better airplane treatments, but not very much attention has been devoted to construction equipment or improvements therein. Any critical survey of the equipment now in use reveals that there is a great preponderance of misfit machinery being utilized in mosquito work. This is not intended as criticism of the users of such units — on the contrary, it may be construed as a compliment to them for improving the efficiency of their operations by adapting to their purposes the available equipment, even though it admittedly does not adequately fit the job to be done.

Manufacturers' Attitude

Until recently, most of the machine builders would not consider building special units, nor would they do much to modify their regular machines to suit our peculiar needs. It is now evident that a change has taken place and we are entering a period when they must again search for business, and may be expected to work with us in developing useful equipment.

We have had to take liberties with the program as originaly printed, but hope this section as presented will be useful.

Now we have Commissioner M. M. Stallman, member of the Essex County (N. J.) Mosquito Extermination Commission, presenting the papers prepared by Mr. Vernon Conant and Dr. Henry Dengler.

THE USE OF TIDE-GATES FOR LARVAE CONTROL ON THE SALT MARSHES

By Vernon Conant

Superintendent, Bergen County (N. J.) Mosquito Extermination Commission

The salt marshes of Bergen County are comprised of low, level flats, adjacent to large streams and subject to daily tidal inundations. The soil material is made up of dark brown or black salt loam containing different amounts of decaying vegetable matter, running from two to eighteen feet in depth. This is underlain by dark gray or bluish clay. In most of our marsh the presence of stumps and roots beneath the surface makes the cutting of a finished ditch exceedingly difficult.

There are eight thousand acres of tidal marsh in our county, all in the metropolitan district, some of which are utilized for building and factory sites. In such areas, dikes and tide-gates have been constructed by this Commission to prevent the tidal inundation. If reclaimed by this method, all the area would have real agricultural possibilities, but this reclamation is very expensive. For the purposes of mosquito control it is not necessary to maintain the water table constantly below the salt marsh surface, but it is important that the water drain off fast enough to prevent the development of mosquito larvae.

In planning salt marsh drainage by dikes and tide-gates there are three points that must be determined. These constitute the cross section necessary to carry off the water; the location of the tide-gates; and the elevation of the flow line to the outlet boxes.

In designing our tide-gates, we feel it is necessary to provide one square foot of orifice for every forty acres to be drained, including the upland acreage draining into the diked area. At this ratio, after heavy rains the water will rise above mean tide in the enclosed area. There are sections of marsh that have been diked and drained for a good many years before this Commission first installed gates back in 1918, so that the elevation is three feet lower than normal, making the enclosed marsh practically at mean sea level.

Originally, all our tide-gates were constructed in the creek chanel, after taking soundings to make sure that all of the boxes would be on an even layer of clay. It was then impossible to work at high tides. In the last few years we find it is more practical to take borings along the creek bank and find a location where the clay strata are near the surface of the meadow. The hard clay is one of the best materials for holding sheet piling, and it is also possible in this clay to excavate a pit in which to construct a new gate.

The water on a diked area can drop no lower than the flow lines or floor of the outlet boxes, and when placed below low tide they deliver more water for a given orifice. The gates on our salt marsh are placed from twelve to eighteen inches below local mean low tide. This gives us the advantage of extreme low tide which occurs about once a month.

In November, 1948, a new tide-gate was constructed at Kingsland Creek in the Lyndhurst Meadow, to replace one that had been in operation a good many years. After selecting a location, the excavation was dug with our Bucyrus Erie 3/8-Yard Excavator. Lines of three by eight inch creosoted sheeting were then driven to refusal, which in this instance was approximately six feet below the outlet floor. A Barco portable gasoline hammer was used to drive all sheeting. On top of this were bolted stringers, on which ten foot sections of three foot Armco asbestos bonded pipe were placed. Two rows of sheeting were set for each section of pipe. All holes were drilled with an electric drill with power furnished by a portable gasoline driven generator. In the front and rear a second line of sheeting was carried to the elevation of high water. Two rows of six foot seep rings made of asbestos bonded material were set in place around the pipes, which will prevent burrowing animals from digging near the pipes and furnish a place for cross currents to undermine the above fill. The clay was then carefully tamped in and the top of the front bulkhead was connected to the rear by tierods.

On the river side of the front bulkhead an apron was constructed six feet wide, just beneath the bottom stringer. This will prevent excess washing of the clay at the outlets of the gates. Wing walls were also made, to prevent the washing of the sides of the channel.

After the Calco automatic drainage gates were set in place at the outlets, a new channel was dug both in the front and rear, connecting the new tide-gates with the existing channel.

An objection to this method of meadow drainage is that the meadow will shrink until it is so low that it cannot be drained without pumping. This can partially be overcome by leaving the gates open during the winter months.

The Bergen County Mosquito Extermination Commission has found the diking and tide-gating of salt marsh areas to be very beneficial in certain sections for the control of larvae, depending upon the location and the natural drainage conditions.

A HIGH CAPACITY LOW-LIFT PUMP

By Henry P. Dengler

President, Union County (N. J.) Mosquito Extermination Commission

In the eastern part of Union County, there is a 2500-acre diked salt marsh in the City of Elizabeth that has been under the moquito control operations of the Union County Mosquito Extermination Commission since 1912. Prior to that, the Board of Health of Elizabeth installed rather extensive ditching systems and performed some oiling beginning in 1902.

This marsh is bordered on the west by upland, on the easterly side by Newark Bay and on the north by Bound Creek for about two-thirds of the distance from the bay to the upland and salt marsh of the City of Newark in Essex County for the rest of the distance from Bound Creek to the upland. Newark Bay is the outlet of the Passaic and Hackensack Rivers, from which the flow is sufficient to keep the salinity relatively low when compared to ocean water.

The tracks of the Jersey Central Railroad from Newark to Elizabeth port divide this marsh so that about 1500 acres are between the tracks and the bay and about 1000 acres are between the tracks and the upland. The only outlets for drainage of the 1000 acres are Great Ditch on the south extremity and Bound Creek on the north extremity of the marsh. These outlets are two miles apart. The entire area is level.

In the early days of mosquito control, this marsh was a typical salt marsh, growing salt hay and, under proper conditions of rainfall and tides, it was an abundant producer of *Aedes sollicitans* and *Aedes cantator* mosquitoes. The past proceedings have recorded old-timer stories of the effects of these mosquito crops on business, industry, and living in Elizabeth and neighboring communities.

The ditching and oiling by the Board of Health and later the Mosquito Commission helped to curtail the mosquitoes considerably except under certain weather and tide circumstances. The outlets of Newark Bay are the Arthur Kill leading south to Raritan Bay and the Kill Van Kull leading east to New York Bay. These Kills or straits are long and narrow. A prolonged easterly or southerly wind can and did hold water in Newark Bay at low tide. If the rivers feeding Newark Bay were at high flow the salt marshes along the bay were flooded for several days.

In 1914, the Mosquito Commission began to install dikes and tide-gates along Great Ditch, Newark Bay shores, and Bound Creek to handle these conditions of adverse winds and tides. This system effectively controlled the mosquitoes, although it increased the cost of control because of higher maintenance. Oiling of ditches continued to be needed to kill off ditch breeding. As long as the installations were maintained and weekly inspection for breeding with any necessary oiling was carried on during the mosquito breeding season, no broods emerged.

Changes in the nature and appearance of the marsh slowly developed. Shutting out of the tidal waters permitted the rains to leach out the salt content of the marsh land and vegetation over the years. Extensive building of homes, factories, and business places in Newark and Elizabeth increased the sewage of the area and the sewage is untreated. Lack of salt and presence of sewage contamination gradually changed the vegetation from low-growing salt hay to the dense taller-growing fox-tail reed. The proper operation of the tide-gates reduced the water level in the marsh to a level 12-18 inches below the surface.

As the top of the marsh dried out from the lowered water level, it gradually shrank to lower and lower levels. The fox-tail reeds burned off annually during winter months after the frosts had killed the tops, producing such hot fires that the marsh surface frequently smoldered and burned in small patches. Gradually, the marsh surface behind the dikes is about 18 inches below the original marsh level as determined by the surface outside the dikes. In the burned areas, the surface is 6-15 inches below the nearby marsh surface.

In recent years, prolonged rains would flood these shrunken marshes for several days. Due to the dense vegetation of the fox-tail reeds, larviciding operations were seriously handicapped or impossible. Paths along the ditch edges are crushed with tractors having wide caterpillar treads, but when the marsh between the ditches was flooded there was little that could be done about it effectively.

Pumps had been under consideration for some time, but to install pumps that could handle rainfall on over 1000 acres was too expensive for our budget when the usual type of pump was estimated. At last year's Annual Meeting, Mr. Joseph H. Palmer described a pump which seemed to fit the needs of this job. It was the Lawrence Propeller Pump, which had a high capacity at low lifts and could be economically installed. Funds were requested in the 1947 budget and granted by the Board of Freeholders to make the installation.

The Lawrence Propeller Pump is extremely simple, consisting of a casing, a propeller, and an uptake or discharge cone. The design affords large clearances and unobstructed passage-ways so that water carrying trash and solid matter can be handled without clogging, which is important in our work. There are two sizes of these pumps, and their capacity is determined by the total lift required and the brake horsepower and speed of the motor or engine. Pump No. 1 will pump 4000 g.p.m. against a 3-foot head using a 4.7-h.p. motor at 520 r.p.m. or 10,000 g.p.m. against 14 ft. head using a 44-h.p. motor at 1250 r.p.m. Pump No. 2 will pump 8,000 g.p.m. against a 3-ft. head with an 8-h.p. motor at 480 r.p.m. or 16,000 g.p.m. against a 14-ft. head with a 67-h.p. motor at 970 r.p.m. All kinds of variations of capacity, head, motor horsepower, and speed are possible within the above limits. Of greatest importance to proper operation for these pumps is the provision for adequate flow of water to the pump. The feed ditch must be large enough to get plenty of water to the pump while it operates.

Since the maximum rainfall expected on the 1000 acres is 6 inches, a total of 163,000,000 gallons of water would need removing before mosquitoes could emerge. These pumps can operate continuously, so 24 hours per day operation is possible for emergencies. One of the No. 2 pumps was installed and powered by a 33-h.p. Ford V-8 Marine engine. With the 8-foot head that we pump against and normal operating speed of 1000 r.p.m., the pump should deliver approximately 17,000 g.p.m. as near as it can be checked. This capacity will remove the above 6-inch rainfall, which is a rare occurrence, in 7 days with 24-hour operation.

During 1947, the pump was operated only during the normal 8-hour working day and the water level of the marsh was constantly well below the marsh surface. Larviciding requirements on this marsh were the lowest for a period of many years. This installation cost $1627.00 for machinery, $1323.40 for materials, and $1559.35 for labor to build it. These expenditures do not include the dredging of a drainage channel to the station of 1090 feet in length. In the annual report of the Union County Mosquito Extermination Commission, you will find some pictures of the pumping station.

Some problems of operation were encountered with the power plant selected after the station was ready to operate. The available water supply for engine cooling was dirty, sewage-polluted, and corrosive. The small water lines on the Ford V-8 Marine engine had to be replaced with larger lines to prevent clogging. Over-heating of the power plant was the principal problem, which we think could be corrected readily by using a heavier engine. Wherever possible, it would be preferable to use an electric motor. There was no problem with the pump, which performs very well, as many here who have seen it can testify.

Our satisfactory results with this installation indicate that this pump is very useful equipment in mosquito work where large quantities of water must be lifted a low elevation at a minimum of capital and operating costs.

Mr. Russel Gies: I think we should emphasize the fact that the surface elevation of the diked salt marshes referred to in the foregoing papers is not the same as for the salt marshes which are open to the tides. The elevation of the open coastal marshes is normally slightly above local mean high tide, but when enclosed by dikes which shut out the sea, the marshes shrink very rapidly, depressing the surface elevation, sometimes to approxicately the level of low tide. Then pumps must be used to eliminate the water in which mosquitoes breed.

Mr. Mulhern: Both Bergen and Union Counties carry on intensive programs to prevent great salt marsh broods from emerging on these sals marsh areas, and we know from our trapping studies and from personal observation that there has not been a single great salt marsh mosquito hatch escaped from these marshes in the past twenty years.

It appears that transportation in mosquito work is still one of the greatest problems involving machinery, and one of the rather poorly solved ones. We require transportation of men, of materials, and of equipment on a daily basis. A considerable portion of our budgets is expended for this item. No branch of transportation is too well provided for. Mr. Roland E. Dorer, State Director of Malaria Contol in Virginia has had in addition to his wide experience in malaria control, a good grounding of experience on the salt marshes both in New Jersey and Virginia. We have prevailed upon him to send in this short paper.

TRANSPORTATION ON THE SALT MARSH

By Roland E. Dorer

State Director of Malaria Control, Norfolk, Va.

The need for transportation over the salt marsh for mosquito control work might be for three reasons: (1) for inspection, (2) to transport equipment for larvaciding operations, and (3) for transporting ditch digging and cleaning equipment.

