PROCEEDINGS AND PAPERS

OF THE

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California Mosquito Control Association, Inc.

AT THE

VILLA HOTEL

SAN MATEO, CALIFORNIA

JANUARY 29 - 31, 1962

Proceedings Committee

W. DONALD MURRAY and E. CHESTER ROBINSON, *Chairman*

JOHN R. WALKER, *Editor*

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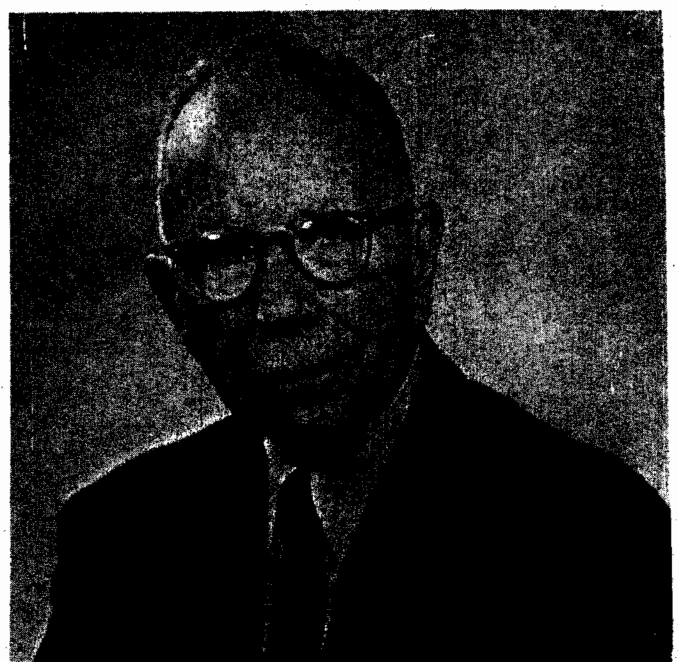
DEDICATED TO THE MEMORY OF LEWIS WENDELL HACKETT



LEWIS WENDELL HACKETT
1884-1962

The recital of the record of a distinguished scientist can reveal little of the real essence of the man himself. This is particularly true of Lewis W. Hackett, M.D., Dr.P.H., Honorary Member of the California Mosquito Control Association, who died at Oakland, California, April 28, 1962.

What endeared him to his friends and colleagues was his kindliness, his personal simplicity, his sincerity, and his humor. It always was a delight to be with him. His erudition in the field of tropical medicine was tremendous, but one never felt overwhelmed by it. He also had the practical ability to put scientific ideas into effective use to prevent disease. Assuredly many doubting public officials were "sold" on his proposals by his personality.

Lewis Hackett was born in Benicia, California on December 14, 1884. He entered Harvard University at the age of 16, received his A.B. in 1905, and his M.D. in 1912. To a large extent he earned his tuition in college. In 1913 he was one of the two physicians to receive the first doctoral degrees in public health granted in the United States. In 1914 he joined the staff of the Rockefeller Foundation, and worked in its International Health Division until his retirement. His work for the Foundation took him to many parts of the world, but mainly to South America and Italy. He succeeded in unravelling the complex epidemiology of malaria in Europe and helped to lay the foundation for the extirpation of that disease in Europe.

His wife, Hazel Woods Hackett, died in 1951. He is survived by a son, Robert N. Hackett, and three grandchildren.

In 1950 he retired from the Rockefeller Foundation and thereafter he lived in Berkeley, California. He became Editor of the American Journal of Tropical Medicine and Hygiene in 1950 and raised that publication to a high standard of professional excellence. He was President of the American Society of Tropical Medicine and Hygiene in 1959. He was Professor of Public Health at the University of California from 1951 to 1962. From 1952 to 1960 he was a Trustee of the Alameda County Mosquito Abatement District.

He was elected an Honorary Member of the California Mosquito Control Association on January 30, 1962.—Harold F. Gray

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CALIFORNIA MOSQUITO CONTROL ASSOCIATION

FIRST SESSION

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

LESTER R. BRUMBAUGH, *President, presiding.*

Welcome to the Thirtieth Annual Conference of the California Mosquito Control Association. If you had been here last week you would have found two or three inches of snow on the ground, so you can see how carefully they have been planning things for us. We have an excellent program scheduled and fine facilities for our meeting. I would like to thank our Board of Directors and the Local Arrangements Committee, consisting of Chet Robinson, Jim St. Germaine, and Don Grant for an excellent job of advanced planning.

You will notice that the theme for the first day is "vector research." We hope that as a result of the discussions to follow we will have a much better understanding of what is happening in research. I know that I am looking forward to this program.

At this time I would like to introduce Mr. T. Louis Chess, Chairman of the Board of Supervisors of San Mateo County, who is here to extend the official welcome to the Association. Mr. Chess—

Mr. Chess: President Les, ladies, and gentlemen. It is a pleasure for me, as Chairman of the Board of Supervisors, to convey to you a hearty welcome to the County of San Mateo. Your president mentioned something about our weather. I just arrived this morning on the train from Phoenix, where I spent four days. They say, 'Come to Phoenix and sunbathe," but the top temperature up to the time I left was 50° in the midday, and it got down to 25° at night. So I'm glad to see, for your sake the sun is shining here this morning and we sincerely hope that you'll continue to enjoy this delightful San Mateo climate while you're deliberating in our midst. I wish for all of you a most constructive and productive conference. I am sure that it will be. We in San Mateo County, and particularly those of us on the Board, are most appreciative of the fine work that the mosquito abatement districts are doing. It certainly enhances the joy of living, especially for those who can now enjoy their swimming pools, patios, barbecues, and other kinds of recreational facilities. I can say enthusiastically that the Abatement District has done a magnificent job here in San Mateo County, and I am certain that the same measure of success has attended the efforts in your respective areas.

I hope that many of you, along with your wives, will find time to visit some of our outstanding shopping districts and the many other points of interest on the Peninsula.

In any event, we wish you a most successful conference, and if there is anything that we can do to help just tell Al Sagehorn what your problem is and the Board of Supervisors will make every effort to assist you. Thank you, and good luck.

Pres. Brumbaugh: Thank you, Mr. Chess. I know that the delegates, their families and guests will take advantage of this fine opportunity to see as much of San Mateo County as possible.

It is my particular pleasure now to introduce Mr. Albert H. Sagehorn, President of the Board of Trustees of the San Mateo County Mosquito Abatement District and Treasurer of San Mateo County. Mr. Sagehorn has given leadership to the Board of Trustees of the San Mateo County Mosquito Abatement District for over 20 years, during which time they have developed an outstanding organization and program. Mr. Sagehorn—

Mr. Sagehorn: Thank you, Les. Ladies and gentlemen. It is a real pleasure to appear before you this morning as one of your own group, and to extend a further word of official welcome. San Mateo County is delighted and honored to be your host.

As Les pointed out, this is the Association's 30th conference, so this organization has been serving the State of California for a long time. I haven't been connected with mosquito abatement for quite that long; however, my appointment first came in 1940, so I am not a junior among you. We have been privileged to have our meetings in various locations throughout the state, and we have always had very fine conferences.

I might give you just a word of background on San Mateo County. It was originally made up of a few large Mexican ranchos. When I first came to the county in 1927 the area was still sparsely settled. The population then was between 50,000 and 60,000, and the county at that time was known to have the highest per capita wealth of any county in the United States. This was on outgrowth of the goldrush days, and a lot of the gold dust settled in Woodside, Atherton, and Hillsborough. With the influx of population, however, the county has been diluted somewhat by people who couldn't hold up the average. I know I was one of those myself. Our population growth has kept pace with the rest of the state, I believe, having reached 439,000 at the last census.

Since I am scheduled to appear at a later point on your program, I don't want to take up more of your time now. I do want to extend to you a most hearty welcome to San Mateo County. It is a real pleasure to be here and to greet you this morning, and as Mr. Chess indicated, if you have any problems I shall be delighted to help you in any way possible. I, too, am looking forward to what I am certain will be an outstanding conference. Thank you.

Pres. Brumbaugh: Thank you Mr. Sagehorn. If any of you wish to go to the horse races and double your investment, Mr. Sagehorn will be happy to furnish you with tickets.

(Editor's note.—Trustees and guests were introduced by President Brumbaugh and Richard F. Peters.)

I would like at this time to introduce our next speaker, Dr. Daniel G. Aldrich, who is going to present information on the role of the University of California in vector research. Dean Aldrich first joined University staff at Riverside, I think around 1942 or '43. After service in the Army, he rejoined the staff as an Associate Chemist in 1950. In 1954 he was appointed Chairman of the Department of Soils and Plant Nutrition at Berkeley. He is a member of many scientific organizations and I hope after today that we can talk him into becoming a member of the California Mosquito Control Association. I know of no one better qualified to speak to us this morning on our research problems and what the University is doing in this field. Ladies and gentlemen, Dean Aldrich.

THE ROLE OF THE UNIVERSITY OF CALIFORNIA IN VECTOR CONTROL RESEARCH

DANIEL G. ALDRICH, JR.
Dean of Agriculture, University of California

Before the end of 1962, according to the California Department of Finance, California will pass New York in population. Two counties, Orange and Alameda, are expected to join Los Angeles and San Diego in the million plus population class between now and 1965. The prediction is that population expansion will continue throughout the state. For the past several years this increase has been at the average rate of about 1500 a day, one-half million per year, almost enough to occupy today's San Francisco.

The honor of soon being first in population brings with it problems with which we are all too familiar. Metropolitan sprawls use land at the rate of about one acre for each increase of 10 people. Urban expansion and agricultural needs require the development of vast new water resources and distribution systems, giving rise to additional problems of drainage and management of liquid wastes. How great these problems may become is suggested by the forecast that California's present population of 16 million will have increased by another 16 million by 1980.

Without belaboring the point, the increase in population and the expanding need for irrigated land, food and shelter, and adequate waste disposal can be expected to favor a substantial increase in noxious insects such as flies, mosquitoes, and gnats, as well as in such public nuisances as dust, odors, and air pollution.

It is quite clear that if we are to deal successfully with present and potential problems, we will have to enlarge the scope of our basic and applied research programs. The ability of insects to develop resistance to DDT, chlordane, dieldrin, and other remarkable insecticides also suggests the importance of the job confronting us.

Before discussing further the tasks which we must face together, it is in order to make some reference to what already has been accomplished in the research activities carried on by the University of California.

The first recorded work for the abatement of mosquitoes in California was in 1903 near San Rafael in Marin County, followed in 1904 in San Mateo County by control work against salt marsh mosquitoes, sponsored by the Burlingame Improvement Club and conducted by Professor H. J. Quayle of the University of California.

In 1910 the first definite anti-malaria mosquito control campaign in the United States was conducted under the direction of Professor William B. Herms, of the University of California, at Penryn in Placer County. Professor Herms was ably assisted in this work by Mr. Harold Gray, who is today an Honorary Member of the California Mosquito Control Association and is on your program this afternoon.

H. J. Quayle reported on mosquito control in Bulletin 178, issued in 1906, and Herms reported on the housefly in relation to public health in Bulletin 215, published in 1911. In later years and up to the time of his death, Dr. Stanley B. Freeborn was a well-recognized leader in the program of vector research. Close cooperation between vector control interests and University research workers has become a tradition.

It is of special interest to me as an administrator to know what is being accomplished in our various fields of research activity. I am sure you will be interested in the large amount of work in progress in recent years relating to flies, gnats, and mosquitoes. Considering only the past 15-year period (1946 to now), our staff people have issued about 300 publications dealing with flies, gnats, and mosquitoes.

- Approximately half (52 percent) dealt with chemical control or health relationships.
- About 7 percent was concerned with biological control or environmental control.
- Of the research support, not including salaries from state appropriations, about 95 percent came from "outside" sources, such as mosquito abatement districts, commercial organizations, California State Department of Public Health, Los Angeles Flood Control District, U.S. Public Health Service, World Health Organization, National Science Foundation, and Office of the Surgeon General of the U. S. Army.
- About three-quarters of the support was devoted to chemical control or health relationships.
- Biological control and environmental control accounted for less than 10 percent of the funds.

At the present time in the Division of Agricultural Sciences, we have 29 research projects in progress dealing with flies, gnats, and mosquitoes. If we include work on non-dipterous pests and vectors such as ticks, lice, and fleas, the number of projects would be greatly increased. Presently there are 67 professional workers and 78 technicians involved in the 29 projects but not necessarily giving full time to a given project. The annual support budget for these projects is $602,000, more than 95 percent of which comes from the "outside" sources. Please note that this figure does not include salaries paid from the State of California appropriation budget.

And here's the breakdown of the 29 current projects according to subject area:

Biological control	3
Chemical control	8
Biology-physiology	8
Taxonomy-morphology	6
Health relationships	2
Environmental control	2

In continuing research in the tradition of Herms and Freeborn, we now have another man on the job to do research in the field of medical entomology. Dr. John Anderson represents a fine addition to our staff at Berkeley. He has taken on the big job of studying Diptera of medical importance—their biology, distribution, and control—and will cooperate with various members of our statewide staff. Another appointment, to pursue studies of helminth parasites transmissible to man or livestock by arthropods, is to be made effective July 1.

Research organization in the University of California is necessarily somewhat different from that in other states. Because of the complex nature of our agriculture, with more than 200 commercial crops, and the great size and varied climate and topography of our state, the Agricultural Experiment Station is decentralized. Agricultural research is conducted on four campuses—Berkeley, UCLA, Riverside, and Davis—as well as at 11 field stations and experimental areas ranging from Tulelake to El Centro.

This organization lends itself well to the modern concept of research: the team approach to problem solving. While individual scientists made great contributions as the era of scientific progress began, the enormous fund of technical knowledge which has accumulated and the increasing complexity of today's research problems have made it necessary to draw upon various specialized fields and talents as they may contribute to solution of a given problem. Thus our research projects are ordinarily organized with teams of staff members. In addition to an entomologist, for example, a chemist, an engineer, a soils specialist, or a toxicologist might be needed.

In working out these projects, we are one University. We can draw upon any person or resource that will contribute to the work at hand. And we are not necessarily limited to the field of agriculture, broad as it is. We may work with medicine, chemistry, or engineering, for example, or may cooperate with other public or private agencies as the problem may require and arrangements can be made.

In numerous instances the Agricultural Extension Service also contributes to the over-all research program through local field plots or tests in cooperation with Experiment Station workers, as well as through the educational work it engages in throughout the state.

As the primary tax-supported research agency of the state, the University of California recognizes its responsibility for conducting research that will serve the needs of society. However, the University also recognizes that other important research agencies contribute to the welfare of the people in this state and that ways must be explored continually to provide opportunity for cooperative effort. Expansion of University research, for which there is a continuing demand, always greater than we can supply, must be subject to existing programs and commitments.

As statewide dean of the Division of Agricultural Sciences, I am happy to discuss research problems with all who are concerned. Obviously, from among the vast array of research opportunities that must be pursued, there are programs of research the University should undertake and others which it should not. Primarily the University is concerned with the more basic, long-term type of research, but the program is somewhat flexible, and we endeavor to meet the needs of a given situation. In some cases the more applied types of work could well be assumed by other agencies, either cooperatively or on their own. In any event, the University would like to know your problems first-hand.

In agriculture, to insure close liaison with those whom we hope to serve, we have a number of committees we consult regularly. For example, commodity groups representing dairy, livestock, citrus, and other important agricultural industries meet with us at specified times each year. We greatly value their counsel, encouragement, and substantial support. This arrangement works very nicely. It establishes a firm basis for understanding and a continuing cooperative relationship with the interests concerned.

I suggest to you that the University would welcome the opportunity to work with a statewide committee of men concerned with the general problem of control of mosquitoes, gnats, flies, and other noxious creatures threatening public health and comfort. Such a committee, made up of men selected from various geographic areas of the state and having knowledge of various ramifications of the vector control problem, could be of immense service in appraising the public need. It could be a nerve center and coordinating unit to assess the most pressing needs in vector control, judging technical aspects, and establishing the financial basis for carrying on such research.

The impact of chemical control of pests upon agriculture and the public welfare needs continuing investigation and evaluation. In assuming the responsibility for such a program, the University must ultimately determine how the program is implemented and conducted. But you may be sure that those on the University staff responsible for such a program would be glad indeed to have the counsel and guidance of a well-chosen committee.

I suggest also that we could well be doing more work in the field of biological control. There is no question that chemicals have done outstanding service in bringing our environment into a better health balance. Much great research has been done in producing miraculous chemicals to perform certain tasks, but in due time insects somehow or other develop resistance. So the chemicals often need help. As in the case of certain agricultural pests, some very satisfactory results have been obtained when biological control methods have been developed and introduced. I believe that more research in this field would be productive, and we would welcome your collaboration.

The idea of setting up a single research center within the University does not, in my judgment, fit well into this picture. We already have well-equipped facilities, suitable libraries, and an excellent staff competent to cover practically all aspects of entomological research. We have these people and facilities in both the south and the north of the state. Our research program is stronger through the use of our total resources, through our organization in many disciplines to make full use of staff facilities.

Over the years we have had excellent relationships with the National Science Foundation, U. S. Public Health Service, State Department of Public Health, State Department of Agriculture, and U. S. Department of Agriculture, as well as with many local or regional organizations throughout the state. Many of these organizations have provided substantial support for research projects in the Agricultural Experiment Station.

As I see it, we should examine together the present and foreseeable insect pest and other nuisance problems arising from the trends in population growth, water development, drainage, and the like. We should then arrange to allocate the work on these problems and secure public support to make such expansion in personnel and equipment as will be required to accomplish our joint purpose. All information developed, of course, becomes public property and is available to all who can use it.

There is no doubt that we have many problems to face in vector research. Let us plan together to make the best use of our total resources for the common good.

Mr. Brumbaugh: Are there any questions at this time? Dr. Aldrich, apparently we don't have any questions. It seems that you have done an excellent job in covering the subject. Thank you very much.

Dr. Aldrich: If they arise subsequently, my main concern is that the people assembled here recognize that we are interested in sitting down and talking about them so that we can accomplish this job which you will be laying before yourselves here in the next two days.

Mr. Brumbaugh: Next on our program is Howard Greenfield, Manager - Entomologist of the Northern Salinas Valley Mosquito Abatement District. Howard is a past president of our Association and is currently the Regional Director of the American Mosquito Control Association. He will present to us at this time an analysis and critique of the California Mosquito Control Association. Mr. Greenfield—

ANALYSIS AND CRITIQUE OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION

Howard R. Greenfield,
Northern Salinas Valley Mosquito Abatement District

Inasmuch as I have been charged with the responsibility of providing an analysis or critique of the California Mosquito Control Association, I might as well remain in character and be direct with you in my opening remarks. I feel honored to have been selected to present to the Association the distillation of thoughts and opinions of our membership. I hope when I have concluded my remarks, which may sound slightly revolutionary to some, that you as members of this Association will agree that we must provide a sound purpose and sustained direction if we are to insure our future growth.

Historically, our present Association has evolved from an organization known as the Mosquito Control Conference, which had its beginning in 1920, and the Conference of Mosquito Abatement District Officials, which was organized a decade later. These organizations were brought into being for a simple, and perhaps all too logical reason—to exchange information. The champions of that day, men such as Professor H. J. Quayle, Nobel M. Stover, Professor William B. Herms, R. E. Hackley, Roland Bendel, and Harold F. Gray, acknowledged the need for both basic and applied research on mosquitoes and mosquito control. They also recognized the importance of recording ecological observations, as well as information on new or improved operational techniques. Furthermore, they recognized the need for better information on insects other than mosquitoes, in order to fulfill their function in the most intelligent and constructive manner.

Why should we bother to take this backward glance into our history? Because if we can understand the motivation that caused these men to gather together to exchange ideas, to pool their knowledge, and to record their experiences, we can then better understand and direct our own future. I believe history clearly reveals that the primary motivating force among these men was the need for organization, the need for a plan, and after the plan—hard work and satisfaction of accomplishment. This conference today is witness to man's organizational ability. It is witness to man's ability to plan, and to accomplish objectives and goals. True, the path leading to our present relatively complex organization was at times tortuous and meandering. Nonetheless, it did have direction and purpose. We have a heritage in mosquito control here that cannot be duplicated anywhere in the world. It has its foundation in concepts of mosquito control developed by profound and dedicated leaders, and executed by skilled technicians and vigorous field workers.

In reviewing the more recent history of our Association, it is evident that we have continued to progress in the same tradition. The C.M.C.A. and its predecessor organizations have exerted strong influence on mosquito control programs, not only in this state, but throughout the country and the world.

The C.M.C.A. has contributed to the development of uniform operational techniques throughout the state. It has stimulated and actively participated in vital cooperative ventures with other governmental agencies. It has provided the foundation for sound salary schedules and has assisted in developing uniformity in personnel requirements and position specifications. Through its Proceedings and other publications it has provided a wealth of information on mosquito control for all agencies actively or indirectly interested in this field. But—the C.M.C.A. has largely ignored its obligations to member agencies that are concerned primarily with the control of arthopods of public health significance other than mosquitoes. We have accepted these agencies into the Association and have accepted their contractual payments; and they have willingly paid their share knowing that the objectives of this Association, as stated in the Bylaws, embrace the broad concept of vector control. Article II, titled "Objecitves," states that . . . "This Association's objectives are to promote cooperation among those directly and indirectly concerned and interested in mosquito control and related subjects."

What are "related subjects"? Certainly gnat control, fly control, and other arthropods of public health concern are related or allied subjects which can readily be interpreted to fit the objectives as stated in the Bylaws. It is evident to me that this Association, in order to continue to represent these other vector control programs and to keep pace with the needs of our burgeoning population, must officially recognize and foster these related activities. This can best be done by expanding the concepts and program of this organization. The foundation for this has already been laid for us. The late Dr. Wilton L. Halverson (1948), former Director of the California State Department of Public Health, in an address to this Association stated:

> ". . . How far this movement in the control of vectors will carry only time will reveal; but it is likely that as the public recognizes the value being received from its tax dollars being spent on mosquito control, it will incline to want like results on rodents and other noxious arthropods. This, of course, will demand that science and the personnel engaged in this specialized field provide the public with assurance of the economic practicability of each undertaking. This we feel can best be assured through utilizing professional services to supply technical guidance to these activities."

Thus Dr. Halverson some fourteen years ago wisely predicted that expanded activity in the field of vector control might well be in our future. He did not suggest that this interest in vector control be solely the responsibility of mosquito control programs, nor do I. We must recognize that the demands of the public will vary throughout the state. There is already evidence of new agencies coming into being prepared at the outset to accept this newer concept of vector control.

Several years ago at our Los Angeles meeting, John M. Henderson, Harold F. Gray, Richard F. Peters, and John A. Mulrennan (1955) reviewed for us the then apparent trends toward a broadened concept of vector control. They stated that the basic forces responsible for the continuing evolution of public health concepts generally, have also influenced our progress in vector control during the postwar period. Technological advances, changes in problems, and the socio-economic progress of the American people have all been important factors. They also pointed out that strong pressures have been exerted for the establishment of vector control units in local health departments to meet the demands of the public. In like manner, there have been strong pressures for some local mosquito control agencies to expand their operations to full vector control programs. I believe that in the past five years many of us have become increasingly aware of these pressures and their implications. The time is now at hand for this Association in its official statement of objectives to recognize that vector control programs are being initiated and are deserving of due representation in this Association.

James R. Douglas (1953), Professor of Parasitology, Department of Veterinary Medicine, U.C., Davis, stated:

> ". . . Although the California Mosquito Control Association would appear to be a somewhat specialized organization dealing largely with the control of mosquitoes which directly affect the health and well-being of man, I would like to think of it as an organization concerned with the control of all arthropod vectors, not only those which affect man, but also those which affect the health of our domesticated animals. Many of our vector control problems in veterinary medicine are regional or statewide and require the application of regional or statewide control measures. The control of horse flies may be cited as an example. What could be more logical than to have these problems handled by this statewide collection of organizations which has had so much experience in the complex field of vector control."

Dr. Douglas commented on the considerable collective experience that we possess, a resource yet to be utilized to the fullest extent. Certainly, from an entomological standpoint this Association has a vast, readily available fund of knowledge regarding flies, gnats, and other arthropods of public health significance, in addition to mosquitoes. Yet we have to a very large extent been content to allow this knowledge to remain dormant and undeveloped. This Association can no longer afford to take this position. This substantial storehouse of knowledge should be made available to all agencies sharing responsibility for vector control programs. We should establish a clearing house where technical information can be catalogued, and made available to all individuals and agencies as needed.

As an Association, we have a responsibility to our co-workers to recognize the role and function of those member agencies that have gnat or fly control as their major program responsibility. Why? Perhaps one of the more obvious reasons is that the laws which govern their operations are the very same laws which govern mosquito control programs. If this Association is to continue, as it should, to represent all mosquito control agencies and all allied vector control programs, then certain steps must be taken immediately to modify and strengthen the structure of our organization. I don't propose to reintroduce at this point the often discussed proposal of a Council of Mosquito Control Agencies, nor do I feel that this type of organization is actually necessary. With a few structural modifications, our present Association can serve effectively the cause of all vector control as it does now for mosquito control.

I would propose that if we want to strengthen the Association we must strengthen the lines of communication between all agencies interested directly or indirectly in vector control problems. In so doing, the office of the Executive Secretary might well become the depository for information pertinent to all vector and mosquito control programs. The provision for such a record center on vector programs would make possible the dissemination of information received from various state, federal, and local organizations. Actually I am suggesting that this Association become the resource center for all to utilize. We must do this if we are to progress as a mosquito control association, much less an association of vector control agencies.

I further propose that we as an Association seriously consider broadening the scope, function, and the membership, thereby allowing all interested individuals and agencies to participate. Determination of Association policies and decisions on what directions we are to take could then be made in a thoroughly democratic and representative manner.

Another necessary structural modification would be that of providing for an Executive Secretary on a full-time basis. When one considers the proposed broadened program of the Association, the demands for additional services through the Executive Office, the increasing number of vector control agencies, and the population trends of the State, the basis for this need becomes unmistakably clear. Also, in recent years an inequitable amount of time, effort, and facilities have been provided by a few agencies in producing the Proceedings, the Yearbook and other publications, and providing for the present office of the Secretary-Treasurer. It is unrealistic that we should try to perpetuate this arrangement.

What of our future? As heirs to the legacy of Herms and Freeborn, and our senior contemporary, Harold Gray, we are confronted with a challenge that will not settle for status quo. If we accept this heritage we must be prepared to accept new concepts and broader horizons, contributing vigorously and creatively to insure not only our own future, but the legacy we too might hope to leave.

This has been a very brief report intended to summarize some of the more apparent strengths and shortcomings of our organization. I hope that it will be accepted as constructive criticism and, most of all, that it will lead to some constructive and progressive action. While I must, for the purpose of this presentation, accept responsibility for the ideas set forth, it is my considered belief that they represent the position of a large majority of our membership.

Again I would say that if we are to continue to be a significant factor in the history and in the development of our State, we must develop and sustain a dynamic, responsive program based on dedicated and imaginative leadership.

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Mr. Brumbaugh: Thank you, Howard, for that excellent presentation. You have given us some important information and many new ideas. Now it's up to us to take some positive action. Howard, I assure you and the members of the Association that we will be discussing this problem tomorrow at our business meeting. It is our hope that our new president will appoint a committee to work on these proposals that Howard is advancing. I think it is very important that we give this careful consideration.

It is my pleasure now to introduce Dr. Archie Hess, Chief of the Encephalitis Section of the Communicable Disease Center activities at Greeley, Colorado. Archie is well known to all of you, having appeared before this group on a number of occasions over the past several years. Dr. Hess has been asked to bring us up to date on the research activities of the U. S. Public Health Service.

Dr. Hess: Thank you, Les. It is always a pleasure to come to your meetings in California. One of the major incentives in coming to your state is that instead of being faced with the job, as is usually the case, of bringing others up to date on the latest developments in the biology and control of mosquitoes, we come out here to have you people bring us up to date. You have, undoubtedly, the leadership of the nation in this field. You people on the firing line in the C.M.C.A. have the most modern and progressive mosquito control program in the United States. With your excellent research program being conducted by the Bureau of Vector Control, and Dr. Reeves and his group at the University of California, we always learn a lot when we come out here, and that's our main objective.

Now as for our work, almost everything we do is in the nature of co-operative endeavors with international, national, state and local public health agencies. For example, all of our field stations, including projects in Massachusetts, Washington, California and Texas, as well as Colorado, are cooperative projects with the State Health Departments. Here in California we are also cooperating with the University of California School of Public Health and with some of your mosquito abatement districts. This, I think, is a wonderful example of working together to achieve research goals, as Dr. Aldrich pointed out in his talk this morning. This is an essential pattern for research in the modern day.

Since most of the data I am presenting are unpublished and have been furnished by these various groups with whom we have cooperated, we shall not publish this summary in the Proceedings. So it won't be necessary to operate the recorder. We shall enter it by title only. This way we can give you some of the late developments that these people might not be ready to release if they were going to be published in the Proceedings.

(Editor's note: Dr. Hess gave an informal, unrecorded presentation with slides.)

Mr. Brumbaugh: Thank you, Dr. Hess. We'll move right on with our program. Our next speaker is Dr. Lindquist, Chief of the U.S.D.A. Research Branch on Insects Affecting Man and Animals. I believe all of you know Dr. Lindquist for his association with the California and American Mosquito Control Associations. For some of you who may not know, he has had the Distinguished Service Award presented to him twice, first for his contributions on DDT, and again last year for his outstanding work in the field of radiation techniques for sterilizing arthropods. Dr. Lindquist—

CHEMOSTERILANT AND OTHER NEW RESEARCH OF INTEREST TO MOSQUITO-CONTROL WORKERS

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With the advent of new and highly effective insecticides in the mid 1940's, control of most of our destructive and disease-carrying insects became infinitely easier and more economical than in the past. These new insecticides revolutionized insect control. Their benefits to mankind in reducing diseases of and annoyances to man and animals and increasing the quality and quantity of food and fiber have been unparalleled in our many years of struggle against insects. For example, of approximately 1¼ billion people subject to malaria, 280 million now live in areas where malaria has already been eradicated by residual sprays containing DDT, dieldrin, and lindane applied to natural resting places of mosquitoes in buildings. Tens of thousands of lives have been saved and millions of people now enjoy better health because of malaria control. In addition, control of insect-borne diseases by insecticides has increased the social and economic welfare of millions of other individuals in may areas of the world.

Unfortunately these superior insecticides have been showing signs of failure in controlling insects and the diseases they carry. Insects, which preceded man on earth, are not giving up easily. They are developing resistance to insecticides at an alarming rate. It is a serious matter when the field operator cannot effectively control mosquitoes or the grower protect his crops and animals against voracious insects.

Another problem is that residues may appear in meat, milk, and crops following the use of insecticides. An immense amount of careful and costly research has been devoted to determining the extent of the insecticide-residue problem and identifying minute quantities in the foods of man and animals. In some situations deleterious effects on fish and wildlife have occurred when insecticides were used unwisely. Because of these obstacles, entomologists and others have been considering different and new approaches to the control of their insect enemies during the past few years. My objective in this paper is to discuss some new research that will assist in overcoming resistance, residues, and hazards of insecticide use. Since I am most familiar with the work in the Entomology Research Division of Agricultural Research Service, the following report deals with research and thinking in that organization. However, it should be pointed out that other groups are conducting excellent research on resistance, residues, and hazards.

Control of Insect Reproduction

The most publicized new approach to insect control deals with the control of reproduction. The sterile-male technique, used so successfully in eliminating the screw-worm (*Cochliomyia hominivorax* (*Coquerel*)) from the Island of Curacao and the southeastern United States, has been of general interest. The method consists of rearing and releasing male flies sterilized by gamma radiation in numbers greater than exist in nature. The preponderance of sterile males, at a ratio of about 10:1, gives them an advantage in competing with normal males for the females within the natural population.

The great success of the sterile-male method depends on the fundamental biological urge of mating. Utilizing the mating urge of insects to assist in control is a thoroughly logical idea. Mating is one of the strongest instincts in animal life and using sterile males to seek out native females and destroy reproduction presents new opportunities. By no other single means, including dispersion of insecticides, is it possible to reach and destroy all the insects in a normal native population with such efficiency.

Advantages of Chemosterilants

Results of research on sterility by gamma radiation led directly to studies on the possibility of using chemicals for the same purposes. It was believed that chemosterilants could be substituted for radiation in an insect rearing and release program and that these chemicals should be easier to use and less costly than gamma radiation. Of far greater importance, however, was the possibility that chemosterilants could be used to sterilize the natural population without resorting to rearing and release of sterile specimens. Sterilizing the males in a natural population would solve any problem that might be created by introducing large numbers of sterile specimens that are bloodsucking or annoying to man or animals.

A chemical that could be used on the natural population to sterilize both males and females would initially prevent reproduction only among those actually sterilized. This first effect would be no greater than that achieved with an insecticide that kills directly. However, the best part of the plan is that the sterile males would not be killed but would remain free to carry out mating with and prevention of reproduction by the untreated females. If, for example, 90% of the females contacted the sterilant, reproduction would immediately cease in those individuals. If 90% of the males also contacted the sterilant, these would be available to compete with nonsterile males in mating with untreated females. There should be a preponderance of these sterilized males over the remaining untreated 10% of the males or any newly emerged males. These numerically superior sterile males would thus reduce the population further and provide a bonus effect over the conventional method of direct kill by insecticides. In this way, a chemosterilant should pdovide a potential 99% control of reproduction instead of the 90% expected from an insecticide. Knipling (1959) has calculated the theoretical population decline of insect and other animal populations subjected to a treatment which causes sterility versus one that produces direct kill. It should be pointed out, however, that the sterility effects must not significantly change sexual vigor or competitiveness of the treated males. A type of sterility which destroys sexual behavior or other habits would have no advantage over direct destruction of the organism.

Ways in Which Chemosteriants Might Be Used

The most obvious way of using any chemosterilant that might be hazardous to beneficial organisms would be with a bait or lure. The bait or lure would draw the insects to be controlled to a central point and exposure to the chemosterilant would be by contact with the residue or by oral ingestion of treated food. Insecticides have proved highly effective, for example, when incorporated in a bait for control of the medfly (*Ceratitis capitata* (*Wiedemann*)) (Steiner *et al.* 1961) and the house fly (*Musca domestica* L.) (Gahan *et al.* 1953). Thus substitution of a chemosterilant for an insecticide might offer a means of producing sterility in a high percentage of the natural population of these insects.

Safe chemosterilants could be used in much the same way as the insecticides now applied as residual treatments on farm buildings or other places where insects rest or congregate. Stable flies (*Stomoxys calcitrans* (L.)) rest on fences, silos, gates, and exteriors of barns and a chemosterilant treatment on these surfaces could possibly provide control. It might also be applied on vegitation in or near swampy areas where horse flies, deer flies, and biting gnats breed and congregate. Some species of mosquitoes could be controlled by residual applications of a chemosterilant to domestic resting places. Treating vegetation near emergence sites might sterilize great numbers of mosquitoes.

Combining an insecticide and a chemosterilant to reduce an initial insect population that is causing trouble and at the same time to gain the benefits of sterility has been proposed by Lindquist (1961a and b). A combination of both types of chemicals could be used in a bait, as a residual treatment of vegitation or buildings, or as a space spray in restricted situations. This plan might at first seem contradictory. There may not seem to be any advantage in killing insects that have been made sterile. However, it must be realized that insecticide treatments seldom kill all the insects coming in contact with the material. Some individuals of any population have a natural tolerance to insecticides. Furthermore, most insect populations have developed varying degrees of physiological resistance to insecticides and some of the insects escape death even though exposed. The advantage of a combined chemosterilant and insecticide treatment is that the insecticide would kill the weaker forms and make the resistant surviving females incapable of reproduction. Surviving sterile males would act as a further deterrent to population increase by mating with newly emerged or other nonsterile females that escaped either treatment. The insecticide in the combined treatment would provide some immediate control, whereas the sterilant would have a more complete and lasting effect in reducing the insect population.

A combined treatment might be an effective way of eliminating the problem of insect resistance to insecticides. Of course, there is the possibility that insects might develop physiological resistance to the chemosterilants. Insecticide-induced resistance is a result of selection of individuals more capable of withstanding the effects of these materials, or with an innate capacity to develop effective physiological systems to rapidly metabolize insecticides and subsequently transmit such characteristics to their progeny. It does not seem likely that chemosterilants would induce such physiological resistance, since the process of selection of stronger individuals by killing the weaker does not seem to take place when these materials are used. Furthermore, chemosterilants act without mortality on the reproductive system, a site of action that does not appear to be involved in the process of selection. However, resistance to any chemical cannot be ruled out. Behavioristic resistance, such as avoidance of the chemosterilant, could perhaps develop in a manner similar to that reported by Schmidt and LaBrecque (1959), who found that house flies avoided malathion-treated baits.

Recent Chemosterilant Research

A screening program to find and develop chemosterilants has been underway at our Orlando, Florida, laboratory for about 4 years. In 1960, a few compounds were found that seemed to have exceptional promise in sterilizing both male and female house flies, mosquitoes, and stable flies. LaBrecque (1961) reported on three ethylenimine compounds known as alkylating agents, commonly referred to as radiomimetic compounds. The unofficial common names of these materials, together with their chemical names, are as follows: aphoxide (tris(1-aziridinyl) phosphine oxide), aphomide (*N*,*N*'-ethylenebis [*P*, *P*-bis(1-aziridinyl)-*N*-methylphosphinic amide]), and apholate (2,2,4,4,6,6-hexa(1-aziridinyl)2,4,6-triphospha-1,3,5-triazine).

Recent research at Orlando by D. E. Weidhaas and C. H. Schmidt (unpublished data) showed that both sexes of *Aedes aegypti* (*Linnaeus*) and *Anopheles quadrimaculatus* Say were sterilized by incorporating aphoxide or apholate in the adult food or placing one of these compounds in the larval water medium. Aphoxide has been especially promising as a residual treatment of resting surfaces.

Tests with apholate on the stable fly at our Kerrville, Texas, laboratory showed that a 48-hour exposure to a residual film applied on glass at a rate of 10 mg. per square foot caused nearly 100% reduction in hatch of eggs from treated females mated to treated males. Of particular interest was that apholate, almost as effective 21 weeks after treatment as at 1 week, showed long-lasting residual properties. Topical application of aphoxide at a rate of 3.7 mg. per fly was slightly more effective on males than on females.

In studying the possible uses of chemosterilants, information is needed on the permanency of sterility obtained with different compounds in each species studied. Obviously a treatment that sterilized only for a day or two would not be especially efficient. LaBrecque, Meifert, and Smith at Orlando explored this possibility with apholate in house flies. Immediately after emergence male specimens were fed this compound in concentrations of 0.1 to 1% for a period of 5 days; thereafter, for the life of the fly, untreated food was given. Normal, virgin females mated at different time intervals up to 26 days with males treated at concentrations of 0.4, 0.5 and 1% of apholate laid some eggs that showed no development and others that showed a little embryological development but did not hatch. At lower concentrations, a small percentage of eggs hatched and some showed no embryological development. It appears, therefore, that male flies sterilized with this compound remain sterile throughout their life.

Age of the insect in relation to exposure to chemosterilants is also important. The house fly apparently must be exposed within 4 days of emergence in order to become completely sterilized. Males of *Anopheles quadrimaculatus* apparently can be rendered sterile by exposure to the compound when older. Young, newly emerged, laboratory-reared males were held separately for 4 days. They were then exposed to aphoxide and caged with virgin females. A high percentage of females mated to treated males laid a normal number of eggs but none hatched. Males were completely sterilized even though they were already 4 to 5 days of age when exposed to aphoxide.

The practical small-scale use of a chemosterilant for control of house flies has been reported by LaBreque, Smith and Meifert (in press.) An isolated refuse dump in the Florida keys was treated for 9 consecutive weeks with a dry, granular cornmeal bait containing 0.5% of aphoxide. The chemosterilant bait was applied in a manner very similar to that recommended for insecticide baits in such situations. House fly populations were reduced from 47 per grid count to 0 within 4 weeks. The number of egg masses from female flies collected at the dump was reduced from 100% to 10% within 4 wteks, and the per cent hatch of eggs from these flies was reduced more than 90%. A similar, but untreated, refuse area maintained a high population of flies throughout the test period. This preliminary experiment shows great promise for the control of house flies but needs confirmation under a variety of conditions, including tests in non-isolated areas.

Effect of Chemosterilants on Vigor

Gamma radiation tends to injure and weaken insects. They are usually not so long-lived as unexposed insects, and somatic damage tends to make treated insects less vigorous and competitive than the normal insects. Such a radiation effect is a serious obstacle to the possible use of gamma-irradiated insects for controlling certain mosquitoes, the boll weevil (*Anthonomus grandis* Boheman), the gypsy moth (*Porthetria dispar* (Linnaeus)), and no doubt other species. Although the screw-worm does not seem to be injured very much by radiation, there is reason to believe that the efficiency of treated males released in nature is reduced. Competitive and vigorous seekers of native females are required to achieve the full effect of sterile insects in control or eradication. If chemosterilants can be developed to sterilize males that are stronger, longer-lived, and more active seekers—and thus more competitive—than those treated with radiation, a great step forward will be taken in the utilization of a sterile-male technique involving the rearing and release of sterile insects.