The need for inspection is not too great because in small areas the ground can be traversed on foot; and in larger areas, inspection can be made by airplane with supplementary ground spot inspection.

The need for equipment to transport heavy larviciding machinery over the salt marsh has largely disappeared. In the old days when oil was used as a larvicide, it was necessary to transport large amounts of heavy and bulk material. Now with the development of DDT emulsions and other larvicides, it is possible to treat large areas with a much less amount of material and lighter spray rigs. In the smaller areas, it is still most economical to larvicide by hand. In many cases in large, extensive areas, an airplane is the most economical. In between these two extremes, there are areas where it is necessary to treat by mobile equipment.

In ditch digging and cleaning equipment, the needs have remained about the same. This type of equipment is rather heavy, and it is hard to conceive how the weight of such equipment can be materially reduced.

Of course, the only principle involved in selecting or designing equipment to travel over the salt marshes is to reduce the bearing pressure low enough so the weight of the equipment will not cause the treads or wheels to break through the blanketing sod. With lighter machines, the need for less bearing area is evident. Certainly, bearing pressure should not be over four to five pounds per square inch. Hewever, this might vary according to the stability of the marsh to be traversed.

Light, caterpillar-type tractors have been found to be useful and the army weasels, also, have been used. Bearing pressure can be reduced by attaching wooden cleats to the cats.

Whatever the equipment, an important point to remember is that the marsh surface should not be materially compressed or torn up. Whenever this happens, another potential mosquito breeding place is created.

Mr. Mulhern: Mr. J. Lyell Clarke is here to present "Transportation on the Upland."

(Mr. Clarke presented here a very fine illustrated lecture on the use of various all-wheel-drive vehicles for off the road use in upland areas.)

Mr. Mulhern: Are there any comments on the transportation question?

Member: I have been wondering what means are provided for getting equipment about on agricultural land to apply fog, mist, etc.?

Mr. Sperbeck: We have been using what we term a ½-ton or ¾-ton pickup, and jeeps. Sometimes we do make ruts, but during the past two seasons we have used pre-irrigation spraying extensively, thus reducing the danger of cutting up the land.

Mr. Mulhern: If there is no more discussion of this topic, we will ask Mr. Gray to present the data on equipment for applying residual sprays indoors, by Mr. W. A. Legwin, Assistant State Director of CDC Activities for the State of Georgia.

Mr. Gray then presented a series of slides showing various types of spraying equipment, particularly a constant pressure two-tank knapsack type recently developed by the Public Health Service. As this has been described in the CDC bulletins, it is not reproduced here.

Mr. Mulhern: There appears to be no discussion of the material presented by Mr. Gray.

It gives me genuine pleasure to present to you your own Ted Raley. Mr. Raley will present data on the subject, "Ground Power Spray Equipment."

Mr. Raley: Tom, I am glad this is a pleasure for you. In surveying this problem I found it wasn't a particular pleasure for me to try to resolve the controversial ideas as to the best type of sprayers to use. Surface indications are that present-day mosquito control practices are guided more by individual opinions than by any concerted effort to utilize the most suitable tools available. This is, however, quite understandable to those of us who have had the privilege of participating in the evolution of mosquito control from the advent of DDT to the present time. Application methods and techniques are now beginning to emerge that appear to be making the most efficient use of the new, highly toxic chemicals. Because of the short time available here, no effort will be made to present physical descriptions of the many machines on the market, but I will summarize my own experiences in using several of the types available.

(Mr. Raley then discussed at length the equipment for applying insecticides as mists, sprays, and fogs. He also presented suggested forms for recording in uniform fashion the results of tests of spray applications, and urged that some such forms be adopted generally as standards, so that there may be uniformity in recording and measuring the results of such tests. Since the meeting, standardized forms based on those of Mr. Raley have been issued by the California Bureau of Vector Control, as appended hereto.)

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC HEALTH

Wilton L. Halverson, M.D., Director of Public Health

Bureau of Vector Control

Farm Credit Building

2180 Milvia Street, Berkeley 4, Calif.

To Whom It May Concern:

The attached form, "Ground Power Spray Equipment Studies — Inspector's Report," has been devised as a standardized report form to be used, if desired, for experimental studies connected with mosquito control activities where ground power spray equipment is used for either adulticiding or larviciding purposes. These pieces of power spray equipment will include any ground equipment utilized in producing insecticidal sprays, mists or fogs.

It is felt that most of the items listed are self-explanatory. A code for larval mosquito sources has been adopted by mosquito control workers in California and it is felt that it would be applicable in any section of the country. This code is listed on the reverse of page 1. On page 2 there is space for a description of the vegetation encountered in a study area. On the reverse of page 2 is a description of how the height and density of vegetation is determined in accordance with standard measurements. This, of course, is purely an arbitrary delineation of the problem of determination of vegetative height and density; however, some such arbitrary standards must be adopted in order to obtain standardized procedures by all mosquito control workers. A sample field inspection record is included in order to better illustrate the method of filling out this section of the report. A notation is made to the effect that standard adult and larval cages should be used for all testing.

The standard adult test cage as used here in California consists of a one to one and a half inch wide strip of galvanized screening brazed onto a flange on both sides. A hole is cut into the circular metal strip so that adult mosquitoes may be introduced into the test cage with an aspirator. After the mosquitoes are introduced, the hole is covered with scotch tape. These cages are then supported vertically at the test stations with bicycle trousers leg guards welded onto ¼ inch diameter steel rods about 15 inches to two feet long. The larval test containers as used here in California are simply paper pie plates placed at the test stations. A minimum of ten specimens of either adult or the larval stage should be used at each test station although 25 of each are preferable. Controls of both adults and larvae are handled in exactly the same fashion and equipment as those specimens used for test purposes with the exception that these controls are placed under similar field conditions but not in such a way that they are exposed to the insecticides.

After each test run the adult cages are carefully washed with an organic solvent such as xylene and then with a synthetic detergent such as Dreft to remove all traces of insecticides which might adhere to the cage surfaces. The control cages are also subjected to the same washing and no attempt is made to segregate these control cages so that should the washing not remove all the insecticide the control mosquitoes would be subjected to the same hazards as those used in the test except for the insecticide applied during the test itself.

BUREAU OF VECTOR CONTROL
Arve H. Dahl, Chief
Robert W. Jones, III
Vector Control Specialist

(The form, "Ground Power Spray Equipment Studies—Inspector's Report" will be found as an appendix beginning on page 94.)

Mr. Mulhern: Thank you very much, Ted Raley. That was fine. I think Ted has touched on a point which is extremely important to all of us in mosquito work. He starts with a suggested form for recording fog and spray application tests. It seems to me that what we need in mosquito work as greatly as we need anything is a system of standards for all purposes and activities. Perhaps it will some day be possible to get a National Standards Committee of mosquito men who can set up recommended standards that we may all adopt and try to work by. This approach is very much worthwhile for the several associations to consider.

Professor John M. Henderson of Columbia University has a great many friends here on the West Coast and he sends his sincere regrets that it was not possible for him to lay aside his duties at Columbia to come out in person. He has sent a paper, and Mr. Arve Dahl will now present a summary of it.

MINOR RESIDUAL DRAINAGE

By JOHN M. HENDERSON, C.E.

Professor of Sanitary Science, School of Public Health
Columbia University

Introduction

Recent developments in larvicidal and imagocidal practices arising from the discovery of DDT and other insecticides of high potency and, at times, lasting residual effect, have tended to curtail the role of drainage in mosquito control. Some enthusiasts even feel that DDT and a brush or even a wisp of straw in the hands of each householder will spell the doom of mosquitoes and the whole realm of house-invading pests. This is comparable to an attitude that the atom bomb has eliminated the need for all other destructive agents in human warfare.

A more rational attitude is that the newer insecticides provide weapons of great value in our armamentarium. The extent to which they should displace other methods of control is related to many variables. Probably their most fertile fields are in the control of rural malaria and *Aedes aegypti,* for temporary or emergent situations and in competition with petroleum larvicides. Their least fertile opportunities are in urban areas and against mosquitoes which do not enter houses. Just as DDT has already been found an inadequate substitute for sanitation in housefly control, so is there a continuing need for water elimination as the simplest, most economical and most dependable method of mosquito control in selected situations; although it must be realized that drainage occupies a more restricted field than heretofore. There is no longer justification for employing 30,000 men on malaria control drainage in a single state, as in Georgia in 1933.

My experience in mosquito control drainage has been primarily with species sanitation programs of malaria control. The bulk of it was in Georgia, from 1930 to 1940 on the control of *Anopheles quadrimaculatus,* and in Puerto Rico and elsewhere in the Caribbean from 1940 to 1944 against *Anopheles albimanus* and *Anopheles aquasalis.* This was supplemented by supervision of the limited drainage program of Malaria Control in War Areas, U.S. Public Health Service, in the United States, from 1944 to 1946 and by general knowledge of malaria control activities in this country since 1930.

The design and practice of mosqito control drainage are affected importantly by local factors, particularly soil types, topography, climate, financial resources, availability of construction materials and equipment, wage scales and type of labor supply, as well as by the bionomics of the mosquito species being controlled. While these experiences fail to provide adequate insight into conditions peculiar to California and to the species under abatement here, certain principles and practices are not only common to all mosquito control drainage but in fact are distinctive of this type of water removal. Some of these will be disussed.

Most drainage for mosquito control comes under the heading of minor drainage, whereas drainage of concern to the constructing civil engineer is mainly major drainage. This is partly because mosquito control needs require only that flooded and impounded areas be dewatered within the breeding cycle; a matter of days in all cases, rather than totally avoided or confined to minutes in time, as with storm water drainage. It is also due to the consuming interest of mosquito control workers in pools and puddles which are beneath the notice of the construction industry.

Mosquito control drainage, of course, is not solely confined to either minor or residual drainage. At times large cross sections may be required due to lack of slope, length of drainage way or large water volumes. Some drainage for mosquito control is also multi-purpose in character. Moreover, the flooding of low lands in stream valleys occasionally must be avoided in the interests of mosquito control, although such need is greatly reduced by the possible alternatives of diking, filling, and the return of overflow waters to the main channel through development of minor residual drainage in the flood plain. These examples of major drainage tend to be exceptions to the general rule.

Since mosquito control drainage generally seeks only to remove water from the ground surface, it also usually differs in principle and practice from most agricultural drainage, which has the objective of lowering the ground water table, although some situations concerned with mosquito breeding in seepage areas constitute important exceptions.

Design Considerations

Time permits only partical coverage of this topic. Principal considerations are perhaps those pertaining to grade of ditch bottom, slope of ditch banks, and avoidance of erosion and siltation within the ditch cross section.

Grade: For minor drainage ditches with bottom widths of 12″ to 30″, an ideal gradient generally is about .3 to .4% in clay, sand-clay, and most loams. Due to the smaller hydraulic radii of such ditches under most flow conditions, and a rougher surface, this will not produce as high a velocity of flow as in sewer pipes at similar grade and will not be self-cleansing from a standpoint of sewerage practice. It does, however, prevent deposition of clay and other fine solids and minimizes the possibility of quiescent pools at low flow and serious erosion during high flow.

The controlling effect of topography generally prevents the selection of an ideal grade, and for this reason the tolerated range in such soils is from about .05% to about .75%. The upper limit is determined by erosion factors. It may be increased slightly under exceptionally favorable soil and wet weather flow conditions in combination, and should be adjusted downward substantially under reverse circumstances. The ceiling grade of .75% for so-called "typical" small ditches may be inreased further to a limit of about 3% by increasingly elaborate erosion-protective devices, including ditch checks. Ditch checks variously may be made of brush, grass sod, field stone, masonry, or concrete. The better types are of masonry or concrete, precast or monolithic, and equipped with tail-water aprons and curtain walls to prevent scour. The free fall usually ranges from 6″ to a foot. In a ditch with a 1% grade, one 6″ ditch check per 100 ft. station will reduce the effective grade to .5%.

The sheer movement of any water at all in a ditch at the minimum grade of .05% depends on whether aquatic vegetation is present in the ditch, since even a moderate density of vegetation will neutralize this rate of fall in a shallow ditch. Some ditches in favored situations may function successfully at a ditch bottom grade of zero, but this is only because of a fluctuating head of water at the outlet, within the ditch system, or both, and reflects the fact that the movement of water in open channels is determined by the water profile, not that of the ditch bottom.

Ditch Bank Slope: During the 18th and 19th centuries a tremendous mileage of ditches was dug in Georgia for agricultural benefit by slaves and later by roving bands of immigrant Irish contract labor. Inland from the coast, many of these ditches passed through clay ridges, draining elevated, permanent landlocked ponds, which, incidentally, were *quadrimaculatus* breeding places. The ditches ranged in depth from 4 to 14 feet, were 2 to 2½ feet in width and had straight banks. Where not maintained, all of these had filled in partially by the 1930's, but, surprisingly, some ditches 50 to 80 years old were still functioning as overflow outlets and half to three-fourths of the original depth still existed.

The straight-sided deep ditches possess many apparent disadvantages from a standpoint of accessibility for maintenance, violates accepted engineering practice, and is impractical in yielding soils. The above illustration is cited, however, to emphasize two principles. The first is that ditch bank slopes should be selected on the bases of soil inspection and engineering judgment on the job; not by adhering to an arbitrary standard. The second is that vegetation destroys as well as stabilizes ditch banks. The long-term enemies of deep ditches in clay subsoils are the shrub and the tree which take root in the ditch banks, and exposure to sun and rain which alternately wet and dry the clay, erode the banks, and age the earth on exposed surfaces into top soil. The walls of the aforementioned straight-sided ditches were deeply shaded, free from vegetation, protected from rain, damp and firm. They remained in perfect condition until the root systems of bordering hedgerows finally eroded the upper banks. Moreover, the deep shade prevented breeding in the ditches of *quadrimaculatus* and many other mosquito species. There is, consequently, some justification for straight sides on deep ditches in hard clay as well as on the marshland ditch which exists so extensively in New Jersey.

Most ditches of significant depth, however, require sloped banks. Typical slopes are: hard clay ½:1 or steeper, softer clays, loams, and firm sand clay 1:1, sandy sand-clay 1½:1, and sand 2:1 or flatter. These slopes are steeper than those used in highway drainage practice, but serve satisfactorily, even though not ideal.

Related to the subject of ditch bank slopes is treatment of the spoil. A berm of at least 1½ feet should be provided on each side of the ditch bank, increasing with height of spoil bank. The spoil may be used for fill, spread, or piled and provided with breaks to admit surface drainage into the ditch at appropriate points. Such breaks also should be made through spread spoil and the spoil should be placed only on the low side of the ditch where surface drainage is apt to carry it into the ditch. On the other hand, continuous spoil banks may be used advantageously in some cases to: (1) prevent bank erosion in deep cuts by guiding surface drainage to protected or lower points of entry, and (2) temporarily impound silt-laden water for sedimentation.

Protection of the Ditch Cross Section

This type includes the prevention or correction of erosion and siltation. Fundamentally, siltation is coped with by designing self-cleansing grades, at least with respect to clay, and by the pre-sedimentation of silt-laden waters. Selection of such grades has been discussed, and it must also be kept in mind that the flushing effect of storm water flows keeps clean many ditches which are not self-cleansing during dry weather. As regards the pre-sedimentation of silt-laden waters, this measure in mosquito control drainage is accomplished principally by intelligent supervision at the job-site, as typified by the following illustration. In southern states a large part of malaria control drainage has involved ditch construction in natural drainage ways to drain upstream ponds or swamps in the drainage ways themselves. Farm road and rural highway crossings are frequently encountered. The great enemy of such drainage construction is the roadside ditch which discharges into the drainage way. By virtue of topographic relief, the slopes of these unlined roadside ditches increase sharply in the vicinity of the drainage way, and their storm water flows may be heavily laden with sand and silt. It is essential that these discharges be temporarily impounded in the low land of the drainageway, with the supernatant entering the outlet ditch. This may be accomplished by admitting the overflow into the outlet ditch several hundred feet above or below the road crossing, with consequent spreading and trickling through the swampland. This is more easily achieved on the downstream side of the road crossing than on the upstream side and requires careful planning to avoid creating impoundments which hold water too long. The more fundamental solution, of course, is to control erosion in the roadside ditches themselves, an undertaking usually far beyond the resources and scope of the mosquito control agencies.

Ditch erosion control practices may be more specifically and comprehensively described. Here too, ditch grades, volume of flow, and soil conditions are fundamental, but man can improvise many measures to compensate for adverse conditions. Some of these are multi-purpose in character.

The engineer in heavy construction solves the problem by the full-lined section, generally of poured concrete, or by closed sections, such as pipe. Such measures may increase costs of construction as much as 500 to 1,000%, and it is up to the mosquito control engineer and the soil conservationist to devise measures more in keeping with the magnitude of their problems and desired progress.

The best compromise between cost and protection is perhaps lined inverts in combination with grassed ditch banks. Either of these can be carried out independently, but together they comprise a complete unit.

Invert Lining

Lined inverts may be pre-cast or monolithic, and built of masonry or concrete. The utilization of such materials as native field stone or broken brick bats, which may be available without cost, requires poured-in-place construction, but when a conventional concrete mix is used, pre-cast production is strongly preferred for the following reasons:

(1) Pre-cast slabs can be produced at a central factory plant (Slide No. 1) under controlled, supervised conditions, for later installation at scattered locations. Factory methods of production, re-usable forms, designed mixes, use of vibrators, bulk purchase and handling of aggregates, and the better mixing, placement, and curving possible under proper management will yield large savings in materials and labor costs and higher strength concrete. Savings are extended by faster placement in wet ditches requiring temporary dams and ditch pumps.

(2) Undermining of the installed slab results in the total loss of poured concrete inverts plus added cost of demolition. Pre-cast inverts can be easily reset.

(3) Admittance of sub-grade ground water into the ditch section is accomplished more effectively with pre-cast slabs. Changes in lined section to meet varying conditions in the ditch can be accomplished more readily.

The two basic units in pre-cast lining are the rounded invert and the flat slab. A typical design of invert slab is shown (Slide No. 2). Each slab is 3 feet long, 2″ thick, and has "tongue and groove" joints at the ends. The retained depth of flow is 6″ and the inside width may vary from 16″ to 24″. Flat surfaces on the underside facilitate sub-grade preparation. The top edges may be provided with continuous ball joints to receive the sockets of the flat slabs, thus permitting independent settlement of the invert and side slabs.

The typical installation in small ditches comprises an invert with grassed ditch banks. The concrete requirement is 1½ cu. yards per 100 ft. station. As required by depth or velocity of flow, the lined section can be expanded by installing as many flat slabs on either or both sides above the invert as may be needed. The concrete requirement of one flat slab, 6″ wide, on each side of the invert is about ½ cu. yard per station. Under exceptional erosion conditions, the flat slabs may be anchored by small T-shaped pre-cast "deadmen," installed as spacers between end joints of the flat slabs. The concrete requirement of these is negligible.

Control of ditch bottom erosion is only one factor justifying lined inverts. Others are:

(1) Bottom-attached aquatic growths are prevented.

(2) Velocity of flow is improved by smoother flow surface, improved hydraulic radius and lack of vegetation.

(3) Mosquito breeding is prevented by the aforementioned factors and a more regular flow section.

(4) When topographic conditions prevent self-cleansing velocities, maintenance costs are lowered by greater ease of cleansing and shallower deposits. Ditches can be easily restored to their exact original grades.

Grassed Banks

The principal topics requiring consideration under this heading are: (1) Selection of grass species, and (2) Planting method.

The proper selection of a ditch bank grass requires specialized knowledge. There is no ideal grass for all situations and locations. Advice should be obtained in each district from soil conservation specialists, county agents, and various other agronomists interested in grasses.

My own experience in Georgia and Puerto Rico was concerned almost exclusively with Bermuda grass and Chinese centipede grass. These ground-runner species were highly satisfactory in most situations within their habitat range. Chinese centipede occurs in coastal and extreme southern Georgia, in Florida, and generally along the Gulf Coast, and in Puerto Rico. It is slower growing but has the denser root system of the two. Bermuda grass was found throughout Puerto Rico and Georgia and of course extends into more northerly latitudes. In areas where both grasses were native, they were planted together, with Bermuda grass furnishing early protection and with Chinese centipede gradually developing and choking out the Bermuda after several years. These grasses were found generally satisfactory in all grades of sand-clay, friable clay, and loam, but would not grow satisfactorily in deep shade or in hard clay, although seldom needed in the latter case.

In California, a soil conservation officer[1] states that the following grasses are most generally indicated, but that broad recommendations cannot be made due to the wide variety of soil and climate: Perennial rye, Bent, Dallas, Tall fescue, Reeds Canary, Red Top, Bermuda, and Kikuyu. These may be supplemented with: Birdsfoot trifoil, Big trifoil, Ladino or White clover and strawberry clover. In considering this list it should be kept in mind that some may be unsuitable under any conditions for the special needs of minor drainage. Certain species may require frequent mowing, and hence are suitable only for major canals or highway ditches with flat bank slopes where mechanical mowing can be practiced. Other species, such as Bermuda and Kikuyu, may be favored in some agricultural communities but viewed as pests and prohibited in others, due to local agricultural conditions.

Bank-stabilizing grasses may be planted by seed, stolons, strip sodding, or blanket sodding, with costs of placement increasing rapidly in the order given. Where it is possible to prepare a satisfactory seed bed and the banks are not subject to early serious damage, seeding is to be preferred due to its economy. Seeding may be practiced on steeper slopes than would normally be possible through application of a hay mulch. Growth of seed and stolons may be accelerated by fertilizing, using a combination of nitrogen and phosphorus, and manure if available. My own experience has been with ditches which have required the more rapid protection provided by the stolon method, although I have never utilized mulch and fertilizer with seed to full advantage. In very erodable soils strip sodding has been necessary on rare occasions, but I have never found blanket sodding necessary. When proper technics are practiced, seeding and stolon planting methods are economical and feasible in the field of low-cost ditching. The following three slides show Bermuda stolons in Puerto Rico (1) freshly planted, (2) about 2 weeks old, and (3) about 2 months old. (Slides 3, 4, 5.)

Combinations of Grassing and Lining

In planning the section to be lined, the first requirement is to contain the normal flow of the ditch within the lined section. In minor drainage, this condition is usually satisfied by the curved invert section alone, but occasionally it is necessary to add a flat slab on each side of the invert. Grassing will usually suffice for the remainder of the ditch bank slope, including surfaces submerged during storm water flow. Experience in Puerto Rico demonsrated that a well-knit stand of Bermuda grass only 2 to 3 months old would withstand a storm water velocity of up to 8 feet per second in straight stretches of full-flowing ditches. Grades in these cases were up to 3%. The velocity referred to was in mid-stream, the rate of flow at the bank being greatly dampened by roughness due to grass growth.

In such situations, however, grass is unable to withstand serious scouring effects on the far side of bends or arising from turbulence below culverts or other constricted sections. Indicated practice accordingly is to install additional flat slabs for a distance of 10 to 100 ft. on the outer bank at curves, with none on the inner bank. In particularly adverse situations it may be necessary to extend the flat slabs to ground level for a portion of the distance. Such measures may be necessary in some small ditches with grades down to .5%. Compensation for turbulence below culverts, on the other hand, requires lining the bank with flat slabs equally on each side, but to a lower height than at curves. The length of added flat slab protection here will vary from 10 to 50 feet. One or two small curtain walls may be found necessary to protect both inverts and flat slabs.

Other Methods of Ditch Section Stabilization

Lack of finances or excessive size of cross-section may preclude even the use of invert lining, and soil conditions may discourage the growth of efficient species of stabilizing grasses. I have in mind one dragline-excavated ditch in erodable clay with a grade of about .3%, bottom width 6 ft. and 1:1 bank slope. This ditch was about 3 miles long, drained a watershed up to 10,000 acres and had a storm water flow depth of about 4 feet. The storm water velocity was very erosive at this grade due to the favorable hydraulic radius of 2.3 and turbulence arising from irregularities.

Preventive measures comprised: headwalls and wingwalls at road crossings, bottom and side wall lining below road crossings, bank aprons on the outer faces of curves at major points of surface water entry and a grade monument at each station. All of this construction was of mortared rap, using native aggregate and chert field stone obtained from the excavation work and adjacent fields; the only cash outlay being for cement. The grade monument consisted of a curtain wall at grade about 6" in width and 15" deep which extended across the ditch bottom and partway up the side of each bank. It served the dual purpose of preventing extensive scour and marking the original ditch grade for maintenance purposes.

Other instances might be cited. Some of them tend to be feasible only when wage scales are low, but the principle of exercising practical ingenuity and resourcefulness in design and construction applies at all times to minor drainage for mosquito control.

Literature Cited

1. Austin, W. W., Soil Conservation Service, U.S. Dept. of Agriculture, Berkeley, Calif. (1948). Personal communication, December 29.

Mr. Mulhern: Thank you, Arve Dahl. There seems to be no discussion of this interesting material sent to us by Professor Henderson, so I shall conclude this section of the program by showing about 4 minutes of motion pictures of the special crawler-mounted machinery used in New Jersey for cutting and recutting narrow ditches on the salt marshes.

(Film of "Farmall" Ditching Machine shown here.)