Recent research by G. C. LaBrecque, D. W. Meifert and Carroll N. Smith (*op. cit.*) at Orlando with house flies in cages, to compare radiation and the administration of apholate, indicates that the chemosterilant is more efficient in producing competitive males than gamma-ray treatment. Some males were given 1% of apholate in the adult food for 3 days after emergence. Others were exposed to 2500 r in the pupal stage and introduced into cages at a ratio of four sterile males to one normal male and one normal female (4:1:1). The hatch of all eggs laid by females was reduced 77% by irradiated males and 82% by the chemosterilized males. Using the above figures, I have made some further calculations. With the 4:1:1 ratio the expected reduction of viable eggs by either method is 80%. The actual 82% reduction of hatch caused by the chemosterilized males is very little less than the 83% theoretical reduction that should occur following use of five sterile males to one each of normal males and females (5:1:1). It appears therefore that the chemosterilized males are much more efficient. In a rearing and release experiment, four chemosterilized males would be able to effect as much control (82%) as would be expected of five sterile males (83%)—ratios of 4:1:1 as compared with 5:1:1.

In other laboratory-mating tests at Orlando, LaBrecque, Meifert, and Smith (*op. cit.*) it was shown that apholate-treated male house flies at 3, 5, and 10 times the number of normal males and females resulted in average reductions of viable eggs of 97, 100, and 100%, respectively. These results are even more significant than those given in the preceding paragraph. The expected reductions of viable eggs at these ratios are 75, 83, and 91%, respectively. Thus it appears that the chemosterilization induces much greater than normal efficacy. If these observations are borne out in practical use, they could have an enormous bearing on control efforts.

It should be emphasized, however, that these experiments measured only the viability of eggs resulting from the mating of sterile males with normal females. It is possible that behavior patterns other than mating efficiency could adversely affect the treatment. Under field conditions, competitiveness and vigor may not be the same as in laboratory cages.

Preliminary competition tests in cages with *Aedes aegypti* indicate that apholate-treated males are considerably more effective, that is, cause greater reductions of viable eggs and are longer lived than irradiated males. The experiments indicate that the chemically sterilized males are more competitive with normal males in mating with normal females.

Research Problems and Hazards of Chemosterilants

Many problems concerning effective use of these compounds need investigation. Migration of insects that have already mated from untreated areas into treated plots may largely nullify results in small-scale treatments. Some insects do not have strong migratory tendencies and are likely to concentrate in or near their emergence habitats. In such situations chemosterilants may be practical. Other insects migrate freely and at least a certain percent of the population may move long distances in sufficient numbers to dilute the sterile-male population in a treated habitat. Community-wide use of chemosterilants may be necessary with many species of insects.

It is well known that the layman desires rapid kill of insects. The use of chemosterilants is not likely to provide immediate relief. A grower might not want to accept the use of this new method even though it might prove more effective and less costly in the long run. Minimizing the destruction of crops and protecting man and animals during the time required for sterile insects to reduce populations may pose problems. Insecticides or other treatments may have to be used initially to reduce populations and then we can rely on chemosterilants to prevent subsequent population buildups. Perhaps, as previously mentioned, a combination of an insecticide and a chemosterilant could be used efficiently.

It is obvious that much field experimentation with any given species of insect will be required to answer the many questions on efficiency and practicability of chemosterilants in insect control. Much more detailed information on biology and habits of insects must be obtained so as to take advantage of the interesting possibilities of using these compounds effectively.

The chemosterilants presently being investigated are considered hazardous. These may never be used in a practical way except under special conditions. However, the main objective of our current research with these compounds is to determine the practicability of sterilizing a native population of insects for control purposes. It is believed that intensive research efforts by federal, state, and industrial workers will develop other highly effective and safe materials.

Genetics, Cytology, and Physiology

Insect resistance to insecticides has stimulated a considerable amount of research on the genetics of resistant and susceptible strains of various insects. It is important to develop all possible information on the factors involved in inheritance of resistance. Plapp *et al.* (1961) reported on the inheritance of resistance to DDT and malathion in *Culex tarsalis* *Coq*. In addition they obtained data on the levels of cholinesterase and aliesterase activity in resistant and susceptible strains. They summarize their work as follows:

1. Experiments have demonstrated that resistance to malathion in the Fresno [California] strain of *Culex tarsalis* is dominant to susceptibility.

2. DDT resistance, present at a high level in the Oak Ridge [Oregon] strain of *tarsalis* and at low levels in the Fresno [California] strain, is recessive to susceptibility.

3. Cross-resistance to DDT in the strain [Fresno] selected with malathion appears to be caused by a separate factor and is not a result of selection with malathion as often happens with the house fly.

4. Quantitative changes in levels of either cholinesterase or aliesterase are not related to malathion resistance, but high cholinesterase levels present in the Oak Ridge strain are inherited in the same manner as is resistance to DDT.

LaChance and Leverich (in press) have studied the effect of radiation on reproductive cells of the female of the screw-worm. The criterion of radiation damage was induction of dominant lethal changes in the oögonia and oöcytes, as measured by hatchability of eggs fertilized by unirradiated males.

Irradiation of female pupae 4 to 6 days old reduced the number of mature oöcytes produced as dose increased, but lowered the hatchability of eggs that were produced. These findings indicated that some dominant lethals persisted through maturation to be detectable in the embryo. Only oögonial cells were present in 4-to-6-day-old pupae.

Differentiation of the oöcytes and nurse cells takes place in old pupae and newly eclosed adults. Irradiation of adults less than 24 hours old interfered considerably with egg production; the younger the female at irradiation, the fewer normal eggs were produced. Irradiation of females older than 24 hours resulted in production of normal number of eggs. In 3-day-old females the oöcyte nucleus is in prophase I; in 4-day-old females, metaphase I; and in 5-day-old females, anaphase I.

In any study to find and develop effective chemosterilants for practical use, the effect of the chemicals on the other cells and organs of the reproductive systems of insects is also important. Morgan and LaBrecque (in press) have gathered excellent information on the effect of apholate in the ovarian development in house flies. They summarize this work as follows:

> "Apholate, when administered in the food of adult female house flies at a 1.0% concentration for a period up to 240 hours, inhibited but did not eliminate ovarian development. Its greatest effect was noticeable at 72 hours after eclosion on the nurse cells of the first and second egg chambers. The chromatin [of the nurse cells] was clumped in irregular masses and the nuclei had bizarre shapes. The oöcytes in the first egg chambers matured but all of the cells in the second egg chambers remained undeveloped during the entire 240 hours. The germarium was also affected, as the third egg chamber did not become visible until 168 to 192 hours after eclosion instead of 96 hours as in normal flies."

In order to gain a better understanding of the effect of chemosterilants on the reproductive system and the breakdown of these compounds by insects, radioisotope-labeled chemicals were employed. Investigations were conducted on the metabolic fate of radiolabeled P^{32} methaphoxide (tris (2-methyl-1-aziridinyl)phosphine oxide) on house flies, mosquitoes, stable flies, the screw-worm, and on mice. At Corvallis, Plapp *et al.* (in press), using house flies, found the chemical was rapidly degraded under *in vivo* conditions. This species was injected with the compound at 100 p.p.m. Fifty percent of the chemical was degraded to water-soluble metabolites within 2 hours and the destruction of tissues in the ovaries was 90% complete within 4 hours. No difference in the rate of metabolism of methaphoxide was observed between one susceptible and two resistant strains of house flies.

In the mosquito *Culex tarsalis*, methaphoxide was detoxified within 24 hours by both larvae and adults. In mice, analysis of various tissues showed that the compound was 90% or more degraded within 6 hours after subcutaneous application at a rate of 100 mg./kg.

Preliminary work by W. F. Chamberlain at our Kerrville, Texas, laboratory indicates that methaphoxide is absorbed more readily, excreted less rapidly, and metabolized less rapidly by the stable fly than by the screw-worm fly. This finding may explain, in part at least, why lesser amounts of methaphoxide are required to sterilize the stable fly than the screw-worm fly.

In connection with research on possible field use of chemosterilants, it has been necessary to determine the physiological age of females of *Anopheles quadrimaculatus*. At Orlando, C. H. Schmidt, D. E. Weidhaas, and D. B. Woodard (unpublished data) developed some interesting and useful information on this subject. The ovaries of field-collected mosquitoes were microscopically examined for the number of gonatrophic cycles that had occurred. Physiological age was determined by the greatest numbers of relics (thickened tissues) found in individual ovarioles. About 20% of the mosquitoes had not laid eggs; 56% had completed one gonatrophic cycle; 17%, 2 cycles; 5%, 3 cycles; and 1%, 4 cycles. Further research showed that older females of this species that had previously mated and oviposited could be completely sterilized and would not lay viable eggs after coming in contact with the residual chemosterilant, aphoxide. That aphoxide will sterilize older females of *A. quadrimaculatus* that have previously oviposited is very encouraging. If it can be determined that chemosterilants will perform this way in the field, their use should be much more effective.

Synergists

Synergists that enhance the effectiveness of insecticides have been of interest for many years. Search for compounds possessing synergistic properties for use against resistant insects has received much attention. Recent work at our Corvallis, Oregon, laboratory with synergists of malathion for resistant mosquitoes and flies is of considerable interest. Plapp and Eddy (1961) investigated the possibility that resistance to malathion in insects might be overcome through use of aliesterese inhibitors. The synergists tested were triphenyl phosphate, tributyl phosphorotrithioate, and tributyl phosphorotrithioite. When combined with malathion, these chemicals reduced resistance of house flies from 100-fold to less than 5-fold. Increased toxicity was also evident with susceptible flies. Malathion-resistant mosquito larvae were easily killed with this combination at ratios of 1:1 and 10:1. These synergists are known to be inhibitors of aliesterase activity in flies and mosquitoes under both *in vivo* and *in vitro* conditions. Results of field tests with the synergists are not available at this time.

Summary

In summary, I can say that much new basic research on control of insects is under way in the Entomology Research Division. The possibilities of using sterilizing chemicals in a natural population of insects for control purposes is exciting. Research progress in this area has been especially good. Studies on insect genetics and cytology will assist in the development of better and more effective control measures. Insect physiology studies, especially on the mode of action of chemosterilants, insecticides, and repellents, will produce new knowledge for use in our fight to reduce insect damage.

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Mr. Brumbaugh: In keeping with the program, we should at this time like to ask Dr. Lindquist to give us a status report on the activities of the National Mosquito Control-Fish and Wildlife Management Coordination Committee.

(Editor's note: Inasmuch as the following formal report became available in time for publication in the Proceedings, this has been substituted for Dr. Lindquist's informal remarks on the activities of this Committee.)

REPORT OF THE NATIONAL MOSQUITO CONTROL-FISH AND WILDLIFE MANAGEMENT COORDINATION COMMITTEE FOR 1961[1]

The National Mosquito Control-Fish and Wildlife Management Coordination Committee has been in existence for 2 years. As its name implies, it is a group formed to stimulate and facilitate the coordination of mosquito control and fish and wildlife management programs in the United States wherever there is a need. An account of its activities during 1960 is contained in *Mosquito News* for June 1961. Following is a brief report of its work in 1961.

A leaflet entitled "Coordinated Control" was prepared and 50,000 copies were printed. Funds for this purpose were provided by contributions of various conservation and mosquito control organizations. The leaflet describes some of the mutual problems facing mosquito control and wildlife workers, the advantages of coordinated programs in dealing with these problems, and the assistance that the Committee and governmental and private organizations can provide in this regard. Copies of the leaflet have been distributed widely, and an additional supply will be provided without charge to anyone requesting them. The aim of the Committee is to distribute the leaflet to all who are faced with a mosquito control-wildlife problem.

Another publication that became available during the year is the Proceedings of the Symposium on the Coordination of Mosquito Control and Wildlife Management held in Washington, D. C., on April 1-2, 1959. Strictly speaking, this is not a product of the Committee but of the meeting that led to the formation of the Committee. The 154-page proceedings include papers on the fundamentals of mosquito biology and control and of wetland wildlife management as well as papers on chemical and environmental programs in relation to mosquito control and wildlife management. Copies are available from the Morris County Mosquito Extermination Commission, P. O. Box E, Morris Plains, New Jersey, at a cost of $2 each.

During the summer the Committee sponsored a 3-day field tour through Maryland, Delaware, and New Jersey to view water development projects designed to integrate mosquito control and wildlife management objectives. Most of the projects observed were based on the impoundment principle. One of the primary values of the tour was the opportunity it provided for workers in one state to see the new approaches being tested in the neighboring states.

The Committee is presently making a special study to determine the variation that occurs in the recommendations of mosquito control agencies for application rates of various chemicals. This subject is timely because of the increased interest in the pesticide-wildlife problem and the known sensitivity of certain fish, shellfish, and wildlife to chemical poisoning.

[1] Prepared by Committee members: Paul F. Springer, Secretary; Robert L. Vannote, Chairman; A. W. Lindquist; K. D. Quartermann; E. A. Seaman, and Ira N. Gabrielson.

Through conferences, field inspections, correspondence, and literature survey the Committee has attempted to keep abreast of the latest pertinent developments in the mosquito control-wildlife field. It has continued to provide information on these and other matters to those requesting it. Where this has not been readily available, it has solicited the information from appropriate sources or has pointed out the need to those in a position to obtain it. The Committee has lent support to efforts to develop well-rounded investigational programs and, in several instances, has been instrumental in helping to develop better coordinated operational field programs.

During the year a questionnaire was prepared on problems needing research and/or demonstration in mosquito control and fish and wildlife management practices. This was sent to state, federal, and private fish and wildlife organizations, and to state and regional mosquito control associations for distribution to member districts and commissions. A total of 108 usable replies was received from some national and regional groups and from organizations in 37 of the 50 states. Fifty-six of the replies were from mosquito control organizations and 52 from fish and wildlife conservation organizations. Replies are still to be received from certain mosquito control districts.

Results of the questionnaire showed that 70 percent of the respondents believed that significant mosquito control-wildlife problems existed, 20 percent said that there were no problems, 7 percent considered the problems to be minor, and 3 per cent had no knowledge of the problems. Problems dealing with environmental programs and with chemical applications were considered to be of nearly equal importance, whereas biological and miscellaneous problems ranked third and fourth, respectively.

Most of the problems in environmental programs were associated with impoundments. These problems were of two principal kinds—construction and water management of wildlife impoundments to reduce the production of mosquitoes, and possible use of impoundments as a mosquito control measure. Related problems included determination of effects of mosquito control impoundments on fish and wildlife and development of substitute methods of mosquito control more favorable to fish and wildlife utilizing large reservoirs. The remaining environmental problems concerned ditching, principally its influence on wildlife and how ditch construction and management could be modified to lessen any detrimental effects on wildlife.

Chemical problems were concerned primarily with the effects of insecticides on fish and wildlife, and the lower animals that they eat or that are commercially important, such as crabs and shrimp. A corollary of this problem was the need for the development of new chemicals, formulations, and methods of application that cause less damage to fish and wildlife.

Biological problems included mosquito control by use of fish and other biological agents and the influence of introduced *Gambusia* on existing fish populations. The principal miscellaneous problem was the need for basic ecological studies of wetlands and their mosquito-wildlife problems. Also mentioned were a determination of the role that swamp-inhabitating birds play as a reservoir of the encephalitis virus and the importance of transmission of the disease by mosquitoes.

Of the 103 usable problems mentioned, 34 were said not to be the object of either study or demonstration. Individual work by either a fish and wildlife or a mosquito control organization was being done on 34 of the problems and joint work on 19. Three respondents did not know the status of work on the problem mentioned and 13 respondents did not reply to this question.

Results of this questionnaire are of value in pointing up research and demonstration problems of greatest importance and will be helpful as a guide for future research and demonstration programs. It is believed that as much as possible such programs should be joint in nature in order to pool resources and to provide the best climate for mutual acceptance of the results. The Committee plans to encourage the further development of coordinated programs by bringing problems mentioned in this survey by mosquito control or fish and wildlife organizations to the attention of potential cooperating organizations in the opposite field.

Mr. Brumbaugh: I would like to call upon Dr. Hess again for the purpose of filling us in on the activities of the Subcommittee on Vector Control of the Interagency Committee of Water Resources. Would you please comment on that, Archie.

Dr. Hess: For the past 20 years or so there has existed in Washington a top-level federal interagency policy advisory group which has had several names. It goes back to both Republican and Democratic administrations. It is now known as the Interagency Committee on Water Resources and they call it Ice Water for short. Until recently, we in mosquito control have not had a voice in this top-level policy group, which makes decisions on almost everything concerned with water resources development. Due to the efforts of Dr. Simmons and his group working with Dr. Lindquist and his group we just recently succeeded in getting a Subcommittee on Vector Control established within this federal group; so now we in mosquito control do have a voice at the top level. The Departments represented at present are Army, Interior, Agriculture, TVA, and Health, Education and Welfare. Dr. Simmons is going to give a report on the work of this group at the Galveston meeting. I might just say, however, that the President does have two task forces which are doing some important work. One, under Marshall Rainey's chairmanship, is developing a cooperative bulletin on Mosquito Prevention on Irrigated Farms. Here again we'll probably use information from the California publication on that subject, but this will be applicable nationwide, with all agencies concerned participating in its preparation. Second is a task force on Cooperative Research to coordinate and integrate the interests of the various agencies. I happen to be the chairman of this group. We have five active research projects, with two more contemplated. Four of these deal with management of irrigation water for mosquito prevention and related interests; that is, taking into account agricultural and wildlife considerations in addition to mosquito control. The other one is a subject we have been trying to get work on for a long time, control of vectors in water-side recreational areas. There is one project each in Washington, Oregon, Utah, Texas, and Colorado. Two of these are being subsidized through NIH research grants. We are very happy to get this cooperative work underway.

Mr. Brumbaugh: Thank you, Archie. Are there any further announcements? If not, the meeting will adjourn until 1:30.

SECOND SESSION

MONDAY, JANUARY 29, 1:30 P.M.

VECTOR CONTROL RESEARCH IN CALIFORNIA

GARDNER C. MCFARLAND, *Presiding*

MOSQUITO AND *HIPPELATES* CONTROL INVESTIGATIONS

MIR S. MULLA
University of California, Riverside

At UCR basic and applied research programs are directed against many groups of arthropods of public health importance. Basic physiological and toxicological studies on cockroaches, mosquitoes, houseflies and other insects provide a basis for understanding the mechanism of action of control agents and the interrelationship of these agents to the biological and physiological behavior of the test organisms. To accomplish these studies, colonies of various species or strains are maintained in the laboratory. In order to develop an effective vector control technology, pertinent biological, ecological and behavioristic information has to be gathered under laboratory and field conditions.

Expanded laboratory and field investigations on the control of ceratopogonids, chloropids, culicids, chironomids, muscoid flies and acarina of medical and veterinary significance are underway at the present time at UCR. Due to the breadth and extent of these studies and the limited time available, only the control technology of the Culicidae (mosquitoes) and Chloropidae (the *Hippelates* eye gnats) will be discussed. An extensive program for the development of adulticidal measures under the auspices WHO is underway at UCR. This program will directly or indirectly aid the research programs needed for mosquito control in California. Due to lack of time this program will not be discussed.

Mosquitoes are widespread in California while the eye gnats cover wide areas of the six southern counties and also areas in Fresno, Tulare, Ventura and Santa Barbara counties. Due to the extensive distribution and population prevalence of mosquitoes and eye gnats for 9 or 10 months of the year, control activities of these two groups as well as midges constitute a major facet of mosquito abatement districts in California.

MOSQUITOES

In California, the current mosquito control technology is predominantly directed toward the abatement of pest and vector species in their aquatic habitats. Although source reduction and biotic control measures are employed whenever possible, the use of chemical larvicides constitutes a major segment of current mosquito control technology. At the present time, there is a need for the development of a variety of larvicides to be employed under diverse environmental conditions. Materials with low mammalian toxicity and high degree of safety to wildlife, game species and beneficial life are much sought for. The development of resistance in mosquitoes to organochlorine and a few organophosphorus compounds necessitates systematic search for more effective and more desirable larvicides. Fortunately the degree of resistance and cross tolerance in mosquitoes to the organophosphorus group of insecticides is not as prominent as in the case of organochlorine insecticides.

The goal of the current investigations is to find substitute materials with larvicidal activity as that of parathion but much less hazardous to mammals, fish, wildlife and beneficial insects. After an initial evaluation of 42 experimental and commercially available toxicants, 6 or 7 materials were found to have biological activity similar to that of parathion against mosquito larvae. Among these, 3 compounds (G-30494, Bayer 29493, and Bayer 25198) had considerably lower mammalian toxicity than parathion. In the field, these compounds yielded 100% control at 0.025 to 0.1 lb. per acre. A large number of the compounds tested, however, were more effective than malathion and DDT, the conventional type of insecticides. Further studies on the biological activity of 25 materials revealed another 6 materials (Bayer 37343, Bayer 29952, SD-7438, SD-7587, Bayer 41831 and SD-7554) manifesting a high degree of activity against the larvae. The toxic hazards of these materials (excepting Bayer 29952) to mammals are considerably lower than that of parathion and some of these are even less toxic than DDT. In field tests, complete larval kill was obtained with 5 to 25 grams of the toxicants per acre.

The administration of highly effective larvicides at low dosages (in gram quantites) has several advantages. In the first place, lower rates per acre are more economical and would result in lower application costs. They have the additional advantage of being less hazardous to wildlife, game species and beneficial life and also resulting in low residues in food and forage crops.

Mosquito Larvicides and Their Relationship to Fish and Wildlife

The effect of several mosquito larvicides on fish and annuran species was studied in field ponds. Of the materials tested against *Rana, Bufo* and *Scaphiophus*, Bayer 38920, Trithion and GC-3582 were toxic. The remaining 15 materials for all practical purposes were innocuous. Long term toxicity of 45 insecticides was studied at multiple rates against the mosquito fish. Of the 45 insecticides tested against this top feeding minnow, about 21 insecticides proved nontoxic at larvicidal or higher dosages. The remaining materials indicated varying degrees of toxicity. Some materials such as Ethyl Guthion, Bayer 34042, GC-

3582 and Bayer 29952 were highly toxic to the fish. These materials may be successfully employed in ridding lakes of trash fish. The top feeding minnow is an ally in the fight against mosquitoes and it should be saved from toxic chemicals. The use of selective insecticides in mosquito control thus holds great promise. Integration and coordination of chemical and biological control in mosquito abatement should be advocated whenever possible.

Water Pollution

The peristence of 24 mosquito larvicides at multiple rates was studied in treated water. Most of the larvicides applied at larvicidal rates disappeared from the water within 24 hours after treatment. The absorption of toxicants onto soil colloidal particles is to be studied. As a whole, judicious use of many mosquito larvicides should not cause serious water pollution problems.

Residues

The need for repeated use of insecticides in or adjacent to food and forage crop stands for mosquito control has created a general concern regarding the occurrence of unwarranted residues. At times it becomes necessary to treat some crop stands for mosquito control during actual harvest of the crop or very close to the harvest time. Initial residues over the tolerance level will be incurred due to larvicidal treatments applied as sprays. The use of granular mosquito larvicides, however, will for all practical purposes yield no detectable residues in the crop. Granular larvicides have many advantages and their use in mosquito control is gaining momentum. Research on the physico-chemical properties of granular insecticides has led to an understanding of these complex systems. Although effective granular formulations of a very few larvicides can be prepared, it is very likely that further research will provide a basis for improving the formulation techniques of many new mosquito larvicides.

Sterilization Techniques

Studies on the potential use of chemosterilants and irradiation to induce sterility in one or both sexes at some stage of mosquitoes are in progress. This phase requires a good deal of preliminary study to determine lethal range and rates which would induce sterility without producing mortality or noticeable changes in biologic behavior. Eggs of *Culex p. quinquefasciatus* irradiated at 880 and 1320 roentgens hatched but the larvae behaved abnormally and died shortly after. Eggs irradiated with 440 roentgens hatched and the larvae are undergoing normal development. It is not known yet whether this irradiation dose would induce sterility or not.

Studies on the effect of a chemosterilant on larval and adult mosquitoes are underway. The chemosterilant used at 5 and 10 p.p.m. did not produce any detectable ill effects. The use of chemosterilants or irradiation for mosquito control requires further studies. Much more has to be learned before they can be used as tools in practical mosquito control programs.

Hippelates EYE GNATS

The *Hippelates* eye gnats are severe pests of man, domestic and wild animal species. They are proven vectors of mastitis of cattle. The eye gnats due to their peculiar feeding behavior have been incriminated in the transmission of several human infectious diseases. The spirochets, *Treponema pertenue*, the causative agent of yaws in the tropics, and *Treponema carateum*, the causative agent of mal de pinto in tropical and subtropical Americas, are believed to be transmitted by *Hippelates* eye gnats. In the United States the eye gnats are incriminated in the transmission of *Haemophilus aegyptius* causing Koch-Weeks conjunctivitis. In addition to the relationship of eye gnats to the spread of this disease, they are highly pestiferous. Real estate developments and recreational utilization of resort areas have been slowed down by the presence of heavy eye gnat populations. Farm labor loss is usually associated with the annoyance brought about by hordes of eye gnats in farming communities.

The potential breeding grounds of *Hippelates* eye gnats in California probably surpass that of mosquitoes. For example, in the Coachella Valley alone over 70,000 acres of land breed eye gnats during most of the year. Similarly other valleys in southern California have thousands of acres of farmland and recreational premises where optimum conditions are present for eye gnat breeding. Due to the extensive and diverse type of breeding grounds of eye gnats, most of the conventional insecticidal treatments are not too effective. Controlling eye gnats over large areas is expensive and cannot be achieved with the use of insecticides alone. Various control approaches supplementing each other have to be developed.

The eye gnats predominantly breed in cultivated farmland. They also breed in recreational land such as golf courses and household gardens and lawns. The females are attracted to moist disturbed soil where they lay eggs singly near the surface. The larvae on hatching work down into the ground feeding on green organic matter from crop and weed residues. The larvae after completion of development pupates near the surface and the adult gnats emerge from the pupae and work their way up through the soil. The adult females fly considerable distances and invade residential and recreational premises.

Control measures developed against eye gnats are based on the available biological and ecological information. The eye gnats can be controlled in the adult stage by the application of insecticides as residual sprays or aerosol treatments. Spray treatments cannot be applied over large areas as is necessary for eye gnat control. The incorporation of a bait or lure in the adulticidal treatment, however, holds promise.

The first step in the development of an adulticidal program is to evaluate and find highly effective compounds. Studies in the effectiveness of 34 insecticides have turned out several highly effective materials. Twenty materials were more toxic than malathion and 14 materials (not included) were less toxic. For field control experiments safe materials with biological activity approximating that of parathion will be investigated. The top seven materials(excluding parathion) will fall in this category. It should be noted that malathion and DDT the two most common insecticides are not effective against the gnats.

Another approach toward controlling eye gnats is through larvicidal treatments of residual insecticides. Materials that would be suitable for this purpose should yield seasonal control with one treatment. The organochlorine insecticides being persistent in soil cannot be used in the desert regions because eye gnats have developed immunity to most of these insecticides. Development of resistance in eye gnats to this group of insecticides in the foothill and coastal regions is not apparent as yet and they can be successfully used in these areas.

In order to find substitute materials for soil treatments applied in the desert areas against the gnats, studies on the longevity of organophosphorus and carbamate insecticides were conducted. Of the 80 experimental and commercially available insecticides, only 11 materials manifested residual activity. The remaining materials would not be practical to use for gnat control. Use of some of these materials with low to moderate residual activity in agricultural pest control programs may also prove beneficial for gnat control.

Of the 11 materials which showed residual activity in the laboratory, Diazinon, SD-4402 and Trithion were tested in the field. Diazinon did not produce control of gnats 2 months after treatment. SD-4402 and Trithion however produced seasonal control at 5 lb./acre.

It should be pointed out that soil treatments for gnat control have been used for a decade now in the Coachella Valley. Due to the inclement weather conditions and intensive farming practices and high organic matter in the soil, the potency of soil insecticides exhausts very rapidly. The chances of finding good gnat larvicides are very small. Therefore the few effective larvicides found should not be used over large areas, but used in areas where cultural control measures cannot be applied.

Cultural Control Measures

Hippelates eye gnats for heavy breeding require moisture, high temperatures, sandy soil, high content of plant organic matter residues and disturbance of the soil. Incorporation of organic matter in the soil can be successfully manipulated for eye gnat control. Organic matter is the primary limiting factor in eye gnat production. Absence of disked under organic matter in the soil will greatly eliminate eye gnat breeding independent of other factors. Laboratory and field investigations lent ample support to this fact. The eye gnats failed to complete development in soil containing organic matter less than 0.46%. In field plots where weed growth was destroyed by a weedicide or frequent diskings, eye gnats failed to develop. Sufficient breeding occurred in plots where normal amount of weeds and cover crops were disked under. Noncultivation also resulted in good control of the gnats. In the presence of good cover crop or weed stand, cultivation assumes greater importance. Noncultivation in perennial crops such as citrus, dates and vineyards was suggested at first in the early thirites and then again in the early fifties. However, farmers are not too enthusiastic about maintaining weed stands in crops and therefore this approach was not and cannot be adopted. Suppression and destruction of weeds by means of weedicides or frequent cultivation in perennial crops (mainly fruit trees) provides the best approach ever developed for eye gnat control. The approach is flexible and if employed in conjunction with adulticidal and soil larvicidal treatments, will go a long ways toward reduction of eye gnat populations. Without this approach eye gnat control with insecticides alone in heavily infested areas is not deemed possible. It is gratifying that some farmers in the Coachella Valley have gone into practicing clean culture on their own.

Repellents

Even with the institution of an efficient control program, there will still be some gnats around to annoy a few individuals who are most susceptible to eye gnat attacks. Chemical repellents if used judiciously will afford considerable relief from these annoying pests. Although many studies on the effectiveness of chemical repellents against ticks, mosquitoes and other Diptera have been conducted, virtually nothing is known on the relationship of these to eye gnats. Olfactometer tests during the past season indicated very few of well known repellents to have high degree of repellency against the gnats. Even the most effective ones, namely Dimelone, ethyl hexanediol, MGK-11 and dimethyl carbate did not prove too effective when tested in the presence of heavy field populations. Delphene, the most effective repellent known against mosquitoes was ineffective in the manner tested. Evaluation of these and other materials on humans is contemplated during the coming season.

Sterilization Techniques

In order to determine the susceptibility of various life stages, eggs and pupae of eye gnats were exposed to various radiation doses. Eggs as expected were more susceptible. Dosages over 2000 roentgens killed the eggs while the pupae survived doses as high as 6000 r.

Sterilization in eye gnats was obtained by feeding the adults on 0.01% solution of a chemosterilant impregnated on filter paper strips soaked in food solution. Many basic biological and behavioristic studies have to be undertaken before the full potential of the use of irradiation and chemosterilants can be determined for eye gnat control.

The use of chemosterilants for gnat control in conjunction with lures and insecticides seems promising. It is surmised that a combination of sterilants and insecticides will take care of insecticide resistant and susceptible members of a population. This concept is only a theory at the present time and requires experimental evidence.

Summary

In summary it can be said that mosquito and eye gnat problems in particular are a product of various agricultural production methods. Recreational and residential activities also add to the intensity of the problem. This being the case, effective control measures can be developed through pooling knowledge obtained by scientists in the various fields of agriculture.

Chemical larvicides will play an important role in mosquito control in California and it is certain

that with systematic research we can keep ahead of the problem.

On the other hand, the use of insecticides alone does not provide a sound basis for eye gnat control in many areas of the state. Weedicides and proper management of farming practices are methods of choice for gnat control. It should be pointed out that for best results, insecticides along with cultural control measures have to be used in many of the infested areas.

VECTOR CONTROL RESEARCH IN THE DEPARTMENT OF ENTOMOLOGY AND PARASITOLOGY, BERKELEY

Ray F. Smith
University of California, Berkeley

Research activities of the Department of Entomology and Parasitology involve four general areas in the very broad and important field of noxious and vector arthropods as they relate to the health and comfort of the people of California. These four areas are interrelated and overlap considerably but for convenience of discussion I have separated them as follows:

(1) Ecology, bionomics and control of arthropods of medical and veterinary importance;

(2) Systematics of arthropods of medical and veterinary importance;

(3) General investigations of insect ecology; and

(4) Insect toxicology and physiology.

Each of these areas is currently active in the Berkeley section of the Department of Entomology and Parasitology, and I shall outline briefly our current and future program in the four areas.

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

It is axiomatic that a solid, background knowledge of the bionomics and ecology of a pest species is required to permit the development of satisfactory control methods and to maintain the pest population at subeconomic levels. Not only is this kind of information required for the precise timing and integration of various control procedures, but often such intimate knowledge provides clues to new or improved methods of control and management. Although these subjects have long been areas of investigation for research groups in California and detailed data are available on many aspects, as yet we cannot say we are approaching a "complete knowledge" of any single species. Actually, the bionomics and ecology of many gnats, mosquitoes, and similar flies are, for practical purposes, completely unknown. The fact that we have hundreds of species of arthropods of health importance in California is an indication of the magnitude of the problem.

Investigations in this area, especially on vectors of disease organisms, have been an activity of the Department of Entomology and Parasitology for over 50 years. Dean Aldrich referred to this in his address this morning, and I am sure I do not have to elaborate to this group on the pioneer activities of Billy Herms and Stan Freeborn in the area of mosquito biology and control in California. More recently at Berkeley, Deane Furman and his students have emphasized problems related to mites and ticks; although, the gnats, mosquitoes and other flies have not been neglected.

Domestic fly control is of increasing concern to all organizations involved in vector control, and some of the mosquito abatement districts are actively engaged in house fly suppression. A few years ago, Dr. Furman demonstrated that under Central Valley conditions poultry farmers can use the competition of the soldier fly, *Hermetia illucens* (Linnaeus), to good effect in controlling house-fly infestations if he manages his plant carefully (Furman, Young and Catts, 1959). This is not a complete solution to house fly problems, but it is certainly a step in the right direction. Our investigations of pest fly problems continues not only with respect to the never ending search for better chemical controls but also to evaluate other approaches. Practical house fly control is, as far as we are concerned, a collaborative project with the Agricultural Extension Service staff as well as specialists in other parts of the University who are concerned with the staggering problem of economical removal and utilization of manure. Research on domestic fly problems will be an important activity for Dr. John Anderson, a recent addition to the faculty at Berkeley, who is stressing a basic program of environmental control as well as the insecticidal approach. Coincidental with this program are investigations of the systematics of the immature stages and the ecology of flies breeding in cattle droppings.

This is a good place to stress the importance of the integrated control approach to vector control problems. Integrated control is simply the combination and integration of biological and chemical control into a single unified pest control program. I stress biological and chemical control because these are our main standbys in the struggle against insect and mite pests. In the final analysis, however, we must integrate not only chemical and biological control but all control procedures and techniques into a single pattern aimed at holding pests at subeconomic levels. Thus, you can see that vector control specialists have been practicing integrated control for many years.

Three principles have been developed which outline the integrated control approach:

1. *Consider the ecosystem.* The total complex of organisms (the pest species, their natural enemies, their competitors, their other associates, their food, etc.), the various agricultural, industrial and social activities of man, and the conditioning environment are considered together as a unit—the ecosystem.

2. *Utilize economic levels.* The population levels at which the pest species causes harm or is a nuisance should be determined and control measures directed to keep the pest below these economic levels rather than to eliminate it completely. Very low economic levels are a characteristic of many but not all vector control problems and consequently this limits the

places where biological control or integrated control can be applied.

3. *Avoid disruptive actions.* Necessary control measures are designed to give adequate control but in a manner which does not upset some other part of the ecosystem. This third principle involves the application of the first two principles, the selective use of insecticides and the augmentation of natural enemies. We assume that natural enemies are present or are available; if they are not present, we have nothing to integrate.

In the investigation of the over-all pattern of pathogen transmission by arthropod ectoparasites, emphasis in the past has been placed on some of the more conspicuous blood-sucking forms. To complete our knowledge of the epidemiology of various diseases and hence our ability to suppress or eradicate them, much additional information is needed on the habits and importance of some of the less conspicuous forms such as the various small gnats and mites. With this viewpoint, we are expanding our investigations on the host selection, feeding habits, vector potential, and other related factors of such small blood-sucking flies as semuliids and ceratopogonids. Future plans include ecological studies of the habitats of species of public health importance.

Our parasitology group at Berkeley, in collaboration with investigators at the Hooper Foundation of the U.C. Medical Center, and the Communicable Disease Center of the U.S. Public Health Service in San Francisco, has also been especially concerned with clarifying the feeding habits, vector relationships, and bionomics of various mites presumed to be parasitic. Interesting recent results include: demonstration of the presence of the *ornithosis* virus of birds and man in free-living mites (Furman, in press); the survival of the plague bacillus, *Pasteurella pestis*, in a mite for 23 hours following an infective blood meal (the mites failed to transmit plague in these tests) (Furman *et al.*, 1961); continued maintenance of cultures of a mesostigmatid mite on dried blood and ready acceptance of this food by 4 out of 6 species of parasitic mites tested. (Furman, 1959a; Radovsky, 1960). Incidentally, these studies have shown that *Haemogamasus* mites, which are widely distributed in the nests of rodents, can survive subfreezing conditions and a month or two without food (Furman, 1959b).

A number of other projects are currently underway. A graduate student (Richard Garcia) is investigating the ecology of the pajaroello tick, *Ornithodoros coriaceus*, together with investigations on the nature of the venom or allergin produced by this "most venomous tick." In this connection, I should mention the very interesting discovery of an entirely new group of symbionts in several kinds of soft shelled ticks by a Research Associate in the Department of Entomology and Parasitology. It is too early to assess the significance of this research, other than that it exemplifies the basic research approach which not infrequently establishes a new frontier, both academically and on an applied basis.

The food habits and other aspects of the bionomics of *Fannia benjamini*, a fly which commonly takes blood from wounds created by horseflies, are under study. This fly is a probable vector of an eye worm, *Thelazia* sp., which infects man in addition to many wild and domestic animals. Other projects include field studies on the ecology of nasal bots of deer (Oestridae); laboratory and field studies on the biology of rodent bot flies (Cuterebridae); and California breeding sites of the annoying blood-sucking gnat *Leptoconops kerteszi.*

Systematics of Arthropods of Medical and Veterinary Importance

The importance of a precise knowledge of the classification of arthropods of vector significance needs no amplification for this audience. Often in the field, you have observed subtle differences in the habits of closely related species which greatly affected their susceptibility to control and management. In such field observations, you have often pointed the way for the systematist. In any event, the need for a sound systematic base for our vector control research is clear.

For over 20 years, the California Insect Survey has been a statewide project of the Berkeley section of the Department of Entomology and Parasitology. The objectives of this survey are to explore fully and critically the extent and nature of the insect fauna of California, to maintain a research collection which will in itself reflect the nature of the insect fauna and provide the basis for analytical studies, and to make available this information in published form. The Bulletin of the California Insect Survey is now in its seventh volume, the collection contains well over one and a half million insects, and continued expansion of both is anticipated.

Eight of the Bulletins of the California Insect Survey have dealt with the taxonomy and distribution in California of insects of public health importance. These have included mosquitoes, horse flies, muscoids, and various wasps. Currently, systematic research is active on bed bugs (R. L. Usinger), reduviids (R. L. Usinger and P. Wygodzinsky), parasitic mites (D. P. Furman and students), wasps, mosquitoes, fleas (Harold E. Stark and Allan M. Barnes), rhagnioids, simuliids (J. A. Anderson) and chironomids (James E. Sublette).

One of the groups of potential vectors most in need of improved systematic treatment is the Acarina. In recent years, considerable progress has been made on the systematics and morphology of several groups. Monographs have been prepared and published on the *Laelaps* of the world (Tipton, 1960) and the Spinturnicidae (Rudnick, 1960). The former are common on small mammals throughout the world and the latter are parasitic on bats. Another monograph is nearing completion on the dermanyssid mites which are blood-suckers on bats and consequently of potential vector significance (Radovsky, ms. in prep.)

General Investigations of Insect Ecology

Much of our research on the bioclimatology, dispersal, distribution, and population dynamics of arthropods has not involved arthropods of medical and veterinary importance directly. However, the general knowledge of population ecology developed in these investigations can have a significant bearing on practical problems. The earlier discussion of integrated control is a case in point.

Professor R. L. Usinger, in addition to his systematic studies on reduviids and bed bugs, is conducting a comprehensive project on host selection in the Cimicidae. Originally this project was designed to test whether bed bugs could be induced, through olfactory conditioning or genetic selection, to select any new hosts. Extensive tests have shown that no preferences were induced in the colonies even after many generations, but significant morphological differences in the strains on different hosts developed. In the original human colony, the ratio of head width to third antennal segment length was 1.51. This changed to 1.41 in the bat colony after many generations. In recent months, a reversal of hosts for two generations, has shifted the ratio back to 1.46. The study is now concentrating on an explanation of these amazing host-induced changes. Another surprising result of Dr. Usinger's study is that the cross between *columbarius* ♀ and *lectularius* ♂ is almost sterile while the reciprocal cross is completely fertile.

Working under an N.I.H. grant at Berkeley, Dr. Carl Mohr has recently published a report on the relation of infestation of mammalian hosts by ectoparasites to size of host and standard range of hosts. Results suggest that what generally passes for "host preference" among certain chiggers and ticks is partly due to area of host body exposed to infestation and area traversed or "covered" per individual (Mohr, 1961). This now permits a sounder evaluation of host preference and other biological attributes. These studies are continuing on the relationship between ectoparasite loads of rodents and the shape of the home range of the host.