SYMPOSIUM: RECENT IMPROVEMENTS AND EXPERIENCE IN THE USE OF AIRCRAFT IN MOSQUITO CONTROL

RECENT IMPROVEMENTS AND EXPERIENCE IN THE USE OF AIRCRAFT IN MOSQUITO CONTROL

By H. H. STAGE

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The advent of DDT in 1943, and the subsequent development of efficient airplane equipment for dispersal of liquid sprays, has increased tremendously the potentialities of controlling mosquitoes. Compared with Paris green and petroleum oils, DDT proved to be very versatile, being usable as solutions, emulsions, suspensions, and dusts, and acting either as stomach or contact poison. In minute quantities it gives effective control of culicine as well as anopheline larvae. Of special importance, it is highly effective as a spray in destroying adults, so that infestations of mosquitoes can be reduced over large areas within a few hours. Operations of this kind during the recent war were carried out against malaria and dengue vectors, sometimes within a few days of the occupation of new terrain by combat troops, thus providing them almost immediately with a degree of protection that could not have been attained in much longer time by more conventional anti-larval methods. Since the war airplane adulticiding has been used extensively for the control of outbreaks of pest mosquitoes.

The American Mosquito Control Association published a special bulletin entitled "The Use of Aircraft in the Control of Mosquitoes," a year ago. This booklet contains much practical information on various phases of airplane spraying. As pointed out in this bulletin, additional biological and engineering research is urgently needed; especially on equipment that will provide more even distribution of the spray and better control of the droplet size, on the most effective droplet size under different conditions, and on the most efficient concentration and formulations of sprays. Most of the organizations represented at this meeting are engaged on various aspects of the mosquito control problem and much information is accumulating on the particular topics under discussion.

In the outline of today's symposium, four subjects are suggested for special discussion.

1. a. Dispersing aerosols by aircraft for controlling *Anopheles* in rice fields.
   b. Dispersing DDT wettable powders with rice seeed for controlling *Aedes dorsalis*. By Thomas M. Sperbeck.
2. Modern techniques in controlling mosquitoes by the Tennessee Valley Authority. By A. D. Hess.
3. Recent advances in controlling mosquitoes, with especial reference to the use of aircraft under Arctic conditions. By B. V. Travis.
4. Present use of aircraft for controlling mosquitoes in California. By A. F. Geib.

RECENT IMPROVEMENTS AND EXPERIENCE IN THE USE OF AIRCRAFT IN MOSQUITO CONTROL

By THOMAS M. SPERBECK

Our plane work in the Sutter-Yuba Mosquito Abatement District is confined mainly to rice field mosquitoes. Our district is in the center of a big rice-growing area about 50 miles north and west of Sacramento. We also have irrigated pastures and river bottom land that sometimes can only be controlled by plane. But the greater part of our plane work is confined to control of rice-field mosquitoes.

In our district we have more than 20,000 acres of rice and we are adding about 20,000 acres more with a recent annexation. Rice fields are a definite mosquito problem twice a year, in the spring and in the fall. I'll discuss the fall problem later.

In the spring, rice fields in our area are flooded before they are sown by plane. From then on fields are kept under water until they are drained before harvest time late in the fall.

So we have the one hatching of *Aedes* eggs and this generation of *Aedes dorsalis* larvae to control.

We have had good luck by adding emulsible DDT at the pumps or canal head gates. However, another method was suggested that deserved consideration and some preliminary tests. This was to apply DDT to the seed just before it was sown by plane or to pre-treat the seed with DDT.

The first thing we wanted to do was to demonstrate that DDT was harmless to the germination and early growth of rice. Usually rice is pre-soaked to that it has already sprouted at planting time. But some growers sow seed without preliminary soaking.

In our experiment we pre-soaked seed 24, 48, and 72 hours before transferring them to jars of water with different dosages of DDT and DDD. We also tested seeds that had not been soaked in advance. We used a specially prepared 10% wettable powder furnished by Rohm and Haas so that we could add the powder in amounts that would correspond to field amounts. Experimentally, we tested amounts a lot higher than we use in the field to control mosquitoes.

We found that none of the dosages, even the highest, had any apparent affect on germination or later development of the seed as compared to untreated samples. In all cases, germination and growth was at least as healthy as the controls.

At rice sowing time, field tests were made with the cooperation of several Sutter County farmers. This was mainly to work out the method of application of the insecticide to the seed. We wanted to find a practical way of mixing the DDT into a plane's rice hopper so that the seeds would be coated. Then, too, we wanted to know when and if the DDT would be released in the water after sowing the seed. We used a 50% wettable powder.

To load a plane for sowing rice, a crew dumps the moist sacks of rice into a loader welded on to the front of a truck. When the loader is full, it is raised so that the truck can drive up to the plane. The crew lowers the hopper so that a spout fits into the plane's hopper. The pilot pulls a trip on the loader and in a few moments, the plane is ready to take off with a full load of about a thousand pounds of seed. The crew is always working against time, so that the plane will be on the ground as short a time as possible. So we had to fit our plans accordingly.

We found that the best way to apply the insecticide was to sprinkle the powder over the seed as the sacks were dumped into the loader. This wasn't highly accurate, but we determined in advance the amount of powder for each load to give the required amount per acre.

Rice seed is pretty thoroughly mixed when it is poured from the loader to the plane and also when it leaves the plane. So most of the seed received a fairly even coating of DDT.

As we had to carry on the experiment along with our other regular work, we were not able to check our results closely. Also, mosquito larvae were scarce in the fields of the experiment. But we obtained water samples in a couple of fields at intervals after the sowing.

Dr. Hoskins of the University ran DDT determination tests and stated that the insecticide was present. DDT had a delayed action and did not show up in the samples until 24 to 36 hours after the seed was in the water. The insecticide seemed to drift into the same spots where larvae usually gather — in the low protected parts of a rice check.

The whole experiment is promising enough so that we plan to continue it this spring. Through the help of the State Bureau of Vector Control, we shall make a more thorough study of the problem, to see if we can work out a quick, inexpensive way of controlling *Aedes dorsalis* at the spring flooding of rice fields. We will test various concentrations of DDT to find the lowest amount needed to kill larvae, and hope to gather more information of value.

In the fall we have the problem of controlling *Anopheles freeborni* with temperatures above a hundred most of the time. We have had good results by plane using a DDT exhaust-aerosol. The method has been in use here now for three years and is similar to the procedure worked out by the Tennessee Valley Authority.

A state study in 1947 by the Bureau of Vector Control in our district determined the minimum amount for maximum results. They found that it was possible to obtain a 95% or better kill of *Anopheles freeborni* larvae with as little as one pint of DDT solution to an acre. That is 25 one-thousandths of a pound of DDT.

The plane was a converted Navy-built primary trainer, a N-3N3 with a 300 horsepower motor. The Army calls the plane a PT-17. It is a biplane that is commonly used for crop dusting and spraying.

The pilot flew at a 25-foot height with a swath of 100 feet. The cost per acre was 30 cents, and included the cost of solvent, and DDT, ground crew wages, and the cost of hiring the plane and pilot.

As nearly as possible this last fall, we followed the same procedure and had the same pilot. The equipment was slightly modified this year. We mix our own material, dissolving 100% technical DDT in Union Aromatic Solvent 40. Then we dilute the stock solution with diesel to make the plane preparation of 5% or four-tenths of a pound of DDT to a gallon.

Our fall problem this year was complicated by extremely hot weather that came as the fields were still under water. Ordinarily, when we are ready to start the plane work, the fields are nearly ready for draining, and we can do a more complete job, because the water has nearly all soaked away soon after we finish the plane work. But this year, late spring rains delayed planting so that rice matured later. Fields were still under water in to late October. This, of course, prolonged the job so that we had to repeat over some fields.

To keep costs down, we wait for a large enough build-up of larvae before we begin. During the summer there are very few larvae in the rice fields. They don't start building up until late August or early September.

Although inspections this year showed that we killed from 95 to 100 per cent of the anopheline larvae, many necessarily escaped because of the fast production rate during the hot weather. Within a few days, larvae start showing up again in a treated field. In one field that served as a spot check through the season, in four days after treatment there were enough larvae again to warrant another application by plane. 95% of the larvae had previously been killed.

Although our rate of application was somewhat higher than during 1947's state tests, our costs were a little lower, principally because of using a lower-priced solvent; also the DDT price was lower. No doubt, the experience we gained during the 1947 tests increased our efficiency and helped lower costs, too. We put out 46 hundred gallons of the 5% mixture at a cost of less than 20 cents an acre. This includes approximately the same costs totalled in the 1947 experiment. The total cost isn't a great deal lower than in 1947, but the amount of acreage we were able to cover was quite a bit greater — to account for the lower acre cost.

Without a plane, we know that control of mosquitoes in rice fields would be impossible. We feel that the people in our district will agree that the money spent on mosquito control of rice fields by plane is well worth while.

DEVELOPMENTS IN THE AIRPLANE APPLICATION OF MOSQUITOCIDES BY THE TENNESSEE VALLEY AUTHORITY

By A. D. Hess

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Introduction

The Tennessee Valley Authority has now accumulated some fifteen years of experience in the use of airplane larviciding for control of *Anopheles quadrimaculatus*. Following the initial investigations carried out in 1934 and 1935, airplane dusting with Paris green at the rate of 1 to 2 pounds per acre was adopted for routine use in the more extensive mosquito breeding areas (Krusé at al., 1944). Experiments on the use of DDT were initiated in the summer of 1943, and the first application of DDT ever made by airplane was carried out at Wilson Dam in June of 1943 under the joint auspices of the Tennessee Valley Authority and the U.S. Bureau of Entomology and Plant Quarantine (Russell at al., 1948). Because of the unsatisfactory physical properties of DDT dust formulations, attention was given to the possibility of using liquid solutions. Certain methylated naphthalenes* were adopted as the ideal type of solvent because of their high solvency for DDT and their high flashpoints, which greatly decreased the fire hazard. Working in cooperation with the Orlando Laboratory of the U.S. Bureau of Entomology and Plant Quarantine and OSRD research groups from the University of Illinois, the venturi exhaust generator was developed and the first field tests were carried out during the 1944 season with very successful results (Metcalf at al., 1945). Accordingly, large-scale field demonstrations were conducted during the 1945 season which led to the adoption of this method for routine use in place of Paris green during the 1946 season. This method involves the use of 20 per cent solutions of DDT in a methylated naphthalene** applied by means of a venturi exhaust generator as a thermal aerosol at the rate of about 0.1 lb. DDT per acre. This procedure provides a much more effective and economical larviciding operation than that obtained with Paris green dusting. With the adoption of DDT aerosoling in place of Paris green dusting there has also been a conversion from the obsolete Stearman Model 4-DX airplane to the Vultee BT-13 (Seaton and Cutkomp, 1948), which has been abundantly available from war surplus. The five larviciding units now in use by the Authority are all of the latter model. Current malaria control programs provide for up to 500 hours flying time including various types of reconnaissance as well as actual application of larvicides and herbicides. Between 40,000 and 50,000 cumulative acres of breeding area are subject to airplane larviciding operations.

Current Larviciding and Herbiciding Equipment

Under favorable meteorological conditions, the DDT thermal aerosols have given almost perfect control with very effective penetration of vegetation and even swath distribution and with no significant damage to wildlife. However, situations are frequently encountered where excessive drift or unfavorable thermal stratification of the air makes it difficult to get an effective dosage onto the treatment area. Such situations have been increased by the fact that airplane larviciding has completely replaced the more expensive and less effective boat and hand operations, thus making it necessary to treat smaller and less accessible areas and to increase the height of flight above the 20-30 ft. elevation which is normally used for the more extensive breeding areas. Attention has, therefore, been given during the past two seasons to methods for producing a spray of a somewhat larger particle size than that obtained with the present exhaust generators. The so-called aerosol produced by these units has a mass median diameter (MMD) ranging from 25 to 50 microns. The desired objective is to produce a material with an MMD of about 75 microns. To simplify discussions, the term "aerosol" has been adopted for materials with an MMD below 50 microns, the term "mist spray" for materials with an MMD between 50 and 100 microns, and the term "spray" for materials with an MMD over 100 microns. Furthermore, sprays are classified as "fine" if the MMD is between 100 and 200, as "medium" if it is between 200 and 300, and as "coarse" if it is above 300. For comparison with the terminology used for ground equipment, the thermal aerosol defined above would correspond to the "fogs" produced by the Tifa machine and the term "mist spray" would correspond at least in part to the fine sprays produced by units such as the Lawrence Aero Mist, the Hession Microsol, and the Buffalo Turbine.

Consideration has been given to two possible means of producing the mist sprays: (1) modified exhaust venturis and (2) conventional spray nozzle equipment. Preliminary tests with larger venturis indicate that one having a throat volume about twice that of the units now in use (that is, with a diameter of 3⅝ inches instead of 2⅜ inches) will produce a mist spray of the desired MMD of about 75 microns. Such a unit would probably be fully satisfactory for routine larviciding use. However, during the past several years increasing use has been made of airplanes for applying 2,4-D herbicides. These materials are very effective for controlling certain aquatic and marginal plants, dosages as low as 1½ ounces per acre giving complete control of American lotus (*Nelumbo pentapetala*). However, certain agricultural crops such as cotton are very susceptible to 2,4-D, and it is therefore necessary to minimize drift. In this respect, the CAA has recently forbidden the application of 2,4-D dust by airplane. Obviously, exhaust generators which produce many fine particles in the aerosol range (under 50 microns) would not be satisfactory, particularly in view of the volatile nature of some 2,4-D derivatives such as the esters. Preference has, therefore, been given to the development of a simple spraying apparatus which could be used for both larviciding and herbiciding merely by changing the size of the nozzle.

The Authority's experimental Vultee was equipped with apparatus having discharge nozzles at each wing tip, each stabilizer tip, and a small spray boom on the tail cone. This permitted a wide variation of spray nozzle combinations, but for larviciding a simple system was adopted with one discharge nozzle at each wing tip and one on the tail boom. This takes advantage of the 42 feet of distance between the two wing tips, thus simplifying the problem of obtaining a "flatter" distribution over the 100-foot swath used in routine treatment. Using conventional types of spray nozzles,* a fine spray was obtained with an MMD as low as about 125 microns, but it was not possible to produce a break-up in the mist spray range of 50-100 microns. Field tests with this unit indicated very effective control and a much higher recovery in the treatment area than was obtained with aerosols, particularly under unfavorable meteorological conditions (Cutkomp et al., 1949). Because of this high recovery, it was possible to reduce the rate of discharge to as low as 0.025 to 0.05 lbs. per acre and still obtain effective control. During the 1948 season, the entire Wheeler Reservoir area was treated routinely with the three-nozzle spray apparatus with a discharge rate of about 0.05 lb. per acre with very satisfactory results. In experimental work this past summer, the center nozzle was eliminated, leaving a single nozzle on each wing tip, thus providing for maximum simplification of the spray appartatus.

Because of the excessive "peaking" and increased danger of damage to wildlife obtained with the spray units described above, efforts have been continued to produce by

*Velsicol NR-70.

**Vesicol NR-70.

*Spraying systems, flat and hollow cone type spray nozzles of various discharge capacities.

mechanical means a material in the mist spray range. This work has been confronted with two difficulties: (1) the lack of basic knowledge on the mechanism of action of spray nozzles in breaking up liquids and (2) the lack of analytical methods of sufficient accuracy for making fine comparisons of swath distributions obtained with different techniques of dispersion. Accordingly, in the spring of 1948 basic studies were initiated on the use of nozzles in securing liquid break-up for airplane spraying operations and on improved analytical techniques for making swath distribution studies. Using stationary towers and special sampling techniques, determinations were made of the relative degree of break-up of our standard larvicidal solution obtained with various nozzles and discharging pressures.* D_0 was adopted in place of the MMD for expressing particle sizes of the sprays obtained. D_0 is defined as "the diameters in microns of a single droplet with the same ratio of surface to volume as a representative sample of droplets in the spray." The empirical equation for D_0 was developed by two Japanese investigators and its validity was confirmed by OSRD research groups at the University of Illinois during the last war (Lewis et al., 1945). D_0 is subject to considerably less variation from sampling errors than is the MMD and usually is somewhat smaller than the MMD.

In the initial studies there appeared to be no significant differences in the D_0 obtained with the hollow cone and flat atomizing types of spray nozzles at comparable rates of discharge, However, the droplet diameter as expressed by D_0 was inversely proportional to the discharge pressure in the limited range of 20-100 lbs. psi under which the tests were conducted. There was indication of a flattening of the curve at the higher pressures and some suggestion that maximum discharge pressures might occur above which the degree of break-up would actually be decreased rather than increased. In the 20-100 lb. range, increased pressures gave smaller D_0 values even though the rate of discharge was increased. It therefore appears that one way of increasing the degree of break-up will be to use smaller nozzles and higher discharge pressures. In current operations the discharge pressure used is only about 40 lbs. psi.

Attention was also given to the placement of the discharge nozzle in relation to the degree of break-up obtained. It was found that the direction of discharge was of considerable importance. The maximum break-up was obtained with the nozzle pointing forward, intermediate with it pointing downward, and least with it pointing backward. This is in agreement with basic studies of the previously mentioned Japanese investigators, who maintained that the break-up of liquids after they leave the spray nozzle is due to the gas atomizing action resulting from the differences in velocity between the liquid and the surrounding air. Obviously, for an airplane in flight this difference in velocity would be greatest with the spray nozzle pointed forward, and this position would therefore be expected to produce the finest spray. The airflow pattern around airplane wings and particularly around the wing tips is a rather complex one, and it would appear that the position and direction of discharge of the spray nozzles have an important relation not only to the degree of break-up obtained but also the ultimate pattern of swath distribution.

*This work was carried out by Mr. C. W. Krusé of the Johns Hopkins School of Hygiene and Public Health.

Techniques for Recovery and Measurement

Two kinds of information are of paramount importance in studying swath distribution of insecticides by airplane: (1) the particle size of the discharge material (which governs to a large extent the swath distribution) and (2) the actual dosage or distribution pattern in the treatment area. The major problems encountered in obtaining this information usually involve (1) the collection of adequate and representative samples and (2) the quantitative analysis of these samples. During the era of Paris green dusting these problems were relatively simple for several reasons. Since the particle size of the dust was not affected by the methods of distribution, accurate analysis of particle size composition could be obtained from microscopical examination of aliquot samples of the dusting materials. In the early period particle counts were also used to provide a rough picture of swath distribution, but, since the larger particles settled in the center of the swath and the finer particles drifted laterally, this did not provide a true picture of swath distribution. A method of quantitative chemical analysis was, therefore, adopted in 1940. Glass petri dishes were placed at intervals across the flight swath to collect the Paris green dust as it settled onto the treatment area. These were transported to the laboratory, washed in hydrochloric acid, and analyzed for arsenic by a simple titration process involving the use of methyl orange and potassium bromide (Asc. Agr. Chem., 1940). The method was rapid, and a number of replicate samples were collected from each station, thus permitting careful statistical analysis and accurate measurement of swath distribution patterns. The accuracy of such analysis was, of course, enhanced by the relatively large dosages of Paris green which were applied (1 to 2 lbs. per acre).

When DDT solutions were adopted for use in airplane larviciding, the Authority was confronted with two major difficulties in securing accurate measurements of swath distribution: (1) the relatively low dosages used and (2) the lack of sufficiently sensitive methods for the quantitative chemical analysis of DDT. Furthermore, since the particle size of the liquid sprays and aerosols was dependent upon the method of dispersal, it was necessary to give close attention to this factor in the individual tests. After trying several methods of collecting samples for particle size analysis, including the Cascade impactor, the simple waved slide technique was finally adopted. In order to minimize the amount of drift before reaching the waved slide, the ship is flown at an elevation of 15 feet, the height being carefully controlled by the use of helium-filled balloons such as are used in CAA weather observation work. This method has several drawbacks, including the fact that it does not collect the smallest droplets, particularly those under 5 microns in diameter. However, these fine droplets are relatively unimportant with reference to the total mass of the spray, and the technique provides a simple way to obtain relative comparisons of particle size composition. After microscopical measurement and tabulation of droplets collected on the slides, the D_0 is calculated.

As previously stated, the lack of sufficiently sensitive techniques for the chemical analysis of DDT has made it necessary to use other methods for measuring swath distribution of DDT larvicides. In the Authority's program the primary objective is to control the immature stages of *Anopheles quadrimaculatus*, and any reduction which may be obtained in adults is purely an incidental dividend. The measurement of swath distribution is, therefore, not concerned with the dispersion of the aerosols or sprays in space but only with the dosage of materials which actually reaches the water's surface in the treatment area. Settling slides have, therefore, been adopted as the ideal method for collecting distribution samples. For general analysis of swath distribution patterns, a simple method of microscopical measurement and counting of the collected droplets has been satisfactory. However, this method is very time-consuming, particularly if it is desired to make detailed comparisons between different methods of dispersal. One difficulty is in the selection of an appropriate spread factor, since the smaller particles have a higher ratio of surface to volume and apparently remain as more discreet spheres than do the larger droplets. Another difficulty is that the large droplets have a much lower frequency than the small droplets but because of their much greater volume have a disproportionate effect upon the total mass of the sample; it is, therefore, necessary to sample much larger areas than contained on ordinary microscope slides if adequate samples of these large droplets are to be obtained. The time required to examine such large samples makes this almost prohibitive for use in making detailed comparisons of individual flight distributions.

Colorimetric analysis was also tried as a method for measuring swath distribution, using a 0.5 per cent solution of an oil-soluble dye (Duponol Oil Red) in the Authority's standard DDT solvent (Velsicol NR-70). Field samples were collected on glass plates 6″ x 9″. These were transported to the laboratory, washed off in acetone, and optical density readings made with a Coleman spectrophotometer and converted to milligrams of dye per millimeter by means of a graph based on readings from standards of an appropriate dilution series. One objection to this method was that the dye broke down rapidly when exposed to strong light and the plates had to be collected immediately after deposition and stored in darkness until analyzed. Furthermore, the method was not sufficiently sensitive for determining the minute dosages obtained in thermal aerosoling operations.

During the past season, work was initiated to develop chemical tracers for swath distribution analysis. First attention was given to certain of the metals, such as copper and lead, for which very sensitive analytical methods are available. One objection to these materials, however, is their wide usage in various compounds and materials which might result in contamination of samples. Alternate metals were, therefore, considered and cadmium was finally selected. Chemical methods were available for detecting this metal in very minute amounts and it had the added advantage that it is not widely used and there is little danger of contamination of samples. Since the ordinary inorganic compounds of cadmium are insoluble in Velsicol NR-70, it was necessary to find a soluble organic compound. Dr. H. L. Haller of the USDA located a source* of organic cadmium and gave a number of most helpful suggestions. Attempts to secure cadmium naphthenate were unsuccessful, but finally a supply of cadmium ethyl hexoate was obtained which has been used in carrying out the studies. Through the cooperation of the Authority's Division of Chemical Engineering a modified analytical technique for the cadmium was developed which makes possible much more accurate measurements of airplane swath distribution than has previously been possible. The material is dispersed from the airplane as a 3 per cent solution of cadmium ethyl hexoate in Velsicol NR-70, which has approximately the same density and viscosity as the 20 per cent solution of DDT in Velsicol NR-70. Two 1-ft. square glass plates are placed at each sampling station across the flight swath and these are "sandwiched" together for transport to the laboratory. Subsequent treatment involves washing in acetone, decomposition of the Velsicol solution, extraction of the cadmium with a carbon tetrachloride solution of dithizone, and measurement of color intensity in a Beckman quartz spectrophotometer. The micrograms of cadmium are read from a calibration curve previously prepared from a standard dilution series of cadmium ethyl hexoate. The final step is to convert the cadmium readings to equivalent quantities of DDT which would be obtained in a 20 per cent solution in Velsicol. The method is considerably more complicated and time-consuming than the simple titration methods which were used for Paris green analysis. However, it does appear to provide an accurate method for swath distribution analysis which will make it possible to secure detailed comparisons of results obtained with different methods of dispersal and also to check upon other methods of analysis such as the drop measurement technique. The cadmium tracer technique was not perfected until the latter part of the season, and only a limited number of flights have been studied. From these it appears that the general swath distribution pattern of the standard thermal aerosol unit (Krusé and Metcalf, 1946) which was determined by the drop analysis technique is reasonably accurate. Next year it is planned to use the cadmium tracer technique to help solve some of the problems of swath distribution which confront us in the refinement of airplane spraying and aerosoling equipment. A detailed description of this technique will be submitted for publication in the near future.

*Harshaw Chemical Company, Cleveland, Ohio.

Conclusion

In conclusion, it may be said that although the Authority's objective is to eliminate permanently all major mosquito breeding areas on its impoundages within a few years and thus minimize the need for routine repetitive measures, airplane larviciding is still looked upon as the ideal standby for handling emergency situations. It is considered as a form of insurance which will provide a means for securing effective mosquito control at a minimum cost during occasional periods when abnormal weather or other unusual circumstances make it necessary to supplement primary control procedures. Efforts to further refine airplane larviciding techniques are therefore being continued. The development of new mosquitocides has proceeded much more rapidly than has the development of equipment for their dispersal. Further refinements in airplane larviciding equipment must, therefore, be made before full advantage can be taken of the various new mosquitocides now available. In addition to continuing the studies on airplane spraying and aerosoling equipment, it is planned that the work next year will include field tests with helicopters.

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USE OF AIRPLANES IN MOSQUITO CONTROL IN CALIFORNIA

By A. F. Geib

Manager, Kern Mosquito Abatement District

For the past 2 or 3 years I have had the opportunity to sit in on many discussions regarding the use of airplanes for mosquito control. From these discussions I have received the impression that there are not two areas or regions where mosquito control problems are identical. Where the problems vary we find the control methods and equipment varying to fit the needs. This seems to be particularly true of airplane equipment and its use in the application of toxicants for mosquito control.

In view of these conditions I am therefore not going to take time to discuss in detail specific techniques of application and types of aerial equipment; but rather just attempt to give you a broad picture of airplane activity in mosquito control in California. In addition, however, I will very briefly mention the results of some of the studies that have been carried on during the past two years.