Microenvironment investigations include a detailed study of the microhabitat in *Neotoma* nests with special reference to the ectoparasites which may serve as vectors of disease agents.

Insect Toxicology and Physiology

An increased knowledge of the physiology of arthropods and the related area of toxicology permits the development of new and more satisfactory control procedures. Such studies are continuous research projects in our laboratories and currently we are actively engaged in the following projects:

1. *DDT metabolism in insects.* Among the several metabolic products of DDT formed in roaches, *Drosophila* and mosquitoes, one has been identified as Kelthane and the enzyme responsible has been shown to be located chiefly in the microsome fraction of tissue homogenates. Both larval and adult *Drosophila* form Kelthane from DDT; but there are marked differences among strains since both larval and adult stages of DDT-resistant flies form the metabolite while a susceptible one did so only as larvae. (Agosin *et al.*, 1961; Menzel *et al.*, 1961) The important energy-converting substance triphosphopyridine nucleotide (TPN) is an essential factor in the reaction. In recent months, this oxidizing enzyme has been prepared in much purer form and a start has been made in more precise localization within tissues. Work at present is with house flies and *Culex quinquefasciatus*, but other species will be included later.

2. *Tolerance to organic phosphates and carbamates.* A general study of differences in proteins and enzymes in susceptible and tolerant strains of flies and mosquitoes by means of electrophoresis is underway with evidence that significant differences occur. Emphasis is at present on esterases since they are of chief interest with resistance to phosphates and carbamates. Esterases (cholinesterases, aliphatic esterases, and aryl esterases) have been separated by electrophoresis in starch gel and their sentitivities to organic phosphates have been determined. It has been found that several phosphates of low toxicity by themselves are strongly synergistic when used with malathion because they inhibit the esterase that destroys malathion.

The carbamate Sevin® is absorbed rapidly into house flies and is also metabolized rapidly so that toxicity is relatively low (LD 50 topical=2μg/♀, contrasted with DDT=0.1μg/♀). Resistant house flies are readily selected by exposure of larvae or adults to Sevin and resistance is too high to determine accurately. Such resistant flies metabolize Sevin even more rapidly. Addition of a synergist such as sesamex prevents metabolism and removes most of the resistance to Sevin. Sevin penetrates slowly into the large milkweed bug but is metabolized very slowly so toxicity is high, e.g., LD 50 topical=0.5 μg/insect. The German roach absorbs Sevin slowly and metabolizes it very rapidly so toxicity is very low (LD 50 topical = 20μg/♂. (Eldefrawi and Hoskins, 1961; Hoskins and Nagasawa, 1961).

3. *Culex resistance.* Seven strains of *Culex quinquefasciatus* and *Culex tarsalis* are being cultured in the laboratory and five are under pressure with DDT, dieldrin, or malathion. High resistance is already established to dieldrin (x120 as larvae and an undeterminable level as adult females) and lesser levels to other compounds. These strains will be used in establishing the dosage-mortality relation for the fully susceptible (rr), hybrid (rR), and fully resisant (RR) genotypes.

4. *Bioassay techniques.* In connection with analysis of resistance in adult mosquitoes, the WHO method for adult females has been improved by use of better solvents than Risella oil for both chlorinated hydrocarbons and more polar materials such as phosphates and carbamates. This is essential for determining the dosage-mortality points with highly resistant strains for which the standard method is not suitable.

The need for more research in the important field of vector control cannot be questioned. The rapidly increasing human population, the intensified utilization of our agricultural lands and water resources, and the increasing use of our wildlands and other recreational areas all point toward greater problems with noxious and vector arthropods in the near future. We at Berkeley are planning to assume our full responsibility for research in this broad area through an expanded and intensified effort along the lines I have described here today.

What is needed is new knowledge which can lift some of our present control practices from a rather crude level of operation to a refined art. We have come a long way in vector control, but the great demands on research are clear evidence of the need for more progress.

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VECTOR CONTROL RESEARCH AT THE UNIVERSITY OF CALIFORNIA, DAVIS

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The University at Davis can take considerable pride in its past accomplishments in the field of insects and other arthropods affecting the well-being of man and domestic animals. I wish here only to mention the studies and publications of S. B. Freeborn on flies and mosquitoes, M. A. Stewart on blowflies and fleas, S. F. Bailey on black widow spiders, J. R. Douglas on various flies and lice of veterinary importance, L. M. Smith on the black gnat, A. D. Telford on pasture mosquitoes, Robert Washino on sewer farm mosquitoes, Rollo Darby on rice field midges, Byron Chaniotis on the effect of larval nutrition of mosquitoes on the tendency to lay eggs with out a blood meal, and N. B. Akesson on the nature of fog and spray deposits. Additional studies were those on mosquito larvicides by Louis W. Isaac, Robert H. Soroker and the writer; studies on house flies by W. Wall, S. F. Bailey, A. Grigarick, R. Bechtel, R. M. Bohart and others, and extensive taxonomy of mosquitoes by S. B. Freeborn and the writer. This is by no means a complete list of past efforts, but it serves to illustrate the point that we have a solid background in this line of work. Also, it leads to a discussion of present efforts.

First it should be stated that we have always had excellent cooperation from the Bureau of Vector Control which has offered advice and material aid whenever we have requested it. Secondly, the mosquito abatement districts have been more than generous whenever they have been asked for help. Specific mention could be made of assistance freely given by personnel of Solano, Sacramento-Yolo, Marin, Alameda, Sutter-Yuba, Shasta, Colusa, San Joaquin, Merced, Delta, Kern and Orange County M.A.D.'s as well as several local health departments.

Current studies centered at Davis can be listed as follows: 1. Mosquito flight habits, primarily *Culex tarsalis,* by S. F. Bailey, W. Iltis, C. G. Moore and the writer. 2. Physiological studies on eggs of mosquitoes, by Charles L. Judson of the Bureau of Vector Control. 3. Behavioral and physiological studies on the biting activity of bloodsucking arthropods, by M. M. J. Lavoipierre of the Hooper Foundation. 4. Host-parasite relationships of filarial nematodes, also by M. M. J. Lavoipierre. 5. A systematic study of the *Culex pipiens* complex in California, by W. Iltis. 6. The nature of the "apical drop" on mosquito egg rafts, by W. Iltis and G. Zweig. 7. Participation in the preparation of a field manual on mosquito-like gnats, by the C.M.C.A. Entomology Committee, of which the writer is a member. 8. Mist-blower evaluations by M. N. El Awady and N. B. Akesson of the Department of Agricultural Engineering. 9. Fly control from an operational standpoint, by S. A. Hart of Agricultural Engineering and Ward Stanger of Agricultural Extension. To this list might be added correlative work on *Drosophila,* studies by the Departments of Irrigation and of Soils on the behavior of water in different soils, and miscellaneous investigations of the School of Veterinary Medicine on possible vectors of animal diseases.

Some of the above, such as the mosquito egg physiology and the mist-blower work will be reported later at this meeting. As we are primarily interested in mosquitoes today, I will not elaborate on flies. Also, some of the other studies are not sufficiently advanced to discuss at this time. Therefore, I will confine myself to a summary of the mosquito flight project and to some comments on the research of Dr. Lavoipierre.

For the past two years the flight study has been ably directed by S. F. Bailey with the assistance of W. Iltis and C. G. Moore as well as several student helpers of whom Don Eliason should be mentioned especially. This work is supported by an N.I.H. grant and, as originally set up, it was pointed at the flight range of *Culex tarsalis.* We have modified and broadened the objective to include the flight habits of *C. tarsalis* as well those of other mosquitoes taken in our traps.

A number of interesting points have emerged and many suggestions for future work have presented themselves. Since much of this is in press or will be written up for publication elsewhere, I shall merely indicate some of the more pertinent results, each of which could be the subject of a report by itself. 1. Last summer 40,500 mosquitoes were marked and released, and 222, or about 0.5%, were recaptured along with 105,000 others. 2. The maximum distance of recaptures was three miles. 3. During July and August the main flight period was from 8 to 12 p.m. and the direction of flight was into the wind. On quiet nights the direction was more at random and flight was more restricted. 4. The seasonal flight peak in our area occurs in mid-July with one or more lesser peaks in August. The size of flights are determined more by the size of the source from which a brood is hatching than by specific weather conditions. 5. The most efficient marking method we have used so far involves fluorescent powders of different colors. Recaptures were made with "dry ice" bait traps, red boxes, and light traps, the first of these giving the greatest returns. 6. Considerable numbers of adults do not leave the rice fields and a surprisingly high percentage of these individuals reproduce without taking blood .Since this last phenomenon may have important implications in the chain of encephalitis infection, a special study of it is being made by Mr. Moore.

Dr. Lavoipierre is examining the intrinsic factors affecting the hunger drive in mosquitoes, specifically *Aedes aegypti* and *Aedes sierrensis*. It has been noted that when a gravid female is prevented from laying eggs she continues an abnormally high biting activity. Eventually, ovarian abnormalities result and the nature and cause of these is being sought. In the filarial work the intracellular phase of the parasite's development, in this case the heartworm of dogs, is being studied. This worm develops in the malpighian tubules of the mosquito, and the timing of the biting cycle of the mosquito with the development of the worm is being investigated.

HIGHLIGHTS OF THE BUREAU OF VECTOR CONTROL'S RESEARCH PROGRAM ON MOSQUITOES DURING 1961

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Mosquito control in California is presently based, to a very large extent, on insecticides. The research program of the Bureau of Vector Control therefore is concerned with studies in this area of endeavor. Insecticides, however, frequently raise more problems than they settle. We therefore believe that the answers to our problems will eventually be found in the areas of mosquito biology and ecology rather than in chemicals which kill mosquitoes. For this reason we must have a strong program on the natural history of mosquitoes and are presently doing much work in this area. My remarks on the progress of the Bureau's research program on mosquitoes will be divided into four categories: mosquito biology, physiology, chemical control, and biological control.

Mosquito Biology

Three years ago we began a study of changes which take place with age in adult mosquitoes (Rosay, 1960, 1961). This work, which was suggested by findings of workers in the Soviet Union (Bruce-Chwatt, 1959), provided a powerful tool for the study of mosquito populations under natural conditions. The basic idea, as all of you know, is that each egg which a female lays leaves an impression (dilatation) in the ovary where it developed. We can therefore determine how many ovarian cycles a female has experienced. We can also estimate how far she is through a cycle by the degree of maturity of the egg. This gives us a linear sequence of events throughout the life history of a female and we have only to add a time scale to be able to estimate her age. Certain changes also take place in males which allow something to be said of their age (Rosay, 1961).

Broods of *Aedes nigromaculis* (Ludlow) have now been studied throughout their life on a number of occasions. Since the time of emergence of the brood is known, we have a check on the adequacy of the age estimation technique. During the past summer 11 such broods were studies in two localities near Fresno. A graph showing the age composition of all of the females dissected in these studies was constructed. Since there was equal sampling throughout each study, the graph gave a fair idea of the longevity of *Aedes nigromaculis* females in the field. It was found that only 30% of the females collected had lived beyond the first egg laying, and less than 3% had survived the second. From these data it may be seen that the average female does not survive her first ovarian cycle. The first oviposition in these studies, which were done at warm temperatures, occurred about 4 or 5 days after emergence. At that time about two-thirds of the eggs of the generation should have been deposited. The second oviposition occurred about eight and one-half days after emergence of the adults and the bulk of the remainder of the eggs of that generation was deposited at that time.

Of the 5,600 mosquitoes dissected during the 11 studies, less than 10% were considered to be "contaminants", or individuals which had moved into the area under study, in spite of the fact that 9 of the 11 studies were done in an area where breeding also occurred in adjacent pastures. Data of this kind indicate to us that *Aedes nigromaculis* is a remarkably sedentary mosquito.

From studies carried out in this way several important findings have emerged:

1. Recently emerged females of *Aedes nigromaculis* are very sedentary. The finding of teneral females of this species indicates emergence within the last day or so in the immediate vicinity.

2. Systematic sampling of a population of this species over its entire history has shown no large, unexpected decrease in the population which would indicate mass movement. In these studies we have found no evidence of true migratory behavior in this species as has been described for the closely related *Aedes taeniorhynchus* (Wiedemann) (see Provost, 1957).

3. Most eggs are deposited on a field 4 or 5 days after emergence of the adult. Subsequent depositions also occur at 4 or 5 day intervals.

4. The average length of life of females of this species is no more than the length of the first ovarian cycle. A very small proportion of the population survives two ovarian cycles.

Physiology

The principal objective of this project is to develop a control technology for *Aedes* mosquitoes based on the egg stage. This has necessitated a thoroughgoing study of the biology of the egg; its structure, development (Rosay, 1959a, b), permeability (Judson, 1958), and hatching responses (Judson, 1960). Since none of the local aedines which develop in ground pools has been colonized, most of the work has been done with *Aedes aegypti* (Linnaeus) and later confirmed with *Aedes nigromaculis*. These studies have been extended to *Aedes sierrensis* (Ludlow) in the past year. This peculiar, tree-hole mosquito has proved to have many interesting qualities. The reduction in concentration of dissolved oxygen necessary to hatch eggs of this species is much greater than in other species studied (Judson, 1960). The susceptibility to hatching stimuli appears to reach a maximum shortly after completion of embryonic development and then falls off markedly with age. The egg may also be rendered transparent without harming the enclosed embryo which facilitates study of development and hatching. The egg of this species develops slowly and responds slowly to hatching stimuli which facilitates study of these processes.

Studies on stimulation and inhibition of hatching of eggs of *Aedes aegypti* have been extended during the last year. Various anesthetics such as ethyl chloride reversibly inhibit the hatching of eggs. Other substances, such as carbon monoxide, cyanide, and ammonia, induce eggs to hatch. These studies may eventually make possible the regulation of hatching of *Aedes* eggs in irrigated areas. The demonstration that these agents in the gaseous state can penetrate eggs which are impermeable to water showed that insecticides could be used to kill eggs. This is in contrast with most previous studies (*e.g.*, Hayes, 1950) which have shown aedine eggs not to be affected by insecticides.

Various insecticides in the gaseous state have been screened for activity against *Aedes aegypti* eggs. The testing of a series of propanes substituted with halogen atoms suggested that bromine substitutions conferred more toxicity than did chlorine substitutions. Similarly, the testing of a series of aliphatic aldehydes suggested that a vinyl linkage enhanced the toxicity of an agent. The most effective ovicide tested as yet is DDVP which at a reasonable concentration, does kill eggs.

Of 17 phosphates tested, 4 had LD-90's of 1 lambda (per quart of air) or less and three of these four contain a vinyl linkage. The toxicity of these compounds to eggs appears to be due not only to their volatility since many volatile compounds do not kill eggs; it seems likely that the vinyl linkage enhances the ability of a compound to penetrate the egg shell and thus increases its effectiveness.

Some of the compounds caused eggs to "hatch" or at least produced a rupturing of the egg shell at the normal line of dehiscence, while others did not. Such rupturing was caused only by compounds characterized by a pungent odor, some of which are "tear gases".

The ovicidal effect of DDVP was tested in the field by applying 2% granules to the soil, exposing eggs of *Aedes aegypti* to the treated area for 24 hours, and then returning the eggs to the laboratory for hatching. Treatment with 1 lb./acre of the toxicant produced mortalities in excess of 95%. Tests were also done on a larger scale under natural conditions with DDVP applied at .6 to .7 lb./acre. These tests on native aedines were not conclusive but did demonstrate the feasibility of an ovicidal technique. Although "oviciding" for *Aedes* mosquitoes is not yet practical, these results are the first to indicate that such a technology is possible.

Chemical Control

Resistance of mosquitoes to our two most used insecticides, parathion and malathion, is now well documented. Resistance to malathion has been demonstrated in *Culex tarsalis* (Coquillett) (Gjullin and Isaak, 1957) and *Aedes nigromaculis* (Lewallen, 1961) and has been suspected, if not demonstrated, in other species. Parathion resistance has been demonstrated in *Aedes nigromaculis* (Lewallen and Nicholson, 1959a) and *Culex pipiens quinquefasciatus* (Isaak, 1961). The original tests on *A. nigromaculis* indicated only a low level of resistance although there was enough to preclude the use of parathion in that area. During the past year a high level of resistance to parathion in *Aedes nigromaculis* was found in Tulare County (Lewallen, 1961); the standard application of 0.1 lb./acre killed only about 35% of the mosquitoes treated in field tests. By assay it was found that the LC-90 of this strain was over 600 times the normal.

In laboratory studies it was found that parathion resistant *Aedes nigromaculis* larvae produced a higher level of metabolites of this insecticide than did susceptible larvae. Resistant and susceptible larvae contained similar amounts of cholinesterase as measured *in vitro* but in living larvae, this enzyme was inhibited to a lesser degree in a resistant than in a susceptible strain.

It was also found that the uptake and excretion of malathion was similar in larvae of *Culex tarsalis* regardless of whether they were susceptible or resistant to this insecticide. Malathion was converted to its more toxic analog, malaoxon, in both strains (Lewallen and Nicholson, 1959b). Malaoxon increased to a high concentration in susceptible larvae but almost disappeared from resistant larvae in a similar length of time. Metabolites of malaoxon were two or three times as abundant in resistant as in susceptible larvae.

The ever increasing resistance problem gave renewed impetus to the search for new insecticides. One, AC5727, was effective in laboratory and field tests at .25 to .5 lb./acre for the control of *Culex tarsalis, Aedes nigromaculis,* and *Anopheles freeborni* Aitken. This material, an experimental insecticide produced by the Hercules Powder Company, is the first carbamate tested by us which holds promise as a larvicide.

The persistence of insecticides in water under field conditions was tested by assaying treated water with mosquito larvae. It was found that in alkaline water, pH 8.8, the effectiveness of malathion began to decline in 4 hours while trithion was effective for 3 days. Both insecticides were applied at .5 lb./acre.

Biological Control

This project was initiated in 1959, since which time many suspected pathogens of mosquitoes have been collected and studied; these include viruses, bacteria, fungi, and Protozoa as well as a few worms.

The bulk of the effort has gone into the study of protozoan parasites of the order Microsporidia because of the pathogenicity and abundance of these parasites as well as the paucity of information concerning them. Thus far, eleven species of parasites of the genus *Thelohania* have been found infecting 10 species of mosquitoes in California; one mosquito, *Culex tarsalis* is parasitized by two species of *Thelohania;* the other mosquitoes, *Culex peus* Speiser, *C. erythrothorax* Dyar, *C. thriambus* Dyar, *C. apicalis* Adams, *Culiseta incidens* (Thomson), *C. inornata* (Williston), *Anopheles pseudopunctipennis franciscanus* McCracken, *Aedes squamiger* (Coquillett), and *A. melanimon* Dyar, are parasitized by a single species. Of these 11 parasites none had been named or described before the initiation of this project and at the present time only one (Kellen and Lipa, 1960) has been formally described. Descriptions of the other 10 species are currently in press (Kellen and Wills, 1962a).

These parasites appear to be remarkably host specific; each is known only from a single species of mosquito. Infected larvae usually succumb to the infection and upon dissolution release enormous numbers of living spores into breeding places. As yet, however, we have not been able to initiate infections in other larvae by feeding them these spores. Progress has been made in this direction recently by the surgical transplantation of parasites from infected to uninfected larvae. To do this, an infected larva is placed on top of an uninfected one and a fine wire plunged through the infected, into the uninfected larva. This technique allows, for the first time, the reliable initiation of new infections in the laboratory.

Some infected larvae survive and adult females from these larvae are capable of transmitting the infection transovarially to their offspring (Kellen and Wills 1962b). This has been demonstrated with 6 species of the parasites. In this way infected colonies of mosquitoes can be maintained in the laboratory. This has led to an immense expansian in our colonization efforts in the last year; we now maintain in the laboratory colonies of *Culex pipiens quinquefasciatus* Say, *C. tarsalis, C. erythrothorax, C. peus, C. apicalis, Culiseta inornata, Anopheles freeborni, Aedes sierrensis, A. aegypti, A. atropalpus* (Coquillett and *Haemagogus equinus* Theobald. We have had abortive colonies of *Culex thriambus, Culiseta particeps* (Adams), *Anopheles pseudopunctipennis franciscanus and A. punctipennis* (Say) as well; chances are good for success in colonizing these four forms.

Thelohania californica, a parasite of *Culex tarsalis*, is peculiar in that it kills male but not female larvae (Kellen and Wills 1962b). Although this phenomenon has not been intensively studied with the other species it may be found only in this one. Indications are that the progress of the infection is not influenced by the sex of the host in four other *Thelohanias* which have been studied.

Two microsporidian parasites of the genus *Nosema* have been discovered. These parasites seem to be less host specific than the *Thelohanias*; one species occurs in three species of *Culex* which are in two different subgenera, *Culex* and *Neoculex*. These parasites are also transmitted transovarially and larvae do not commonly show massive infections. The parasites are most easily detected in pupal and adult mosquitoes. Although adults may have massive infections, no deleterious effect on the host has been shown as yet, either in fecundity or longevity.

Last year we reported the isolation of a presumably polyhedral virus from *Culex tarsalis* (Kellen, 1961). The virus was maintained by feeding infective virus crystals to larvae. In the last series of tests this year the exposed larvae did not develop detectable infections and the virus was lost. We are presently attempting to recover the virus from the breeding place where it was originally isolated. This happening demonstrates the difficulty of maintaining strains of pathogens in the laboratory in the absence of reliable *in vitro* or tissue culture techniques. The virus holds promise as a control agent as it killed substantial proportions of the larvae exposed to it and possibly all which actually became infected.

Attention has been directed recently toward one of the several bacteria which have been isolated from live but moribund mosquitoes. One of these, a gram-negative rod of the genus *Aeromonas*, produces a fatal septicemic infection and can be transmitted *per os*. This organism also appears promising for the control of mosquitoes.

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VECTOR CONTROL RESEARCH NEEDS BY CONTROL AGENCIES IN CALIFORNIA

C. Donald Grant

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When we hear of these many research studies in the fields of insecticides and vector control, not only in California and the rest of the country, it might appear presumptuous to claim a need for an augmented research program. Each year several sources compile extensive bibliographies and abstracts of the voluminous studies provided by a wealth of agencies and universities, but each year many of our control workers in California review these lists and feel just a little bit poorer proportionately in our resources of knowledge and technical development to keep pace with the rapid evolution of new and increased problems from our resourceful and indefatigueable insects.

This is not a criticism of the many excellent studies produced in this field of research, but it is the contention that our current research facilities are far from providing the full scope and type of specific studies that have long been necessary to place mosquito and vector control, as a specialized function, on the cost-efficient and reliable basis demanded by so many interests in this period of rapid development, of excessive population by-products, this period of countless new chemicals with their potentials for good and bad, in this period of struggle by all agencies for the coordinates, time and taxes with which to achieve the objectives which we have long foreseen. The fruits of research are not forthcoming overnight, and only a small portion of the desired objectives of today can expect to be provided in the next several years, while the problems of tomorrow become increasingly critical.

The problems facing mosquito and vector control agencies in California have been compounded by the rapid evolution of several different factors which might be grossly summarized as follows:

1. The creation of extensive new sources by increased water usage and the rapidly growing pollution by organic matter in many such sources.

2. Increased exposure of the population through development of new lands in the habitat of varied noxious insects, and the creation of favorable breeding areas for previously small populations of noxious insects through accumulated organic by-products of our population growth.

3. The wealth of new and inadequately tested insecticides and potentials in physical formulations as well as developments in new equipment and techniques surpassing our ability to calibrate, evaluate and perfect them for precision application in vector control methods.

4. Increased legal restrictions from potential hazards to the interests of fish and wildlife, agricultural commodities and human exposure which are rendering many economical control techniques unfeasible and demanding greater precision, procedural reliability and new approaches at every step.

5. The many unknown potentials awaiting further evaluation in all phases of vector control which are compounded by constant evolution of the above mentioned factors, and in the absence of such evaluation serve to inhibit the initiation of needed control programs.

These factors are the most significant to control agencies, but many equally important factors could be cited for the interests of public health, agriculture, fish and wildlife, etc.

Any one of the specific problems encountered may be met and surmounted in some manner by the knowledge or facilities currently available. We are having to do it every day, and shall continue until better know-how is provided; but still we are aware that efficient expenditure of public funds demands a considerable increase in knowledge and technical development in control methods to meet the full scope and diversity of these problems in the efficient and reliable manner demanded, both now and in the future.

Although this discussion is titled research needs in vector control, a comprehensive review of our needs in control work makes it obvious that research is only one of several integrated factors necessary to put our programs on a scientific basis for meeting the desired level of efficiency and reliability that is being demanded of us. Research may provide the data which we urgently need as a foundation, but the program structure entails full utilization of this knowledge through compilation, study, analysis and practical incorporation into control technology. Fulfillment of the completed structure is a task beyond the resources of the individual district and thus entails a supplementary program of technical development vested in a body working intimately with a research program in its restricted sense.

Before receiving too many pot shots from the audience, I would like to emphasize that control procedures practiced in California are as advanced as any in the country, with a body of capable and ingenious personnel in the local programs; but the fact remains that as the complexity of sources grows and the restrictive demands of other interests curtail procedures, there is not the level of technical know-how at the command of any district to provide the continuous level of efficient abatement work on a scientific basis as is demanded now or in the future.

In gross summary we may cite our major needs as follows, although the compendium of specific suggestions garnered over the past few years is too lengthy to mention.

1. We need continuing studies on the biology, biochemistry and environment of our nuisance and

disease bearing species, for guiding and aiding our control program and specific procedures.

2. We need a centralized office where we may expose our problems and seek information, and where such office has coordinated sources of information and efficient liaison with other offices to pursue worthy requests.
3. We need a comprehensive analytical and evaluative study of procedures, materials and equipment used specifically in vector control and based on principles of field effectiveness.
4. We need an augmented program of technical development: a program of study and consultation in accord with the previous analysis and evaluation whereby principles of efficiency may be properly selected for the specific objective.
5. We need studies and recommendations on community planning, water pollution, water management, waste removal and processing, on the potentials of extensive water development programs, on new noxious insect potentials and on the best methods of survey, evaluation, prevention and control of such increasing insect potentials.
6. We need an augmented program of exploratory and developmental work in the vast array of new potentials in physical types and specific substances now feasibly practical in specific control needs.
7. Especially, we need development of methods, such as biological control which will ultimately serve to reduce our top-heavy reliance upon insecticidal applications.

It is not intended here to mention the methods of attaining these many needs, and obviously they cannot all be attained; however, the types of problems as here given and the varied effort required for such needs strongly indicates the need for a coordinated approach by responsible State bodies in helping to provide the necessary means to attain the objectives indicated in these needs, just as it demands the effort by our control agencies to assimilate and incorporate such knowledge into their practices for the welfare of the people of our State.

We have enjoyed an excellent relationship with the Bureau of Vector Control and their research program, and in some cases this pertains to studies effected through the University of California at its different campuses. It is hoped that a greater and fully integrated program coordinately conducted by these bodies will better provide for control needs in *both* research and the attendant technical development, for one aspect provided without the other on a well integrated basis would be inadequate for the interests of control agencies.

THE OUTLOOK FOR RESEARCH IN THE UNIVERSITY OF CALIFORNIA

JAMES R. DOUGLAS
University of California, Davis

As Dean Aldrich has pointed out, the University of California has been deeply involved in research on vector and noxious arthropods for more than half a century. As a member of the faculty of the University I hope you will not consider me unduly immodest when I say that I consider the record excellent in all respects. Furthermore, so far as I can see, the outlook for the future is even brighter than the record of the past.

Dean Aldrich this morning referred to some of the problems which will inevitably accrue as a result of the phenomenal growth in population which California is certain to experience. In addition to the problems which he mentioned, there is another problem of equal concern and that is the impact of the population expansion on the University of California. The enrollment on all campuses of the University last fall was just over 54,000 (an increase of about 20,000 since 1954. In the fall of 1970 it is expected, in fact virtually assured, that there will be more than 95,000 students in the University. By the year 2000 there will be something over 200,000 students enrolled in the statewide University. These are staggering figures and they represent staggering problems. One problem is in communication, which often tends to become more difficult as a result of growth and decentralization. We sincerely hope that this problem can be avoided. We are determined to make the effort, to maintain and augment our intramural channels so that the free interchange of ideas and information continues.

It is unfortunately often difficult for one who is not a member of the University staff to obtain a clear over-all view of the University's activities in a particular field. It was largely because of this situation, which resulted in an increasingly prevalent view that the University really wasn't doing much in the way of research on fly, gnat and mosquito problems, that it was determined we should take a long hard look at our efforts in this field. Consequently, last May Dr. Paul Sharp, Director of the Agricultural Experiment Station, appointed an eight man committee which he charged with the responsibility of drawing up a statement describing the current research programs relating to flies, gnats and mosquitoes. He also asked the committee to evaluate the program in order to determine what needed to be done. Finally, he asked the committee to make recommendations how the needed research could best be carried out, including appropriate levels of cooperation with non-University agencies.

For those of you who are not familiar with the Fly, Gnat and Mosquito Research Committee, Statewide, I would like to take a moment to tell you about its membership. Listing them alphabetically the first is Dr. J. R. Audy, a world famous medical entomologist, who is now Director of the Hooper Foundation for Medical Research on the San Francisco Campus and Director of the International Center for Medical Research and Training. Next is Dr. J. N. Belkin, whom many of you know. He is a medical entomologist on the Los Angeles Campus who has made major contributions in the field of mosquito biology and taxonomy. Dr. R. M. Bohart whom you just heard, also an authority on mosquitoes, is vice-chairman of the Department of Entomology at Davis. I am the fourth member of the committee, also its Chairman, and the only "ringer" in the group. Next there is Dr. C. A.

Fleschner, Chairman of the Department of Biological Control at Riverside. As Dean Aldrich pointed out this is an area of research that certainly demands an intensive effort in order to exploit its full potential in the control of arthropods affecting the health and welfare of man. The sixth member of the committee is well known to all of you, Dr. R. L. Metcalf, distinguished chemist-entomologist, and Chairman of the Department of Entomology at Riverside. Dr. Bill Reeves, whom you all know well, of the School of Public Health in Berkeley is the seventh member of our group. The eighth member is Dr. Ray Smith, whom you have also heard from today, Chairman of the Department of Entomology and Parasitology at Berkeley, and incidentally, President of the Pacific Coast Branch of the Entomolological Society of America.

With possibly one exception, who pride forbids me from naming, you surely must agree that this group of men is certainly well qualified for the assignment they have undertaken.

The members of the committee were pleased, and possibly a little surprised, when the data was brought together, at the magnitude of the University's previous and current research effort on flies, gnats and mosquitoes.

As a first step in improving our communications and understanding of the problems that face us on a statewide basis the committee has recommended to Dr. Sharp that a permanent advisory committee be formed, representing the appropriate segments of the University such as Agriculture, Engineering, Medicine, and Public Health and including non-University representation from such fields as Public Health, Fish and Game, Water Resources, Mosquito Control, and Agriculture. A well constituted committee representative of the diverse interests in California would be of inestimable help to the University in anticipating the problems in the difficult years ahead, and determining how, and by whom they should be solved. Such a committee would also be a potent force in marshalling the necessary support for the programs they considered essential for the University to undertake.

My crystal ball is not prescient to a degree which will permit any reasonable accuracy in predicting just what problems we will face in future years. However, one can say with certainty that basic research, in a broad sense, will provide the firm foundation essential to our understanding and solution of the problems as they arise. This is the area which the University of California considers to be its particular prerogative as a state agency. I fully realize that there is little general agreement on what constitutes basic research as opposed to applied research and I will not attempt a definition here. I think perhaps that very often the difference lies simply in the motives of the investigator: For example, if he synthesizes new compounds in a search for an insecticide, this is applied research. On the other hand if his interest is in examining chemical structures and properties, this is basic research. This is not to say what the University does not or will not undertake *ad hoc* projects seeking practical solutions to problems or to meet emergency situations. In fact this type of research is an obligation of most members of the Agricultural Experiment Station staff. In general, however, developments in technology such as the refinement of control procedures and their adaptation to meet specific situations is properly the kind of research which the University would prefer to leave to other agencies or to undertake in cooperation with other agencies where adequate staffs of field personnel are available.

It has been said that great voids exist in our knowledge essential for a rational program of control of flies, gnats and mosquitoes. This is unquestionably true. However, this is not a unique situation. The quest for knowledge is a continuous process and although we may think we have all the answers with respect to a certain problem we often suddenly realize that the problem has changed in some significant way which poses new problems to be solved. My favorite illustration of this point involves a well known entomologist, who in 1947 informed me in all seriousness that the economic entomologist was all through and might as well turn to collecting butterflies or find some other gainful occupation. He maintained that DDT would eradicate whole populations of insects and leave nothing for the entomologist to do. I hardly need to remind you that less than one year later the first failures of DDT were observed, due to resistance on the part of the insects. You all know the rest of the story only too well.

In planning for the future, although we may not be able to state precisely what problems will arise, we can plan to build a research organization capable of dealing with any problem when it is identified. It is the recommendation of the Fly, Gnat and Mosquito Research Committee that the creation of a research Center or Institute on a single campus of the University is not a good way to accomplish the desired results. As has been pointed out, the University has capable investigators, who are intimately concerned with these problems, at Berkeley, Davis, Los Angeles, Riverside and San Francisco. Many of these men have a special area of competence not found on other campuses. In the aggregate they can focus far more research effort on a given problem than could the staff of any conceivable Research Center. I believe that, by using the Agricultural Experiment Station as a nucleus, since it appears that most of our problems in this field are at least agriculture-related, we can draw in appropriate specialists from other segments of the University as needed to help on a given research program. This is being done, and in my view, it is the best way to make maximum use of the tremendous resources of the University.

Cooperative research programs are characteristic of the University, not only intramural programs but those involving non-University agencies. I can cite two examples familiar to most of you: The cooperative project on insect borne encephalitides between the University and the California Department of Public Health is a good example of a mutually fruitful relationship. Another example is found in the cooperative efforts of the University and the abatement districts in the field evaluation of insecticides. Others, equally productive, could be cited. I believe that, if we are to discharge our obligations to the state, such cooperative efforts must be strengthened and extended.

The responsibilities of the University in the next couple of decades are awesome to contemplate. The establishment of new campuses and the expansion of present campuses will increase problems of communication, not only between campuses, but between the University as a whole and non-University groups. We must make certain that we do not lose sight of each other's problems. This will require a determined effort by all of us. The interagency advisory committee I mentioned should be an invaluable device in this respect.

The University of California is somewhat unique among public institutions of higher education. It insists that every member of its faculty engage in some type of scholarly research or creative activity in addition to his teaching responsibility. I believe the wisdom of this is policy is apparent. The University will continue to be the primary public research agency of California. It is our joint responsibility to assure that the research programs of the University are properly responsive to the needs of the state. If we plan together for the future then the outlook will indeed be bright. We urgently solicit your cooperation.

THE OUTLOOK FOR FUTURE VECTOR RESEARCH IN CALIFORNIA

RICHARD F. PETERS
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In attempting to develop a theme for this presentation I inevitably returned to the word "ecology," which emphasis underlies the past, present, and more than likely will continue to dominate the future of our vector control research. Experience gleaned in this field serves to emphasize that "ecology" applies as much to people who are responsible for the conditions which cause and sustain vectors as it does to the undesirable animals which are the object of research. Furthermore, the people involved are not a special kind, restricted to any one social or geographic segment of the human population. They reside everywhere—in communities, suburbs, rural areas, and in remote locations. They are employed in commerce, industry, agriculture, and recreational pursuits. Their omissions and unknowing commissions of various contributory actions about the home, at work, and at play are primarily responsible for some of the more critical vector problems which confront California today and which threaten to increase with our burgeoning population. Since vectors, at least those originating from water and organic wastes, are largely symptoms of man-made environmental shortcomings, it follows that their causation is complex and their control often obliges changing established environmental conditions and practices. When someone else's economics are affected in bringing about desired changes, vector control is intimately concerned with the realm of human ecology.

While there is a tendency to stress the importance of man-made vector problems, we must also recognize the vector problems associated with nature, which still largely remain to be solved. To a great extent they are to be found in the mountainous portions of California scheduled for maximum recreational development. Some, however, are to be found in the rolling foothills, gradually becoming suburbia.

Reputable predictions call for approximately one-third the total area of California to become metropolitanized early in the 21st century, accomodating an eventual statewide peak population of over 40,000,000. Add to this density dilemma the transient population which will be attracted to the California recreational scene, and it is apparent that virtually every vector habitat of the state will be invaded. The competition for space is only now beginning to be felt. We are told that by the close of this year we can claim the dubious distinction of being the most populated state in the country. Vector-wise these population statistics mean approximately four pounds of added refuse plus approximately 250 added gallons of waste-water per new person per day—both of which must be dealt with effectively. Then ponder the mounting liquid and solid wastes of expanding industry, plus the increasing plant and animal by-products of agriculture. How forbidding the outlook of residing in California at the time of its population saturation!

In attempting to evaluate the basis for present-day technology in mosquito control, it is evident that we must pay primary homage to two fundamental discoveries: (1) that of Sir Isaac Newton in the 17th century relating to the Law of Gravity—water drains downhill, and (2) an 18th century observation that an oil film on a water surface would kill mosquito larvae. These two principles, with modern refinements, plus the super-fish, *Gambusia affinis*, have continued down to the present day to comprise our basic technology in vector control. More often than not the equipment available for accomplishing the end result has been designed for some other purpose. Is it not likely, therefore, that modern public health vector control technology could be improved?

Following World War II the Bureau of Vector Control obtained its charter as an integral part of the Division of Environmental Sanitation of the State Department of Public Health, at that time breaking off from the Bureau of Sanitary Engineering. Its initial task was that of taking appropriate steps to suppress any possible mosquito-borne diseases which might have been introduced through service men returning to California from all corners of the earth. This assignment was met and successfully achieved through qualitative and quantitative strengthening of local mosquito control agencies throughout the state. Today the number of organized local mosquito control agencies has doubled to presently number about 60. The territory covered by your agencies has increased seven-fold, now embracing over one-fifth of the total area of California. Your collective budgets have increased 1000%, with well over five million dollars having been expended for mosquito control in California in 1961. Accompanying the post-war growth and development of this statewide program was the advent of modern organic insecticides. DDT and its relatives cut a wide swath throughout the state for approximately four years until resistance asserted, creating operational distress for the dependent control programs. In due course the phosphate insecticides made their debut to provide brief respite. Also following World War II, the program for development of the state's water resources got into full operation, with irrigated agriculture undergoing a dramatic increase in acreage. The present irrigated acreage, now in excess of eight million acres, is expected to be doubled at maturity of the federal and state water plans.

By 1950 it became evident that the growing mosquito problem had to be dealt with and it was at this time the Bureau of Vector Control, in co-operation with the California Mosquito Control Association, began its ecology-oriented research program. Then and now the program has been largely undertaken through a small portion of the state subvention funds, with the support and encouragement of your Association and our Vector Control Advisory Committee. From the beginning, the vast majority of local agencies recognized the need to amplify the mosquito control research program, and gradually the need to broaden its scope to encompass vector control research in general has become apparent. The recent history of your Association has been that of urging such a vital development.

Referring to the present status of our research program, as Dr. Barr reported earlier today, the Bureau of Vector Control is presently engaged in a limited research program of mosquito ecology, ethology, biological control, physiology and toxicology, all seeking to improve control technology, plus our contribution to the Cooperative Encephalitis Study at Bakersfield. Col. Stanley J. Carpenter is gathering much valuable data on the ecology of mountain *Aedes* which is aimed at specific mosquito control measures in these recreational areas. We are also making modest contributions to other phases of vector control research, particularly relating to small mammal and ectoparasite ecology and vector-borne disease control, domestic flies, several midge and gnat species, schistosome dermatitis, wasps, triatomids, cockroaches, and several other lesser vector problems. We are acutely aware that the aggregate of our vector research is insufficient to match the human population timetable and the vector consequences confronting the State of California. Furthermore, within our capacity to appraise the statewide effort of all vector research agencies combined, it appears that the overall research need is far from being met.

What, then, is to be done? As all of you know, your Association has urged through official resolutions addressed to the Department of Public Health that an expanded vector control research program be developed in California to meet this evident need. Specifically, a co-operative vector control research program proposal, involving the Department of Public Health and the University of California, is under review and evaluation by both agencies at this time. Some discrepancies appear to exist in understanding, interpretation, emphasis and semantics which we are eager to negotiate and resolve. In our judgment, the expressed objectives and functions of the proposal transcend all other considerations. We believe that research in the field of vector control, because of its broad implications and diversity of application, cannot be conducted exclusively by any one agency or program. Our program has always sought to stimulate and motivate the maximum vector control research possible through all federal, state, local, and private resources. We have diligently attempted to adjust our research program to avoid conflict or duplication and to complement to the extent possible all vector research being done elsewhere in California. In fact, we are or have been party to a number of fine co-operative research relationships on most of the campuses of the University of California, with several private and state colleges, the U. S. Department of Agriculture, the U. S. Public Health Service, and a great number of local agencies. It was appreciation of this successful interagency working relationship that led to the development of the co-operative vector research proposal which was contained in the 1960 Governor's Committee Report on Agricultural Chemicals and Recommendations for Public Policy. It was also the respected counsel of the late University of California Chancellor Stanley B. Freeborn that provided us the maximum encouragement and outlook for success through such a co-operative interagency endeavor. Dr. Freeborn was intimately aware of both agricultural and public health vector research programs, state and federal, having been a vital force in Communicable Disease Center activities during World War II, and having served on the Advisory Committee of the Bureau of Vector Control from its inception.

Looking ahead, it is foreseeable that a multiplicity of complicated physical, chemical and biological circumstances confront the field of vector control. The following conditions appear likely: more public concern over pesticide residues; further discoveries of pesticide concentrations in the food chain; continued manifestation of vector resistance to chemicals; increasing amounts of liquid and solid organic wastes having to be dealt with on decreasingly available space; extensive spreading of water to restore the underground supply; the development and the delivery of millions of acre-feet of water to virgin lands; the irrigation of millions of additional acres of marginal and sub-marginal cropland; the likelihood of conversion utilization of sea and waste water; an acceleration of recreational area development; the arrival of the face fly in California to disturb any possible complacency regarding domestic fly control; and the possibility of *Psorophora* becoming established in the Central Valley. These and other prospective developments promise to make our collective future in vector control both vital and fascinating. Many of these circumstances amount to transitions which will exist until residential, industrial, agricultural, conservational, and recreational patterns are finally established. It is apparent that the official and voluntary representatives of each interest will be obliged to work out their destinies in a spirit of complete co-operation.

It is also clearly evident that new—perhaps boldly different—vector control technologies will be required in the future to deal successfully with the complicated setting in which we will be working. The time is overdue to redirect vector control research emphasis. Expedient control measures, based upon conventional pesticides should continue to be developed and utilized for emergency purposes. The main effort, however, should be applied to the ecology of the individual, significant vector species in California and the control methods of choice should be determined from the research findings. The possibility of developing alternate control measures is great, based on the variety and environmental diversities of vectors. The opportunity to utilize the various vector peculiarities and idiosyncracies as a basis for developing new control measures is fascinating, and the growing availability of new scientific tools and materials from other areas of research invites broader application to vector research.

At present the total State Department of Public Health expenditure for mosquito control research in California amounts to less than 3% of the five million dollar statewide program. Private industry considers that it can only hope to maintain itself while investing in research at a rate four to five times this magnitude. Beyond mosquitoes, the statewide effort on all other vector control research is incredibly little.

Perhaps it can now be concluded that my outlook for future vector control research in California is as follows: Today a critical need exists for expanded vector control research—yesterday was the time to recognize it. Tomorrow will find us faced with an even higher price tag for remedying what might have been prevented at moderate cost had it been undertaken today.

We look forward to an era of much closer cooperation in the future California vector control research program, in participation with federal agencies, the University of California, other state agencies, industry, and, of course, local vector control agencies, particularly those of your Association. Irrespective of agency identity in California's future vector control research, we believe a program essentially as proposed should be supported and implemented with the least possible delay. We consider the proposal to be comprehensive yet modest; possessed of vision yet sound. We are resolved to perform our defined role with maximum competence and dedication on a solid ecological foundation. Our belief is that if each agency would undertake the maximum amount of vector control research based upon availabilities and resources, the sum total of effort would probably be considerably short of that needed to safeguard our population-prone state from its vector-prone problems.

Mr. McFarland: Our next speaker, Harold Farnsworth Gray, is a charter member of our organization, an honorary member of both the American and California Associations, and recipient of many honors and distinctions in public health and engineering over the past 50 years during which he has been pioneering in the field of mosquito control. We will now call on Harold Gray to give his review and comments on the two research symposia presented this afternoon.

SYMPOSIA ON VECTOR CONTROL RESEARCH: DISCUSSION

Harold F. Gray
Honorary Member, A.M.C.A., C.M.C.A.

"I have six honest serving men who taught me all I know. Their names are: what, and where, and when, and who, and why, and how." That quotation from Kipling is interesting for the reason that the last two words, "why" and "how," are the basis of all research.

I wish to express my tremendous admiration for the high quality of the various discussions and the papers that have been given today. The high caliber of the papers presented at our many meetings has been obvious, and it is gratifying to see the way this quality has increased from year to year. Take that as a compliment to all of you.

Relating to the first paper by Dr. Aldrich this morning, he presented a percentage estimate of the types of research being carried on by the University of California at all its branches. Frankly, I was disappointed at the relatively small amount of pure research (10%) in vector biology. There are still so many unanswered questions in vector biology and also in ecology, and they are so fundamental to our ability to control vectors that I hope more effort can be encouraged in this area of research.

Mr. Greenfield spoke on the idea of a wider range of vector control as contrasted with mosquito control only. Many of us agree with him, but this reluctance to expand has an historical background and a practical basis. For many years we had too much to learn about mosquito control, and in many places our control was not sufficiently effective for us to feel capable of widening our field. Funds were not adequate except in a very few agencies to take on additional functions, and there was not, in some instances, a public demand for these other functions. We could not go too far nor too fast. "Be bold, be bold, be not too bold."

Mr. Greenfield has suggested that there are district and state organizations that could merge and consolidate into one national organization. For example, the California Association, the Utah Association, etc., could dissolve themselves as such associations and become chapters or parts of the American Association. I have long realized that there are some advantages in this proposal. In fact, in the past I have suggested that we could well study the types of organization used by the American Waterworks Association or the Federation of Water Pollution Control Associations. In the American Waterworks Association we have state or regional sections in which the members are all members of the American Waterworks Association, but we are also members of our local sections. In contrast, in the Federation of Water Pollution Control Associations, our members are members of, say, the California Water Pollution Control Association, or of the New York, or what-have-you Association, and those associations are the members of the Federation. Now, which might work out the best I have no idea, but I think you probably may have to pick out some such idea and work it out in the way that seems appropriate to our particular conditions. However, I would hate to see too much nationalization and not enough local autonomy. Your interest, perhaps, is greater when it's closer to you and your function, both geographically and in other ways.

Dr. Lindquist, whom I always enjoy, made the remark that experiments are being made with no idea as to where they will lead. That is real research. I maintain that the most valuable research is that which, in finding an answer to one question, turns up several other questions which cry for answer. His descriptions of the experiments in chemosterilants already has produced more questions than answers. Wonderful!

Now then, Dr. Smith. I'm just going to refer to his matter of integrated control. I've long been an advocate of using all appropriate means to accomplish results in our field and never been so hidebound or stiffbrained that you can't adapt your control measures to changing situations. Use every means that is appropriate. I am reminded somewhat of the Merchant of Marseille who was on a business trip to Paris when he received a telegram from his wife saying, "Mother has died. Shall I embalm, bury, or, cremate?" He replied, "Do all three. Take no chances." I'm also pleased that Dr. Smith mentioned systematics. Some people seem to think that systematics is a very academic thing, but we need to learn everything that we can about these organisms which we are combatting. We must know what species we are dealing with and also be able to recognize the variations within species. Even apparently minor markings on eggs (e.g., *Anopheles maculipennis*) may be indications of variations in mosquito physiology and ecology. So, don't despise systematics. Practically every one of our university people, and some of us not in universities, have done useful work in systematics and we are happy to be able to make use of their findings.

Dr. Bohart gave a recital of many experiments which illustrate how many questions can arise in this field of vector control. I listened with very great interest to what he had to say. I have had the privilege of talking with him on many occasions over a considerable period of time and I hope I know a little bit about some of his ideas.

I surely like the way Don Grant has presented the general needs in California. He always gives us a scholarly, well-thought-out viewpoint on our problems.

Dr. Douglas concurred with some basic ideas that I have held over a good many years, and I think you've heard me talk about them sometimes in the past. But there is one point that he made that I am a little uncertain about, and that is on some of this integrated research. How do we know what research is always needed? Are we prescient enough? Are we good enough crystal gazers to be able in all cases to know what is required? I think we should always have a few mavericks around who will not be regimented and directed, and who will go off on some tangent on their own. God knows what will come out. Again I say, the best research is that which raises more questions than it does answers. We have to leave something for future generations.

I was very happy with Dick Peters' emphasis on ecology. He also brought in the concept of human ecology in relation to vector ecology. I think that sometimes we have failed to give enough thought to this. I have heard this before in statistics, but when he comes to talking about what's going to happen with all this population explosion, I'm apalled. Of course I won't be here. Our grandchildren will probably have to face that thing, but I'm asking something like the tag line that Senator Goldwater uses in his papers and addresses—"Where do you stand, sir?" I'm going to ask, where can we stand!

I am not sure that all the people who talk about research always and consistently have been talking about the same idea, for the word "research" is used by different people with rather different connotations. Without any desire to be pedantic or to quibble about semantics, it would seem desirable to try to distinguish somewhat carefully between what is really research and what is technology, or as we sometimes use the term in mosquito control, operational investigation. Perhaps we may say that basic research is concerned with ideas, technology with practical results. In the field of vector control, the operating agencies, state and local, do the latter to a considerable extent for the purpose of greater effectiveness or economy in operation. The former we do to a relatively small extent if at all. Those of us who are, or who have been, in practical vector control work usually do not have the facilities, the time, or perhaps the inclination or ability, to indulge in real research—sometimes called basic or pure research. Sometimes we impinge rather closely upon it, as for example, the studies on ovicides or the blue-green algae, but most of our investigations are performed for the solution of practical problems done on an *ad hoc* basis. But many of us realize that we need more than these operational investigations or technology if we are to progress in our field of work. We know, or at least we should be aware, that if progress in basic research should cease, technology would in time wither. Someone must ask *why* about many things and have the time to think about them.

There is no requirement that those who are doing practical work in any field of human endeavor should not think about purely theoretical aspects of the work; nor is there any requirement that those who are doing primarily theoretical work should not think about practical applications of their study. In neither case does the one preclude the other. I shall not enlarge upon these statements, for to make an adequate presentation would require more time than your patience would permit. However, I may illustrate what I mean by an incident which is reported, if my memory is correct, to have occurred between Michael Faraday and Benjamin Disraeli when the latter was Prime Minister of England. Faraday showed Disraeli that if a loop of wire was rotated between the poles of a magnet an electric current would be produced. Disraeli was not much impressed and asked Faraday what use it would be. Faraday, after some thought, said, "Well, some day you may tax it." Just think what would happen to this country if the assets of the Pacific Gas and Electric Company and the Pacific Telephone Company were not available for taxation.

The problem in the present instance probably revolves about the question of, "Who can best do what?" I believe it would be generally considered that a great university would be the most appropriate place for the conduct of pure research, because the personnel and the facilities are presumed to be available there, and I am sure they are in our University of California. Also, technological investigations, under appropriate conditions of personnel and funds may be more successfully carried on by operating agencies such as corporations publicly and privately owned. I think Dick Peters mentioned that somewhere around 10 to 20 percent of investment in research is considered necessary by some of our great corporations, as compared to the 3 percent that we are doing. But neither is prohibited from performing functions which are primarily the field of the other. Corporations do carry on studies in pure research as well as in technology. And our own University of California carries on technological investigations in such fields as agriculture and engineering.

It seems to me to be most desirable in the situation we have been discussing today that there should be cordial cooperation and coordination between the various interests represented, so that there can be obtained the most effective use of the facilities of each in the solution of problems in the field of vector control, and also that there shall be a minimum of duplication. Possibly, in relation to California, a coordinating super-committee above what Dr. Douglas has suggested may be helpful, with three men, one representing the University, one representing the State Department of Public Health, and one representing the Mosquito Control Associations. I think this committee could function, then, effectively. I believe that this all can be done in the spirit of cooperation for the benefit of the people whose servants we are.

Mr. McFarland: Thank you, Harold. We might first ask Dr. Douglas if he has any questions to ask of other panel members.

Dr. Douglas: No. There may be some questions from the audience.

Mr. McFarland: We'll come to that a bit later. Don Grant, do you have any questions you would like to ask the other members of the panel?

Mr. Grant: There might be one question, though it might better be answered by Dr. Aldrich and Dr. Merrill, in regard to mechanics for providing the supplementary aspects to the research program. Perhaps someone from the University would like to comment on how the University might participate in technical development work with various local agencies. As was brought out, we have had a very effective association in this regard with the Bureau of Vector Control. Their field staff provide necessary liaison with our control agencies. They are intimately familiar with our practices and our technical and administrative needs. In this present arrangement we have a reliable resource where we can take our questions and obtain consultation, where we can review our needs and where they will divert their research efforts to obtain answers to immediate questions. This is probably a function which needs considerable augmentation. If the University is broadening its program of research, I think it is very important that these activities be integrated with the State Health Department and other organizations sharing our common interest in mosquito control.

Mr. McFarland: Dr. Douglas, would you care to comment on Mr. Grant's remarks?

Dr. Douglas: I think this illustrates a point I referred to earlier, and this is the problem of communication. I believe Dean Aldrich this morning mentioned the fact that he was available to discuss problems with any group and mentioned the fact that we do have this machinery which is in operation very successfully with respect to other interests. He mentioned various commodity groups, etc., which the University uses as a very good device to find out just exactly what the people think of the job that they are doing and what they think we should be doing. I see no reason whatever for a lack of rapport here between the mosquito control interests on one hand and the University on the other.

Mr. McFarland: Thank you, Dr. Douglas. Would other members of the panel like to comment on this? If there are no further questions, I would like to thank all of those who have contributed to these two stimulating symposia on research which have been presented this afternoon. We shall adjourn now until the hospitality hour at 6:30, to be followed by the banquet.

THIRD SESSION

TUESDAY, JANUARY 30, 9:00 A.M.

ANNUAL BUSINESS MEETING

Presiding: LESTER R. BRUMBACH, *President*

(Role of members was called by Secretary Murray. A quorum was present. Inasmuch as the recording equipment was not operating properly at the time, the record of the business meeting printed here is limited to submitted reports of committees and the report of the auditor.)

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

January 11, 1962

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

Gentlemen:

We have examined the balance sheet of the California Mosquito Control Association, Inc., as of December 31, 1961, and the related statement of surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Our report includes the following financial statements:

Exhibit A—Balance Sheet, December 31, 1961.

Exhibit B—Statement of Surplus, Year Ended December 31, 1961.

Schedule 1—Schedule of Expenditures with Budget Comparison, Year Ended December 31, 1961.

We believe the statements are practically self-explanatory as presented. The minutes of your meetings indicate that your secretary-treasurer keeps you well posted on fiscal affairs, and we have found no material requirements for correction.

General activities revenues exceeded the budget estimate of $3,225.00 by $589.96, and conference activities revenues exceeded the budget estimate of $7,140.00 by $461.75.

OPINION

In our opinion, the accompanying balance sheet and statement of surplus present fairly the financial position of the California Mosquito Control Association, Inc., at December 31, 1961, and the results of its operations for the year then ended in conformity with generally accepted governmental accounting principles applied on a basis consistent with that of the preceding year.

Respectfully submitted,

M. Freedom Meeker
Certified Public Accountant

MFM:hs

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

BALANCE SHEET

December 31, 1961

EXHIBIT A

ASSETS

Petty Cash		$ 72.92
Cash in Security First National Bank, Visalia		5,318.94
Total Assets		$5,391.86

LIABILITIES AND SURPLUS

Liabilities		-0-
Deferred Revenue (1962 Surplus)		$ 178.00
Available Surplus (Exhibit B)		
Derived from general activities	$4,167.73	
Derived from conference activities	$1,046.13	$5,213.86
Total Liabilities and Surplus		$5,391.86

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

STATEMENT OF SURPLUS
Year Ended December 31, 1961

EXHIBIT B

	Budget Estimate	Derived From General Activities	Derived From Conference Activities
Balance Available, January 1, 1961		$4,816.97	$ 169.64
Add Revenues			
Corporate Member Contracts	$ 2,700.00	$2,900.00	
Associate Member Dues	50.00	24.00	
Sustaining Member Dues	250.00	750.00	
Sale of Publications	175.00	118.46	
Miscellaneous (Entomology Com.)	50.00	22.50	
29th Conference Registrations	1,500.00		$1,775.00
29th Conference Exhibits	2,250.00		2,535.00
29th Conference, General	3,390.00		3,291.75
Total Revenues	$10,365.00	$3,814.96	$7,601.75
Total Available		8,631.93	7,771.39
Deduct Expenditures (Schedule 1)		4,464.20	6,725.26
Balance Available, December 31, 1961		4,167.73	1,046.13

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

Schedule of Expenditures with Budget Comparison
Year Ended December 31, 1961

SCHEDULE 1

Classifications	Budget as Amended	Actual Expenditures	Under-expended
Administration			
Advertising	$ 150.00	$ 108.00	$ 42.00
Communications	600.00	364.52	235.48
Office of Secretary	600.00	600.00	----------
Office Supplies	200.00	173.56	26.44
Proceedings Publication	2,503.44	2,503.44	----------
Committee Expenses (Note 1)	727.97	373.99	353.98
Auditor	150.00	150.00	----------
Contingencies	150.00	17.68	132.32
Total Administration	$ 5,081.41	$ 4,291.19	$ 790.22
Capital Outlay			
Tape Recorder	$ 200.00	$ 173.01	$ 26.99
Total General Activities	$ 5,281.41	$ 4,464.20	$ 817.21
Conference			
General Expense	$ 5,130.62	$ 5,130.62	----------
Proceedings, Recording	175.00	118.61	56.39
Proceedings, Stenographic Service	276.03	276.03	----------
Proceedings Publication for AMCA	1,200.00	1,200.00	----------
Preparation for 1962 Conference	200.00	----------	200.00
Total Conference Activities	$ 6,981.65	$ 6,725.26	$ 256.39
General Reserve	$3 ,000.00	$----------	$3,000.00
Total Budget and Expenditures	$15,263.06	$11,189.46	$4,073.60

Note 1: The total authorized transfers from Unappropriated Reserve as recorded in the minutes amounted to $1,920.09. This amount was in excess of the available total by $222.03. To confine the transfer to the $1,698.06 in the Reserve, only $127.97 of the $350.00 transfer on January 30, 1961 to Committee Expenses for the use of the Forms Committee was considered transferred. This particular transfer proved to have been in excess of actual need.

REPORT OF THE PROGRAM COMMITTEE

The objective of this Committee was to prepare the program for the 1962 Conference of the California Mosquito Control Association. To accomplish this objective four meetings of the full committee were held during the year.

At the first meeting it was decided:

a) to expand the Committee to include representation from Mosquito Abatement District Trustees, the University of California and the California State Department of Public Health;

b) to make the 1962 Conference mainly a California conference;

c) to get a consensus from California mosquito control agencies on what subjects are of prime interest and concern; and

d) to make time available for submitted papers.

The present Conference is a product of fulfillment of these goals.

The Committee wishes to extend special thanks to the State Department of Public Health for taking charge of the printing of the Conference programs. Special thanks are also extended to Eugene E. Kauffman, Marion C. Bew, Robert H. Peters and Gordon F. Smith each of whom took responsibility for developing and moderating a major section of the Conference program, and to the entire Committee for its understanding and patient help.

Lester R. Brumbaugh
John H. Brawley
Marion C. Bew
Richard F. Peters
Deane P. Furman
David E. Reed, Chairman

REPORT OF THE LEGISLATIVE COMMITTEE

The Legislative Committee met twice during 1961, as a Committee and with the Board of Directors for advice and recommendations. Several Bills of the Legislative Session were passed as presented by the CMCA on recommendation of the Legislative Committee.

1. Assembly Bill No. 760 which exempts mosquito abatement districts from the provisions of the District Act was passed (Section 2206).
2. Senate Bill No. 357 which specifies the provisions for use of flashing lights by mosquito abatement districts and other agencies, was passed. This Bill amended various sections of the Vehicle Code and Business and Professional Code. In short, this legislation provides for the use of amber flashing lights and prohibits the use of red flashing lights by mosquito abatement districts.
3. Senate Bill No. 2429 which modified Section 2283 of the Health and Safety Code permitting the charging of land owners for spray work of districts prior to hearing, was passed.
4. Budget Items 395 and 396 of the Governor's Budget, which provided funds for mosquito and gnat research were passed as recommended by the Governor. A great deal of Committee work and work by a number of the districts was involved in order to prevent deletion. Without this hard work by the California Mosquito Control Association, no doubt the funds would have been deleted to the detriment of the public health and wefare of the people of California.

On the recommendation of the Legislative Committee, the Board of Directors of the California Mosquito Control Association went on record as opposing the Dingle Bill (H.R. 4668). This legislation would needlessly complicate the fine careful work of the mosquito control agencies throughout the United States, including California.

The Legislative Committee, subsequent to the 1961 Session of the California Legislature has received recommendation for future legislation. This includes recommendations that Section 2274 be amended to incude gnats specifically. Also, a recommendation was received regarding the possibility of amendment of Section 54970 of the California Government Code respecting boundary changes of special districts. There is the possibility that certain districts by mutual agreement could have a boundary change between districts. It is recommended by the 1961 Legislative Committee that the new Legislative Committee for 1962 carefully study these two recommendations and any other legislative recommendations presented by persons and agencies interested in amendments or new legislation for the improvement of mosquito and vector control in California. It is particularly important that these recommendations be received early by the Legislative Committee so that appropriate Bills with the proper Legislative sponsorship can be prepared early in the fall for submission to the 1963 Legislature.

One Legislative Bill supported by the California Mosquito Control Association that failed was that involving military leave of United States Public Health Service Reservists employed by the State of California. This was not a CMCA Bill; however, it was supported by the CMCA.

In conclusion, the Chairman wishes to thank the members of the Legislative Committee for their fine support and work on the Committee and for the excellent support received by the Board of Directors and membership of the CMCA.

William Bollerud
E. Chester Robinson
T. M. Sperbeck
J. D. Willis
Gardner C. McFarland, Chairman

REPORT OF THE EQUIPMENT AND PROCEDURES COMMITTEE

The Committee's principal activity during 1961 was the organization of the Equipment Show which was held at the San Joaquin Mosquito Abatement District Depot in Stockton on March 24.

In addition to arranging the Equipment Show, the Committee has the function of gathering and compiling information on new equipment and making this information available to the membership. The method of distributing information once it has been compiled has been discussed at Committee meetings. It has been suggested that the use of California Vector Views as a medium be explored, since it is a publication which receives wide circulation.

It is the Committee's recommendation that the Equipment Show be continued and that the use of Vector Views as a means of distributing new equipment information be considered.

Richard J. Arnold
Ernest Campbell
G. Paul Jones
Melvin L. Oldham
T. G. Raley
Sidney H. Ryall
Kenneth G. Whitesell
Stephen M. Silveira, Chairman

REPORT OF THE EDUCATION AND PUBLICITY COMMITTEE

The Education and Publicity Committee met twice during 1961. Although it was originally planned to hold an administrative session during the fall of 1961, it was agreed that, because of the increasing number of meetings, it would be more desirable to forego a fall meeting and instead co-sponsor, with the State Bureau of Vector Control and U.S. Public Health Service, a vector-borne disease training course March 26 to 30th, 1962. This meeting will be held in Berkeley at the State Health Department Auditorium. The Committee recommends that key representatives of mosquito control agencies plan to attend.

Richard F. Frolli
Norman F. Hauret
H. C. Pangburn
T. G. Raley
Robert H. Peters, Chairman

REPORT OF THE FORMS, RECORDS, AND STATISTICS COMMITTEE

During the year 1961 the Forms, Records, and Statistics Committee completed the following projects:

(1) *1961 Year Book:* A total of 650 copies were distributed on July 30, 1961 at a total cost of $218.51. The unit cost was $0.34 per copy. A report dated August 4, 1961 to Secretary Murray presented details on costs and distribution.

(2) *Salaries and Working Conditions:* This twenty page report dated November 1, 1961 was prepared by Stephen M. Silveira as a member of this committee. Mr. Silveira has been requested to present a special report on this project.

(3) *Leaflet, "Mosquitoes About the Home":* During the year 1961 we sold 2,000 copies of this leaflet printed in 1959. At the present time we have 3,000 copies in stock.

This Committee recommends that the Forms, Records, and Statistics Committee be replaced by a Year Book Committee and a Salary Survey Committee to carry these two annual projects.

Norman F. Hauret
John G. Shanafelt, Jr.
Stephen M. Silveira
Jack H. Kimball, Chairman

REPORT OF THE FORMS, RECORDS, AND STATISTICS SUB-COMMITTEE ON SALARIES AND WORKING CONDITIONS

During 1961, the Forms, Records, and Statistics Sub-Committee on Salaries and Working Conditions completed a twenty page compilation of administrative information as submitted by forty-five agencies. This summary, dated November 1, 1961, was distributed to the membership November 15, 1961 by Secretary Murray.

This compilation presents an up-to-date summary of the following subjects:

(1) 1961-62 budget estimate
(2) Number of employees—maximum and mini-minimum
(3) Number of holidays per year
(4) Work days vacation per year
(5) Work days sick leave per year
(6) Working hours per week
(7) Retirement plans
(8) Group hospital insurance plans
(9) California unemployment insurance participation
(10) Expenditure for annual audit
(11) Expenditure for aircraft insurance
(12) Expenditure for automotive and general liability insurance
(13) 1961 salary schedules for 16 job classifications

The Chairman wishes to thank all reporting agencies for their cooperation in making this invaluable summary possible.

Stephen M. Silveira,
Sub-Committee Chairman

REPORT OF THE ENTOMOLOGY COMMITTEE

The 1961 Committee consisted of twelve members, two of whom were new. Five general meetings were held during 1961. Two of these meetings were of particular importance.

The first meeting was devoted entirely to the Committee's Fifth Annual Entomology Seminar. This seminar was held on the San Jose State College campus, on April 21-22. Approximately 70 workers interested in culicidology enjoyed the active discussions on (1) Principles of Aquatic Ecology, (2) High Altitude Mosquito Ecology, (3) Vector Control Education and Training, and (4) Interpreting Vector Control to the Public. The meeting included an excellent banquet, featuring an illustrated talk on Glacier National Park.

The second meeting of particular importance was held at the Bureau of Vector Control field station at Fresno on June 8-9. Inasmuch as the mosquito control agencies have felt that the mosquito population measurement program is a vital part of their respective control programs, the Association presidents for the past several years have assigned this activity to the Entomology Committee for study. This meeting was one of several held with the representatives of the Bureau of Vector Control to study ways and means to improve and standardize techniques in the mosquito surveillance program.

Work in 1961 consisted of the following: (1) development of functional, non-technical adult and larval keys for six families of our most common mosquito-like gnats in California, (2) preparation of illustrations of one representative species of each of the six families listed, (3) preparation of a glossary of terms used in the key and text, and (4) writing an ecological description for each of the families listed. Plans for publishing the "Field Guide to the Common Mosquito-Like Gnats of California" are to be completed by the 1962 Committee.

Plans are also being explored with the Bureau of Vector Control Research Unit for developing a technical training activity for entomologists and other interested personnel of mosquito abatement agencies to disseminate information on new techniques in insect pathology, vector physiology, ethology, and toxicology.

The Committee wishes to thank all those who have contributed to its various projects.

Richard M. Bohart
Dean H. Ecke
Jack Fowler
Richard F. Frolli
Eugene E. Kauffman
Thomas H. Lauret
James L. Mallars
Harry L. Mathis
Lewis A. Paden
John G. Shanafelt Jr.
Merrill A. Wood
Embree G. Mezger, Chairman

REPORT OF THE FISH AND WILDLIFE COMMITTEE

The Fish and Wildlife Committee has been devoting its efforts toward improving communication and understanding on problems of mutual interest to the Association and the State Department of Public Health, the State Department of Fish and Game, the U.S. Fish and Wildlife Service, and the National Mosquito Control-Fish and Wildlife Management Coordination Committee.

In February 1961 the Fish and Wildlife Committee participated with the above agencies in a tour of all principal duck hunting areas and reserves in California.

The American Cyanamid Co. sponsored the development of a motion picture, with sound and color, entitled "Modern Mosquito Control," part of which was taken in the Los Banos Waterfowl Management area. To our knowledge this is the first time that film coverage has been given to cooperation between mosquito control and fish and wildlife organizations.

Upon invitation of the Bureau of Vector Control, the Fish and Wildlife Committee participated in a training program for personnel of the State Department of Fish and Game.

The Committee mailed a questionnaire to all mosquito abatement agencies in the state inquiring about complaints on damage to wildlife from insecticide operations. Replies were received from 34 agencies, 26 of which have no record of damage to wildlife in their area. Only three of the remaining eight agencies have proven cases of injury to wildlife. These occurred during 1952 and 1953 when chlorinated hydrocarbon insecticides, which now play a relatively minor role in mosquito abatement operations, were used almost exclusively.

The Fish and Wildlife Committee is arranging for the Association to co-sponsor a Western Wildlife Management-Mosquito Control Conference in October 1962, in cooperation with the National Mosquito Control-Fish and Wildlife Management Coordination Committee, and the California Departments of Fish and Game and Public Health.

Gustaf F. Augustson
Oscar V. Lopp
Thomas D. Mulhern
H. C. Pangburn
E. Chester Robinson
T. M. Sperbeck
William L. Rusconi, Chairman

REPORT OF THE INSECTICIDE AND HERBICIDE COMMITTEE

Work on the Insecticide and Herbicide Guide got off to a slow start, due largely to the death of Leon Hall, previous Chairman of the Committee, and the necessity of attempting to determine what editing and plans he had in mind from the materials available in his files. Copies of the preliminary draft were sent to Dr. Irma West of the State Health Department and Robert Z. Rollins of the State Department of Agriculture for comment, and partial revision has been made based on their comments.

Considerable discussion has taken place regarding the presentation of use data, dosage, etc. of specific insecticides.

It is now the opinion of the Committee that the concept of a simple *guide* should be abandoned in favor of a more extensive *manual* form of presentation. This would involve more detailed discussion of the subject matter and inclusion of more subject matter. However, part of the material already prepared is in considerable detail. The manual could be prepared in loose leaf form to allow for periodic revision of parts.

It is the feeling of the Committee that a study should be made of state and federal regulations as they relate to the use of toxicants by mosquito abatement agencies. These regulations were written and adopted with agricultural uses in the fore and the peculiar necessities of mosquito abatement operations are not applicable in many ways. This may be especially true in the case of the Miller amendment.

It is, therefore, the recommendation of the Insecticide and Herbicide Committee that:

1. work be continued on a manual publication on insecticides and herbicides used in mosquito control; and that

2. a special study of both state and federal regulations, as they relate to mosquito control, be made and the results reported for action or information.

W. Donald Murray
David E. Reed
Bryan T. Whitworth
Merrill A. Wood
Gordon F. Smith, Chairman

REPORT OF THE SOURCE REDUCTION COMMITTEE

The Source Reduction Committee held three meetings this year.

Many districts have shifted more effort to dairy drain control in the last few years. This emphasis on dairy drain control brought out the lack of information available on these problems. Therefore, the Committee's efforts this year have been directed to dairy drains with discussions at the meetings on methods of handling these problems and the viewing of Kodachrome slides to illustrate pertinent points.

The 1961 Source Reduction Papers, stressing mosquito control in dairy drains, were published and distributed to all C.M.C.A. members.

This Committee is sponsoring a symposium, to be presented this afternoon, on administrative policy and methods of developing a source reduction program. We hope to develop an open discussion at this symposium which will clarify some of the more controversial points in source reduction policy.

This Committee would like to recommend the following for 1962:

1. that a Source Reduction Seminar be sponsored;
2. that the publication of Source Reduction Papers be continued; and
3. that continued emphasis be placed on dairy drain problems and that the Bureau of Vector Control be encouraged to devote some time and research facilities to this problem.

Maurice V. Brown
F. A. Compiano
E. L. Geveshausen
Ray McCart
D. A. Merritt
Vaughn J. Miller
Dennis Ramke
William Reilly
Calvin Rourke
Harold D. Townsend
Coy Worden
George R. Whitten, Chairman

REPORT OF THE RESOLUTIONS COMMITTEE

(The following resolutions were presented by Harold F. Gray, Chairman of the Resolutions Committee, duly seconded, and unanimously carried.)

1. That the Association express its gratitude to the San Mateo County Mosquito Abatement District for its assistance in the arrangements for this conference.
2. That the Association express specific thanks to C. Donald Grant, Manager of the San Mateo County Mosquito Abatement District, for his help in the conference arrangements.
3. That the Association express its thanks to Willys Motors, Inc. for its assistance in the Hospitality Hour.
4. That the Association express its thanks to Durham Chemical Company for its part in furnishing a coffee bar for the conference.
5. That the Association express its appreciation to all exhibitors for their assistance in assuring the financial success of the conference, as well as for their part in presenting products of interest and value to the conference.
6. That the Secretary of the California Mosquito Control Association send a letter of appreciation to the appropriate office of the University of California for the participation of the University faculty in the program of the conference.
7. That the Association express its appreciation to the Villa Hotel for its cooperation and the excellent arrangements and facilities for the conference.
8. That the Association express its appreciation to the Local Arrangements Committee for its part in developing the conference.
9. That the Orange County Mosquito Abatement District and John G. Shanafelt, Jr. be thanked for their part in printing the conference program.
10. That a letter of appreciation be sent to the Director, State Department of Public Health, expressing appreciation for the participation of members of the State Department of Public Health in the conference program.

REPORT OF THE NOMINATING COMMITTEE

Gardner C. McFarland, Chairman of the Nominating Committee, presented the slate of officers proposed by that committee.

President	John H. Brawley
President-Elect	David E. Reed
Vice-President	J. D. Willis
Past President	L. R. Brumbaugh
Secretary-Treasurer	W. Donald Murray
Trustee Member	Marion C. Bew

Oscar Lopp moved, seconded by William Rusconi and unanimously carried, that the nominations be closed and that the secretary be instructed to cast a unanimous ballot for the officers recommended by the Nominating Committee.

Regional Representatives selected by their respective regions are:

Sacramento Valley Region	Kenneth G. Whitesell
Coastal Region	C. Donald Grant
No. San Joaquin Valley Region	Oscar V. Lopp
So. San Joaquin Valley Region	Richard F. Frolli
So. California Region	Norman F. Hauret

ALTERNATE SESSION

TUESDAY, JANUARY 30, 9:00 A.M.

MOSQUITO CONTROL OPERATIONS

EUGENE E. KAUFFMAN, *Presiding*

COORDINATING AIRCRAFT WITH GROUND EQUIPMENT

C. E. OWENS
Fresno Westside Mosquito Abatement District

As the Fresno Westside Mosquito Abatement District has had only three years of mosquito control operations experience, it is still undergoing some growing pains. The District has an area of 1,325 square miles, and is 70 miles long from north to south. The major mosquito producing areas cover about half the District, and are located primarily along the northern and eastern boundaries. These sources, in order of importance, are rice, drain ditches, sloughs, pastures, alfalfa, and duck clubs.

The Fresno Westside District is essentially a rural area. Considering the size of the District and the size and intensity of the mosquito producing problem, the small cities and the limited industrial development within the area make for a low level of assessed valuation and tax support. Confronted with these circumstances, the District has to work toward speed and mobility in mosquito control. This is why we have emphasized the use of aircraft and mist blowers.

During the spray seasons of 1959 and 1960, District personnel had to depend chiefly on ground equipment, with contract aircraft as support. In 1961 an airplane was purchased. This resulted in spray operations being changed from ground equipment supported by aircraft to aircraft supported by ground equipment. In other words, in 1959 and 1960 contract aircraft were used to spray large areas that could not be sprayed by ground equipment, whereas in 1961, with the availability of District owned aircraft, ground equipment was used in areas that could not be sprayed by aircraft.

The main sources that were sprayed by the District plane were rice (over 19,000 acres), pastures, duck clubs, alfalfa, and large slough areas.

Mist blowers and other ground equipment were used in areas that could not be sprayed by aircraft. These included drain ditches, small sloughs, rice seepage, areas containing dense vegetation, areas around buildings and under power lines, and pasture and alfalfa sources of five acres or less.

Each operator is assigned a working zone, the size depending on the work load. Operators work under the direction of supervisory personnel, usually division inspectors. The division inspector is responsible for inspecting both before and following treatment. All mosquito sources within each operator's zone are inspected. If aircraft treatment is indicated, a request is turned in to the field supervisor who is responsible for coordinating control needs with the pilot's schedule. From time to time these airspray requests are checked back by the field supervisor or division inspectors in order to verify priority of needs.

One problem the District has had to face in its control program is the lack of adequate aircraft to cover all mosquito problems requiring attention. The number of airspray requests turned in by the field staff frequently exceed that which can be taken care of by our single aircraft.

Another problem has been that of obtaining good penetration of airspray at present application rates after the first of August when rice and weed growth begin to reach their maximum. Increasing the volume of liquid spray in order to get the insecticide down to the mosquito larvae slows down the airspray operation to such a point that certain areas may go untreated. We have been working with the possibility of aircraft application of granular insecticide. This would be done by contract aircraft. With an efficient ground crew, the District owned aircraft, and contract aircraft for graiular applications, we hope to be able to solve what we feel is our present major problem in mosquito control.

ORGANIZING AIR AND GROUND LARVICIDING OPERATIONS FOR MAXIMUM EFFICIENCY

TROY EARLES
Tulare Mosquito Abatement District

The Tulare Mosquito Abatement District was formed in 1943 with an area of 160 square miles, covering the city of Tulare and surrounding area. In 1948 the area was increased to 562 square miles. The first District budget was based on a 12¢ tax rate. In 1952 the tax rate was increased to 14¢, supported by a $16,500 State subvention fund, for a total budget of $86,916 during fiscal year 1952-53. The gross budget for 1961-62, based on a 15¢ tax rate, without State subvention, was $183,634.

The species of mosquitoes that constitute our major problem are *Aedes nigromaculis* and *Aedes melanimon,* both of which have adapted to the irrigation practices commonly associated with agriculture in Tulare County, and *Culex pipiens quinquefasciatus,* which breeds in cesspools, gutters, fish ponds, etc. Other important species which occur in this area are *Culex tarsalis,* the principal vector of encephalitis, and *Anopheles freeborni,* the malaria vector.

A full scale source reduction program is working towards the reduction or elimination of mosquito sources. Numerous drainage projects have been undertaken with equipment owned and operated by the District. A D-4 tractor with dozer blade and carryall, and a 99-H Austin Western road grader are available to the farmers at a nominal fee. During 1961 the program for improving dairy waste water disposal systems was stressed. A number of reservoirs were constructed and made accessible for jeeps equipped with power sprayers to maintain larval and weed control. These reservoirs were constructed large enough to accommodate the specific dairy herd. In most cases these reservoirs must be pumped out at least twice a year. The District has available to the farmer a 10-inch hydraulic pump which can be operated from the power take-off unit on either a jeep or tractor. This pump has been used extensively throughout the District and is available to all farmers having water disposal problems.

The District recognizes the fact that source reduction is a long-range program. It must still rely to a large extent on temporary chemical control methods. Our chemical control is accomplished primarily by the application of insecticides by airplane and hand methods directed against the larval stages of the mosquito. Adulticiding is used as a supplement when required. Due to the development of resistance to chlorinated hydrocarbons in 1953 and 1954, the District was forced to change insecticides. It now uses only organophosphorus insecticides—parathion and malathion.

During the 1961 season the District's 562 square miles were divided into 11 zones, with one man assigned to each. Working on the theory that all land under irrigation should be checked twice each week, the District has devised what we feel is a very efficient method for covering each zone on a regular schedule. Each zone is divided into three parts and given priority numbers 1, 2, and 3. Starting the first part of the week, one day is spent in each area so that on the fourth day the operator should start back in Area 1, etc. The fields are inspected and, when feasible, are sprayed by hand or power equipment. If the field cannot be so sprayed in a reasonable length of time the District-owned airplane is used. Airspray request slips are filled out by the operator, land marks are designated, and information is given on breeding area, general layout of field, and acres to be sprayed. These slips are turned in to the foreman each night. The foreman then goes over the fields to be sprayed with the District pilot, and jointly they determine the priority status of the various fields. The pilot sprays only those fields designated by the operators or foreman. In order to cover a large area as rapidly as possible, we use centrally-located landing fields to minimize ferry time. Each landing field has loading facilities set up to meter insecticides and water into the airplane.

The District owns and operates a Call-Air A-5 low wing monoplane, powered by a 150 hp Lycoming engine, capable of carrying loads up to 100 gallons. The dispersal equipment is set up to facilitate standardization of our type of operation. The District has been operating its own aircraft now for three years. In 1959, the first season, the plane covered 50,706 acres, averaging 106.3 acres per hour. In 1960 a total of 71,021 acres were sprayed for an average of 134.3 acres per hour. In 1961 the total acreage and average dropped slightly due to the smaller areas being flown. Total acreage for 1961 was 67,875, with an average of 124 acres per hour. Parathion has been the primary insecticide used to combat mosquitoes by airplane. This material is applied at the rate of 1.0 gallons per acre or 0.1 pounds per acre. The plane is flown at altitudes of 15 to 20 feet, giving a swath width of 66 feet. The droplet size is regulated so that it is relatively large in order to minimize the hazard of spray drift.

Precautions for safety in the handling and application of all injurious materials are stressed by the District, and all standard safety devices are furnished.

Future plans to improve coordination of our spray program include the possibility of purchasing a larger type of aircraft capable of carrying a bigger pay load. Loading time and ferry time have been vital factors in our operations. We feel that a larger plane would improve the efficiency of our air spray program. In the event a second plane is purchased, we hope to retain our present unit for use in smaller acreages.