Prior to World War II there were a few occasions in which airplanes were employed for controlling mosquitoes here in California. These were larviciding applications spraying diesel oil for control of salt marsh *Aedes*.

It was in the fall of 1945 when DDT, in dust form, was first used as a larvicide applied by airplane for control of *Aedes dorsalis* in flooded duck ponds. These were most successful.

Since these first larvicidal applications of DDT the use of airplanes for mosquito control in California has made rapid strides forward. At the present time aerial applications are accepted as a standard method of control by many well-established mosquito abatement districts in the State.

The use of airplanes has been influenced by the need to control:

1. *Aedes* species, developing in tremendous numbers from extensive areas of irrigated pastures, river bottoms, initial flooding of rice fields, salt marshes, and practically all irrigated crops of the Central Valley.
2. *Anopheles freeborni* that develop in thousands of acres of rice fields of the Sacramento and northern San Joaquin Valleys.

During 1948 eight mosquito abatement districts utilized aircraft to control mosquitoes, spraying a total area of 295,160 acres.

Operations were largely larviciding, but some adulticiding and pre-hatching applications were made routinely.

The gross cost of this work, including spray material, was approximately $117,343, or an average cost per acre of 0.40 cents.

Equipment

Three districts own and operate their own ships, with the balance being handled by private contractors.

Planes being used are the Cub class with 65 and 85 h.p. engines and PT-17 Stearman biplanes utilizing 220, 300, and 450 h.p. engines. The Stearman is the type most commonly used.

Aerosol spraying equipment is used for the control of *Anopheles* in the rice fields and to some extent for *Aedes* and *Culex* species, but application of most larvicides is done with spray boom equipment. All spraying equipment is designed to pump the larvicide from tanks and discharge through nozzles attached to booms, with wind-driven gear and centrifugal pumps.

Approximately 55% of the larviciding material used is a 10% DDT diesel oil solution applied at an average rate of .4 lb. to the acre. The balance, or 45% used is an aqueous emulsion of DDT.

Some districts use emulsions of DDT exclusively and others to a lesser extent. This material is applied at .25 to .4 pounds to the acre.

Application of larvicides wih light planes is usually made with a 30 to 40 foot swath width and ½ gallon to the acre. With Stearman type plane the swath width varies from 75 ft. to 100 ft. at ½ to 1 gallon to the acre. The height of flight with both type planes will vary from 15 ft. to 100 ft. or more depending upon obstructions encountered. Over open pastures most applications average 15 ft. to 20 ft.

Costs

Cost per acre for aerial application of insecticides varies considerably. The size and shape of the area flown is probably the most influencing factor. When large areas can be sprayed the maximum number of acres can be covered at a minimum cost. From district to district the average per acre costs vary from a minimum of .265 to a maximum of .53, or an average in the State of .40 per acre.

Studies

During the larviciding season of 1947 the California State Department of Public Health, Bureau of Vector Control, and the Kern Mosquito Abatement District jointly studied the use of airplanes for mosquito control. This activity was carried on in the Kern District at Bakersfield.

District owned and operated PT-17s were used in testing the aerial application of DDT against *Aedes* larvae. Insecticides were applied by aerosol sprayers and from nozzles attached to wing booms. In both types of equipment wind-driven pumps were utilized to discharge the liquid under pressure.

From approximately 150 study flights, on which comprehensive data were obtained, we found that spray applications proved more effective than aerosol when used as a larvicide against *Aedes* species. Spray applications of DDT, which proved consistently better than aerosol, were made using diesel oil solutions and aqueous emulsions. Of these two materials the aqueous emulsion proved to be the superior toxicant. This confirmed observations made by the district of comparable results from applications made the previous season.

So that a more complete comparison of toxicants might be obtained, similar studies were continued during the 1948 larviciding season. In these studies only spray applications were made. They were undertaken not only in the Kern Mosquito Abatement District but also in the Merced Mosquito Abatement District at Los Banos. It was decided to conduct them concurrently at different locations to compare results obtained in one area against the other. It was also felt that under such circumstances it might possibly bring to light conditions peculiar to one region that might affect the results.

A total of 25 study applications, using 85 h.p. Aeroncas, were made during the season at Los Banos, compared to 33 flights, using 220 h.p. PT-17s at Bakersfield. Both type ships flew at comparable heights, approximately 15 ft. with the Aeronca laying down a 35 ft. swath to the Stearman's 75 ft. swath.

All flights were made for control of *Aedes* larvae in irrigated pastures and alfalfa fields under what would be considered comparable conditions. Four-tenths of a pound of DDT was applied per acre. Results were based upon percent of kill of third and fourth stage larvae.

A minimum of 5 applications were made in both areas with each of the following toxicants.

5% DDT (BKH) Water Emulsion

10% DDT (BKH) Water Emulsion

5% DDT (BKH) in Diesel Oil

10% DDT (BKH) in Diesel Oil

5% DDD (Rhothane) Water Emulsion

Results in the two areas were not appreciably different with the aqueous emulsions of DDT but varied considerably with the diesel oil solutions. At Los Banos with the 5% DDT emulsion the average larvae kill for the five applications was 96%, while at Bakersfield it was 99.7%.

With the 5% diesel oil solution Los Banos obtained an 88.4% kill compared to a 53% kill at Bakersfield.

The applications of 10% emulsion and 10% diesel oil at Los Banos resulted in a 94.6% and 94.4% kill respectively, or for all practical purposes identical. At Bakersfield the 10% emulsion resulted in a 96% kill compared to 53.3% with the 10% oil solution.

At Los Banos with DDD or 3-D, 5% emulsion, five applications, resulted in a 77% kill to 31% at Bakersfield.

To very briefly summarize the results of this work, the aqueous emulsions at Los Banos had a very slight edge over diesel oil solutions but not enough to show an appreciable difference. At Bakersfield this was not the case. The DDT aqueous emulsion applications resulted in a 97.8% kill compared to a 53.1% for diesel oil solutions. In both areas DDD proved inferior to DDT.

Comparing the diesel oil solutions to aqueous emulsions in the two areas we find results as follows:

98.6% kill with a 5% aqueous emulsion.

95.4% kill with a 10% aqueous emulsion.

67.7% kill with a 5% diesel oil solution.

72% kill with a 10% diesel oil solution.

Or: 97% kill with aqueous emulsion to a 69.8% kill with diesel oil solutions.

It is interesting to note that airplane spray applications of DDT aqueous emulsions have been markedly superior to DDT diesel oil solutions for three successive years at Bakersfield. However, in a single year's trial at Los Banos the aqueous emulsion is only slightly better than the oil solutions, actually so little different as to be insignificant.

These data are a brief summary of the airplane study work carried on for the past two years by the Bureau of Vector Control and mosquito abatement districts in California. In the near future comprehensive detailed reports will be published covering these studies of aerial application of insecticides for mosquito control in this State.

Summary of Recommended Procedures

Mr. Harvey I. Magy, Vector Control Specialist, Bureau of Vector Control, in coordinating and evaluating cooperative airplane studies in California, submits the following general recommendations to workers in this State using airplanes for the control of mosquitoes:

1. For the control of *Aedes dorsalis* and *A. nigromaculis* larvae in intermittently flooded pastures by airplane:
   a. For 3rd and 4th instar larvae:
      1. *Light to medium vegetation density:* Use 0.4 pounds of DDT per acre applied with a spray plane. This dosage may be obtained by using one-half gallon of 10% DDT in a water emulsion or in oil solution per acre. (Percentage concentration is based upon two pounds DDT per ballon being equal to 25%.)
      2. *Heavy vegetation density:* Use 0.5 pounds of DDT or one-half gallon of 12½% DDT solution per acre applied with a spray plane.
   b. For 1st and 2nd instar larvae:
      1. *Light to medium vegetation density:* Use 0.20 pounds DDT per acre, or ½ gallon of 5% DDT solution applied with a spray plane.
      2. *Heavy vegetation density:* Use 0.30 pounds DDT per acre or one-half gallon of 7½% DDT solution applied with spray plane.
   c. For more consistently reliable control, DDT water emulsions are recommended over DDT Diesel oil solutions.
   d. Use an airplane such as a PT-17 with a 220 horse power motor, or greater, flown at 75 foot swaths and at 15 foot heights.

2. For the control of *Anopheles freeborni* larvae in rice fields:
   a. Use 0.025 pounds of DDT or one pint of 2½% DDT diesel oil solution per acre applied with a thermal aerosol plane, patterned after those developed by the Tennessee Valley Authority.
   b. Under conditions of rice fields in Sacramento Valley during Autumn when anopheline larvae recur rapidly after treatment, the rice fields should be resprayed at intervals of approximately ten days.
   c. Use an airplane such as a PT-17 plane with a 220 horse power motor, or greater, flown at 100 feet swaths and 15 foot height.
3. All airplane treatments should be done early in the morning in order to take advantage of low air temperatures, which have been found to be most important, as well as other favorable meteorological conditions.

LOOKING BACK HALF A CENTURY FOR GUIDANCE IN PLANNING AND CONDUCTING MOSQUITO CONTROL OPERATIONS

By William B. Herms

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In retrospect, about forty years ago malaria-mosquito control operations began in California (Penryn, Placer County), and better than fifty years ago in other parts of the world. Such distinguished and honored men as Ronald Ross, W. C. Gorgas, Malcolm Watson, and J. A. Le Prince courageously pioneered large-scale mosquito control operations when faith was really needed in a big way. You of 1949 are treading on solid foundations of long experience. I wish all of you could have attended the exercises in Washington, D.C., May 14, 1948, commemorating the fiftieth anniversary of the discovery by Ronald Ross of the method of transmission of malaria. This was a truly inspirational event.

Several weeks ago the chairman of your program committee assigned to me the task of "looking backward" and "looking forward," all in one thirty-minute glance. I will obediently take a backward look with full knowledge, on biblical authority, that at least one person suffered the penalty of being turned into a pillar of salt for just one short backward glance. My short backward look does not imply a yearning to return to what existed in California some forty years ago when there were between 5,000 and 6,000 cases of malaria annually in this state.

Malaria has now practically vanished, and there are few living today who remember what was some forty to fifty years ago a serious menace to rural life in the Great Central Valley of California. I do not infer that mosquito control alone deserves credit for this notable reduction in malaria, but I do contend that anopheline mosquito control work had more to do with this than some folks are willing to concede.

A backward look may reveal suggetions helpful not only in the conduct of future mosquito control operations, but may also give us renewed courage to go forward to better effort on behalf of those the world over who look to this group for aid, particularly the citizens of California who have invested heavily in mosquito control as you all know. Yours is, therefore, a serious responsibility based on *good will* — your constituents look expectantly and confidently to you for the abatement of annoying and disease-bearing mosquitoes. You have a job to do — do it with sincerity and devotion. Continue to be worthy of the good will of your constituents.

Perhaps we may see what I mean by devotion and perhaps we may also see how far we have come in our work and more particularly what must still be done were I to relate some incidents from my own experience. Actually we haven't too much to crow about, and that had better be left to those who follow in another half century.

Something over fifty years ago, to be more exact, September, 1898, a young man hopefully left his home to enter college, presumably to prepare himself for the practice of medicine. There were thoughts of expertly administering quinine to sufferers from ague when and if he got back. He did pursue medical studies but he did not return to practice medicine. One thing was certain, his mind was set on malaria, for he still suffered from the effects of half a dozen years of Ohio Valley malaria and had seen much of it as a boy.

The year 1897-1898 was eventful as you all know, for it was the year in which Ronald Ross, the Englishman working in India under the inspirational guidance of Patrick Manson, announced the discovery that malaria is carried by dapple-winged mosquitoes (*Anopheles*). Could it be that the young man read the statement by Ross published in the *Indian Medical Gazette* for July, 1899? I know he did not, but this is the statement, "in order to eliminate malaria wholly or partly from a given locality, it is necessary only exterminate the various species of insects which carry the infection. . . . It remains only to consider whether such a measure is practicable. . . . Theoretically the extermination of mosquitoes is a very simple matter."

One might also believe that the young man heard the exultant words of Ronald Ross —

"This day relenting God
  Hath placed within my hand
A wondrous thing, and God
  Be praised, at his command

"Seeking his secret deeds,
  With tears and toiling breath,
I find thy cunning seeds,
  O million-murdering death.

"I know this little thing
  A myriad men will save;
O death, where is thy sting
  Thy victory, O grave!"

Before we proceed further with the life of the young man — now not so young — I should remind you that the discovery made by Ronald Ross was indeed important, for he was twice awarded the Nobel prize in medicine. Then, too, in our day, 1948, Paul Muller received the Nobel prize in medicine for his discovery of the insecticidal property of DDT *now* extensively used in mosquito control operations. Yes, you are engaged in some very important work, which deserves your devotion.