AN AIRCRAFT CENTERED LARVICIDING PROGRAM

Burton A. Fentem
Merced County Mosquito Abatement District

The first attempt to control mosquitoes on a community-wide basis in Merced County was in 1923, when an area of 17 square miles around the City of Merced was placed in the Merced Mosquito Abatement District. In 1941 the area was expanded to 90 square miles, and in 1945 the entire county of 1,995 square miles was formed into the Merced County Mosquito Abatement District. The first county-wide district budget in 1946 was based on a 15¢ tax rate supported by a $40,000 State subvention fund, for a total budget of $137,500. The gross budget for 1960-61, still based on a 15¢ tax rate—but without State subvention—was $266,156.

The mosquitoes which cause our major problems are the floodwater species, *Aedes nigromaculis* and *Aedes melanimon*, which have adapted themselves to the irrigation practices commonly associated with agriculture throughout Merced County. Other important species which occur in lesser numbers are *Culex tarsalis*, the principal vector of encephalitis, and *Anopheles freeborni*, the malaria vector.

Our problem area consists of approximately 1,700 square miles. While elimination of mosquito breeding sites is our primary objective, and the District operates a source reduction program to achieve this objective, it must still depend largely on the more temporary chemical control methods. Because of the extensive area requiring control, the District has found it expedient to use airplanes as the principal means of dispensing insecticides, supported by ground spray equipment. Our chemical approach is limited almost exclusively to larviciding, supplemented by occasional adulticiding as required. As a result of resistance to the hydrocarbon insecticides encountered in the early 1950's, the District now uses only organophosphorus insecticides, parathion and malathion, supplemented by a small amount of larvicidal oil.

During the 1961 season the District operated four Call-Air spray planes, and rebuilt one Call-Air observation plane. Three of the spray planes were used on a full-time basis, and one was reserved for standby to supplement the other aircraft when the workload became excessive. All spray planes are standardized for efficiency of operation. We employ three pilots and an A and E mechanic on a full-time basis. The mechanic performs the maintenance work on all of the planes, and also serves as a standby spray pilot. All airplane maintenance, including major overhaul, is performed in the District's shop. The planes are based at strategically located depots to minimize ferrying. The District operates from five airstrips and maintains loading facilities at each. These one-man mixing and loading facilities operate on a siphon principle, utilizing water pressure to suck a measured amount of concentrate into the delivery line in which the field strength spray is metered into the plane.

One of the major functions of the ground surveillance group is to indicate on maps the specific mosquito production areas to be treated by the planes. Ground surveillance also includes evaluating the effectiveness of insecticide applications, both from the air and from the ground. The aerial operation is under the supervision of the Chief Pilot who coordinates this service with ground surveillance activities. Because of the large area, communications between the various operational groups are of extreme importance to the efficiency of our program. This effectiveness of communications throughout the District is achieved through the use of ten two-way radio units.

The over-all program of the District is based primarily upon a larviciding approach, but at times we find it necessary to use the planes also for adulticiding. Either parathion or malathion is applied by air-spray, depending upon the situation. Parathion is applied at the rate of one gallon per acre, or 0.075 pounds per acre. Malathion is also applied at the rate of one gallon per acre, but at 0.375 pounds per acre. These application rates are effective in this District since resistance to these chemicals has not been exhibited. The size of the spray droplets is kept relatively large to minimize the hazard of spray drift. In spite of the recent stringent legislation regarding spray residue tolerances, the District has not been charged with any loss resulting from excessive spray residue on any crop or animal, and no case of honey bee kill has been brought to the attention of the District. As a result of close coordination between the District and the County Farm Advisor's office, we received clearance for our chemical program. In a general letter sent to the dairymen of the county, the dairy Farm Advisor published the following statement regarding our spray program: "The very low concentration of parathion and malathion used will not injure your livestock or get into the milk supply."

The District stresses safety in all phases of its operation and provides the usual safety devices such as rubber gloves, goggles, respirators and protective clothing. Showers are located at all loading facilities. Cholinesterase blood tests consisting of red blood cell count and plasma reading are made at intervals prescribed by the County Health Officer.

The District owns all the aircraft it operates. This is extremely advantageous to the District's operations since the planes are always available for use as needed. It is also possible for us to treat both large and small areas economically, even to fields of one acre or less.

For operational purposes the District is divided into nine zones, each of which is under the surveillance of a ground control operator. The planes operate from five airports strategically located within the District, so that ferrying time to any specific job is at a minimum. All necessary depot facilities are installed at each airfield. This facilitates complete coordination between the ground surveillance organization and the aerial services.

We are planning to increase the efficiency of the air operations by installing two-way radios in all planes, again coordinated with the ground units. We are also installing in each plane a metering device which will measure the amount of insecticide applied on each individual spray job. The availability of a granular insecticide dispensing device which can be adapted for use on our planes is being investigated. We intend to install a granular dispenser on at least one plane as soon as suitable equipment can be located. We are continually attempting to improve all phases of our air operations, such as improvement of insecticide handling facilities, better planning to reduce ferrying time, and incorporation of any other measures designed to reduce the application cost per acre.

It is recognized that Merced County represents one of the most severe mosquito production areas in the entire State. On the basis of cost analyses, all mosquito sources which we control by aerial operations are being treated economically. Considering the limited budget on which the District operates, this is a deciding factor in the over-all effectiveness of the program.

MOSQUITO PROBLEMS ASSOCIATED WITH URBAN DEVELOPMENT

Jack Fowler
Sacramento County-Yolo County Mosquito Abatement District

The Sacramento County-Yolo County Mosquito Abatement District is a large program. It extends across the heart of the Sacramento Valley from the foothills of the Sierra-Nevada to the Coast Range. A large percentage of the waters of the State flow through our District. With 8 incorporated cities and numerous populous sections, our urban problem is of major magnitude. In addition, the agricultural economy includes extensive acreages of rice and permanent pasture adjacent to large communities. Inexpensive, abundant water assures the continuation of these irrigated crops. The two primary mosquito species of our counties are the vectors of encephalitis and malaria, and housing developments move closer each year to major crop areas.

Let me single out one urban area we call the "bedroom" of Sacramento, which lies north of the American River. This is the fourth largest unincorporated urban area in the United States. In this section, hardpan and resulting poor drainage exists. You haul in fill if you want a lawn; to plant a tree, you blast. Septic tanks drain on top of the ground. To date, in this area alone, there are now 12 county sanitation districts, a growth of 10 sanitary districts in the last 14 years.

Planning is 5 to 8 years behind actual subdivision development. In 1949, we had 4 control zones in this area; today, 11 control zones are needed because of the increased problems. In 1947, our total population was 293,200. Today, our population is over 600,000. In this same period, service requests jumped from 605 per year to more than 2200 this past season (a high percentage of these turn up a premise mosquito source).

The nearest rice fields are within one mile of residential sections, but with the substantial flight range of our vector mosquitoes, even sources in Placer County to the north contribute huge numbers of mosquitoes into our urban areas.

Access to many local sources is an increasing problem. Many are in narrow public easements. Access is often through the sideyard or along the back fence to reach these sources. As new subdivisions move out into sylvan settings, man brings his mosquito production with him.

One road camp crew used to keep up with the ditch cleaning in our north area; now there are two crews. Another difficult situation for us to cope with is citizens using these community drains for trash disposal. Within hours after debris is hauled away, fresh piles of grass clippings, cast-off appliances, old lumber and discarded toys begin to clog the drains. Larvicide control is seriously hampered, even for a man on foot.

Sources not previously mentioned include idle food vats at food processing plants, fire barrels in every lumber yard and moulding and pencil factory, low river seepage areas in residential sections, log ponds, goldfish ponds, tube-testing tanks at service centers, rain barrels, oxidation ponds at sewage plants, cemetery vases, swimming pools early in the season, and septics tanks and drains.

When one considers the fact that more than 90% of mosquito sources in California are man-made, it is possible to appreciate the additional problems created by urban development. Even with major improvements, including concrete lined drains, curbs and gutters, and use of naturalistic methods such as *Gambusia* fish planting, three times as many control operators are required in areas that have become urbanized.

MOSQUITO CONTROL AND THE URBAN SPRAWL IN MARIN COUNTY

Harry L. Mathis
Marin County Mosquito Abatement District

The Marin County Mosquito Abatement District was originally formed for the purpose of controlling the salt marsh mosquitoes, *Aedes squamiger* and *Aedes dorsalis*. The year was 1915; the main equipment was a shovel; the only insecticide was diesel oil; the transportation was horse and buggy. The goal was to eliminate the sources or kill the "wrigglers." Public contact was practically nonexistent; the term *Culiseta* was unknown; *dorsalis* was called *Culex;* and mosquitoes from non-saline sources were completely ignored.

Although the basic goal has remained unchanged, the former methods of operations no more resemble those used now than a pair of roller-skates resembles a Rolls Royce. In fact the bridge is so great that it will be more meaningful to compare today with the yesterday of about fifteen years ago.

Since our main problem has been salt marsh mosquitoes, and since our marshes are on a rapid decrease, being filled, leveed, etc., it has often been thought and said that our problems must be lessening all of the time. The contrary is true, and the reasons are neither simple nor singular.

Years ago most marshes were either completely open to daily tidal action or completely leveed, with fair to excellent drainage ditches leading to automatic tidegates. Neither situation is conducive to *Aedes* production. Today, with the great influx in human population, many new suburbs are being built on filled marshland. This land filling, in a great percentage of cases, will cover only a small part of the marsh, and due to the great desire for waterfront property this filling is done near the outlet of our once excellent drainage ditches. The builders put in only that drainage which is legally required and this is often inadequate until the marsh is completely filled. The consequences of this are: a once large, well-drained field becomes a smaller field holding water and mosquitoes; a tidegate that once was easily accessible for maintenance becomes a tidegate well protected by homes and fences making the entrance of a drag-line impossible; an area that once was devoid of humans becomes a populated area with people living immediately adjacent to an old marsh which has suddenly become a new mosquito source.

Areas that once had 20 or more *Aedes* by pants leg count in 30 seconds are now beautiful and expensive tracts. While that number of mosquitoes would be intolerable in a populated area, it may be regarded as negligible if the area is uninhabited.

None of the area adjacent to the Marin County Mosquito Abatement District is under organized mosquito control. Homes in this County used to be almost entirely in the hills of Marin where drainage was never a problem. With mass home building taking place, the movement is into the flat marshlands which lends itself more to the stereotype homes of today's suburbs. Two new subdivisions have been started just within the District boundaries. Outside are thousands of acres of uncontrolled marshes. We have been partially controlling these marshes after our own are done, but now they may become as important as our own area.

Aedes is not the only genus affected by the population boom. *Culex pipiens* has found a new home under some buildings erected on the fill of old marshes. Typical is a new deluxe motel. It is built on piling in marsh fill and has a concrete slab foundation. Recently the ground has shrunk away from the slab leaving depressions and hollows which catch and hold lawn water, etc. This has led to *C. pipiens* production in great numbers and a very difficult situation to spray. Many homes have developed this same condition, but on a smaller scale. When an excessive number of homes are confronted with adult mosquitoes, the job of locating all of the sources becomes a very arduous task.

Many creeks that once were completely dry by midsummer now are beds holding hundreds of isolated pockets of water. This is caused directly by the greatly increased number of people watering lawns, washing cars, etc. The results are obvious, more *Culex* and *Culiseta* production, consequently more larviciding.

Although many new homes are being built in our wooded areas, very few trees are cut in the process. Trees are a thing of beauty; therefore, they are left growing all around homes, through porches and sometimes through the house itself. It cannot be claimed that *Aedes sierrensis* has become more abundant, but people have been moving into tree-hole mosquito areas. Along with this movement the mosquito tolerance level of the inhabitatnts has decreased. Fifteen years ago, when mosquitoes were relatively prevalent, we averaged about 200 service requests per year. Today, on a Monday following a warm weekend, it is not uncommon to receive well over 100 calls in one day. Inspections show an average of 0.8 mosquitoes observed per 20 minute checks in ideal wooded areas on warm evenings. This average is derived from inspections in the areas producing the most calls. These figures indicate the low level of tolerance among the newer populace. One area in Marin generally has more mosquitoes flying than any other inhabited area, yet we average fewer service requests from there than almost any other town. This area consists predominantly of "old-timers" in a location where little new development has taken place.

In brief, our mosquito population has greatly decreased, but the number and diversity of sources has increased tremendously. As a result, we are confronted with a wider range of species, requiring sharper control precision and efficiency. Fortunately, along with on increasing population comes an increase in assessed valuation, making funds available for better materials and equipment, and for the development of improved techniques. In other words, with urbanization one can expect new problems as well as the means for answering those problems.

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FOURTH SESSION

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

PRESENTATION OF HONORARY MEMBERSHIP TO DR. LEWIS W. HACKETT

JOHN H. BRAWLEY, *Presiding*

Mr. Brawley: We have a provision in our By-Laws which enables us to award an Honorary Membership to any individual who has performed outstanding service in the interest of mosquito control in the State of California or elsewhere. In 1955 Harold Farnsworth Gray became our first Honorary Member. In 1960 Stanley Barron Freeborn, now deceased, became our second Honorary Member. Today we are presenting our third Honorary Membership. I call on our first Honorary Member, our senior statesman, Harold F. Gray, to introduce our distinguished guest for the benefit of those who may not know him.

Mr. Gray: President John and fellow members, this is a distinct honor to me for the reason that the gentleman I am about to introduce has roots that go back to somewhat the same source as my own. He was born in a little town in California known as Benicia, which also had the honor of being the birthplace of both my father and my mother. To produce three such fine people it must have had some really good roots.

He is a doctor of medicine—Harvard. He is a doctor of public health, also Harvard—a bit in a rut at that point. For practically all of his professional life he has been in the service of the International Health Division of the Rockefeller Foundation. He has been sent all over the world and has done tremendous jobs in the control of malaria and other tropical diseases. These were outstanding contributions, but by no means his only other accomplishments. I can truly say of him, as of Tennyson's "Ulysses," he has

> ". . . become a name;
> For always roaming with a hungry heart
> Much have I seen and known; cities of men
> And manners, climates, councils, governments,
> Myself not least, but honored of them all;"

I don't believe there is a malariologist or tropical disease expert of any importance in the last half century that he did not know intimately and on the most respected terms. He has written a great deal. One of his books I consider to be a classic in medical literature, a perfectly fascinating book which every one of you should read. It is entitled "Malaria in Europe." It did much to unravel the *maculipennis* complex in Europe and the relationship of its various sub-species to the transmission of malaria. In addition to his work in Europe he had a long experience in South America. He has been a trusted advisor to many people in the field of public health, and many governments and organizations have honored him.

For some ten years he was the Editor of the American Journal of Tropical Medicine and Hygiene, which he raised to a high standard of scholarship, and in 1959 he was President of the American Society of Tropical Medicine and Hygiene.

Only in recent years, since he retired from the Rockefeller Foundation, has he been able to settle down. Living in Berkeley during this time, from 1952 to 1960 he was a Trustee of the Alameda County Mosquito Abatement District.

I could go on and on telling you in detail of the career of this gentleman, but I have no intention of trying to gild the lily or to pile Ossa on Pelion. His works will be remembered, I think, as long as there is medicine and as long as men try to control human diseases. At the present time I am trying not only to introduce him, but also to pay a return tribute of thanks to him, as he was the master of ceremonies when you were so good to me on the occasion of my receiving your Honorary Membership at Los Angeles in 1955.

A wonderful person, a great scientist, a real humanitarian—I present Dr. Lewis Wendell Hackett.

Mr. Brawley: It gives me great pleasure to present to you this certificate of Honorary Membership in the California Mosquito Control Association. Congratulations, Dr. Hackett.

Dr. Hackett: Thank you very much. This is a distinction of which I am very proud, and for which I am very grateful. After listening to Harold Gray's poetic introduction I almost think I deserve it. I am reminded of the old professor who had a graduate student come to congratulate him on being made Professor Emeritus of his university. The grad said, "I think you should have been made emeritus long ago!" Well, it just turns out that I have been writing a book on the various aspects of malaria control and other diseases. It occurred to me that the great progress—the great forward advance—began to take place after I retired, and so I am sure there may be some connection between these two things. However, I notice that the malariologist and the student of mosquito behavior have not been eliminated by DDT—they have not been eradicated. This reminds me again of this old professor. The grad said to him, "I see that this is examination time. In talking to some og the students outside, I find that you are asking the same old questions." The professor replied, "Well, yes. The problems remain the same. It's the answers which keep changing."

Thinking over my career, sometimes you see statistics in public health journals about how many lives are saved by public health men. We have to defend ourselves in some way and that is a good way to boost our reputations. Think of the thousands of lives that I probably saved. That reminds me of the young lady who went on a transatlantic liner and kept a diary. On the first day she wrote, "This is a fine ship and there are 600 passengers. I was invited to dine at the Captain's table." On the second day she wrote, "The Captain invited be onto the bridge." On the third day she wrote, "The Captain made improper advances, which I sternly repudiated. He has threatened to sink the ship if I do not yield to his demands." On the fourth day she wrote, "I have saved 600 lives."

I want to thank you again for this wonderful tribute which I shall keep for the remaining few years of my life and bequeath to my son.

Mr. Brawley: Both Dr. Hackett and Mr. Gray have contributed immeasurably to our knowledge of mosquito-borne diseases and mosquito control, and we are deeply indebted to them.

We're also indebted to another group of people who are devoting their time and their energies as a public service to their community. I'm speaking of the trustees of the local operational programs. They have many problems, many questions, and many thoughts concerning not only their respective programs, but also the Association as well. This afternoon we are going to try to bring some of these questions and some answers before you. Our moderator for this discussion is the President of the Board of Trustees of the Sutter-Yuba Mosquito Abatement District and the trustee representative on the Board of Directors of the California Association—Mr. Marion C. Bew.

Mr. Bew: Thank you, Mr. President. Following two such illustrious gentlemen as Dr. Hackett and Mr. Gray, their accomplishments seem to make ours rather pale by comparison. We do have a few problems though, and we have about an hour and twenty minutes for our four speakers to bring these into focus and to give us the benefit of their experiences. Our first speaker will be Fred DeBenedetti.

HOW DOES THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION SERVE THE TRUSTEES OF MOSQUITO ABATEMENT DISTRICTS?

FRED DEBENEDETTI, *Trustee,*
San Joaquin Mosquito Abatement District

Within the few years during which I have had the pleasure of attending your meetings I have been literally amazed at the progress that has been made by the California Mosquito Control Association. You have gone a long way in this brief time. Today, we can sit down at the common table and share our ideas, our experiences, and our plans, and from this we are able to develop sound, uniform working programs. I used to think that ours was the only district, and I wasn't particularly interested in what the other districts were doing. Fortunately this attitude has been replaced by a desire to work together and we have learned the value of pooling our thinking. Through the C.M.C.A. we have come up with a uniform pattern of operations from one end of the State to the other. It is a dynamic program and it is doing the job. As we all know, however, with increased population, expanding industry, and more and more land coming under irrigation, the job yet to be done is even bigger.

Those of us who are trustees have only one thought in mind—to do the best job possible with the taxpayer's dollar. It is as simple as that. We want the job done effectively and economically. Most of you trustees were appointed because you already have a reputation of serving your communities well. Your board of supervisors or city council pointed you out and said, "This is the kind of man we want to represent us in this particular department as a trustee." I'm proud of the fact that I serve as a trustee. I think all of us should be. Our manager and his staff do the job and we get the credit.

With all our coordination and planning, however, once in a while we make a mistake. Through the C.M.C.A. we profit by each other's mistakes. Somebody down the line says, "Don't do this; we've tried it and it didn't work." By the same token, we can share new information and those ideas that did work. I could give you many illustrations of this, but you've heard them all before.

As a trustee, and from my own personal observations, I might mention some of the things that aren't being done—at least not adequately. The person that you're responsible to is John Q. Citizen, who pays the bill. All too frequently he doesn't know you fellows and he doesn't know me. He's only interested in the tax rate and whether the job has been accomplished. Where at one time he had a thousand mosquitoes in his back yard and they were accepted, today if he has half a dozen you hear about them. People take things for granted. They don't know what you're doing. Some of them don't care. They just want results and they don't want to spend any money. The point I am making is that we are very short in one thing, and that is public relations. Let the people know what you're doing. If you don't they'll criticize. They may never give you any credit, but they are certain to criticize if there is an opportunity. The best illustration I can give you is a little article that came out of Washington a few days ago—"Milk consumption drops in the United States." And why has it dropped? One reason is that people are afraid to drink milk because of the insecticides used on forage crops. They know that we use insecticides, but they don't know about all the precautions being taken to eliminate all possible hazards. This is one place where a group like the C.M.C.A. could accomplish even more through better public relations. I could give other examples, but will stop here with a final recommendation that you let the public know what you are doing.

Speaking as a trustee, I think that the Association is doing a wonderful job. We have a fine group of managers and trustees. I would like to see an extension of the idea of a Trustees' Breakfast like we had this morning, where we can sit down over a cup of coffee and say, "Hey, Joe, what do you do about insurance? How much do you pay your manager? Where do you get your seasonal help?" These are just a few of the things that are on our minds as trustees that can be resolved through our active participation in the Association. Thank you, gentleman, Mr. Chairman.

are comprehensive, very well prepared reports. The entomologist every once in a while shows us colored slides of various areas of our County, the problems they are facing or those they have licked, and the cooperative work with Flood Control Districts. So we don't have to go out and observe every problem first-hand to know what is going on. The problems are reviewed for us, and we can read about them. From this we can approach the problem of policy-making intelligently. We also approve budgeting, salaries, and other fiscal matters. Incidentally, we don't hire anybody. That's the function of our Manager. A manager should have complete authority to hire and fire and to operate the district without unnecessary interference. It is our function to back him up.

When the manager, or the entomologist, has difficult cases to deal with in working with the public, we should be available to back him up where he needs support. Every once in a while, during the past 10 years that I've been there, we have found it necessary to haul some recalcitrant individual in and talk to him. Prior to this, Mr. Kimball, our Manager, patiently explains to these people that they cannot create or maintain a mosquito nuisance and reviews the laws governing us and governing them. If they don't listen, then we ask them to come in. Then when they come before 15 or 20 people sitting very impressively at a table they are more inclined to do something about it. In this way we support the positions of the manager.

Also, Mr. Kimball found it necessary on one occasion to fire one of our men. Well, he just thought, "The heck with the Manager; I'm going to go to the Board." He came in with a sad story and we found out that he was all wet. Again, we were able to take a position in support of our manager.

These are some of the more important functions that I feel are a proper role of a mosquito abatement district trustee . . . thank you.

Mr. Bew: Thank you Sandy. We can now call for discussion of these papers.

Mr. Gray: The problems of the trustees have been well covered in Bulletin No. 4 of the American Mosquito Control Association. Thinking back to the trustees' meeting in Disneyland last year, I don't remember a single question that was under discussion that was not answered, or at least the basis for an answer presented in this Bulletin No. 4. And I would urge all of you trustees to authorize the purchase of enough copies of Bulletin No. 4, "Organization for Mosquito Control," so that every trustee can have one. You can get it from Ted Raley, Secretary of the American Mosquito Control Association. Here's a bulletin, prepared by committees of the Association who sat down for several days and went over all of the things we have been discussing this afternoon. There were trustees, engineers, entomologists, and district managers on the committee. At $2.00 a copy it's well worth the price and will be of real value to everyone of you trustees.

SYMPOSIUM ON ADMINISTRATIVE TECHNIQUES IN SOLVING PROBLEMS OF SOURCE REDUCTION: INTRODUCTION

ROBERT H. PETERS, *Moderator*
Northern San Joaquin County Mosquito Abatement District

This year, 1962, marks a decade of use in California of the term *source reduction.* It is now the accepted reference for permanent type mosquito control directed at environmental change by eliminating or minimizing mosquito sources. Ten years ago, at the Twentieth Annual CMCA Conference, the author and Edgar A. Smith, then manager of the Merced County M.A.D., met to organize a symposium on this subject, and after due discussion agreed on the term *mosquito source reduction.* In that year's Proceedings (1952) can be found this term used for the first time.

Needless to say, this by no means infers that this approach is only ten years old, merely that this terminology has now been accepted. However, I am sure that such veterans as Harold Gray, Ernest Campbell, and others who have preached and practiced mosquito source reduction over their many influential years, are equally satisfied that this term is not only understood, but generally applied in California.

In performing mosquito source reduction as part of a program, it is interesting to consider the legal basis authorizing this departure from the routine repetitive spray activities which are more commonplace in our total control operation.

Our "Mosquito Abatement Act," found in the California Health and Safety Code, is somewhat vague relative to source reduction and this approach must be interpreted from the following inclusions.

DIVISION 3
CHAP. 5, ARTICLE 4, DISTRICT POWERS
SEC. 2270

(a) Take all necessary or proper steps for the extermination of mosquitoes . . .

(d) If necessary or proper, in the furtherance of the objects of this chapter, build, construct, repair, and maintain necessary dikes, levees, cuts, canals, or ditches upon any land . . .

(k) Do any and all things necessary or incident to the powers granted by, and to carry out the objects specified in, this chapter.

In Sec. 2276 under the abatement procedure, authorization is given the mosquito abatement district to direct the owner to ". . . perform any work that may be necessary to prevent the recurrence of breeding . . ." Thereby, this legislation apparently implies that representatives of the district are qualified to promote actual change of environment. Consequently, by implied authority our mosquito abatement agencies have initiated programs of mosquito source reduction which follow the true intent of public health procedure, namely, preventive functions aimed at environmental change to eliminate, or reduce to a practical minimum, the many existing sources of mosquitoes.

Because of the fact that mosquito sources are so variable in size and location, it is obvious that a single approach or method of accomplishing the desired end life, such as legal affairs, accounting, business, professional services, governmental procedures, science and agriculture, is desirable in evaluating program needs and in establishing district policy. In practice it is apparent that most of our district boards are representative of such a cross-section of vocations. This was made apparent at the American Mosquito Control Association meeting last year at Disneyland when members in attendance at the trustees session reported their individual occupations.

I believe the next important factor in board balance lies in the variance of individuals in their willingness or ability to expound or convincingly express their views, hence one dominant personality might unduly influence many major decisions counter to the judgment of a majority of capable but less outspoken members. This is a normal development, but may be considerably offset by selection of trustees who have shown a willingness to profess their views. Of course, one dominant voice might still be the best and wisest one, but usually we encounter another imbalance, that of extremism in either progressive or conservative approaches. We must confess that there are times for both and the interplay of checks and balances offered by the views of different personalities help serve to keep the district policies and program on a sound basis.

Not all mosquito abatement districts take the initiative in recommending or suggesting representatives for board membership to appointive bodies, although it is felt that the majority of our districts do so to some extent. Without attempting to usurp the prerogatives of the cities or the county board of supervisors, it is often in the best interests of the district and its residents for the district to offer recommendations on appointments. This may be especially important where individuals are known to possess those attributes which might best serve to balance out the previously mentioned board constituency.

When we turn to the consideration of attributes desirable in one member of our governing board, it is thus in terms of the board as a whole and to be modified thereby. But there is still considerable latitude for presenting desirable qualifications of the individual independently from such membership.

An appointee should first of all have the will, even desire, to serve the interests of the public; for without this, his participation, attendance, and contributions will usually prove to be more of a detriment than an aid to the board.

He should have awareness of, or familiarity with, the constituency which he represents—knowing the land, its people, and its economics—so that he may be guided to serve their interests along with those of the total district in determining policy and expenditures.

It would be desirable for the trustee to have a fair comprehension of business and political procedures so as to provide a basis for evaluating the merits of expenditures, program and policy. However, usually several members of a board have qualifications in these fields and may be expected to balance out any deficiencies in such considerations, even though it entails frequent extra discussion.

The quality or attribute of awareness as to district and board activities, policy determinations and the reasons behind them through regular meeting attendance and individual perceptiveness can considerably aid the development of consistent policy and program and help to avoid time consuming repetitive discussion (or rehashing) of previously explored lines of action or reasoning.

Stature is a quality often resulting from individual successful achievement giving one a sense of self assuredness which at the same time carries a sense of responsibility to himself and to others. This attribute present among members of a governing body serves largely as a safeguard against unreasonable or precipitous action by promoting reflection and temperance upon rash proposals.

A willingness to take the trouble to become better informed as to the actual theories and practices of mosquito control, through reading, meetings, conferences, etc., by at least some members of the board is not only desirable but important to the responsibility of evaluating the program and efficiency of the district's operation under direction of your administrator. At the same time, an informed board is better able to perceive the justification of any technical programming or proposals by your administrator.

Many individual traits of personality or qualifications in various fields of knowledge could be cited as advantageous to a member's service on the board, as mentioned previously in the constituency of the entire board. Most groups will normally possess a good variety of backgrounds and personalities when five or more members are present. The one problem to avoid would appear to be extremism, radical or conservative, whether in an individual or in composition of a group. To this end, the natural variance of individuals, so long as they are willing to express themselves, will serve to keep the district on a sound course.

WHAT SHOULD BE THE FUNCTION OF A MOSQUITO ABATEMENT DISTRICT TRUSTEE?

A. Sandy Steiner, *Trustee,*
Orange County Mosquito Abatement District

Mr. Chairman, gentlemen, and Mr. Parliamentarian: I think there is a little mistake. I have not *chosen* the subject, "What Should be the Function of a Mosquito Abatement District Trustee?" After these last three speakers, all the thunder has been taken out of my speech. Everything that I had planned to say about the functions of a trustee has already been covered. I am glad that I did not prepare a paper because I didn't know what the other panel members were going to say and I figured something like this was going to happen.

What else can I add? Perhaps I am left to review verbatum the technical duties of a trustee. Now, I did go up and put on a white shirt and tie, which I very seldom do. This reminded me of a story about a very well-dressed fellow, a real fashion-plate, who went into the doctor and complained of not feeling well. He said, "My ears are ringing all the time." The doctor looked at him and said, "I can see that, your eyes are bulging right out of your head. This is something serious." So he had him undress and he examined him and finally said, "Well, I think we are going to take your tonsils out. We'll see if that will help any." The patient made good progress in the hospital so the doctor discharged him. He immediately got all dressed up again and—bingo! His ears started ringing and his eyes were bulging out of his head again. This time the doctor concluded, "We'll have to take you right back and remove your appendix." This routine went on until they finally took out everything he had to spare. When he was released from the hospital for the last time he again got dressed up in his best clothes and—you guessed it—his ears started ringing and his eyes were bulging out of his head. This time the doctor said, "Well, I can't do anything more for you. I suggest that you take your money out of the bank, buy some clothes and a new car, and go out and live it up. You don't have much longer to live." So, following the doctor's advice, he went and ordered some new clothes, including some new shirts. The man measured his neck and said, "16½". "No, no," he said, "I always wear a 14½ shirt." The tailor said, "Now listen, if you do that, your eyes will bulge out and your ears will start ringing." That's the way I feel when a collar is tight.

Now, for this business of being a trustee. I have a little trailer park down in Newport Beach, right on the bay. Across the road (this was some ten years ago) we had a lot of mosquitoes, and there was a mosquito-producing ditch behind my trailer park. There is also a city park close by and there was drainage from a hill, from cesspools, and from natural springs. So I developed a petition and obtained signatures from people in the area, and with it sent a threatening letter to the County Health Department, with copies to the City Council and to the Mosquito Abatement District, telling them that if they didn't do something about it I was going to do this and do that, and raise hell with them. So our mayor called me in and said, "Sandy, I tell you what we'll do. We are going to appoint you as a trustee on the Orange County M.A.D. board." So, they sent me up to Santa Ana to represent the City of Newport Beach. We haven't had a mosquito since.

As for the functions of a mosquito abatement trustee, I believe a man must serve to the best of his ability and conscience, applying the best that he has to offer in terms of his background and education. I think one of the main duties as a trustee, representing a large group of people, is to safeguard their best interests as any other public servant, a policeman or fireman or anyone in whom the public puts its trust. Being a taxpayer myself, I'm looking out for the interest of the property owner and residents so they will get the best possible mosquito abatement for the money invested. I'm happy to say that our assessment for mosquito abatement down there is .0096—less than a penny per $100 assessed valuation.

Another thing that a trustee should do is to attend board meetings regularly, and give as much time as he can spare in attending state and national meetings. I have found that it has repaid me tremendously for the time I have taken from other things. I attended my first C.M.C.A. meeting in Berkeley in 1952, and since then my wife and I have attended three or four of these State Association meetings. We have obtained much personal satisfaction from this—as human beings and as citizens of these United States. It has been a real education to participate in this manner and to be exposed to these very high caliber men whom we have listened to and met personally from time to time—dedicated men with outstanding education and experience. The information they pass on at these meetings, that which we were able to grasp, is of great value to all of us.

I recently told a friend that I was going away, and he said, "Where're you going?" "I'm going up to San Mateo." "Oh, what are you going to do, play golf up there?" "No, I'm going up to the mosquito abatement conference." "What the hell is that? We don't have any mosquitoes around here." And I said, "Well, that's why I'm going up to San Mateo. That's the reason you don't have any mosquitoes around here. We have a mosquito abatement district that takes care of the problem. If we didn't have a control program you wouldn't be able to go out and play a game of golf. You wouldn't be able to go out and have a glass of beer in the backyard when you go home, because you'd be pestered by mosquitoes." I also get telephone calls from time to time. They call me up, "Hey, are you the man that's on the mosquito abatement district board for Newport Beach?" I say, "Yeah." "Well, get those damned mosquitoes out of my backyard over here. Come on up and see what you can do about it." "Well," I say, "I have absolutely nothing to do with chasing mosquitoes. We have a mosquito abatement district staff for that purpose." And I give them the telephone number. That's another function of a trustee—with a little reverse English on it. A trustee should not try to do the job that he has hired trained people to do. I have never attended a board meeting of any district except our own. I have received a liberal education in ours, however; and I think we have one of the best mosquito abatement boards in the business. I know that we have a very capable manager and entomologist, and I know that the mosquito problem in the County of Orange is under excellent control. Again, the function of a trustee is not that of chasing mosquitoes, but to facilitate the work of the manager, the entomologist and our men in the field to see that they have the equipment and the backing necessary to do a good job.

I don't know how the other boards function; however, I would like to have an opportunity to visit other boards and sit in on some of their meetings. We believe we have a wonderful organization. There are now 25 of us on the Orange County board. We have new cities born every once in a while. One just came into being a little less than a month ago, and the new city council promptly sents its appointed representative to our board.

I have some reports here that will show you the way our Manager prepares our agenda. He gives us the report on all the past month's activities. He gives us a complete report on all expenditures, of course. He also gives us a complete report on the amount of control work undertaken in all sections of the County, the number of service requests, etc. These

WHAT WE DON'T KNOW ABOUT MOSQUITO CONTROL

CARL W. MULLER, *Trustee,*
Turlock Mosquito Abatement District

This is really an imposing audience to speak to on "what we don't know about mosquito control," especially after the session we had yesterday. As I stopped to consider what might be said on this subject, and after listening to the discussion all day yesterday which referred frequently to what we don't know about mosquitoes and mosquito control, it occurred to me that the best way that I could make the presentation here would be to suggest that you read the statements which were made by Mr. Grant and Mr. Peters when they are published in the Proceedings. They covered most of the points that I might have made if I had a broader technical knowledge of the subject.

There is one question which has occurred to me, however, which may have a bearing on what we don't know about mosquito control, and that is—"What are the yardsticks that can be used to determine the unit costs of killing mosquitoes?" We give a large amount of attention to methods of mosquito control, and this is certainly important; however, it seems to me that we could profit much by further exploring how each aspect of the job can be done most efficiently and economically. I know that these considerations enter the mind of every manager and every trustee who has to participate in developing an annual budget. I like to think that we in our district are doing a top-notch job, and that this has always been true; but, it would seem to me, perhaps we have made mistakes in the past that other districts had made and recognized before us, or maybe we have recognized past mistakes that others are going to be making tomorrow. So I'm wondering if it would not be possible to establish some common yardsticks that can be used to analyze the management tools necessary in order to do a more efficient job. It seems to me that in this particular area there is certainly room for further progress. We're all very conscious of the problem as it affects special districts. We were told yesterday that our population is going to double in 15 years, and that it will double again in the next 25 to 30 years after that. The present competition for the tax dollar is certain to get much worse. Somehow we are going to have to take care of all the new and increased needs and at the same time meet these tax demands within our collective ability to pay.

The one question, therefore, that I would like to leave with you is, "How can we do the job that needs to be done with an ever increasing level of efficiency so we can keep pace with rapidly changing conditions and do this within the tightening limitations of our tax structure?" Since my subject is "what we don't know about mosquito control," I obviously don't have the answer to this question. I do think the question is vital, however, and the answers are going to have to come from this group. Thank you.

Mr. Bew: Thank you Carl. Would anyone care to elaborate or comment on Carl's question? Harold, you've been in this a long time. Do you have any ideas along this line?

Mr. Gray: I think I can in part answer one question, and that is that we have a procedure known as cost analysis among both engineers and accountants. The principles of cost analysis are quite well known and are at least partly applicable to the problems of trustees. In this case, however, we are dealing not with commodities but with living organisms. Sometimes we may be able to kill mosquitoes on the basis of one one-millionth of a cent per individual mosquito and sometimes the cost may be several dollars per mosquito, so this kind of cost analysis has its limitations. There are too many variables to be considered.

The second question he raised was that of the yardsticks, so-called. I think all districts can, by using simple accounting methods, establish relative norms of costs per lineal foot of insecticide application, cost per acre of spraying a particular marsh, and cost per application by airplane of a ton of insecticide, cost per acre of spraying, etc., but even there you have many, many variables which limit the manner in which these data can be utilized. Within any one district, however, I think it is possible to compare from year to year certain differences on a unit basis. Even there it must be remembered that you may have entirely changed conditions from year to year that will limit the value of this kind of cost accounting.

WHAT ATTRIBUTES ARE DESIRED IN SELECTING A TRUSTEE?

A. H. SAGEHORN
President, Board of Trustees, San Mateo County Mosquito Abatement District

Although a wide scope of desirable attributes might be found in one trustee, or more easily prescribed for an individual, it is questionable that the many desirable qualities could be found in balanced proportion within any one individual. Nor is it necessarily desirable that all members of a governing board be similarly blessed with a balance of these attributes. It would thus appear that a second major consideration is essential in resolving the titular subject, i.e., "what attributes are desirable for representation in the board constituency as a whole?"

In a large board, such as the Orange County District with 25 trustees, balanced representation of interests and experience may be more readily achieved than in boards with the minimum of 5 trustees. An important factor in board constituency is the counterbalancing of dominant personalities or special interests in order to avoid extremes of policy in such an autonomous governmental body. To be sure, in agricultural areas it is normal to have strong representation from agriculture, but at the same time the interests of other businesses, suburban residents, and professional workers should not be ignored.

It is obvious that a board constituency having knowledge and experience in many phases of community would not be applicable to all agencies. As a result, emphasis has varied among the mosquito abatement agencies as to manner or procedure of meeting these numerous source reduction problems. Basically, however, source reduction programs in California have fallen into one of the three following approaches: (1) legal approach; (2) negotiated approach program with contracted equipment; (3) negotiated approach with district equipment. These will be discussed in that order by the speakers which follow.

MOSQUITO SOURCE REDUCTION: THE LEGAL APPROACH OF THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

Gardner C. McFarland
Southeast Mosquito Abatement District

Source reduction as applied to mosquitoes and other vectors or nuisance species by public agencies has one fundamental characteristic, that of legal authority based in law. Interpretation and use of law may vary and be modified by various techniques. The fact remains, however, that law is the basic foundation which enables competent public agencies to make effective use of various educational and cooperative abatement procedures which result in voluntary compliance with legal requirements.

As a result, the public interest is properly protected without the need in the great majority of cases of resorting to the naked letter of the law. In a few instances, however, it becomes necessary to use legal enforcement measures. This may be true for a number of reasons, such as honest difference of opinion, obduracy, a complete disregard of the public health and welfare. When faced with source reduction problems caused by the last two reasons of non-compliance, it becomes necessary to initiate appropriate legal steps. The word "initiate" is used advisedly since the simple first step will usually be all the action that is needed.

Procedures followed by the Southeast Mosquito Abatement District in such cases include verbal notification of source reduction measures required, followed by written notification of issues involved and direct quotation of legal procedures that will be invoked in event of non-compliance. At this stage of the case, every effort is made to enlist the moral pressure of other groups in contact with the affected party. This could include city or county officials or representatives of various departments of such agencies. Other contacts could include trade associations affiliated with his particular endeavor or individuals in the same line of activity who have recognized the rightness of the necessary source reduction program. If these approaches fail, then the standard procedures authorized by law are followed. These include steps followed in conducting approprate hearings, and subsequent steps as outlined in Sections 2271 through 2292 of the State Health and Safety Code. Of course a number of other laws or ordinances are available if needed for the particular case. These include nuisance provisions of the Health and Safety Code and various local city and county ordinances.

The question is raised at times whether or not effective legal action can be taken against public agencies that cause mosquito nuisances. It would appear that Section 2289 of the Health and Safety Code would authorize collection of funds for money expended by mosquito abatement districts for control of such nuisances. However, actual collection of such funds might be rather difficult, if not impossible. Of interest is a recent Los Angeles County Counsel ruling that maintains that Sections 2271 through 2273 of the Health and Safety Code not only means that such an agency is liable, but that authority is present for that agency to carry out the abatement. In fact, the ruling further states that it is the legal duty of such an agency to perform the abatement.

In conclusion, it can be stated that the basis of success of various educational and negotiated abatements rests on the legal enforcement powers of public agencies charged with the responsibility of carrying out the abatement.

MOSQUITO SOURCE REDUCTION: THE LEGAL APPROACH OF THE CONSOLIDATED MOSQUITO ABATEMENT DISTRICT

T. G. Raley
Consolidated Mosquito Abatement District

From the beginning, the primary objective of Consolidated Mosquito Abatement District has been efficient mosquito control. While temporary control measures to keep mosquitoes away from people still account for a large part of the budget expenditures, good progress has been made on the most economical control method, source reduction. Concrete evidence of the economies realized from the source reduction program is the steady decline in the District's tax rate. Admittedly, income from the present rate of slightly under 9 cents is about the same as that realized from the beginning rate of 15 cents, but at least increased wage and material costs have been absorbed by reducing the mosquito source area.

As sufficient factual information was available to the Board of Trustees, a determination was made on the District's course of action. The policy that has had perhaps the most influence on all phases of District operation, and has needed no revision since its adoption, deals with mosquito sources. This is: . . . *man made mosquito sources shall be corrected by the property owner.* Other policies that support this action are: . . . *natural mosquito sources will be corrected by the District,* and, *mosquito sources on property owned or controlled by other tax supported agencies will be corrected through cooperative effort.* While at times it has been difficult to separate man made from natural sources, having three parts for the source reduction program has made its administration easier.

With the direction well defined, practical guide lines for conducting daily operations to conform with District policy were necessary. In that mosquito sources are so varied, the administrative guidance that very quickly developed became almost a slogan — *mosquito source reduction requires patience, persistence, and records.*

While it is no more important than the other requirements, patience is the most difficult to practice. District powers and generally favorable public opinion offered temptations to demand immediate correction of all known mosquito sources. To minimize the charge that the District was throwing its weight around, and to take advantage of the cooperative nature of most people when they understood what they could do to help, men were hired for a direct educational program. These carefully selected employees' main assignment was to visit with landowners, or their responsible representatives, where there were known aggravated mosquito sources. On-the-spot discussions of the problem were directed toward improvements that would benefit all parties concerned. Getting voluntary cooperation on corrections from hundreds of people required patience, patience, and more patience.

As understanding is reached and a plan for progressive improvement agreed upon, accomplishment is all too often rather slow. Invariably the intent is good but making the necessary improvements and carrying on proper maintenance is quite easy to forget in the press of making a living. Weekly reports from the field crews on the status of each known major mosquito source serve as a guide for revisiting the laggards. A persistent effort is made to stay with each problem until the original agreement is fulfilled.

Adequate records serve so many purposes that their value can never be overemphasized. One of the more important functions they serve in the District's source reduction program is when the legal powers provided in the Mosquito Abatement Act have to be exercised. In fairness to the vast majority who cooperate voluntarily as they understand the situation, the few who show no interest in community health and welfare are stimulated by all and any means available to the District. The pattern that has developed can be summarized as follows:

(a) Problems related to household, community, and industrial waste disposal are referred to the County Health Department.

(b) Problems related to agriculture are referred to the District Board of Trustees or the District Attorney.

(c) Problems created by other public agencies are corrected by a joint effort or by a charge for direct costs.

(d) Problems created by a combination of nature and man are approached in the same manner used for public agencies.

No problem is referred for possible legal action until every practical effort has been made by District employees to get voluntary acceptance of individual responsibility. Even the situation that sparks immediate action for referral to the District Attorney, right of entry, is slowed enough to permit follow-up visits by administrative personnel.

Most aggravated mosquito sources did not occur overnight and reasonable improvements are not expected overnight. Progressive reduction and proper maintenance of the source through an educational program, placing responsibility on the person creating the public nuisance, is returning direct benefits to the taxpayer and to the Consolidated MAD.

MOSQUITO SOURCE REDUCTION: THE NEGOTIATED APPROACH OF THE SAN JOAQUIN MOSQUITO ABATEMENT DISTRICT

Fred A. Compiano
San Joaquin Mosquito Abatement District

Negotiated source reduction programs in mosquito abatement districts may vary a great deal because of the different problems existing in each district.

The area served by the S.J.M.A.D. has many different types of sources including natural, industrial, residential, and agricultural, the latter being the largest contributor to problems in source reduction. Rice, for example, may be considered a problem in source reduction because of seepage. This may be controlled without too much of a problem by providing proper drainage and good, compact levees and borders around the perimeter of the field. However, water contained within rice basins presents a different and more complex problem, and it appears that more study should be done in this field so that a solution can be obtained. In other crops, such as irrigated pastures, alfalfa, clover and certain row crops, mosquito production may be considered largely preventable in San Joaquin County.

The S.J.M.A.D. source reduction program does not intend to hurt the farmer, and according to the principals of proper farming established by the agricultural service, the source reduction program would usually be helping the farmer to do a more efficient job. This encourages better use of the land and results in a significant saving of our valuable water supply. Some initial capital expenditures will usually have to be made, but resulting improved efficiency will compensate for this expense in most cases.

It is perhaps improper for the mosquito abatement district to resort to legal pressure unless it has first offered advice and help to the farmer. Criticism should be constructive, which infers that a logical solution must be presented. We may ask other agencies to help, but source reduction is the problem of the district and we should be concerned with every phase of its development.

In the solution of agricultural land management problems, several parties are frequently involved; this sometimes complicates the picture. The S.J.M.A.D. has proceeded on these problems by cooperating with one or more property owners. Some of these problems entail such services as engineering in regard to soils, water, rights of way, and cross sections and profiles pertaining to the physical characteristics of the areas involved.

The S.J.M.A.D., as it should, has always assumed the responsibility of eliminating or reducing mosquito sources which exist on land in its natural condition, as stated in the Health and Safety Code. The District should, however, cooperate with and help the landowner reduce or eliminate mosquito sources on developed agricultural land. Where feasible, we expect the landholder to share in the cost of such work; however, the proportion of cost share varies with each situation. District personnel are utilized for engineering surveys, construction, and other services needed in the project. The amount of labor to be contributed by the District is determined by management. It would not be practical to set a limit on labor contributed, as each project must be judged on its own merits and the long range benefits to the District by way of accomplishing desired results.

At the present time, the District owns no equipment; however, bulldozers, drag-lines, and other types of source reduction equipment are rented from various companies. The District furnishes the personnel necessary to operate this equipment, and has found this arrangement to be very satisfactory. In most instances the District has been using this equipment on natural sources, mainly along riverways, sloughs, and creeks. Our area is fortunate in having many pieces of heavy equipment available for hire. At the present time, we believe it is more economical for the District to rent equipment than own it.

Because of the many ramifications of the source reduction program in our area, the District must use cooperation, persuasion and education to accomplish the goals of a good program. However, if these methods fail, it may be necessary to request individual conferences at District Headquarters to motivate reasonable solutions. In such cases, the legal procedure would only be introduced as a last resort.

MOSQUITO SOURCE REDUCTION: THE NEGOTIATED APPROACH OF THE TURLOCK MOSQUITO ABATEMENT DISTRICT

Stephen M. Silveira
Turlock Mosquito Abatement District

The Turlock Mosquito Abatement District has actively participated in source reduction since the District's formation in 1946. In the early days most of the District's efforts were directed toward correction of natural sources along approximately 80 miles of river bottom within its boundaries. Later the District's program was expanded to include source reduction in the vastly more complex agricultural type sources.

The T.M.A.D. uses the "section survey system" as the basic tool in conducting its source reduction program. All known sources which are susceptible to source reduction are plotted on detailed sectional property owner maps, and entomological data are collected to indicate the relative importance of these sources.

After all this information was plotted and evaluated, it became apparent that various types of earth moving equipment would be needed to do the job on a wide variety of sources. The next step was to determine the number of different pieces of equipment needed and the probable productive time per year for each machine, based on the amount of work available or possible within the District. It was found that the minimum actual productive time on each machine would have to be between 750 and 800 hours per year in order to obtain a rate comparable to that charged by local custom operators.

Actual productive time will vary with the operator and the type of equipment being used. Delays or breakdowns can reduce actual productive time on a seasonal or annual basis as much as 35% (20 minutes in every hour). For the District's purposes, in arriving at production rates and hourly costs, the average of 30 minutes of productive time in every hour was used. The working season in Stanislaus County averages about 250 days per year.

To determine the per hour cost figure for earth moving equipment, we alloted 30% for capital investment and interest on the machine, 10% for transport of the machine to the work site, 15% for repairs, maintenance, fuel, oil and grease, 40% for labor costs, and 5% for general management overhead.

Since the minimum hours of productive time required were near or above the maximum hours of productive time probable, it became evident that the District should explore the possibility of hiring or renting equipment for its source reduction program.

A wide variety of earth moving equipment was found to be available locally. Irrigation Districts indicated that they would make their equipment available to T.M.A.D. at cost when it was used within their respective boundaries. It was learned that rates charged by private operators were reasonable due to the lively competition for available work in the area.

The findings resulted in the District's policy of hiring or renting earth moving equipment when it is required in its source reduction program. This policy has worked out satisfactorily for T.M.A.D. It has allowed the District to choose the right piece of equipment for the job. This is important in a widely diversified agricultural area. It has simplified administration of the program by eliminating the necessity of billing, collecting, and cost accounting for this type of equipment.

The District does not contribute financially toward equipment hire for work done on agricultural sources limited to a single piece of property. District participation on these sources consists of technical advice and labor for construction of drainage structures. When drainage is done on an area-wide basis involving a number of properties, the District may assume a proportionate share of equipment costs in addition to labor for construction. The District may, and frequently does assume the entire cost for work done on natural sources.

We feel that we get as much cooperation from property owners in our source reduction program as we would if the District owned earth moving equipment.

It has been our experience that the probability of maximum cooperation from property owners is enhanced when it can be demonstrated that the work to be done will benefit the property owner directly and when his views and preferences are considered. The question of whether or not the District owns earth moving equipment is seldom a factor. By recognizing that source reduction benefits should coincide with agricultural benefits, and by developing an attitude of genuine assistance, cooperation from property owners will be forthcoming.

While it is true that the equipment rental and hiring policy of T.M.A.D. has worked out very well for us, I do not want to leave the impression that it will solve everyone's equipment problems. It must be remembered that the needed equipment must be available locally at reasonable rates. If local farming operations are such that seasonal peak workloads make equipment unavailable during critical periods, this could seriously hamper a source reduction program. In some areas competition for available work does not exist, which would cause rates to be excessive.

Since it can be demonstrated that successful and economical source reduction programs can be conducted without district ownership of equipment as well as with district owned equipment, both approaches should be given careful consideration. Each of the district's needs should be fully determined, together with a thorough survey of local equipment availability, before making large capital investments in earth moving equipment.

MOSQUITO SOURCE REDUCTION: EQUIPMENT POLICIES OF THE NORTHERN SALINAS VALLEY MOSQUITO ABATEMENT DISTRICT

Howard R. Greenfield

Northern Salinas Valley Mosquito Abatement District

The need for evaluating the relative economy of district-owned and contracted equipment has been covered quite thoroughly by the previous speakers. They have also reviewed the legal approach as contrasted to the negotiated approach to source reduction. It seems that we are talking about many different kinds of situations and in our analysis we may tend to oversimplify. In any event, conditions will dictate the type of program that will eventually be found most appropriate for each agency.

In our particular area we neither had the opportunity to make a survey of equipment costs when we started source reduction work in 1952, nor an opportunity to assess cooperative willingness on the part of our community. We were projected into source reduction through just plain, outright need to reduce some very evident sources of mosquitoes. If we had tried to control these through chemical means we probably never would have seen a reduction in our tax rate. With this thought in mind, the Board decided that our first policy would be that of embarking upon a drainage program through the framework of a reclamation district. This district was formed in 1917, paid off its bonds in 1951, and then ceased to function —though it remained a legal entity on the tax rolls of Monterey County.

This reclamation system which traversed much of the District area was one of the primary sources of mosquitoes in the entire 400 square miles. It was a collection system for industrial wastes, as well as sewage disposal units that were built over, on, and through the ditch. It was a disposal system for flood waters and for agricultural waste waters from row crop irrigation, highly charged with organic fetrtilizers.

We embarked upon this program by purchasing a dragline and hiring a man to run it. We had no knowledge of where it would lead us; we could not foresee at that time the program which has since developed. By the time we had finished the first 23 miles of ditch-cleaning and effectively reduced one of our biggest sources, we were being besieged with requests to take on new problems.

So our policies gradually evolved. We based our judgment primarily on the estimated cost of temporary control over a period of 5 years compared with the cost of source reduction or permanent control. If we could expect to recover the cost of a source reduction effort in 5 years we would then proceed on this basis, regardless of whether it was on private property or whether it was a cooperative project.

In many cases we had to go to four, five, or as many as seven property owners to accomplish an objective. In such situations we would institute a cooperative project. Sometimes we were unsuccessful; in such cases it became apparent that we were going to have to obtain outside help.

We found that in our area we have two very active soil conservation districts. At that time one of the districts was headed by Merrill Wood. Merrill suggested that the two agencies, the Soil Conservation District and the Mosquito Abatement District, negotiate an agreement whereby our records and equipment would be available to them, and vice versa. Their services, their knowledge, and their program planning would be available to us. This was the first agreement in California that was arrived at in this fashion. Since that time our cooperative projects have been largely based on the joint efforts of the soil conservation districts and our mosquito abatement program.

We have also negotiated a program with our County Health Department. By so doing we can utilize some of their laws which at times are more direct, as far as legal interpretations go, than those under which we work. Specifically, we enlisted the aid of the Health Department to help in resolving our industrial waste and sewage disposal problems. Again, all such projects were planned on the basis of the original concept that we were the responsible agency for the reduction of mosquito problems in our county. If the temporary costs over a 5-year period were so much, and the source reduction costs presented a favorable comparison, we would do the job at no cost to any farmer or property owner. This philosophy continues throughout our operations today.

We have also been fortunate in enlisting the aid of the Flood Control District. Flood control has become a very important consideration, not only in mosquito work, but in the lifeblood of the community.

These three agencies are now solidly enlisted in support of our program. This cooperation of course extends both ways, the Mosquito Abatement District assisting their programs wherever possible. Thus, ours is a mutual aid program, developed to include all agencies sharing the responsibilities for water and land management within the local governmental jurisdiction.

The project now has progressed to the point where we no longer have these major natural sources to consider. We have cleaned these large drainage structures and are now working our equipment on smaller projects in which property owners participate actively. During the past several years we feel that we have been quite successful in motivating farmers in our area to undertake source reduction for their own benefit. No longer do we have to say, "Here is a ditch that needs cleaning because it is a mosquito source." They now recognize that there are additional benefits to be derived from clean ditches and are doing the job themselves. If they wish technical assistance, or if they need engineering consultation, we provide such services.

Weed control has been an important part of our source reduction program. Unless maintenance work is performed on the reclamation ditches that we have constructed and cleaned, we would be involved constantly in a very costly mechanical program. We now use chemical weed control materials which result in clean ditches lasting for 3 to 7 years.

We are, of course, prepared to use the legal approach in source reduction if necessary. Fortunately we have not had to resort to this thus far. We depend upon the Public Health Department to assist us in our program of controlling mosquitoes in industrial wastes and sewage. We work with various city and county agencies. We frequently work with the Recreation Department, particularly where we can assist their program through our weed control. We use the services of the Soil Conservation and Flood Control Districts because they are available to us, and these agencies understand our needs as we understand theirs.

In summary then, we do not in actual practice charge directly for our services. We feel we have thus far been able to accomplish the same result cooperatively, through education and persuasion. Experience has convinced us that this approach to source reduction fits our partciular area and the mosquito control problems unique to the Salinas Valley.

MOSQUITO SOURCE REDUCTION: EQUIPMENT POLICIES OF THE DELTA MOSQUITO ABATEMENT DISTRICT

George R. Whitten
Delta Mosuqito Abatement District

In December of 1953 the Delta Mosquito Abatement District purchased a T. D. 9 Tracklayer with dozer and carryall scraper. This was the beginning of a long range source reduction program which has continued to date, and from all indications will continue until we have eliminated our last breeding source.

The District has purchased additional equipment to supplement the program and all of this equipment is available to farmers in our District. The District does contract work on private property and is paid by the farmer at a rate slightly below commercial rates. There is no intent on the part of the District to make a profit from this work. The only intent is to reduce the potential breeding areas for mosquitoes. This we are doing with a direct physical attack on this problem, not only because it is a breeding source for mosquitoes but, more important to the farmer, because it is a method of increasing his production and consequently his income.

Our public relations with the farmers are excellent. When they have a water management problem they call or come to the office for help. This keeps our equipment moving fairly steadily all year round. Without the equipment we would be a governmental agency telling the farmer how to run his business. With our equipment we are a friendly agency helping him solve his problems.

In order to develop a source reduction program that will be successful in its assigned task, every district must find the basic reasons why the breeding areas in that district exist. In our own District approximately 85% of our control effort is directed towards problems created by agricultural activities. In the Delta District we have based our source reduction program on the premise that we are the logical agency to be most concerned with water management, including irrigation, drainage, dairy drains and any other agricultural problem which is a direct, or indirect, source of mosquito production.

The technical information available in the field of water management is voluminous, and in many cases beyond the farmer's comprehension. I feel that part of our function is to assimilate and interpret this technical information into practical methods for solving problems. This, if carried to its ultimate goal, means actual construction of return systems and drainage systems of various kinds. Of course, the district must be careful not to encroach on private contractors as this would be unfair competition. We have successfully avoided any problems in this line for the last nine years. I have been told by several contractors that our activities have not interfered with their business and that the problems we work on are of such a nature that they would find it difficult to make a profit on them.

When a farmer has one of these problems, what better place to turn than to the mosquito abatement district? We should have an answer for him and a positive method of solving his problem. The farmer must make a living on his property; consequently, we must provide him with an economical answer which will benefit both him and the district. If we, whose job it is to control mosquitoes, can't find a way to eliminate the breeding areas, how can we expect the farmer to do it?

I would like to say at this point that I have never met a farmer who, in his effort to provide a living for himself and his family, was deliberately trying to raise mosquitoes. On the contrary, in most cases he is simply following local custom or the teachings of the previous generation. Cultural practices are slow to change, but they do change. If in our work we can accelerate these changes we will be fulfilling our obligation to the taxpayer. An honest attempt to upgrade the quality of agriculture in our District has been a foundation upon which we have built our source reduction program.

I am sure that some will think we have gone too far in providing this equipment for contract work on private property. All I can say to this is that the people of the Delta M.A.D. are satisfied with our program and, from a technical standpoint, we feel that we are progressing, possibly not as fast as we would like, but in the proper direction.

SYMPOSIUM ON ADMINISTRATIVE TECHNIQUES IN SOLVING THE PROBLEMS OF SOURCE REDUCTION: DISCUSSION

RALPH PIEPGRASS, *Trustee*
Delta Mosquito Abatement District

This is quite a handicap to put a farmer under—to come up an speak to a distinguished group of technical people. My lack of confidence puts me in mind of a story I heard when I was working for my rich uncle back in Fort Knox, Kentucky. It seems there was a second lieutenant with brand new bars on his shoulders who had just gone through artillery school, and he was such an outstanding success in one phase of artillery gunfire that he was put in charge of a group to train them in this particular activity. On the occasion of his first session with his new class he looked out over the audience and, lo and behold, there were nothing but colonels, majors, captains, and first lieutenants. He thought it over a moment and said, "Gentlemen, there are undoubtedly two dozen men in the United States Army much better qualified to conduct this class than I." Then he paused for a bit and looked around and said, "Fortunately, I don't see any of them here so I will proceed."

I couldn't help but think as I have been sitting through this session, which is my first, that yesterday morning when these professors and doctors of philosophy and science were giving their dissertations that they talk and entirely different language than that familiar to us laymen. I then recalled the professor who was going home from a day's work and was aware of a slight headache. So he walked into the drugstore and the clerk came up to him and said, "What can I do for you, sir?" He thought it over a minute and said he would like the tablet form of the acetic acid ester of salicylic acid. The clerk stopped him and said, "Oh, you want aspirin." "That's right, I never can remember that name."

I was asked to come up here to give a response. I couldn't find out exactly what a response was supposed to be, but it seems to me it should be a summation of what my fellow panel members have given here, interpreted from the point of view of a trustee and a farmer.

I agree very much with Mr. Benedetti when he says our relations with John Q. Public are important and that we must make every effort to get these people to understand clearly the problems and responsibilities of the district so they know where we are going. Unless the public understands your objectives, your programs may be hampered by various obstructions.

As many of you know, in the average person's mind there are three kinds of mosquitoes. There is a little mosquito and a big mosquito and a great big mosquito. But, lo and behold, I find out when I get around our mosquito abatement men that there are 16 or so different kinds found in our District alone. Certainly this suggests that we had better educate the people. And where is the best place to educate them? I think, in our public schools.

As a trustee in a district I form one link in a chain of public relations. We have, among others on our board, the head of the local junior college district in Visalia. Now, no farmer is going to Ivan Crookshanks and tell him something about mosquitoes. They'll call me, another farmer, on the phone and say, "What is the District doing and why are you doing it?" The people in Visalia are more apt to call Ivan when they have a mosquito problem, or in Woodlake they may call Charlie Smith and say, "Charlie, I have some mosquitoes, what are we going to do about it?"

So a board of trustees should consist of a group of men capable of talking the language of these scientists and pass on technically reliable information in a manner understandable to the average citizen, and at the same time build our public relations so we can go ahead and get the job done.

Now this legal approach intrigued me very much and, gentlemen, frankly I am a little bit disappointed. I thought you were going to come out and say, "Let's throw the book at them and make them pay for it and be done with it." However to me that would be entirely wrong. At one time my brother and I farmed together and we had under our control about 1600 acres, and we were Don Murray's number two producer of mosquitoes. We were also number two on his cost account sheets at the end of the year. If Don had come out and said, "You're going to have to pay for this control," we would have been out of business on that piece of land. Fortunately our District did not take that attitude. They were willing to work with us and I think that they will agree that over a period of years real improvements have been made on that piece of land. If they had thrown the book at us with a hard legal approach, that problem would still exist—in somebody else's hands. The land would not be in production, it would not have increased in assessed valuation, and it would not be a source of revenue as it is today. Therefore, the farmer would have failed and the District would have failed to control the mosquitoes.

There exists the possibility that rigid application of these laws could lead to unfortunate results. If you will read through this book, the California Health and Safety Code, (I have not read through it completely but I have read the section on "Mosquito Abatement Districts and Mosquito Control") there is a little section in the back on the dissolution of districts. If you upset enough people, the tide of public opinion could result in your district being dissolved. If something like that happened it might take years to recover. Good public relations will prevent such occurrences.

I like the approach of using contracted or district-owned equipment to aid the farmer in correcting his problems. When one uses district equipment to work an individual's land, however, one must be careful not to show favoritism. In other words, if people can say, "You helped Joe and you didn't help me," that is not good.

Another thought has occurred to me about equipment. It would seem to me that a district could expect more dependable and uniform results using the same equipment and the same operators for each job, and this might constitute an advantage in a district having its own equipment and operating personnel. When you are managing your own equipment, working with and helping farmers, you may have better control over your activities. At the same time, you run into the problem mentioned earlier of being in competition with people whose business it is to make their living doing that kind of work. The Delta District has been successful in avoiding this particular problem with a program designed to create a desire in other people to follow the good practices that have been demonstrated. This creates more business.

In general, it has been my observation that in this business of source reduction it is better to be working with people who are agreeable than to force them to do something that they don't want to do. In other words, you can lead people a lot farther than you can drive them.

Wondering how to bring this discussion to a close, I am reminded of the story about the town which had built a new church and had invited a guest speaker. When the visiting speaker came into the church he was quite intrigued—there wasn't a single seat in the auditorium except in the back where there was one row. He sat up there on the podium and watched the people come in and sit down, and when the row was filled the usher would press a button and the seat would roll to the front and another pew popped up in its place. This kept up until time to start the service. The guest speaker said, "My, that's a wonderful way to fill the church." However, he was really wondering how they were going to empty it. He had been told they always remained on schedule in that church and that they would close promptly at 12 o'clock. He watched the clock very carefully and as time went on he kept wondering how they were going to empty the church. He talked just a little too long and exactly at 12 o'clock a trap door opened under him and he dropped out of sight. He never did see how the church was emptied.

FIFTH SESSION

WEDNESDAY, JANUARY 31, 8:30 A.M.

DAVID E. REED, *Presiding*

PANEL: NEW PESTICIDE MATERIALS, FORMULATIONS, AND APPLICATION TECHNIQUES

GORDON F. SMITH, *Moderator*

MOSQUITO ABATEMENT DISTRICT FAN STUDIES: INVESTIGATIONS ON THE ENERGY RELATIONS IN THE AIR PATTERN FROM SMALL AIR CARRIER SPRAYERS

NORMAN B. AKESSON AND MOHAMED NABIL EL AWADY
Agricultural Engineering Department, University of California, Davis

Work has continued on the studies of existing fans used for mosquito control air-carrier sprayers by the mosquito abatement districts in California. Several machines were studied in the laboratory last year and two more units were worked on during 1961. The procedures were as before; the fans were dismounted from the usual jeep rig and instead were driven by a 4-cylinder Wisconsin engine through a torque transducer unit. The fan discharge was connected to a small tunnel or duct in accordance with National Fan Manufacturers' test specifications.

The fans tested this year were (1) a modified version of the Modesto unit with a 15″ diameter wheel 10″ wide, and (2) a unit built by the Turlock District which was a Sturtevant 509 air wheel 16″ in diameter, with a sheet metal, adjustable discharge position case of dimensions similar to the original Sturtevant case.

The modified Modesto fan was tested. The three curves taken show total pressure (P_t) and shaft horsepower and efficiency (s.hp and $Eff._m$) for three operating speeds 1,000, 2,000, and 3,000 rpm. The maximum efficiency is now at 2,000 rpm at 45%. The output is 800 cubic feet per minute and the pressure is 7.4 inches of water, or about 120 miles per hour velocity. However, at 3,000 rpm (see figures 1-5) the output rises to 1,700 cfm at 42% efficiency and 7.6 inches or 125 mph. Thus, the fan performs best at higher rpm for the type outlet (8½x5 inches) used. However, this is a considerable increase in performance over the older style Modesto case where obstructions in the fan inlet caused a low efficiency.

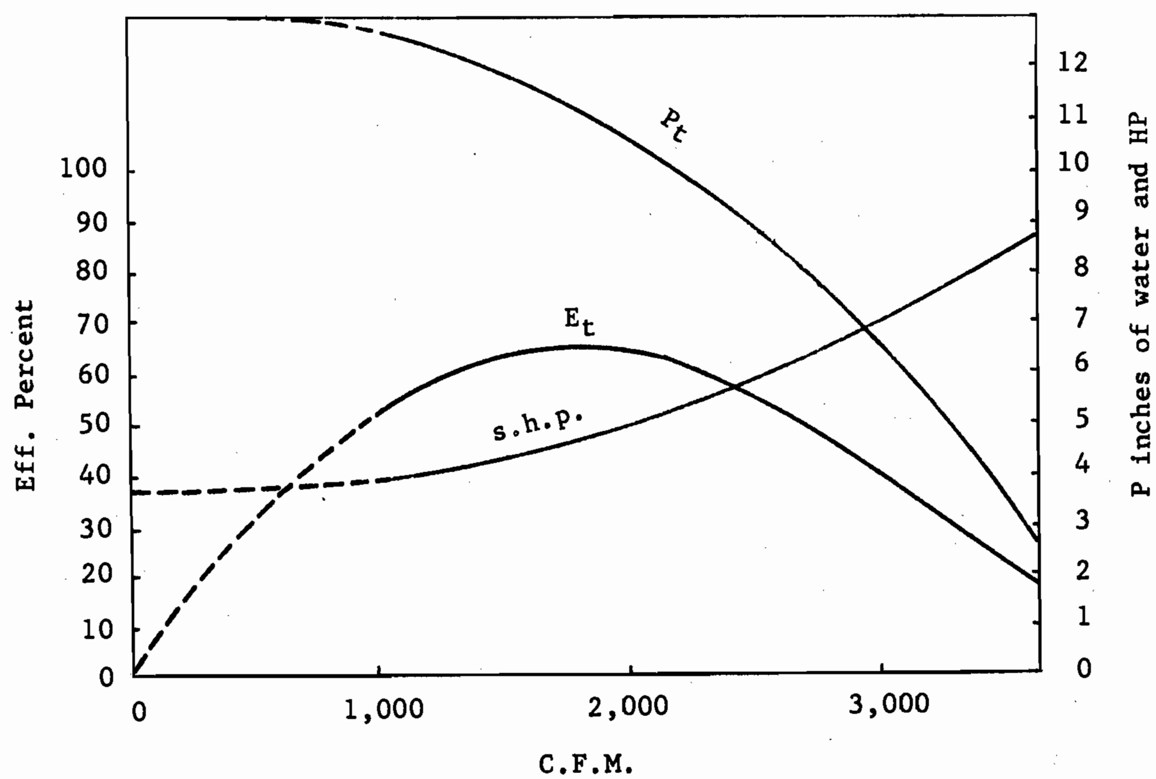

FIGURE 1.
Fan outlet data on Turlock fan, 3,000 r.p.m.

A comparison of the two fans at 2 outputs is given below.

3,000 rpm cfm	P_t	mph	Eff. %	hp
Orig. 1,700	4.5	96.5	29	3.7
Mod. 1,700	7.6	125.5	42	5
3,000 rpm				
Orig. 2,000	3.5	85	27	4
Mod. 2,000	5.3	104.5	40	5.4

This shows rather positively the much-increased effectiveness of the modification. Comparison with a larger wheel such as the Stockton Sturtevant 611 at 19 1/8 inch diameter shows the better choice when a higher output of 3,000 cfm is desired.

	rpm	cfm	P_t (mph)	Eff. %	hp
Mod. Modesto	3,000	3,000	5.9(110)	26	6.8
Stockton St.	2,400	3,000	5.9(110)	45	5

Here the cfm and P_t coincidentally come out the

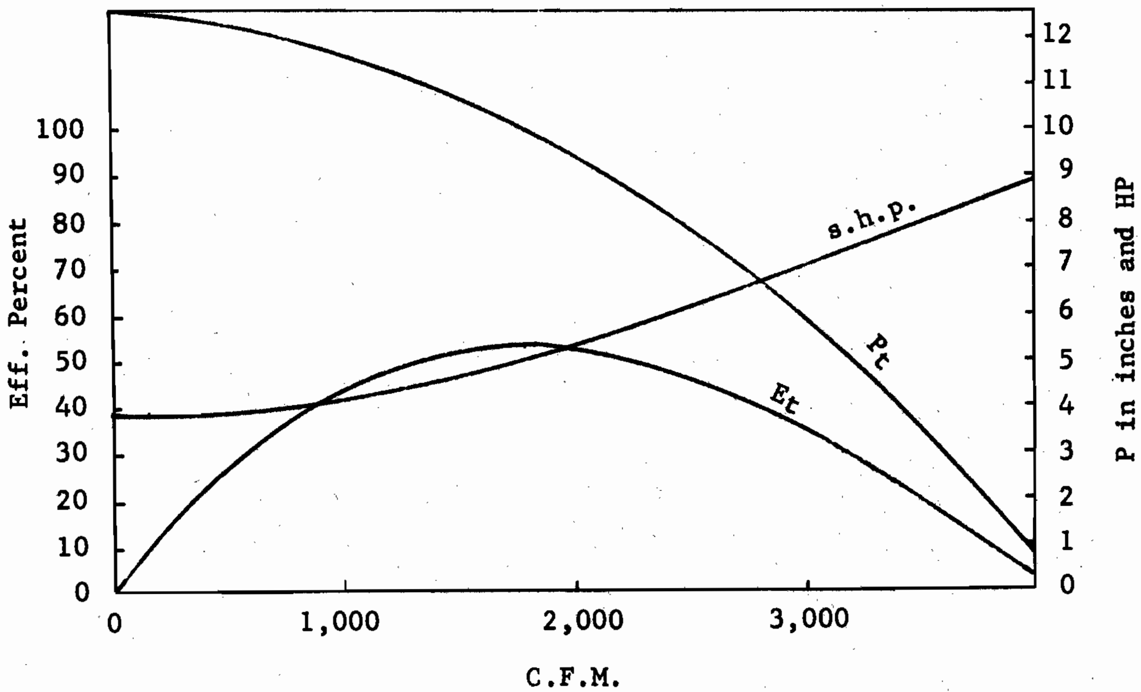

FIGURE 2. Air duct data on Turlock fan, 3,000 r.p.m.

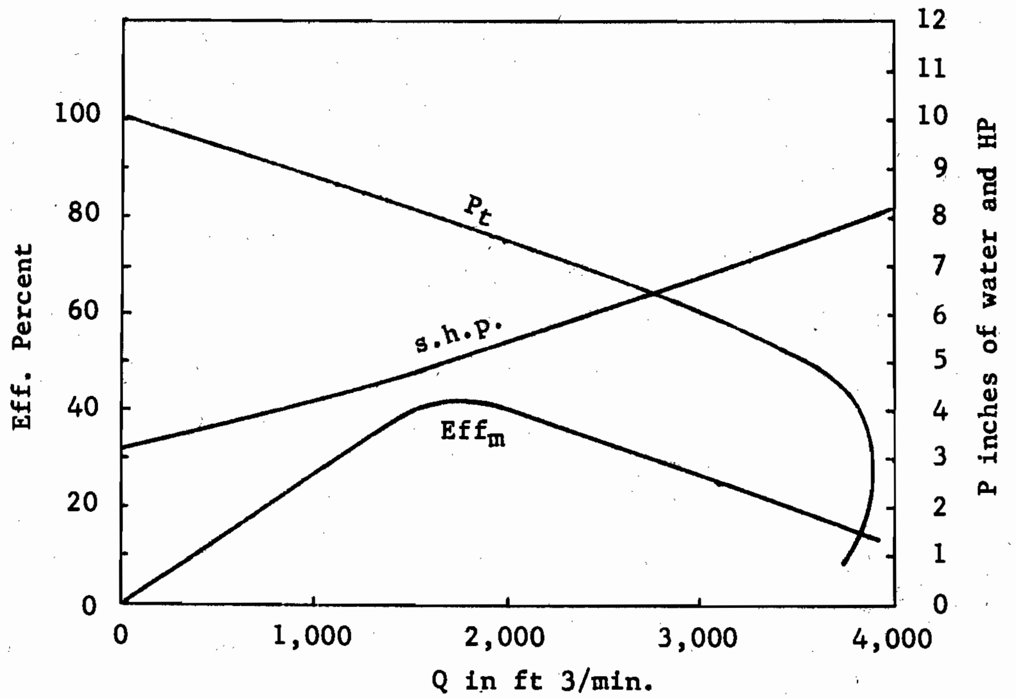

FIGURE 3. Modesto modified fan, 3,000 r.p.m.

same, but the smaller wheel must turn faster and is less efficient, using more horsepower.

Thus, the choice of wheel is dependent on the velocity and volume of air desired to perform a given job.

The second unit tested, the Turlock job, was given a thorough examination to determine, if possible, a relation between the laboratory testing procedure in the tunnel with a less elaborate field test procedure with single Pitot tube tests on the discharge of the fan. Curves shown are: 3,000 rpm (a) fan outlet; (b) air duct; 2,000 rpm air duct; and (c) test of fan mounted on jeep.

Also it has been observed throughout the test program that these type fans (Sturtevant air wheels) of straight paddle blade type configuration, with few blades (4-8) operate at highest efficiency when the rpm is high, giving a high pressure in the fan case. This pressure is usually of the order of 8 to 14 inches

P_t MEASURED *IN DUCT* 14x14 INCHES

	rpm	cfm	P_t	mph	Eff. %	hp
	1,000	500	1.4	54	25	0.3
	2,000	1,500	4.4	95	55	1.9
	3,000	2,000	9.0	140	52	5.5
Free Discharge	3,000	3,650	2.7	78	14	8.2

P_t MEASURED *IN NOZZLE* 8.5″ DIAMETER

	rpm	cfm	P_t	mph	Eff. %	hp
	1,000	500	1.3	52	23	0.4
	2,000	1,500	5.0	101	59	1.9
	3,000	2,000	10.5	176	64	5.1
Free Discharge	3,000	3,650	3.0	79	18	8.6

The difference in efficiency is most noticeable at 3,000 rpm. For 1,000 and 2,000 there is not much change. The conversion of approximately 6.3 inches of P_t (difference between free air discharge P_t of 2.7 and the limited discharge to give P_t of 9 inches) for

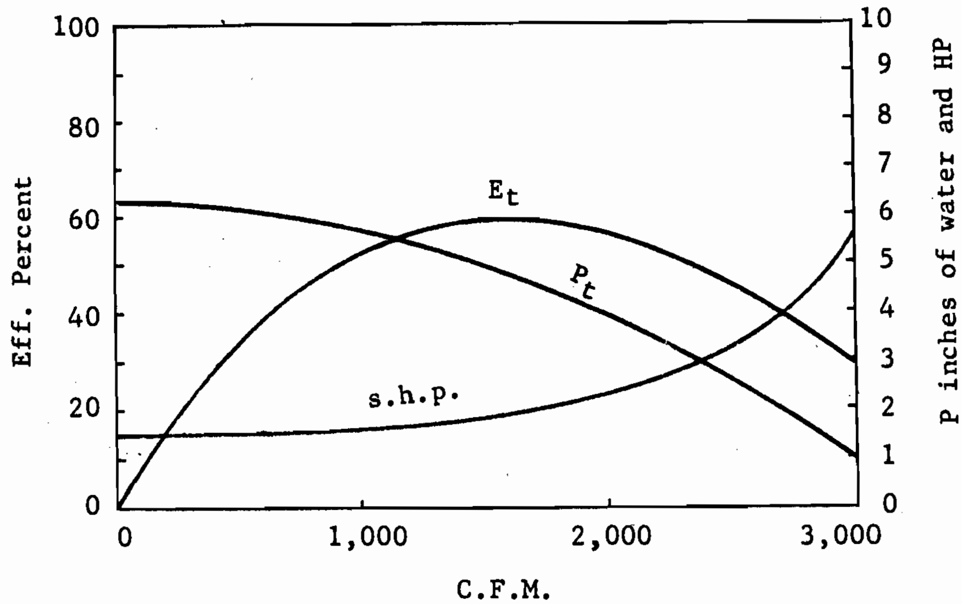

FIGURE 4.
Air duct data on Turlock fan, 2,000 r.p.m.

of water. If 100% conversion of this energy was made to velocity discharge, the fans would then maintain high efficiency when discharging into free air as they are normally used in the field. However, it is evident that this is not the case and the high efficiencies observed when P_t is high in the tunnel cannot be obtained under free air discharge conditions.

To evaluate this situation further, the Turlock fan was tested in the tunnel, but the P_t was taken both at the nozzle discharge of the fan (8.5″ diameter 56.5 sq. in.) and in the 14x14 inch duct. (See curves following.) Here the conversion of high pressure potential of the fan can be observed by reading the P_t in the fan outlet and the P_t in the duct.

duct measure and the difference of 7½ inches conversion for the nozzle shows an increase of 12% in efficiency.

If the free air discharge values are compared the 2.7 inches in duct compared with 3 inches in the nozzle (logically the velocity pressure of discharge) shows a small increase of efficiency (14 vs. 18%) in favor of the nozzle. Unfortunately this latter situation is the point at which this fan was operating with the 8.5-inch diameter nozzle. Obviously, in order to obtain greater efficiency the nozzle should be smaller which will give further conversion (represents loss in power as noted above) problems, but would put the fan in a better operating position. If this is done the outlet velocity would go up from the 78 or 79 mph shown to perhaps 140 or even 180 mph to obtain the higher efficiencies shown. The cfm would then drop to 2,000.

Comparisons (see curves) of data in the tunnel with simple Pitot tube at fan discharge data show very good correlation indicating that a single field measure of fan discharge can be satisfactory for a general evaluation of the fan. Power input would of course be more difficult to determine in the field.

The question then becomes one of determining what range of volume vs. velocity will best serve the job to be done, that of distributing spray drops over the greatest width swath with reasonable uniformity.

The junior author (El Awady) has completed his Master's of Engineering thesis on the study of an air jet and has determined certain air jet characteristics in relation to the energy and mass transfer characteristics of this jet. For example, he has shown that an increased nozzle diameter with proportionately lower velocity of discharge actually can produce a downstream pattern of the same size, when the energy remains the same, but by means of a jet requiring less initial energy. In other words, the larger nozzle, and thus larger initial size of the jet with large volume of air actually produces the down-stream air colmun for less power than is required for a small nozzle with high velocity air flow.

Further studies will be carried on to determine the penetrating qualities of high velocity vs. high volume jets and also the matter of transport ability of these jets. Further work will also be done on a different fan type, the mixed flow blade as exemplified by the Sturtevant Silentvane series. These fans have higher volume and lower pressure peak efficiency characteristics which may prove to be advantageous in this use.