Now back to the young man for a few moments to bring out another element of importance. Fortunately the young man fell into the hands of two (one at once and the other later) sympathetic teachers who seemed to understand his impatient respect for the academic and theoretical aspects of a college education, and above all sympathized in a very real way with the youngster's overwhelming desire to know "what goes on in Nature in The Rough." The first of these teachers was Dr. E. W. Berger, a distinguished zoologist in his day, from whom the boy learned more on field trips than in the classroom. Berger had just previously received his "Doctorate in Science" from Johns Hopkins University. The other teacher was Herbert Osborn, the great entomologist, who is still living. With him I (the personal pronoun is appropriate once you do know the identity of the young man, now no longer quite so young) spent many happy summers on the shores of Lake Erie begining in 1904, and learned from Professor Osborn and with him in the field what made *Anopheles quadrimaculatus* the successful species that it is among animals that constitute the animal kingdom. I was thoroughly indoctrinated with the importance of field ecology and the value of the experimental method. I commend to you a thorough first-hand knowledge of "what goes on in the field."

The next step is important, for it was the year of decision, i.e., was it to be a strictly academic career in an Eastern University, or was it to be, what seemed then hazy, a career (perhaps brief) at a then little known University at Berkeley, California (Stanford was much better known). My Harvard professors (for I was then a fellow in zoology in the Harvard Graduate School) shook their heads — I was taking an awful chance; particularly, said they, get out of Agriculture as soon as possible. Anyway, no matter, we would be nearer China, and I did want to do Missionary work of a sort there — so as you well see I remained in California, where there was also opportunity for missionary work.

On a chilly, foggy afternoon in August, 1908, the young man who entered college in Ohio in 1898 (ten years previously) arrived in Berkeley, California, with his wife and young son. When I took my first look at the then sparsely built campus and the small rather creaky wooden building known as the "Entomology Building" hard by what is now Sather Gate, I almost felt that it was all a gloomy mistake. Even our bathing suits which we had placed handily in our suitcases were now inappropriate. But across the hills lay the great Central Valley of California, and there I soon learned was malaria deeply entrenched in agricultural practices; irrigation was literally the life blood of California agriculture, and farmers were particulaly "touchy" on this subject, as I quickly leaned. In the 1907-1908 University "Announcement of Courses," I found the description of a course entitled "Mosquitoes" given by Professor H. J. Quayle, whose publication on that subject on this coast (J. B. Smith, New Jersey) was a pioneer. Professor C. W. Woodworth was already engaged in salt marsh mosquito control operations in both San Mateo and Marin Counties. I must confess that my interest in salt marsh mosquitoes was very mild — they were not vectors of malaria or of any other disease; however, I was soon drawn into that situation.

In 1909 (March), a few months after our arrival at the University of California, it was my good fortune to be invited to become a member of the staff of the Agricultural and Horticultural Demonstration Train (a joint Southern Pacific R. R. and College of Agriculture enterprise). My job was to show by means of exhibits and demonstrations how "Medical Entomology and Parasitology" (exactly so listed in 1909) could benefit the farmer in bettering living conditions on the farm for his family, his help, and his domestic animals. The first of these trains worked Southern California to the Mexican border during March, 1909, and some months later Northern California to the Oregon line. I learned much about malaria as a real menace to California agriculture during that experience. Harold Gray, who was one of my students at the time and a field assistant, got some early experience in this connection too.

Actually the completion of that experience you will note in the announcement of courses (1909-1810). Herms was not only offering a course in "Medical Entomology," but also a course for advanced students entitled "Rural Health Problems." I would like to add that at times both President Benjamin Ide Wheeler and the Dean of Agriculture (Dean E. J. Wickson) spent some days with us on the Agricultural Demonstration Train. I am naive enough to believe that they approved of my efforts in the *College* of *Agriculture* at that time. I must let others determine how University of California Presidents and Deans of Agriculture have rated my work since.

In the November, 1910, bulletin of the State Board of Health (an indication of my early association with that State Department) the closing sentences of a brief article which I wrote are these: "What this State wants is the colonization of the great inland valleys and the productive foothills of the Sierra; and the control of malaria is one of the great problems to be solved. But the problem is one that can be solved as we are coming to see, and that at a reasonable cost." In those days many argued that it would be prohibitive, particularly since it meant *the control* of the Sacramento River. This of course was not correct. In that same bulletin (1910), lest we forget, the then Secretary of the State Board of Health, Dr. W. F. Snow, stated that there were 112 deaths from malaria in Caifornia, of which 104 were in Northern and Central California, and there were between 5,000 and 6,000 cases. The annual loss due to malaria was then estimated at $2,820,000, an indication of the economic importance of this disease.

Opportunity to test my knowledge of malaria came in December, 1909, when Mr. Fred E. Morgan wrote, "We here in the Placer foothill region (Penryn) want to fight the malaria mosquito, but do *not* know how to proceed. . . . Can we expect some aid in this?" My answer in part was as follows: "A campaign such as you wish to undertake should begin as an educational movement. . . . This can be done while the ground is being covered and points of attack marked. I recommend that at first a vigorous campaign be made in some restricted isolated area where *Anopheles* mosquitoes and malaria have been extremely bad, in order to demonstrate beyond question the practicability of the plan."

As soon as the plan became known, the undertaking was severely criticized and denounced by certain boosters and certain newspaper editors as being the wrong kind of advertising. My answer was plenty of work, and very soon we read in the same papers these words, "An open policy of education, with evidence of active work toward the eradication of a disease, immediately engenders confidence." Mine wasn't an academic, directed-from-the-campus campaign. This was a movement and it gained momentum, in fact it hasn't slowed up yet.

Early in February, 1910, I began spending my weekends in Placer County, without cost for services to the community and at no cost to the University, not even my expenses. In November the Penryn Anti-Malaria-Mosquito Committee headed by Mr. H. E. Butler, a man of great faith, reported a total expenditure of $715.75, which included everything from the pay given my field agents, Harold Gray included, the cost of a knapsack spray pump and 360 gallons of oil; much corrective work was done by the growers themselves. The area protected covered about eight square miles. The success of that first campaign as reported by the local committee was far beyond my expectations. For details concerning the operations of this and other early campaigns, see Herms (1912), *Malaria, Cause and Control* (Macmillan Co., N.Y.).

My next summer (1911) was spent in Europe in order to visit the malaria-ridden Roman Campagna, various schools of tropical medicine, and as a delegate to the International Hygiene Exhibit in Dresden, Germany. In those days we bore credentials bearing the great seal of the State of California, and we also bore all expenses out of our own pockets, at least I did. On the European trip I was greatly encouraged by Dr. G. H. F. Nuttall, Director of the Mattins Institute of Parasitology at Cambridge University, England.

On my return to California there quickly followed requests to organize anti-malaria-mosquito campaigns in Oroville, Bakersfield, Redding, and Los Molinos. My first field assistants were Herbert Leak, Ben Bairos, Charles Woodworth, Earl Cornell, and Harold Gray. The latter (the engineer) is still in the game after forty years with some time out on other jobs. He too accepted the challenge, and we have worked together hand in hand for many years.

Obviously, except for an overall picture and a fair intensive knowledge gained at half a dozen points, we still had little knowledge of the msoquitoes of California, and we haven't much yet. On the evening of March 8, 1916, there took place a dinner meeting at the Hotel St. Francis (San Francisco) which I now believe to have been the most important conference on Malaria ever held in California. This was a meeting called by the Commonwealth Club to hear a report from a committee on malaria of which Doctor George E. Ebright, then President of the State Board of Health, was Chairman. In addition to a formal report by Dr. Ebright, papers were presented by Dr. Ray Lyman Wilbur, President of Stanford University; Dr. K. F. Meyer, and Dr. George H. Whipple. There was also an illustrated lecture on malaria by the writer of this document. Two recommendations were made by the committee; first, that mosquito control districts be formed which shall cover all malaria-infested areas in California and that this be done as rapidly as possible; second, that if by the end of the year 1916 this plan be found ineffectual or unsatifactory, the legislature should appropriate funds to be used by the State Board of Health to employ a sufficient number of inspectors to undertake the field work of malaria extermination under the then authority of the State Board of Health.

A state-wide mosquito survey seemed to me to be essential. On March 4, 1916, (a few days prior to the meeting referred to above) the State Board of Health authorized such a survey in these words, "to undertake, in cooperation with the University of California, a survey of malaria and mosquitoes in California under the direction of Professor W. B. Herms, assisted by Mr. S. B. Freeborn, provided the funds of the Board will permit financing the plan." Actually funds were appropriated for the purpose.

The survey was conducted during the summers of 1916, 1917, and 1919 (a year out for World War I, when I was stationed at Newport News, Virginia), covering practically every nook and corner of California; the mileage by automobile was approximately 20,000 miles. Much valuable information was collected, together with numerous mosquitoes, principally anophelines. (See Freeborn's *Mosquitoes of California.*) At a meeting of the State, County, and Municipal Health officials, held at Riverside in October, 1919, I presented a paper quizzically entitled "What Shall We Do with Our Information Concerning Malaria in California?" — What now!

We had found that 13 counties harbored three-fifths of all of our malaria and comprised an area of about 20,000 square miles, with a death rate due to malaria of 14.2 per 100,000 for the year 1916; furthermore that these counties comprised about half the size of Mississippi, which had a death rate of 5.9 per 100,000 for the white population. In other words, these thirteen California counties had a malaria death rate more than twice that of Mississippi, then regarded as one of the most malarial states in the United States. Shasta County, with an area of about 3,000 square miles, had a malaria death rate of 64.1 per 100,000 population as late as 1918. My question was indeed pertinent — What were we to do with this information?

A malaria control demonstration financed by the State Board of Health and supervised by S. B. Freeborn was conducted at Anderson, Shasta County, during 1920. By May, 1915, the California Mosquito Abatement District Act had been approved (Assembly Bill No. 1665, Chapter 584), resulting immediately in the formation of Marin, Three Cities (Peninsular cities), and Kern (Dr. Morris) Districts. There are now 42 mosquito abatement and 6 pest abatement districts in California covering over 20,000 square miles, with operating budgets totaling nearly two million dollars. Compare this with our beginning in 1909 at Penryn with an area of 8 square miles and an operating budget of $715.

Almost from the beginning of our work it was my hope tht the State would appropriate money to aid in the control of mosquito vectors, witness the following quotation from an article of mine in the November, 1911, issue of the Sacramento Bee: "No single act of the Legislature is more badly needed, and likely to bring greater results, than an act appropriating at least $200,000 toward the control of malaria. . . . This amount wisely spent under expert direction, could be made to reduce malaria permanently by more than 75 per cent in three or four years." In 1946 subvention funds amounting to $400,000 were voted by the Legislature for vector mosquito control. It took the added weight of an indictment against *Culex tarsalis* as a vector of arthropod-borne encephalitis and more particularly the threat of Japanese B encephalitis (which did not materialize) to secure direct aid from the State. Now we had a species sanitation problem with a vengeance, malaria vectors with a fairly well defined breeding situation and the encephalitis vector presenting a widespread generalized mosquito breeding problem. This reminds me of the words of Ronald Ross written as early as 1910: "Since 1899 I had gradually become convinced that anti-mosquito campaigns had better be conducted, not only against anophelines, but against all kinds of mosquitoes at once." Certainly these are significant words written by the founder of malariology.

Now with the availability of a subvention fund of $400,000 for vector control and a difficult disease potential, together with a whole series of complications not for discussion here, a demand was made for a distribution formula. Only those who participated in the almost fruitless discussions appreciate how difficult it is to develop an accurate formula based on epidemiology (potential and real) and potential as well as real vector incidence. In short, numerous mosquito control agencies within the state entered upon a scramble, each intent upon getting his so-called share of the subvention funds. When we keep our eye on money instead of mosquitoes, money becomes the root of evil. The only workable formula in this case is the "Golden Rule."

The time for big operations was at hand — we jumped from the hand spray pump era to the airplane and power sprayer era in the course of half a dozen years or less. Perhaps in this the pattern may have been set by the Federal Government during the war years. Big spending had become the mode. Above all a potent insecticide had been placed in our hands in 1943, DDT, and the face of the earth, it seemed, had to be covered in a hurry — it was indeed the DDT era and big machinery was a means to an end. In our eagerness to apply the newer insecticides, no doubt with all too little knowledge and understanding, I fear many of us lost sight of the importance of permanent corrective work, which was stressed as fundamental in our early operations.

We have placed emphasis on mosquito *control* through the years; however, we must face squarely the possibility of vector eradication now frequently urged. The young man (Thomas Aitken) who named our potent western malaria vector, *Anopheles freeborni,* is now engaged in a campaign to completely eradicate the malaria vectors from the Island of Sardinia. Some of you heard him say a few weeks ago that this is being done by the use of small hand sprayers, and 33,000 men are being employed in the eradicatory campaign — an expensive project. Sardinia is an island comprising 9300 square miles and a population of about 1,220,000. The situation is such that anopheline vector eradication appears to be possible and the objective is being achieved. The eradication of the introduced *Anopheles gambiae* from a considerable area in Brazil, also at heavy expense, was thoroughly justifiable (see reports). The eradication of *Aedes aegypti* is also thoroughly practical in certain communities. There seems to be no good reason for undertaking an expensive vector eradicatory campaign in California. I still believe we can handle our mosquito-borne disease problem economically by keeping potential vector populations below the level of public health importance. A high degree of protection against pest mosquitoes may also be had at reasonable cost.