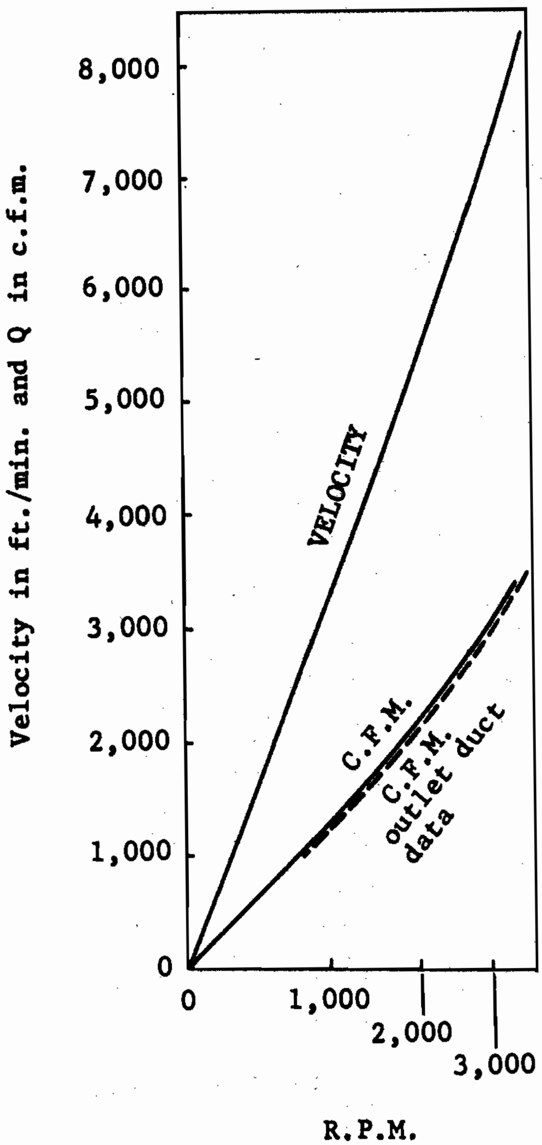

FIGURE 5.
Test of Turlock fan on jeep

MOSQUITO CONTROL WITH GRANULAR LARVICIDES[1]

M. S. MULLA
University of California, Riverside

The use of granular formulations of insecticides for mosquito larval control dates back to the late twenties when paris green and sand mixture was used as a larvicide. However, great interest in the use of granular materials for mosquito control and the abatement of other vectors and pestiferous species was not shown until after the advent of synthetic insecticides. The new insecticides are highly effective against mosquito larvae and are readily soluble in organic solvents. These two features especially led to the development of impregnated or coated granular formulations. The high biological activity of most of the materials against mosquito larvae made it possible to prepare low concentrate formulations, thus avoiding problems associated with high concentrate granular insecticides. The solubility characteristics of the organic insecticides in solvents of various kinds also made it possible to impregnate mineral and nonmineral carriers with the toxicant solutions, obtaining uniform products.

Granular insecticides are ideal formulations for mosquito larval control. They can be effectively used for the treatment of breeding sources covered with plant canopy and also under all other conditions where spray treatments can be applied for larvicidal purposes. Since granular materials are especially designed to penetrate plant cover and leave little or no residues on plant foliage, they are not expected to kill adult mosquitoes resting on plants. Mosquitoes coming in contact with the water surface or moist ground during oviposition or otherwise, however, may get lethal doses of the poison.

Granular insecticides if properly formulated are free of dust and fines and should result in no appreciable drift of the particles even under conditions where sprays cannot be applied. The particle size requirement of granular formulations currently used as larvicides in California is such that they are considered to be much safer to apply than sprays. The granular formulations are neat to apply and are less bulky to transport and much ground can be covered with these in a relatively short period of time.

Advantages of granular larvicides are many but some of the important features are discussed below:

[1] These studies are being supported by Consolidated, Fresno, Kern and Westside Mosquito Abatement Districts.

1. *Penetration Through Plant Canopy.*—Granular formulations are unique in penetrating plant canopy and delivering the toxic dose to the breeding source under the plant cover. This feature provides the most important basis for the use of granular larvicides. Parathion granules (2% impregnated on 20/30 Volclay KWK) applied by aircraft penetrated dense alfalfa growth and delivered over 90% of the intended dosage to the water placed under the canopy. Parathion sprays applied by aircraft in a similar manner penetrated the plant cover very little. Less than 20% of the intended dosage was accounted for in the water.

2. *No Drift Problem.*—Since granular formulations recommended for mosquito control in California have particles larger than 500 microns in diameter, drift of the particles away from the treated sources is practically nil. From information gained from preliminary studies on residues and penetration of parathion sprays and granules, it was calculated that over 50% of the intended dosage applied as sprays was not accounted for either by the residues or the amount of toxicant that penetrated plant cover. This portion of the intended dosage is believed to have been lost due to the drift of the spray droplets. For parathion granules over 90% of the intended dosage was accounted for. It is thus obvious that breeding sources of mosquitoes covered by plants would require higher rates of the toxicant applied as spray than would be necessary

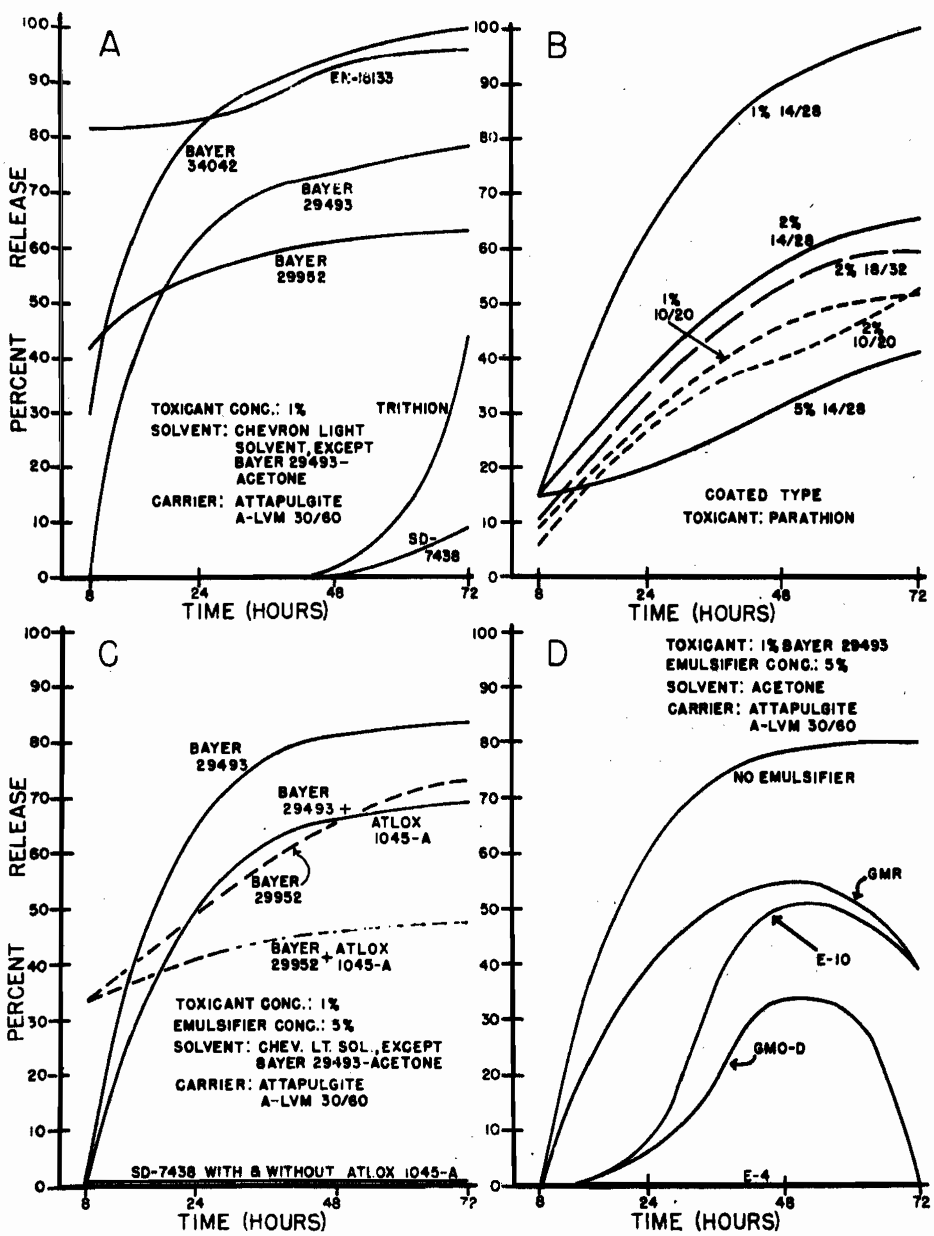

FIGURE 1.

Studies on the various aspects of granular mosquito larvicides. A: various toxicants, B: coated granules, C: Atlox 1045-A surfactant and D: Hodag nonionic surfactants.

where it is applied in the granular form. The economy resulting from this differential in dosage would more than offset the high cost per unit of toxicant formulated.

3. *Little Toxic Residues in Crops.*—Since granular particles pentrate plant cover and create no drift problems, they are believed to produce no residues in crops treated for mosquito control. Studies in the Hemet-San Jacinto Valley and southern San Joaquin Valley lent support to this belief. In these studies, initial residues of 3 ppm to 26 ppm of parathion and Baytex were found in alfalfa when the toxicants were applied at 0.1 lb./acre as sprays. The magnitude of residues incurred was higher in manually treated crops than that treated by aircraft. Hay treated with the granular formulations of these two materials had no appreciable residues. The residue problem of mosquito larvicides in crops will have an important bearing on the development of new mosquito larvicides. Since residue data and tolerances for many of the new and highly effective larvicides are not available or cannot be obtained in due time, it would be impossible to use these new materials as sprays in agricultural areas. Permission to use these materials as granules in agricultural areas on a no residue basis can be more easily secured than for the spray treatments.

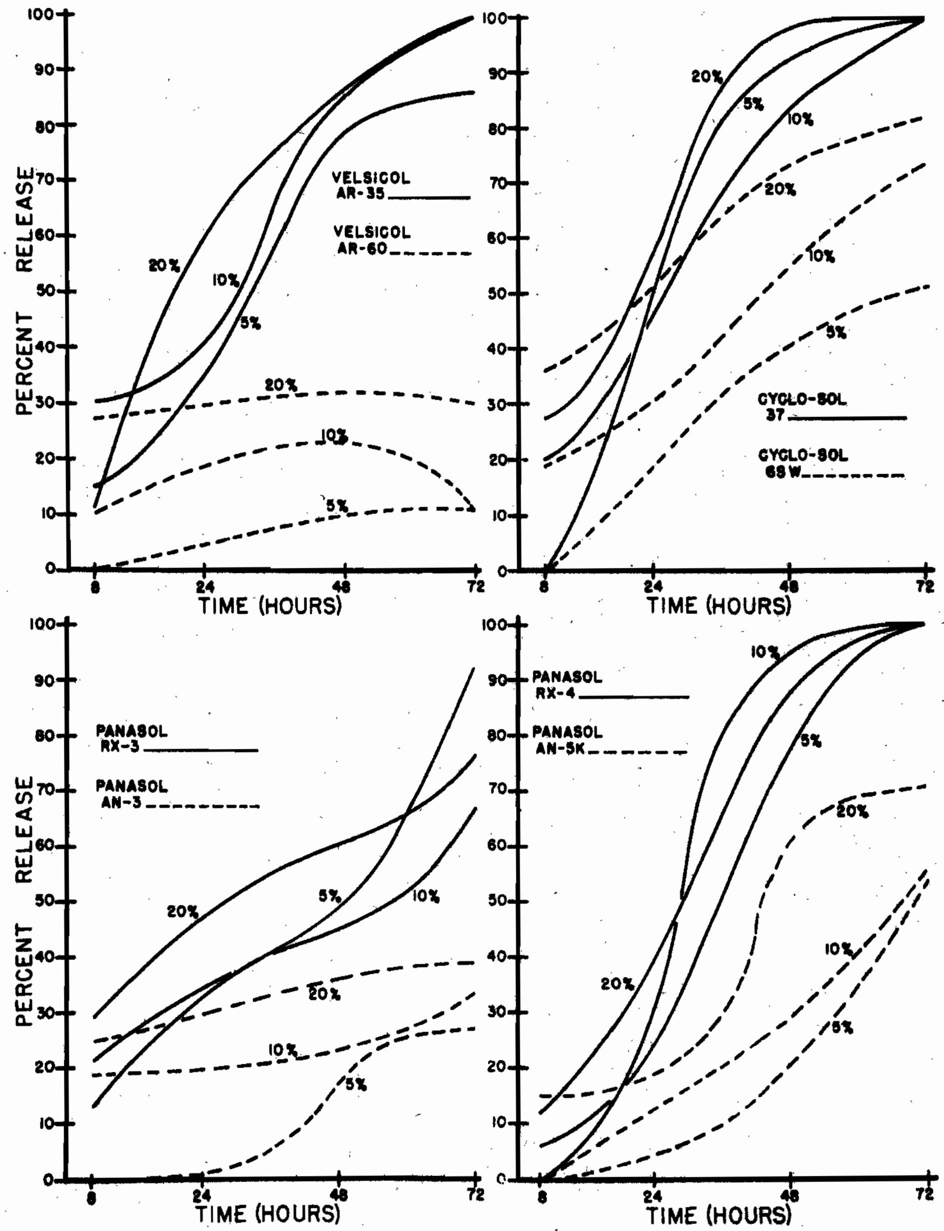

FIGURE 2.

Effect of concentration of 4 pairs of volatile and low volatile petroleum solvents on the release of parathion into water from granular formulations. All formulations were 1% parathion on 30/60 A-LVM attapulgite granules.

4. *Reduced Toxic Hazards to Beneficial Insects.*—The application of granular insecticides to breeding sources of mosquitoes located in agricultural areas would pose no serious hazard to natural enemies of phytophagous insects. This reduced hazard is brought about by the nature of granules which penetrate plant cover, causing no drift problems and leaving no toxic residues in crops treated for mosquito control. Parathion sprays caused mortality of bees in hives placed in treated fields and also in field population. Granular parathion on the other hand caused no appreciable mortality.

Spray treatments will kill beneficial insects in flight during application or as long as the spray particles remain suspended in the air. Subsequent mortality will occur as the plant inhabiting insects come in contact with the deposits left on plants.

Due to the complex physical and chemical nature of insecticides, solvents and carriers, it is not possible to develop an effective granular larvicide without knowing the physico-chemical properties of each ingredient that goes into the formulation. The interaction between the various ingredients of the formulation has to be thoroughly investigated. Laboratory studies conducted in the past 2 years have elucidated certain aspects of granular formulations of parathion and a few other larvicides (Mulla 1960a,b,c; Mulla and Axelrod 1960a,b, 1962).

The effectiveness of the formulation should be further determined under various types of ecological and biological conditions characteristic of the environment of the species against which control measures are directed. A formulation which releases toxicant into water slowly might be effective against mosquito larvae which develop slowly. The same formulation, however, may prove ineffective against species which develop rapidly. Ecological conditions such as temperature (Mulla and Axelrod 1960) edaphic conditions, pH, organic matter content of the water and the complex aquatic microflora and microfauna may profoundly influence the effectiveness of a granular material. Uniform distribution of granular particles is imperative for high efficiency and can be obtained with special types of power and manually operated devices. The development of a compressed air gun by the Orange County Mosquito Abatement District and the horn type granular applicator by the Consolidated Mosquito Abatement District (Raley 1961) and the efforts of Kern Mosquito Abatement District (Geib 1961) to assess granular distribution by aircraft are aimed toward achieving better economy and control with granular larvicides.

Although numerous studies on the various aspects of granular larvicides have been reported (see literature cited), further work on other aspects of formulation technology of granular insecticides is in progress. The results of these investigations are briefly discussed below.

Carriers.—Forty-four brands or types of organic and mineral non-metallic granular carriers were studied for their role in releasing parathion into water. Of the two organic carriers, namely, corn cob grit and alfalfa ground, the former product released parathion faster.

In the group of mineral carriers, Celite, Vermiculite, Frianite, Sericite and most of the attapulgite and montmorillonite type granules yielded rapid release of parathion. The non-absorbant type of granules, such as calcium carbonate, Emtal and pyrax®, released parathion slowly.

The particle size of granular carriers profoundly influenced the release of parathion into water. As the particle size of the carrier increased, the extent of release of parathion from the particles decreased. For making low concentrate impregnated parathion granules as needed for mosquito control, most of the carriers studied have adequate sorptive capacity.

Toxicants.—Various toxicants behaved differently when their solutions in Chevron Light Solvent or acetone were impregnated on A-LVM 30/60 attapulgite granules (Fig. 1-A). American Cyanamide EN-18133 and Bayer 34042 were released faster than Bayer 29493 (Baytex) and Bayer 29952. The latter two materials were released much faster than Trithion and SD-7438. It is therefore evident that various toxicants formulated as granules in the same manner do not manifest the same efficiency.

Surfactants.—The role of surfactants in the performance of granular mosquito larvicides has not been adequately studied. It is altogether possible that release of water soluble and insoluble toxicants can be enhanced by the addition of a proper surfactant. Preliminary studies on the role of surfactants were initiated. The use of Atlox 1045-A (polyoxyethylene sorbitol esters of mixed fatty acids, Atlas Powder Company) depressed the release of both Bayer 29493 and Bayer 29952 (Fig. 1-C). Hodag nonionic surfactants having various degrees of solubility and dispersibility in water materially depressed the release of Bayer 29493 into water (Fig. 1-D). Water solubility of the surfactant seems to be related to increased release of the toxicant. The surfactant E-10 (a water soluble polyoxyethylene alkyl aryl ether) released more Bayer 29493 than 1-4 a water insoluble polyoxyethylene alkyl aryl ether. On the other hand, a water dispersible glycerol ester surfactant GMO-D (glycerol monooleate) released less Bayer 29493 than a closely related glycerol ester GMR (glycerol monoricinoleate). From these studies it is apparent that surfactants play an important role in the formulation of graular insecticides. Impregnation of emulsion concentrates on carriers to prepare granular insecticides would have a profound effect on the final effectiveness of the toxicant. The role played by a particular surfactant should be therefore well studied.

Toxicant Concentration and Particle Size.—The effect of concentration of parathion in coated granules and the effect of range of particle size on the release of parathion into water was studied (Fig. 1-B). As the concentration of parathion in the formulation increased, the magnitude of release decreased. A 1% 14/28 mesh formulation released parathion much faster than a 2% 14/28 mesh and a 5% 14/28 mesh formulation. Similarly 1% parathion on fine particle granules (14/28) released faster than a 1% parthion on coarser particle (10/20) granules.

The importance of toxicant concentration and particle size in the effectiveness of granular insecticides is well established. These two factors should be taken into consideration in the formulation technology of mosquito larvicides.

Solvent Concentration.—The role of solvents in the performance of granular formulations of parathion has been reported earlier (Mulla and Axelrod 1960b). The effect of solvent concentration in the formulation upon the release of parathion, however, was recently elucidated. Four pairs of volatile and low volatile solvents were studied (table 1).

TABLE 1.
The flash point and distillation range of 4 pairs of petroleum solvents

Solvent	Flash Point (°F.)	Distillation Range (°F.)
Velsicol AR-35	40	64
Velsicol AR-60	220	100
Shell Cyclo-Sol 37	75	13
Shell Cyclo-Sol 68W	151	54
Panasol RX-3	81	84
Panasol AN-3	220	84
Panasol RX-4	81	38
Panasol AN-5K	190	265

In all four pairs studied, there was a direct relationship between magnitude of release of parathion and concentration of the low volatile solvents (Fig. 2). For the volatile solvents, however, there was no definite relationship between solvent concentration and the release of parathion. The release of parathion from granules prepared with various concentrations of volatile solvents was practically the same for the various formulations.

The most effective solvents for impregnation of granular carriers with parathion are those solvents which are highly volatile (Mulla and Axelrod 1960b). The concentration of this type of solvents in the formulation as evidenced here does not materially affect the effectiveness of parathion formulations as prepared in the tests. The concentration of low volatile solvents, show a definite trend. These solvents, however, are not suitable for the preparation of parathion granules for use in situations where rapid release is desired. Therefore, the desired concentration of effective solvents used should be maintained at a level where good impregnation of the carrier with the toxicant can be achieved.

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LIQUID FORMULATIONS OF INSECTICIDES FOR MOSQUITO CONTROL

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In considering liquid formulations of insecticides for mosquito control, residual applications, mists, and aerosols must be included along with larviciding methods. The utility of residual applications has been realized in many parts of the world, and this method of adult mosquito control occupies an important place in the sum total of available control methods. For the most part, aqueous suspensions of wettable powders or emulsion concentrates are used for this type of application.

The use of aerosols and mists also occupy an important place in adult mosquito control, and these methods are used to a certain extent in California. This type of control involves the dispersal of fine droplets of insecticide into the atmosphere with special equipment.

Experience in California has indicated that chemical control at the source, while mosquitoes are still in the larval stage, has generally given the most satisfactory results. For this reason, emphasis has been placed upon the development of formulations suited to application in an aquatic environment.

Liquid larvicide applications are made with low pressure, compressed air, hand can sprayers, mist sprayers, vehicle mounted pressurized sprayers, and by airplane.

The insecticidal properties of oil sprays applied to water surfaces have been known in mosquito abatement for a considerable period of time, and still are used in certain control situations. Incomplete kill of larvae and phytotoxicity limit extensive use of oils throughout the state.

Since 1946 emphasis has been placed on the use of synthetic organic compounds for the control of mosquito larvae. One method of applying these compounds has been as oil solutions where they have proven efficient in some areas (Smith 1952).

By and large, the most extensive application of chlorinated hydrocarbons and organophosphorus compounds has been in the form of aqueous sprays obtained from emulsion concentrates.

The application of aqueous sprays has been beset with many problems. The degree of solubility of the toxicant in water, in various solvents, and the use of the proper emulsifying agent in hard water, alkaline water, etc. must be considered in order to obtain proper results. Materials with low water solubility are dissolved in a suitable solvent and combined with an emulsifier to disperse the solvent-insecticide mixture in the water.

Solvents—A variety of solvents are available to formulate emulsion concentrates. These are classified into three main groups: (1) the aliphatics such as diesel and fuel oils, mineral oils, and kerosenes (specific gravity between 0.75 and 0.80); (2) the xylene-range aromatics such as xylene, Socal #2, Toxisol B, and Espesol #5 (specific gravity from 0.84 to 0.87); (3) the heavy aromatics such as Panasol Am-2 and Velsicol Av-55 (specific gravity from 0.86 to 0.99).

Factors to consider in selecting solvents are phytotoxicity, solvency of the insecticide, flash point, cost, and availability. In general, the xylene-range aromatics and the heavy aromatics are used to formulate insecticides since some insecticides and emulsifiers have little or no solubility in the aliphatics.

For each kind of solvent there may be a particular concentration and type of emulsifier which gives the best performance. A solvent-emulsifier combination which works well for one toxicant may be less effective when used with another toxicant; or a combination which is designed for a particular concentration of toxicant may be unsatisfactory when used with the same toxicant at a different concentration.

Emulsifiers.—In mosquito control work, the demand for stable emulsions has resulted partly from the fact that spray equipment does not contain agitators to keep solutions stirred, and also from the belief that a stable formulation will perform most satisfactorily as a mosquito larvicide.

There appears to be little or nothing in the way of experimental evidence, however, to support the view that stable emulsions will give a better kill of larvae than a fast-breaking formulation. This may be particularly true with organophosphorus compounds where the kill is usually achieved within the first few hours after application.

The classes of surface active agents commonly used in formulating mosquito larvicides include: non-ionic type ethers, alcohols, and esters of polyhydric alcohols and long chain fatty acids (Metcalf 1952).

Emulsifiers or surfactants are characterized chemically as possessing a fairly large oil soluble group and a water soluble group in the molecule. The presence of oil soluble and water soluble properties in the same molecule causes these materials to align themselves in certain ways at the surface of water. This causes a reduction in surface tension and also accounts for the ability of these substances to emulsify oil in water, the interfacial tension between the oil droplets and water being lowered by the emulsifier. Dispersion of the oil in water is made possible since the oil soluble portion of the emulsifier molecule associates with the oil and the hydrophylic part of the emulsifier molecule extends into the water phase.

Emulsifiers are classed as non-ionic, anionic, or cationic (Freed 1958). Cationic emulsifiers are phytotoxic and generally are not used in insecticide formulations.

Anionic emulsifiers give a rapid bloom in water and quickly disperse an insecticide-solvent combination. This type of emulsifier breaks very rapidly however and will not form a stable emulsion. Non-ionic emulsifiers disperse solvent-insecticide very slowly and present some difficulty in getting the insecticide into the water. Once the insecticide is in the water it remains for a long period.

The most satisfactory emulsions are formed from combinations of anionic and non-ionic emulsifiers, taking advantage of the desirable properties of each (Behrens 1958). Some desirable features of each type are presented in Table 1.

TABLE 1.
Features of non-ionic and anionic emulsifiers.

Non-ionic emulsifiers	Anionic emulsifiers
1. Improve action in hard water	1. Improve action in soft water
2. Improve emulsion stability at high use concentrations	2. Improve emulsion stability at low use concentrations
3. Improve performance in warm water	3. Improve performance in cold water
4. Improve aging stability of the concentrate	4. Improve spontaneity

Some examples of anionic, non-ionic and combinations of emulsifiers are presented in Table 2.

TABLE 2.
Illustrations of various types of emulsifiers.

Non-ionic	Anionic/non-ionic	Anionic
Triton X-100	Agrimul N4R	Emcol H-300X
Emcol H-500X	Antarate 9184	
Agrimul 70A	Triton X-151	

TABLE 3.
Emulsifiers grouped according to the class of compound with which they are commonly used.

Thiophosphates	Chlorinated Hydrocarbons
Agrimul N4R	Emcol H-300X
Agrimul N4S	Agrimul A-100
Atlox 3387	Igepal CO-430
Atlox 3335	Triton X-100

TABLE 4.
Some emulsifiers used in formulating parathion and malathion.[1]

Parathion		Malathion
Triton X-155	mixture	Emcol H-141
	mixture	Toximul MP
Triton B-1956	mixture	Agrimul WL
Emcol H-500X		Triton X-155
Antarate 9184		Atlox 3387
Igepal CO-630		Mal 20A

[1] The listing of emulsifiers used in insecticide formulations is for illustrative purposes only and does not imply the endorsement of the products listed. Conversely products of a similar nature which are not listed are not to be implied necessarily as being unsatisfactory.

Special types of formulations.—Liquid formulations of insecticides are sometimes incorporated into or onto a carrier or vehicle of inert material to form what has become popularly known as granules. Another method of formulating liquid materials with handling properties similar to granules may be forthcoming in the application of microencapsulation techniques which are presently being developed (anonymous 1961). In this process, the droplet of insecticide is covered with a thin layer of a water soluble polymer that can be varied for release time. Various sizes of droplets, various kinds of coatings, and various thicknesses of coatings can be produced by this method. The feasibility of this approach in mosquito larviciding operations awaits experimental trials.

Another method of handling liquid formulations has involved the so-called invert emulsion technique in which droplets of aqueous solutions are surrounded with an oil film upon dispersal from special equipment. This reduces the evaporation of the spray droplets. The feasibility of this method has been demonstrated in weed control and probably could be used with insecticide applications.

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PESTICIDE RESIDUES AND MOSQUITO ABATEMENT

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I have one advantage this morning in that I have no slides, and I do not think I will be using any terms that will be foreign to you. I'm happy to be here to discuss some of the problems in regard to the regulations and laws, etc., as they relate to pesticides and their usage. When Gordon Smith first asked me, some time ago, if I would speak on this subject to this group, I questioned in my own mind whether or not my presence would be of any value. At that time I did not know how many mutual problems we had in relation to agricultural pesticides, the use of these pesticides in agricultural entomology and mosquito abatement. Recently, as Mr. Smith mentioned, I've worked with a few people in mosquito abatement and I find that we do have some mutual problems.

The question probably has arisen in your mind in regard to mosquito abatement, why you might be concerned with residues, tolerances, registration of chemicals, exemptions of chemicals, etc.—particularly as most of these laws and regulations pertain primarily to agricultural usages and agricultural production; however, we have a mutual concern in that these laws are made for all groups and all people. Another thing that is apparent with some mosquito abatement operations is that often mosquito control is being carried on over agricultural products or agricultural land. Also, in some cases the controls used may affect wildlife. These problems are similar to those we face in agricultural pest control.

Other mutual problems are residues and drift. Residues occur when you apply an insecticide or any other pesticide. Drift occurs regardless of who applies it or how it is applied. As Dr. Mulla pointed out, you will undoubtedly get less drift with granules, but there is always some. Therefore, I think we do have many things in common that would seem worthwhile to discuss for a few minutes this morning.

First, I believe we should mention the various laws which regulate the use of pesticides. I'm not going to bore you with any details of the laws, but I would just like to mention in passing that they are the basis for my presence here this morning. We are concerned with both state and federal laws, and I would like to mention the federal laws first. There are two agencies that are charged with the responsibility of enforcing and handling the various federal laws. The first is the U. S. Department of Agriculture. They have one particular law called, "The Insecticide, Fungicide and Rodenticide Act," that affects the use of all chemicals. Any chemical used for controlling insects, mites, plant diseases, weeds, desiccating a crop, growth regulation, etc., all come under this law. This law pertains to the registration of the product. Before it can be sold in interstate shipment it must be properly registered by the U. S. Department of Agriculture, and this registration is a basic requirement before we can make effective use of a chemical on a commercial basis in the field. In order to obtain a registration there are certain requirements that must be met. These involve the use or effectiveness of a particular material, i.e., it must do the job that has been claimed for it; toxicity data must be available on both the acute and chronic toxicity; and there must be information to show what the residue will be when the chemical is used as suggested. These are the bases for acceptance of a label which must indicate the uses of the product, the hazards involved, and the various precautions. A product may be registered on the basis that a residue exists and when used as suggested the residue will not exceed the tolerance, or if no residue occurs it will be registered on a no residue (NR) basis, and if we use it properly we do not have to be concerned about residues. However, if a residue does occur, then the Food and Drug Administration establishes safe tolerances for the chemical and the USDA must make sure that the suggested use will not result in a residue that is above the tolerance.

How do these laws affect mosquito abatement? First, as I have already stated, these laws apply to all who use pesticides. There are no exceptions as far as that is concerned and if the chemical is to be used for controlling noxious insects or other organisms then it must be registered for this particular use. Those who are concerned with abating mosquitoes or other types of animal life can frequently help in obtaining this particular type of registration. They can obtain the field data necessary to prove the usefulness of the product so that it can be properly registered and sold for use throughout the areas where it would be effective. Obtaining these registrations is one of the ways in which those in mosquito abatement can be helpful. In the past this phase has sometimes been overlooked.

The Food and Drug Administration enforces the Food, Drug, and Cosmetic Act, and under the section of this Act frequently called the Miller Amendment—or officially, the Pesticide Amendment—tolerances are established for pesticide chemicals on crops that will provide safety to the consumer of agricultural products. This amendment was enacted to provide a procedure for setting up safe tolerances for residues that may appear in or on our agricultural products, or exemptions from a tolerance if there is no consumer hazard involved. The Food and Drug Administration has stated that the public will not be placed in a category of guinea pigs and it is the responsibility of those who produce food, feeds, drugs, and pesticide chemicals to prove that these are safe to use and that the final product upon which the chemical is used will be safe when it goes to the consumer. Prior to the Miller Amendment, those who prepared and put on the market various chemicals could do so if they felt that these were safe and could be used in the field. It was up to the Food and Drug Administration to prove that the material would be injurious. This was a long and costly process and, of course, there were very few of these evaluations made. Since the Pesticide Amendment was established, it is now up to the producer or the manufacturer of the product to prove, before a chemical can be put in the field, that it is absolutely safe. This is where all of us have a rather large rôle now because we can help in this evaluation of the chemicals. I am not sure whether you are aware of it now, but ordinarily the time from inception of a chemical in a laboratory to use in the field is around four years, and the cost to do the work ranges from one-and-a-half to two million dollars. Usually this money and effort is spent on obtaining sanction to use the chemical in crop production, but in some cases the use is for controlling noxious insects. As I mentioned earlier, in abating mosquitoes materials are sometimes used over crops or the material may drift to a crop and a residue may occur. It then is the responsibility of those who use the chemicals to be sure that there will not be an excessive residue on the crop when it is harvested. Therefore, you in mosquito abatement have a very definite responsibility in this respect.

As I have pointed out, if a residue occurs a specific tolerance has to be established for each agricultural commodity on which a residue occurs, and in some cases a material may be legally used for mosquito control but this same material may not have a tolerance established for it on food crops. If, in mosquito control, a residue does occur on a food crop, then a tolerance must be established and those who do this work can help in establishing these tolerances by accumulating the experimental data necessary. The University has had occasion in the last two years to help in establishing tolerances on food crops that were necessary because of mosquito abatement activities. We've also had an opportunity to help in obtaining registration for the use of certain materials used on food products because this was necessary in order to control mosquitoes. The farmer will not allow you to put chemicals on his crop unless it is legal to do so.

The state laws in regards to registration and tolerances are similar to the federal laws. All chemicals that are used, regardless of the purpose, must be registered with the State Depuartment of Agriculture, Division of Chemistry. The State Department of Agriculture is also responsible for the inspection of foods for residues to determine if they are within the tolerance before they go to market. They also issue licenses to commercial pest control operators, and are responsible for the permits for the use of various chemicals. The permit system as far as mosquito abatement is concerned applies at present to parathion. Possibly in the near future some of the other materials will be included. I think that it is important to bring before you these laws.

Now I'd like to mention a practical side of this problem as it might concern you. I've already stated that in treating for noxious pests it is sometimes necessary to treat over a crop, or the drift from the application may be over a nearby crop; also, the chemicals used may affect honey bees or other pollinators, other beneficial insects, wildlife and, of course, public safety. I know you are aware of these problems, but these are the same problems we in agriculture face; therefore some of the work we do is applicable to you.

At the present time the farmers of this state are greatly concerned about residues on their crops. Mr. Smith mentioned the fiasco of the cranberries which occurred two years ago and had everybody upset. At the present time we are again having problems with residues, especially on dairy feeds and in milk, and I would not say that we are in the best position as far as residues are concerned on these products. Residues in milk or on hay are of great concern to most dairy producers. Since milk and dairy products have a zero tolerance for all pesticide chemicals, the feeds must be nearly free of chemicals that can accumulate in milk following feeding. Although most MAD's are using phosphates this may not always be the case and you may use materials that could appear in milk. Thus, you must be aware of the possibilities that could occur if you treated over or near a forage crop with a material that is not allowed on hay or other forage. These same considerations should be given to food crops and to other feed crops destined for feeding to beef animals.

I have already mentioned bees and Dr. Anderson will speak in detail on them in a few minutes, but I would like to emphasize the problem of bee losses due to pesticides. The bee industry, as you well know, is worth several million dollars—about $6,000,000 as far as honey and beeswax are concerned—but this industry is more important than that because of the service it provides pollination. There have been some very serious losses in the last few years because of pesticides, particularly since we changed our pest control recommendations from chlorinated hydrocarbons to the phosphates and carbamates. Because of the serious bee losses, the beekeepers do not know whether they can live in California or not. I will not go into any more detail than that because I know that Dr. Anderson will explain it, but it is one of our very serious problems at the present time and you should be concerned because of the parathion and other phosphates you use.

There were a number of cases of overtolerances of various pesticides on the hay and the feed crops in 1961, and as a result of not being able to sell such hay to dairymen the hay producers will not tolerate some of the things that they put up with last year. You may remember in 1960 everybody was quite concerned about residues and a special effort was made to reduce these. In 1961, probably because things went well in 1960, there was a relaxation about the use of pesticides, and as a result our present problem of residues developed. For 1962 it looks as though the farmers will be more careful and they will not allow pesticides on their hay unless they are sure it is legal to do so. Some growers may go so far as not to allow you to treat over their crops this year, even with parathion. There have been a number of dairies shut down and many loads of hay stopped, and this leads me to believe you will find that the farmers will be taking a different viewpoint this coming season as far as the use of chemicals around their property is concerned.

I think this brings us to the problem that we all should be very much concerned with in the usage of these chemicals. We should be sure, first, that we are using registered materials, unless we are doing it on an experimental basis. If a residue occurs, we should be sure our usage will not result in a residue that exceeds the tolerance. We must have data to back up these usages. We should use the proper materials at the right time and do whatever is necessary to protect the beneficial insects. I think most of all there is a need for good public relations and improvement of our public image in this regard. Some of the consuming public do not have a very good image of those who sell or use pesticides in the field. They think we are all trying to poison them. This is a rather small, but a very vociferous group, and it is growing larger all the time. Therefore we must take steps to show our side of this problem. Then there is another group that think we are poisoning and killing off all of the wildlife. We have to do everything possible within our power to show that we are not poisoning the public, that we are following the laws and rules and regulations, that we are not upsetting nature, and that we are benefitting the public.

In relation to our public image I would like to show you some of the articles that are sent out to California consumers pointing out that we who use pesticides are careless and are poisoning the people of this state. This is one that was circulated in 1960—"Consumers Must Check Poison in Foods." Then there is a long mimeographed page describing the uses of pesticides and urging that letters be written to the Governor and others whose names are listed, asking them to help stop the people of Imperial Valley, and especially the University of California and the Agricultural Extension Service, from poisoning the people in California. Another one, put out in 1961, says, "Stop this Poison. Don't give babies poisoned milk! Protect yourself from cancer, hepatitis, kidney diseases, arthritis, arterial sclerosis, heart disease, so-called virus infection of the digestive system, ulcers, degenerate diseases, all triggered by small doses of poison." And once again particular areas of California are picked out as the trouble spots and the readers are asked to write to the Governor and others about this. The last and most recent one says, "Stop Poisoning Meat." This is a letter printed in a newspaper in California, as a paid advertisement, but it gets circulation and has been reproduced and sent to groups all over the state and out of the state. It begins, "The Honorable Abraham Ribicoff, Secretary of Health, Education and Welfare, Washington, D. C., etc.," and it says, in effect, that we have been doing well in preventing the problem of residues in milk but what about meat, because the same materials that we wouldn't allow to be fed to dairy animals we're now feeding to beef animals, so something must be done. It goes a little further and says that this can be borne out by a statement from the Chief of the Division of Chemistry of the California Department of Agriculture. At the end it says to write letters to your meat packers, your Congressman, your representatives in the State Legislature, to Secretary Ribicoff, Governor Edmund G. Brown, demanding a zero tolerance, etc. Now these could be kind of humorous if they weren't so serious. They are serious because they affect a lot of people. This type of "literature" is frequently being distributed and it is our responsibility to do something about it. We should not allow another situation bordering on hysteria to develop because of pesticide residues. We should all combat this by pointing out at every opportunity, how these chemicals are regulated, how they are safe when used properly, and explain our own programs. This is a real problem, and all of us who are concerned with the use of chemicals have a real responsibility to see that they are used properly, that residues are kept at a minimum, and that the public knows we are using these chemicals properly.

Now, what we can offer you from the University. I know when Dean Aldrich spoke on Monday he offered cooperation on certain phases of research, and I'm sure you will find this is the feeling of all of those in the University who are responsible for research.

In regard to the actual control of pests, you've heard reports from others stating that this work is underway. Also, regarding some of the residue and application problems, we can pool our resources. We have done much on residue analyses, and very possibly some of these results could be helpful in your work if we knew what your problems are pertaining to residues. If we have better communication between our groups it will work to our mutual benefit. Our basic considerations in the use of chemicals are the same as yours. Therefore we should make unified effort to solve these problems.

EFFECTS OF MOSQUITO ABATEMENT PESTICIDE TREATMENTS ON HONEY BEES

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Department of Entomology,
University of California, Riverside

Previous speakers have mentioned how important honey bees are to California, but I would like to comment further on this subject. Soon after the white man arrived in North America, he brought over honey bees to help him out. These bees soon spread all across the continent and now you will find them both in the wild stage in hollow trees as well as under domestication in apiaries. In the U.S., apiculture is a multimillion dollar business, with California as the leading state. It has been said that honey bees are far more important to agriculture as pollinators of various crops, such as alfalfa, deciduous fruits, and many vegetables, etc. We could not get along without the bees, so we're going to have to take care of them as best we can. Now where does the mosquito abatement district fall into this important picture? We know that many of the agricultural pesticides that have been applied have done a lot of damage to bees. So the question arises, "Do M.A.D. treatments hurt the bees?" Before answering this question let us briefly review the honey bee-pesticide research Larry Atkins and I have been doing over the past ten years. We have been working on this problem from the standpoint of injury from pesticides that are used to control agricultural pests. Then in the last few years we started getting complaints and questions about the possibility of mosquito abatement treatments hurting bees. To understand this research problem better I would like to show a series of colored slides that explain how we conduct our laboratory and field experiments. [Two dozen colored slides were projected which showed in detail the laboratory and field test equipment and methods. Since this information has been published in the Journal of Economic Entomology Vol. 45(3), 1952; Vol. 47(6), 1954 (2 articles); and Vol. 51(1), 1958) it will not be repeated here.]

Our first field tests on mosquito abatement treatments were made in 1959 in the fresno area. In these experiments parathion (1/10 lb./acre) was flown directly over colonies of bees, and it was found that the colonies were not hurt appreciably, but there was a complete loss of all the bees that were out visiting flowers in the treated area at the time of treatment.

In 1961 studies were made on the possibility of poisoning water. In the laboratory, 50% honey-water was treated with parathion at 1, 2, 3, etc. on up to 20 parts per million. In one test this poisoned water was fed to bees for two hours and then replaced with clean food. In another test the poisoned water was fed continously for three days. In the first test (2 hour feeding time) it was found that with up to 2.5 ppm no kill of bees occurred. At 5 ppm there was 27% kill. At 7.5 ppm 73% kill. Above 7.5 ppm 100% kill was obtained.