There is an interesting item in the December, 1891, issue of *Nature* concerning the use of fish in mosquito control, namely: "An English gentleman living on the Riviera, having been troubled by mosquitoes, discovered that they bred in the large tanks kept for the purpose of storing fresh water, which is (was) rather a rare commodity at this Mediterranean resort. He put a pair of carp in each tank and succeeded in this way of extirpating the insect pest." This item leads me to state that the top minnow, *Gambusia affinis,* was brought into California by the State Department of Public Health in 1922, when 600 of these fish were brought in by truck in milk cans. I recall the hot summer day when this truck was on its way to Chico with Stan Freeborn aboard keeping the fish alive. There are no doubt many millions of these top minnows in nearly every part of the State — they were estimated at 50 to 60 million in midsummer of 1929.

It might interest you to know just when and where the California Mosquito Control Association came into being. The program, dated March 26 and 27, 1920, opens with a paper by your present speaker entitled, "Mosquito Control an Important Factor — The Development of the State's Resources, and the Necessity for Coordinated Effort." The afternoon of the second day was spent in the field near San Mateo. The sessions were held in Agriculture Hall, University of California.

Mosquito Control Conference

Agriculture Hall - University of California - Berkeley, Calif.

March 26th and 27th, 1920.
March 26 (Friday) Room 204

Morning Session.

10:00 a.m. Mosquito control an important factor in the development of the state's resources; necessity for coordinated effort.................... W B. Herms

10:30 a.m. Business session. Organization of California Mosquito Control Association with discussion of its possible activities.

12:00 m. Lunch.

Afternoon Session.

1:30 - 5:00 p.m.
Laboratory session................................Room 204
a — Demonstration of publicity methods.
b — Identification of mosquitoes.
c — Diagnosis of malaria — smear making and staining, with microscopic examinations.

Evening Session.

6:30 p.m. Dinner and "Get-together" meeting.

8:00 p.m. Round table smoker for purpose of discussing Finance and Legislation................S. B. Freeborn

March 27 (Saturday)

Morning Session.

9:00 a.m. - 12:00 m.
Discussion Meeting (Room 294) Short ten minute talks to open discussion.
a — Drainage methods..................M. E. Franklin
b — Oiling methods.......................H. E. Woodworth
c — Influence of rice fields.............W. C. Purdy
d — The Urban problem................E. H. Rolison
e — Salt Marsh problem.................N. M. Stover
f — The Rural problem..

Afternoon Session.

12:20 p.m. Leave on Key Route Ferry for San Francisco — Lunch on Ferry Thence to San Mateo via Interurban electric to visit "Three Cities" Mosquito Abatement District. Field trip under direction of N. M. Stover, Superintendent of the District.

5:00 p.m. Business session and adjournment (Probably in San Mateo)

Now that we have taken a backward look over a period of about half a century all told, what did we see that will aid in doing a better job of mosquito control during the next fifty years? I am sure you recognized a degree of devotion on the part of the so-called old timers. They had dedicated themselves to a task and stayed with it. To you I say *keep faith* with the folks who look to you for the accomplishment of mosquito control. It's the long run that counts. *Know well the insects* (mosquitoes) against which you are contending; none of us knows enough about the habits and behavior of mosquitoes; your entomologist who is trained to understand the ways of insects is an important integral part of the whole project; if your project is to succeed, the engineer (or his equivalent) and the entomologist (or biologist) must work in harmony. Neither the entomologist nor the engineer should be regarded as a temporary element in your program, to be employed precariously out of temporary supplementary (subvention) funds. The day will come when proponents as well as opponents will agree that the investment of state subvention funds in entomological guidance, as well as engineering guidance, was a wise investment. Forty years' experience in mosquito control, particularly vector control, has taught me the soundness of this procedure.

Education of the public has been considered an important part of *our* program from the very beginning, and must continue to play an important part in *your* work.

Emphasis was placed on *permanent corrective* work at the very outset, and I am most happy to add my approval to the paper on that subject presented at this session by Harold Gray, who understands my philosophy of mosquito control thoroughly.

You are concerned with insecticides; be wise and understanding in their use. Continue searching for a specific culicide. Don't be penurious to the point of missing your objective entirely, but scrutinize your budget most carefully. Remember that you are spending the people's money and that you should account for every dollar even more carefully than you do your own. Be prudent now; the time may be near when even the managers will have to get their feet wet handling a spray pump. *Keep your house in order.*

As long as people anywhere in the world suffer and die from mosquito-borne diseases your job is not done.

You have better tools to work with, better insecticides, much more knoweldge, and better men to apply these, and a lot more money to work with, hence much more is expected of you — but you should still be men of great faith, devoted to an important task. I wonder what reports will be heard at meetings of these associations forty years from now. I hope it may be said then that no longer do millions of human beings suffer and die from mosquito-borne disease as they do today. It probably won't be because mosquitoes have been exterminated, but because men have learned to *control* them.

And now, whether you have suffered from malaria or from the vicarious exposure to the painful bites of *Aedes sollicitans* or *Aedes nigromaculis,* you may be assured of an abode in Heaven, for so reads (in part) this interesting poem in *Tropical Medicine News* of August, 1944:

"You pile up the blankets and try to get warm,
Yet shiver and shake like a leaf in a storm;
Your head's like a furnace, your throat like a drain,
And your body's one racking all-overish pain,
While burning hot needles are piercing your brain —
You're having a touch of Malaria.

"If by chance you should see a poor wreck passing by,
Yellow of skin and a watery eye,
Bones all a-rattle, with lips turning blue,
Who gibbers and blinks like an ape at the Zoo,
Don't shoot the poor devil . . . it's only he's due
For another attack of Malaria.

"'Tis said when you die and arrive at the Gates
Of Heaven's abode where Saint Peter awaits,
It counts not at all if you've squandered your time,
What sins you have done, or the depth of your crime,
You've a box seat reserved with the martyrs sublime
If you've suffered on earth from Malaria."

Mr. Washburn: Thanks a lot, Professor Herms. We always like to hear from you. Your paper is a real climax to this conference.

We have a few things to wind up the Conference. We would like to call for announcements now. Chet Robinson, on the motorcade? Some of these announcements are important, so try to remain if you can.

Mr. Robinson: Just a very short announcement to those who are going on the motorcade. At the desk just as you go out the hall there are tags to put on your suitcase. Please put on your name so that we can have them. Also, a mimeographed two-sheet paper giving the cars that you are going in.

Mr. Washburn: California's thanks go to the American group for participation and joint efforts in putting on this Seventeenth Annual Conference. I think it has been a very fine thing. Many of us have seen old friends, and have learned some new ideas. I know that we will carry them back home and have a better year in the future. If there are no other announcements I will duly close this Seventeenth Annual Conference of the California Mosquito Control Association. Adjourned.

THE EIGHTEENTH ANNUAL CONFERENCE OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION WALL BE HELD IN BERKELEY, CALIFORNIA, FEBRUARY 2 AND 3, 1950.

APPENDIX

[Sheet 1 — Front]

GROUND POWER SPRAY EQUIPMENT STUDY

Inspector's Report

Study No.......................Agency.......................Inspectors.......................

A. Date: Day..........Month..........Year..........Hour..........a.m., p.m.

B. Location:.......................

C. Operational Factors:

1. Type of Contol: Adulticiding.......................Larviciding.......................

2. Method of Application: Spray..........Mist..........Fog..........

3. Data: (A) Swath Width.......................(E) Presure Used.......................

(B) Treatment Time.......................(F) Volume Used.......................

(C) Acreage.......................(G) Type Nozzle.......................

(D) N.P.H.......................(H) Material.......................

4. Gross Characteristics:

(A) Dense Mist or Fog.......................(F) Poor Penetration of Vegetation.......................

(B) Light Mist or Fog.......................(G) Quick Break (Down in 30 Sec.).......................

(C) Even Spread on Water.......................(H) Long Suspension.......................

(D) Uneven Spread on Water.......................(I) ....

(E) Good Penetration of Veg.......................(J) ....

5. Particles (A) Size.......................(Microns, Mass Median Diameter)

(B) Distribution No. per Field.......................Magnification.......................

D. Meteorological Factors:

1. Air Temp.: (A) 6 ft. high.......................(B) 1 ft. high.......................

2. Relative Humidity:.......................%

3. Wind Velocity:.......................ft./min.

Wind Direction: N..........NE..........E..........SE..........S..........SW..........W..........NW..........

E. Biological Factors:

1. Type Water Area:.......................
(Code) (See Reverse)

2. Origin of Water:.......................
(Code) (See Reverse)

3. Water Temperature:.......................° F.
(Average 5 Surface Readings)

4. pH:.......................
(Average 5 Surface Readings)

5. Water Depth:.......................
(Average at Maximum Infestation, Nearest 1)

6. Vegetation: Present..........Absent..........

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[Sheet 1 — Reverse]

CODE FOR MOSQUITO (LARVAL) SOURCES

I. Natural Water
- A. Streams
- B. Lakes
- C. Overflow
- D. Seepage
- E. Low Spots
- F. Marsh — Fresh Water
- G. Marsh — Salt Water

II. Rain Pools
- A. Temporary Pond
- B. Permanent Pond

III. Irrigation Water
- A. Canals & Ditches
- B. Seepage
- C. Boxes
- D. Overflow
- E. Tail-End Spread
- F. Low Spot
- G. Stand Pipe
- H. Flooded

IV. Industrial & Community Wastes
- A. Lagoons
- B. Stream Bed
- C. Sewer Farm

V. Domestic Sources
- A. Dairy Drains and Sumps
- B. Water Troughs
- C. Faucet Drips
- D. Refrigeration Units
- E. Cellars
- F. Catch Basins & Gutters
- G. Fish Ponds
- H. Waste Disposal Units

VI. Miscellaneous Sources
- A. Water Tanks
- B. Artificial Containers
- C. Excavations
- D. Tree Holes
- E. Hoof Prints

[Sheet 2 — Front]
— 2 —

		7. Vertical Vegetation	8. Horizontal Vegetation
A) Height of Cover:	1) Low		
	2) Medium		
	3) High		
B) Density of Cover:	1) Light		
	2) Medium		
	3) Heavy		

C) % of Cover Over Water Surface

(See Reverse for Additional Information on Vegetation Factors)

9. Algae: (A) Present.......... Absent..........
(B) Surface.......... Subsurface.......... Bottom..........
(C) Per Cent of Relative Water Surface Area Covered.......... Nearest 25%

10. Flotage: (A) Present.......... Absent..........
(B) % of Water Surface Covered..........

F. Entomological
Note: Pre-Inspection to be made at time of treatment

FIELD (NATURAL) INSPECTION RECORD

	Pre-Treat Inspection	6 Hours Post Inspection		12 Hours Post Inspection		24 Hours Post Inspection		48 Hours Post Inspection	
		No.	% Kill	No.	% Kill	No.	% Kill	No.	% Kill
Date:									
Time of Inspection									
Hours after Treatment									
Numer of Dips									
No. and Stages Present:									
1 & 2									
3 & 4									
Pupae									
Total									
Adults									

Laboratory Specimens
Submitted

Location of No Kill or Small % Kill

Remarks:..........

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[Sheet 2 — Reverse]

Height of vegetation to be determined by: Low, two inches or less; Medium, two to twelve inches; High, 12 inches or over.

Density to be determined by using a standard dipper with handle having an overall length of six feet, placed in a horizontal position and observed from a distance of 10 feet. Light cover will be when 75 per cent or more of the total measuring unit is observed, Medium will be when between 25 per cent and 75 per cent of the unit is visible, Heavy will be when 25 per cent or less is visible.

[Sheet 3]
FIELD (ARTIFICIAL) INSPECTION RECORD

Species | Stages Used:

Stations	⅛ Mile	¼ Mile	½ Mile	1 Mile	1¼ Mile	Control
No. Adults						
Per Cent Kill — Hours	% Hours	% Hours	% Hours	% Hours	% Hours	% Hours
	1	1	1	1	1	1
	6	6	6	6	6	6
	12	12	12	12	12	12
	24	24	24	24	24	24
Stations	**25 Feet**	**50 Feet**	**75 Feet**	**100 Feet**	**200 Feet**	**Control**
No. Larvae						
Per Cent Kill — Hours	% Hours	% Hours	% Hours	% Hours	% Hours	% Hours
	1	1	1	1	1	1
	6	6	6	6	6	6
	12	12	12	12	12	12
	24	24	24	24	24	24

Standard Adult Cages and Larvae Cages to be used for all testing.

Remarks:

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