Where they were fed continuously the break came at 5 ppm instead of above 7.5, and the 2.5 ppm treatment resulted in 67% kill. These data indicate the amount of parathion bees can tolerate in their drinking water. The question is how much parathion gets into their drinking water from a normal 1/10th lb./acre application? If all of it went in the water and the water was an inch deep it would be about 0.5 ppm. Thus, this readily shows that with normal treatments—the amount getting in the water is not enough to be toxic to bees, providing the water is an inch or more in depth.

If the water is 1/10th of an inch deep, then 1/10 lb./acre should result in 5 ppm and it is apparent we would be approaching the poisonous level. Thus, there may be a possibility of poisoning bees with these treatments when treated watering areas are just damp ground. However, it should be pointed out that the soil may tie up the parathion, and it may take more parathion than has been found necessary to kill bees in the laboratory where material has been put in water or in tin pans. It should also be noted that the damp edge of the water areas in the field are almost always connected with deeper water and the insecticide may be dispersed out into the deeper water, thus, decreasing the concentration. Usually there is a fluctuation in the water level in the field reservoirs resulting in alternate covering and uncovering of the damp areas at the edge of a pond, thus further diluting the pesticide. The laboratory tests are more severe on the bees than one would expect tests to be because in the laboratory the poison was thoroughly mixed in the honey-water which serves as food as well as moisture to partially starved bees. Also, in the field the bees get their water from many places and there is a good likelihood of their getting it from a noncontaminated place. Also, when granular materials are used, the insecticide is released gradually over a longer period of time, so there would be less concentration at any given time in the field than would be present in the water treated with parathion emulsion in the laboratory. Undoubtedly there are many other factors that could be given that would indicate laboratory treatment to be more severe on bees than field treatment. All of these facts indicate that the field contamination of water is not too likely. However, additional tests are needed to prove this point.

In 1960 field tests were conducted in which the effect of parathion granular and spray treatments were compared on honey bees in alfalfa in bloom. These experiments were made in Kern County and in cooperation with Dr. M. S. Mulla of UCR, the Bureau of Vector Control, and the Kern and other mosquito abatement districts.

In these tests parathion was applied at 1/10th lb./acre. The granular parathion was a 2% coated material on sand (16-22 mesh with 11,018 particles per gram) and was applied at about 5 lbs. per acre. The parathion spray was made from a 25% emulsion concentrate and applied in one gallon of water per acre. The granular application gave no kill of bees in cages in the field, or of bees visiting the alfalfa blossoms in the field, and no kill of bees occurred at the colonies. The spray treatment resulted in complete mortality of bees exposed in screen cages which were flown over. Appreciable bee mortality occurred up to one hour after treatment in bees exposed in cages placed in the field after treatment. Reduction in field force was also noted in the spray treated field and appreciable mortality was noted at the hives for over a day.

Pie pans (8½″ diameter) were filled to about ¾″ deep with water (450 cc). The granules appeared to bounce off of the alfalfa plants and funnel into these pans placed in the alleyways between the rows of plants, while the sprays hit the foliage and more or less stuck to the foliage. This may explain why a higher concentration was obtained in the pans with the granules than with the sprays. By bioassay, using mosquito larvae, the granules showed about 1.3 ppm parathion in the water, while the sprays showed only about 0.3 ppm. The granular treatment did result in enough parathion in the water to kill bees when they were forced to feed on it and nothing else. One tenth part per million parathion is about the maximum needed for controlling mosquito larvae, and frequently much less will give adequate control. Data at hand indicate the granular application will require less material per acre and will be slower in release of parathion, causing less concentration in the water at any given time and less toxicity to bees. There would also be less waste of material. Granules would be more effective for mosquito larvae in water under vegetation but equal to spray in open water. With granulars, less weight is applied per acre; therefore, a greater pay load can be carried. Some operators in Kern County have had successful control with as low as 2 pounds of granular materials per acre. Compare this to 8 pounds or one gallon of spray per acre.

The granules cost more than sprays for a given amount of material, but this cost difference is compensated for by being able to use less, as well as possibly being a more desirable mixture to apply.

The best procedure would be to utilize both granule and spray applications. That is, in those areas where sprays can be used without harm to bees, or where there is no bee problem—then use the spray. If there happens to be a lot of bloom in the area to be treated and there is a possibility of poisoning bees, then use the granules to be on the safe side. It is much better to never have a case of poisoning of bees than to come up with just one poisoning of bees. It is not so much the cost of paying damages as it is the adverse publicity that arises when bees are killed.

Recently the volume of granule treatments has increased rapidly. In 1960 there were just a few tons used. In 1961, there were many tons used.

We have prepared a one-sheet answer publication (OSA 115) on the toxicity of various pesticides to honey bees. These are available at your local California Farm Advisors Office or from the University of California Extension Entomologist. This OSA does not give recommendations on the use of pesticides. It is purely a listing of all of the materials tested to date and gives their relative toxicity to honey bees as compared both in the laboratory and in the field, using DDT as a standard.

There is only one reference in regard to mosquito abatement treatments being toxic to honey bees and that is by Scudder 1950. This information, buried in one of the Public Health Reports, states that DDD and DDT at 1/10th lb./acre for mosquito control was not harmful to bees. However, it should be noted that 10 times this dosage of DDT is currently required for mosquito larval control in California.

In conclusion, it is suggested that mosquito abatement operators using parathion sprays contact the beekeepers in the area and let them be aware of the time, materials, and type of treatment to be used. An informed apiculturist is more understanding and is less liable to complain about his bee losses. Use the granules whenever possible. Do not treat over the hives. Avoid treating fields in bloom, and do not overdose. Also, try not to hit the watering places, although all of our data indicate that this may not be too important.

In conclusion let us consider a little 4-line poem which says:

"He loved the bees alive
And thought they were his friends
But when he sat upon their hive
They stung him in the end."

PRESIDENTIAL ADDRESS

John H. Brawley
President, California Mosquito Control Association, Inc.

What is wrong with the California Mosquito Control Association? We have heard this question many times in recent years and sometimes the implication seems to be that the whole structure is unsound, beyond hope of repair, and should be abandoned. Perhaps the intent is merely to focus attention on the need for self analysis and improvement. In this case it becomes a good question with a constructive purpose. But either way it represents a negative approach to the problem. We should be asking ourselves, "What are the good points of our Association? How can we make it an even better organization?"

I will not attempt to enumerate its many achievements through the years. This is the Thirtieth Annual Conference and if there is anyone who can truthfully say that he has not derived some benefit from this Association, then he is indeed like the proverbial man who was wiser in his own conceit than seven men that can render a reason.

Its greatest asset is you—the members. Through your collective efforts you have made it one of the finest organizations in existence. Your desire to protect humanity from disease and discomfort is one of the noblest ambitions that any man can have. Your good will, sincerity of purpose, and devotion to duty are becoming more apparent with each passing year. As individuals you are the nicest people I have ever known.

The Objects of this Association, according to the By-laws, are, " . . . To promote cooperation among those directly and indirectly concerned with and interested in mosquito control and related subjects, to stimulate the development of improved methods and techniques and to disseminate information in relation thereto, and to aid in the advancement in this field in California and elsewhere." This indicates a sincere desire to help build a better world and a better life for mankind through better control programs.

What can we do to promote and give substance to these high ideals and ambitions? I believe that:

1. All classes of membership should be allowed full participation, including the right to vote.
2. The Association should promote legislation which will provide a greatly expanded program to provide additional knowledge and assistance in the development of improved methods and techniques.
3. All actions by the Association should be pre-

ceded by discussion, careful consideration, and deliberation. We must expect honest differences of opinion but in the end the wishes of the majority must prevail so that a small minority group cannot frustrate the desires and ambitions of the organization.

4. Political action should be accepted as a necessary tool for the accomplishment of major objectives; but it should be used discreetly, and we must beware of letting this activity become the primary function of the Association.
5. We should promote professional standards aimed at encouraging the employment of capable administrators with the ability, experience and knowledge to carry on efficient operational programs. We must not make the mistake, however, of presupposing that academic degrees are necessarily the only measure of a man's knowledge and capabilities.
6. The Association should provide ideas, information, assistance, and guidance but should never attempt to regulate, dictate, dominate, or interfere in the local operational programs.

If you do not agree with these proposals and others which I will make in the future, it is your right to oppose them vigorously and I will not be offended so long as this opposition is expressed in an honorable and democratic manner. In turn, I will respect your ideas even though I may not agree with them. The path of least resistance often leads each of us to be negative, to oppose, and to try to maintain the status quo. We live in a fast-changing world where that which was good enough yesterday may be obsolete today and an antique tomorrow. The law of survival dictates that we must either adapt or die.

SUBMITTED PAPERS

ONE-MAN JEEP WITH AUTOMATIC AIR SUPPLY FOR LIQUID AND GRANULE LARVICIDING IN ORANGE COUNTY

Albert H. Thompson

Orange County Mosquito Abatement District

The Orange County Mosquito Abatement District controls an area of 762 square miles. Much of this area contains many mosquito sources created by the drainage of excess irrigation water from residential areas and agricultural operations into street gutters, catch basins, roadside ditches, culverts, and flood channels.

In controlling these sources in the past we used a conventional CJ2A Jeep with 4-wheel drive operated by one man. Spraying with this Jeep was inconvenient and dangerous because the operator had to spray driving against the traffic. It was possible, of course, to spray driving with the traffic but we felt that when spraying in this position we did not do a thorough job.

Since it was felt that the equipment we had did not accomplish the desired results, and since we wished to eliminate driving against traffic, the District ordered four Jeep DJ3A Basic Dispatchers with right-hand drive and automatic transmission equipped as follows:

Automatic transmission
Right-hand drive
Front canvas top
Oil bath air cleaner
Heavy duty shock and springs
One-third front passenger seat
Locking differential
Directional lights
Outside rear view mirror
Five tires – 6:40 x 15 tubeless
Oil filter
Positive crankcase ventilation
Color: Michigan Yellow

The automatic transmission enables the operator to spray at a slower, uniform speed without shifting gears, so the operator has a free hand at all times for spraying. With the right-hand drive the operator eliminates a hazard by driving with the traffic. Another advantage is that he is closer to the source and, therefore, does a more efficient job.

Inasmuch as these Jeeps are to be used primarily for spraying street gutters, catch basins, roadside ditches, etc., it was thought that the locking differential, allowing both wheels to pull, would give us an added safety factor since some of this spraying is done in suburban areas.

The District uses compressed air for spraying liquid and granule insecticides. Since the DJ3A Jeep Dispatcher is not equipped with a power take-off, an air compressor with a magnetic clutch was mounted under the hood. A few minor changes were required to make this installation. The battery was moved from its present location and installed under the left front seat. In order to do this, a hole was cut in the floor board and a galvanized box was installed allowing the top of the battery to be 3 inches above the floor board. A longer battery cable had to be installed and the positive cable was used for the ground. The existing hold-down bracket was used, a wooden box was made to cover the top, and a slot was cut out of the top of the box for checking and adding water to the battery. With the battery removed, a sturdy mounting bracket and space was available for the compressor. A two-cylinder Quincy Model X8 compressor was found to be just the right size for this area and to supply the amount of air needed to operate the conventional spray gun for liquid larvicides as well as the compressed air gun. In order to drive this compressor, an additional pulley was added to the Jeep engine fan pulley.

To prevent excessive revolution speed on this compressor (1000 r.p.m. maximum), we first installed a dog clutch for engaging and disengaging the compressor at certain speeds. This method was unsatisfactory due to the operation of the clutch. The next thought was a magnetic clutch as used on automobile air conditioning units. We were able to purchase a 7-3/8″ magnetic clutch manufactured by Electro Lock, Inc. from a local dealer.

Before the clutch could be installed on the Quincy air compressors, a minimum amount of machine work was required. The front bearing housing was machined and threaded so a collar could be mounted. This collar was necessary in order to install the electric coil. Since the magnetic clutch pulley was tapered, the shaft of the compressor on which the pulley was mounted had to be machined to a taper shaft. Also, a 5/16" USS thread was tapped into the end of the shaft to secure the pulley and clutch assembly onto the shaft. The pulley rates were worked out 5" to 7-3/8" so that when the operator was driving 5 miles per hour the compressor would supply enough air to operate the spray gun for liquid larvicides as well as the compressed air granule gun.

To enable the operator to engage and disengage the compressor at his convenience, a switch was mounted on the dash for operation of the magnetic clutch. A warning light was installed to alert the operator when the compressor was in operation.

After installation of the compressor and magnetic clutch, we then mounted a 40-gallon compressed air spray tank. This tank will be used for oil insecticide. Equipped with a pressure regulator and filter, it will also act as an air reservoir for operating the air gun. So that both the air gun and spray gun could be hung in a position for easy handling, we mounted a bracket on the right side of the windshield frame. The spray gun was mounted on the side of the Jeep in a one-inch pipe bracket. A two-gallon portable granule container was also mounted on this side of the Jeep. This portable container holds 20 pounds of granules and permits the operator to spray granules from the moving vehicle or, when necessary to leave the vehicle, to treat sources at any distance from the vehicle depending on the length of 1/4" air hose provided.

We feel that the continuous supply of compressed air from this automatic unit has many advantages. It eliminates time lost in starting as well as mechanical failures of the conventional auxiliary engine. The unit requires a minimum of space and maintenance. There is no noise, and therefore a greater degree of traffic safety. Instruction time for temporary operators is also reduced. Our cost was only $160.00, including $80.00 for the compressor, $40.00 for the magnetic clutch, and $40.00 for the necessary machine work and mounting.

The only disadvantage of this air supply system is that the compressor is subject to excessive r.p.m. if the operator fails to disconnect the magnetic clutch before driving at speeds exceeding 15 m.p.h.

Although this unit has operated in the field satisfactorily we feel that a direct drive compressor without the magnetic clutch would provide the simplest and most foolproof operation for a continuous air supply. Consequently, we have not as yet adopted the above-described unit as standard equipment on our vehicles used for suburban mosquito control. We are now looking for a compressor of adequate capacity that can be driven directly off the engine of the Jeep Dispatcher. A TU-Flo 500, either air or water-cooled, has been recommended to meet our requirements and also to fit within the available space under the hood. We are awaiting a report on cost and availability of a standard kit that will permit installation in a Jeep DJ3A Dispatcher without any alterations other than moving the battery as described.

ORANGE COUNTY COMPRESSED AIR GRANULE GUN: DESIGN AND OPERATION

Jack H. Kimball and Albert H. Thompson
Orange County Mosquito Abatement District

The Orange County compressed air granule gun was successfully used during the 1961 season to apply 15 mesh granules to small roadside ditches and large flood channels for the control of mosquito larvae. One unit was in routine use by a seasonal operator covering a 24 square mile suburban area containing typical street gutter, catch basin, and roadside ditch sources.

A second unit was used by a permanent operator to treat large flood channels of varying widths, depths, and invert conditions. During these extended field trials there were no failures of either the granule gun used by the unskilled seasonal operator or by the permanent operator. However, continuous operation of this gun depends upon freedom from oversized granules. Insecticide purchase specifications should clearly indicate maximum size of granules.

Description of Granule Gun

The granule gun is assembled from commercially available parts costing approximately $100.00, not including the compressed air supply. A standard sandblast gun has been adapted to suck the granules from a simple container and to eject them at any desired uniform rate of discharge. For each type and size of granule the rate of discharge is determined by the following factors: (1) air pressure; (2) gun air jet diameter; (3) nozzle diameter; and (4) length of suction hose. The maximum effective throw from the gun is approximately 40 feet for 15 mesh sand core granules. The actual throw varies with the volume of air released by the gun, which is controlled by the jet size and the air pressure at the jet.

Design:

The maximum rate of air supply to meet our field conditions was found to be 5.8 cubic feet per minute of free air delivered at 70 pounds per square inch. Two hundred feet of 1/4" one braid air hose is used to permit treatment at that distance from the vehicle. The granules are fed to the gun through a short suction hose (1/4" i.d. windshield wiper hose) from a lightweight portable container. A standard two gallon gasoline can with 5/16" i.d. brass tube extending to the bottom and soldered in place serves as a convenient portable container with a capacity of twenty pounds of 15 mesh granules. A Kelco Model G790C sandblast gun equipped with 1/16" and 3/32" air jets used in combination with 3/16" and 1/4" tungsten carbide nozzles has proved a reliable and trouble-free metering device for granules of many types and sizes.

Calibration:

We have used the 15 mesh sand core granule produced by Durham Chemical Company to calibrate our gun. These granules produce very little dust as they pass through the ejector and are heavy enough to travel forty feet against a moderate breeze. Table I presents the rate of granule discharge in pounds per minute and the effective throw in feet for each air jet nozzle combination with air pressures at 30, 50, and 70 pounds using a short suction hose three feet long and a long suction hose of twelve feet.

TABLE 1.

Rates of discharge and effective throw using 15 mesh sand core granules, Orange County compressed air granule gun

Air Jet Diameter	1/16" Air Jet		3/32" Air Jet	
Nozzle Size Number	No. 3	No. 4	No. 3	No. 4
Effective Throw from Gun				
30 lb. Pressure at Jet	20 ft.	20 ft.	30 ft.	30 ft.
50 lb. " " "	25 ft.	25 ft.	40 ft.	40 ft.
70 lb. " " "	30 ft.	30 ft.	-------	-------
Rate of Discharge—lb./min. Long Suction Hose (12 feet)				
30 lb. Pressure at Jet	0.61	0.73	0.93	1.25
50 lb. " " "	1.18	1.17	1.30	1.78
70 lb. " " "	1.34	1.55	----	----
Rate of Discharge—lb./min. Short Suction Hose (3 feet)				
30 lb. Pressure at Jet	1.30	1.66	1.44	2.25
50 lb. " " "	1.57	2.39	1.72	2.88
70 lb. " " "	1.90	2.86	----	----

Operation of Granule Gun for Mosquito Control

The granule gun has been used very effectively for many breeding source problems, including preflood treatment of duck ponds. However, our purpose in perfecting this equipment was to increase the effectiveness and the efficiency of our routine treatment of streets drainage and flood channels through the use of granule larvicides. Standard treatment during the 1961 season was the application of 5% malathion sand core granules at the rate of ten pounds per acre for a dosage rate of 0.5 lb. of malathion per acre. Since each breeding source is physically different in size, shape, and distance from a moving vehicle, it is necessary for the mosquito control operator to determine the granule gun discharge rate that will produce the required treatment. To determine this factor the operator must first determine the swath width to be treated, the speed of travel (on foot or in a vehicle), and the maximum throw to give uniform distribution of granules. With these three job requirements determined, he refers to a "Field Guide for Mosquito Control Operator" (Table 2), to select the granule gun factors that will produce the gun discharge rate for the required treatment of that particular job. Table 2 presents a selected list of typical job requirements in Orange County.

Advantages and Disadvantages

The compressed air granule gun is a welcome addition to the District's assortment of larviciding equipment. Although it is no substitute for the mist-blower or the positive high pressure pump and the compressed air units for spraying many types of sources which require oil solution and water emulsion, the distribution of granules by compressed air had many advantages for the type of source described. The equipment is compact, light, and requires only routine maintenance. All component parts are commercially available at an initial investment much less than equivalent conventional liquid spray units. The weight of 5% malthion granules is only one-quarter of the weight of an equivalent water emulsion spray; 2% parathion granules would be only 1/8 as heavy as the water emulsion. Consequently our heavy trucks used for flood channels can be replaced with Jeeps that can carry a full day's supply of granules. The most important advantage over liquid spraying of flood channels is that the distribution of granules is not affected materially by breezes or updrafts within the channels. Consequently many channels can be treated from a moving vehicle on the bank that formerly had to be sprayed from the bottom. Also, the granules penetrate the grass and other vegetation which develops as the season progresses. The volume of liquid sprays has to be increased up to 10 or 15 gallons per acre as vegetation increases. Another advantage is that malathion granules applied for mosquito control have eradicated heavy infestations of chironomid larvae where ordinary oil solutions and water emulsions have been ineffective. This season the high percentage of complaints caused by chironomids has been practically eliminated.

The disadvantage of granules is, of course, the fact that their cost is considerably higher than liquid larvicides. Treatment by 5% malathion granules costs

TABLE 2.

Field guide for mosquito control operators: Distribution of 15 mesh sand core granules. Using Orange County compressed air granule gun for 10 lb./acre application rate.

JOB REQUIREMENTS			Gun Discharge Rate Required	GRANULE GUN FACTORS				Actual Gun Discharge Rate
Swath Width	Max. Throw	Travel Speed		Air Pressure	Jet Size	Nozzle Size	Suction Hose	
ft.	ft.	mph	lb./min.	psi.	in.	no.	ft.	lb./min.
By Moving Vehicle								
5	15	5	0.5	30	1/16	No. 3	12	0.61
10	20	5	1.0	50	1/16	No. 4	12	1.17
20	30	5	2.0	70	1/16	No. 3	3	1.98
30	40	5	3.0	50	3/32	No. 4	3	2.88
By Walking								
5	15		0.2		Use Horn Seeder			
10	20	2	0.4	30	1/16	No. 3	12	0.61
20	30	2	0.8	30	1/16	No. 4	12	0.73
30	40	2	1.2	50	3/32	No. 3	12	1.30
40	40	2	1.6	50	3/32	No. 3	3	1.72

$1.70 per acre as compared to $0.30 for DDT-toxaphene emulsion. Use of parathion granules in the future will reduce the cost to approximately $0.70 per acre and will reduce the application rate from ten to five pounds per acre as well. In spite of the material cost of granules, it is our feeling that the use of granules for mosquito control in street drainage and flood channels is economical because the granules have been extremely effective in the control of mosquito as well as chironomid larvae and because the Orange County compressed air granule gun permits positive application with light equipment and less effort by the mosquito control operator.

MOSQUITO AND CHIRONOMID LARVAE CONTROLLED BY GRANULE LARVICIDE APPLIED BY ORANGE COUNTY COMPRESSED AIR GRANULE GUN

JOHN G. SHANAFELT, JR.
Orange County Mosquito Abatement District

Excessive numbers of service requests were received by the Orange County Mosquito Abatement District and the Orange County Flood Control District due to large numbers of chironomids emerging from a flood control channel and invading the adjacent heavily populated subdivision. As a result, a special project was undertaken to control mosquito and chironomid larvae by the application of malathion granules.

The original breeding source was a 2.6 miles section of the Westminster Flood Control Channel. Except for a .3 mile concrete lined section, the channel was of earth. Twelve feet deep, thirty-five feet wide at the top and fifteen feet wide at the bottom, it carried off excess lawn irrigation water during the summer months. Early in the season the channel was vegetation free, except for moss on the bottom, and carried 3 to 6 inches of slow-moving water. Water was always present in the lower three-quarters; however, the upper quarter carried only an intermittent flow from sporadic irrigation practices of the residents. The amounts of granules applied varied with the amount of water present at the time of treatment.

The concrete lined section was constructed during the 1930's and had not been designed for mosquito or chironomid control. The lack of an access road prevented the use of mechanized equipment. Mud had a tendency to collect across the flat bottom, providing footing for weeds, as well as a very desirable habitat for chironomids. This section was treated by hand dispersal of the granules with a horn seeder.

Field tests run by Dr. L. D. Anderson and Dr. E. C. Bay, University of California Experiment Station at Riverside, indicated granular malathion and parathion to be of possible value. They suggested that either insecticide applied at the rate of one pound actual per acre should control chironomids. Since the District was using 5% malathion granules at the time, and a ready supply was available, this material was selected for the field applications. The application rate set was 20 pounds of 5% malthion granules per acre. Application was from the bank by a two-man crew working from a Jeep. The vehicle had been especially designed to provide constant air pressure to operate the Orange County compressed air granule gun. Each treatment was applied by the specially trained shop foreman. A necessary part of the shop foreman's training was to develop an ability to adapt the figures on "rates of granule discharge and effective throw" to field conditions, thus assuring the prescribed 20 lbs. of 5% malathion per acre of channel bottom.

In order to keep a close check on the project, routine treatment was eliminated in favor of "controlled" treatment. Applications were made only upon the District Entomologists's recommendation. Spot inspections were made routinely, but treatment was called for only when mosquito larvae had reached the third instar or when chironomids reached fourth instar. Pre-treatment inspection was facilitated by spot use of 8 lb. malathion mosquito larvicide (a considerable amount of emulsifier is necessary for good results), squirting a thin stream from a squeeze bottle across the stream bottom. If chironomid larvae are present they will leave the mud within a minute or two. Population estimates can then be made quite easily. Pre-treatment counts averaged 500 larvae per square foot.

Eight applications were made during the season. Two were for mosquito control only and one was limited to a 1.6 mile section of additional channel. The information in Table 1 covers the entire treatment period.

On two occasions a small pot-hole beneath a road crossing was overlooked and mosquitoes reached the pupal stage. These spots were treated by an applica-

TABLE 1.
Application of malathion granules for mosquito and chironomid control (1961).

No.	*Date*	*Material*	*Lbs. Used*	
1	Jul. 5	5% Mal. Volclay Granules	77.0	2.6 mi.
2	18	5% Mal. Sand Core Granules	48.0	
3	Aug. 2	" " " " "	48.0	
4	28	" " " " "	38.0	mosquito control only
5	Sept. 5	" " " " "	30.0	" " "
6	16	" " " " "	41.0	
7	Oct. 5	" " " " "	45.0	1.6 mi.-new section
8	20	" " " " "	88.0	4.2 mi.-old and new

tion of .2 lb./gal. malathion in diesel oil. The total amount used was 1 quart. As the season progressed, moss and weeds increased, and although the additional growth caused the rate of water flow to diminish and level to rise, no application problems were encountered with the granules.

Eight applications of malathion granules (20 lbs. of 5% malathion sand core granules per acre) applied by the Orange County compressed air granule gun controlled the emergence of chironomid larvae from the Westminster Flood Control Channel during the 1961 season. No service requests attributable to chironomids were received from the adjacent homes after the control program began.

USE OF AGE DETERMINATION TECHNIQUES TO LOCATE SOURCES OF *CULEX QUINQUEFASCIATUS*

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AND
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Culex pipiens quinquefasciatus Say is often associated with breeding sources that are not visible by surface inspection by mosquito abatement workers in California. These sources include irrigation pipe lines or irrigation tile drainage fields, and in urban areas, subterranean street drains, septic tanks, and cesspools with their attendant leach areas that might be exposed or broken at the surface. Since many mosquito sources of this kind are very difficult to find, it was thought that the age determination technique (Rosay, 1961) might be a valuable tool in determining whether adult mosquitoes found at a given resting place originated from a local or from a distant source. This would be especially significant for *C.p. quinquefasciatus* inasmuch as it has been generally accepted and demonstrated by mosquito control workers that this mosquito does not travel very far from its source.

The age determination technique uses gross anatomical changes to indicate the longevity of the specimens being studied. Characteristics include the degree of rotation of the male terminalia, the loss of pupal remnants in the form of muscle tissue in the abdomen, the presence of meconium, and the stage in the development of the female ovaries.

The area selected for applying this technique is a residential subdivision on the fringe of a dairy area. This area had given considerable trouble over the years. In 1961 it was decided to make an all out attempt to eliminate all possible mosuito sources. The dairies were carefully inspected and all possible sources were placed under a rigid, routine treatment and source reduction program. In addition, 52 premises were inspected by mosquito control personnel. In spite of excellent surface control, repeated complaints were received from several residences, the most persistent of which was surrounded on all sides by other homes. It was observed that all specimens were *C.p. quinquefasciatus*, predominantly males. The weather had turned cool and at times was cold; still mosquitoes occurred in substantial numbers.

Between October 27, 1961, and January 11, 1962, six collections were made from one premises. Of the various morphological characteristics that could be used, the simplest was found to be the degree of rotation of the male terminalia. Table I indicates the findings.

TABLE 1.
Hypopygial rotation of male terminalia, *Culex pipiens quinquefasciatus* males, Dairy Valley, California.

Date	*None*	*Partial*	*Complete*	*Total*
10/27/61	16	3	1	20
11/21/61	----	--	1	1
12/7/61	31	3	2	36
12/11/61	7	4	3	14
1/11/62	----	1	2	3
Totals	54	11	9	74

It is of interest, that only 9 of the 74 specimens from these five collections were completely rotated. Based upon Rosay's study of the effect of temperature on the time reuired for rotation, it was estimated that these males were no more than 53 hours old, probably less. The other significant fact was that all of the mosquitoes collected were of this one species, suggesting a hidden source or sources.

Several potential mosquito sources were located as a result of intensive inspection. On December 7, a reinspection revealed a possible source from a broken irrigation valve and a hidden standpipe approximately 100 yards south of the adult collection station. While no mosquito larvae or adults were taken from these two possible sources, it was also noted in subsequent inspections that these standpipes were still being used for irrigation purposes. After the fourth inspection on December 11, it was deduced that the mosquitoes were probably coming out of the vents from the sewer lines in the homes. As a result, ten vents in homes immediately surrounding the collecting station were capped with screen. Nevertheless, adult mosquitoes persisted. On January 11 a neighborhood survey was reinstituted. Directly behind the collection station another suspected source was found when one of the inspectors located a broken laundry drain pipe that was connected to an underground cesspool.

Although the degree of rotation of the male terminalia was relied upon to help solve this problem, female mosquitoes were also dissected. Of 12 females dissected, three had pupal musculature remnants, three had meconium present, and four had not taken a blood meal. Most appeared to be in the first cycle of ovarian development. Two were found to be in the second ovarian cycle based on the number of ovariole dilations. This would tend to corroborate the fact that the entire population was generally young.

Considerably more experience is needed to utilize female characteristics reliably. Nevertheless, we believe we can report some supporting data with a fair degree of assurance. Female characteristics will be used to a greater extent in future studies.

In conclusion, it is believed that based upon age determination techniques the population of adult *C. p. quinquefasciatus* mosquitoes was emerging from a newly discovered adjacent underground source. Based on the degree of rotation of the male terminalia, most of the males were less than 48 hours old. Dissections of 12 female mosquitoes for gross anatomical changes also indicated a young population originating from a nearby source.

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CHIRONOMID CONTROL WITH MALATHION GRANULES

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In the early spring of 1958, the Southeast Mosquito Abatement District received great numbers of service requests for abatement of large numbers of chironomids affecting residential areas that surround 1,000 acres of water spreading basins. These basins were used by the Los Angeles County Flood Control District to replenish underground water supplies. After preliminary investigation by our District and the Bureau of Vector Control, State Department of Public Health, recommendations were made to the Flood Control District that a research program be established under the direction of the University of California at Riverside. This recommendation was followed and a number of reports of research findings of the research team of Dr. L. D. Anderson and Dr. E. C. Bay have been reported in the literature and at meetings of the California Mosquito Control Association. Service requests have been received in increasing numbers regarding chironomids the past several years from every area of the District, and particularly from residential areas adjoining concrete lined open flood control channels. There are approximately 150 miles of these concrete lined channels with relatively flat bottoms and shallow slopes. Many of the channels have slopes of less than one foot per mile. Water from lawn drainage and other sources in these channels provides an ideal environment for growth of algae and deposition of silt. Water depth varies from one to six inches, with a silt and debris layer varying from one-half to two inches in depth. This silt layer provides an ideal environment for production of chironomids of various species. In addition, good conditions for production of mosquitoes are provided.

Since the District was already involved in the abatement of mosquitoes in these channels, it followed that control of chironomids should be undertaken with the hope that both insects could be controlled simultaneously. Several excellent recommendations of the University of California at Riverside regarding rough fish, such as carp and catfish, for biological control could not be followed in this program due to the shallowness of the water. Investigation was then initiated on the use of malathion formulations for control.

Malathion was selected since it had shown some promise in Dr. Bay's work, both as an emulsion and in granular form. Application methods for granules were investigated. These included hand operated rotary spreaders, horn seeders, granule injection in mist blower air blast, and granule injection by means of sand blasting guns. Hand operated rotary spreaders and horn seeders were discontinued due to excessive labor demands and uneven rate of application. Excellent results were obtained using sand blast guns. Techniques of development and use of this method have been reported at this meeting by J. H. Kimball, Manager of the Orange County Mosquito Abatement District.

Several reports indicating ineffectiveness of 5% malathion coated sand granules were received, so it was decided to experiment with different mesh sand granules as well as with emulsion. The area selected for testing these formulations was a ten acre expanse of water in the bed of the San Gabriel River adjoining 7th Street in Long Beach. Water depth varied from one inch to four feet. The water expanse was featured by general open area with very little algae or plant growth at the shore line. Approximately one to four inches of silt overlay the sand bottom.

Materials used included an 8 pound malathion emulsion applied at the rate of one pound of active material per acre, 5% malathion coated sand granules (10-20 mesh), and 5% malathion coated sand granules (20-30 mesh) applied at the rate of one pound of active material per acre. The emulsion was applied with a Bean power spray unit and the granules by means of a sand blast nozzle with a No. 4 aperture.

Results of the three formulations used revealed that the malathion emulsion gave less than 10% reduction in chironomid numbers, the 10-20 mesh granules gave approximately 90% reduction, and the 20-30 granules gave almost 100% control. These control percentages were observed at 96 hours after treatment. Chironomid larvae counts gradually increased after this period to former counts at the end of 14-21 days after treatment.

Conclusions

Poor results with malathion emulsion were no doubt due to insufficient material at interface of water and surface of silt layer. Since silt under the conditions stated is very soft, it would follow that more effective results could be expected with finer mesh granules since there would be less tendency for them to settle through the top silt surface and away from the chironomid larvae. Thus, the zone of dispersion of insecticide would be less than that settled on the surface and adjacent to the larvae.

The effective prevention of emergence of adults by the 20-30 mesh material for approximately two weeks is accounted for by virtue of approximately 100% kill of larvae. Reinfestation occurs approximately 48 to 96 hours after treatment so that new emergence of adults would occur in 12-21 days depending on water temperatures and the particular life cycles of the species of chironomids present.

AN INEXPENSIVE, DISPOSABLE TRAP FOR ODOR-SEEKING INSECTS

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The trap described here was designed primarily for use as a placebo for harassed residents of Borrego Valley until adequate control of *Hippelates* eye gnats could be achieved by more basic methods. Observation of the trap under field conditions has, however, indicated that it may have value in entrapping insects beyond its originally conceived function.

Materials. The trap consists of two 1-pint polystyrene food jars, a paper-and-cloth paint strainer with a ¼-in. hole cut out at the apex, a 4½-in. length of bailing wire and a bent paper clip.

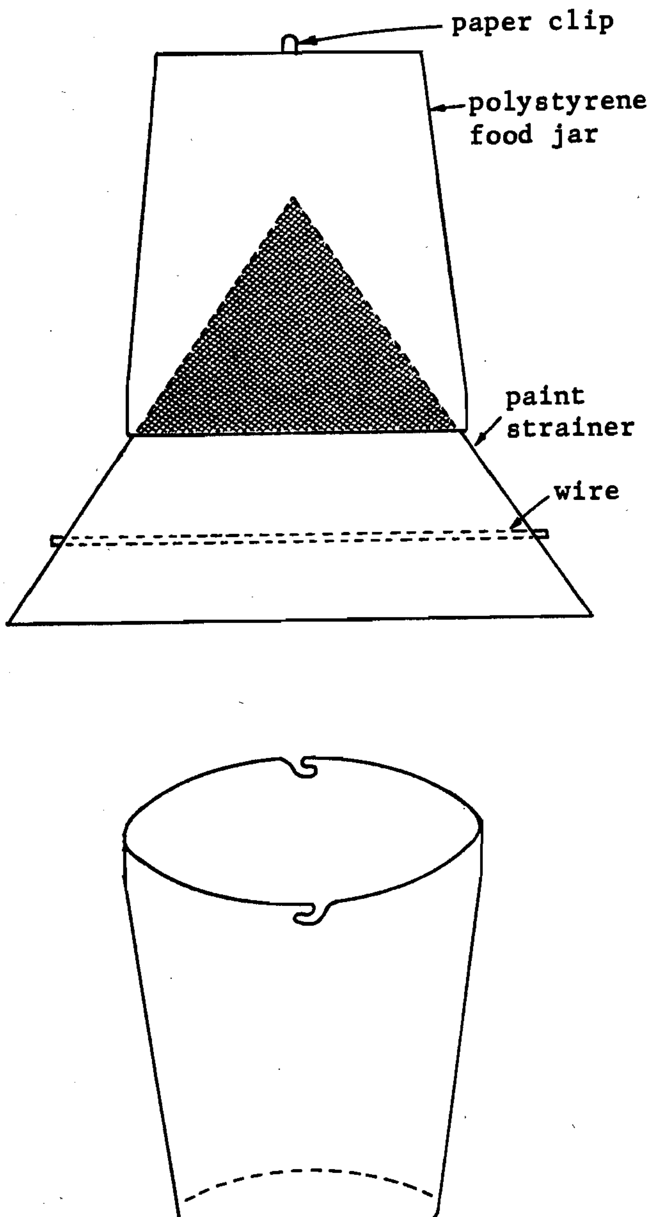

Figure 1.
The Borrego trap

Construction. Roughen the inside rim of one of the cups with a knife blade. To this surface apply a coat of polystyrene cement. Attach the paint strainer to this surface immediately so that the cloth part of the strainer is inside the jar. Place this assembly, cone base down, on a work area. Bend the paper clip into a 'T', apply a dollop of cement to the bottom of the cone-jar assembly, and attach the 'T' shaped paper clip upside down; this is the attachment from which the completed trap is hung. At a point 1⅜ in. from the base, pierce the cone with the length of bailing wire. Push the wire all the way through, piercing the cone at precisely the same point on the opposite side. Leave the wire in place, and apply small dollops of cement to each end so that it will remain in place inside the skirt of the cone. This is the hanger for the bait jar. Dip the skirt of the cone in black paint up to the point where the cone attaches to the jar. (This step can be eliminated if one can obtain black paint strainers with white cloth for the screen.) At this point the upper part of the trap is finished.

Turning to the other cup, heat a steel rod (an ice-pick will do nicely) and apply it to the rim of the cup, burning an 'ear' into the rim. Do the same to the other side of the rim, making certain that the 'ears' are directly opposite each other and that they are mirror images. The trap (Fig. 1) is now complete.

Fill this cup with the desired quantity and quality of bait, and screw the 'ears' onto the wire in the cone-jar which has been hung from any desired support.

The trap is used with some success to reduce eye gnat populations around homes in Borrego Valley, but it might be found useful by others for the purpose of entrapping certain other flying insects which are responsive to olfactory stimulation.

The main advantages of the trap are: it works; it is neat, light, and easy to transport; it is remarkably inexpensive and all of its component parts are readily available. (One trap can be made for about 15¢ and an expenditure of five minutes time. Two hundred and fifty traps can be made for about 10¢ each with a corresponding reduction in time of labor per trap.)

The observed disadvantages of the trap are: it is only 80% as efficient as the Tinkham trap; it is so fragile that its period of usefulness averages only one month in Borrego Springs area; and insects are more difficult to remove than from the Tinkham trap. Most of these disadvantages could, however, be eliminated by simple and obvious modifications to adapt the trap to the specific purposes of the user.

BACTERICIDAL EFFECTS OF INSECTICIDES AS RELATED TO OVIPOSITION BY MOSQUITOES

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Investigations completed by the author have shown that the oviposition behavior of certain species of mosquitoes may be influenced by the products of bacterial metabolism occurring in natural waters. These investigations have shown that the products of bacterial fermentations taking place in the soil beneath the water of mosquito habitats may be the principal attractants for ovipositing females of *Culex peus* Speiser.

The relative concentrations of these decomposition products have been manipulated by providing extra fermentable materials to the soils or by slowing the subsequent decomposition of the fermentation products. Killing the bacteria of the surface water which would ordinarily degrade the fermentation products accomplishes the latter (Gerhardt 1957, 1959).

Field trials have shown that surface water treated with a variety of algicides, most of which are also good bactericides, is much more attractive for oviposition by *Culex tarsalis* Coq. than untreated water (Gerhardt 1957).

Thus, a variety of bactericidal agents may well act similarly to increase the attractiveness of natural breeding waters. There is some evidence that certain insecticides commonly used in mosquito control may act in this manner and result in increased mosquito production after the immediate effect has dissipated (Gerhardt 1956).

The question arises: what is the relative bactericidal power of the various insecticides often applied to mosquito breeding waters and are some likely to produce exaggerated oviposition responses?

Methods

A series of insecticides was prepared in various replicated dilutions. All insecticides were technical grade materials without the usual adjuncts to formulation. Each insecticide was prepared in acetone and added to samples of natural water so that the final dilutions ranged from 1 part per 1,000 to 1 part per 10,000,000. These samples were then incubated for 48 hours at 37°C.

Following incubation, the samples were filtered through membrane (Millipore) filters. The filters were stained with fast green dye and mounted on slides. A direct microscopic count was made of the bacteria thus filtered.

The natural water used in the experiment contained an average of 54 microorganisms per unit of membrane filter surface. Millipore filters are marked so that each square unit represents 1/100th of the total filter area or about $3mm^2$.

The counts obtained in like manner from the treated samples, were compared with the normal count.

Results

The concentrations at which significant reduction in numbers of microorganisms occurred is recorded in Table 1.

TABLE 1.

Concentrations of insecticides which show significant bactericidal action.

Chlorinates		*Phosphates*	
DDT	1:100,000	Malathion	no sig. action
Dieldrin	1:1,000,000	Parathion	1:1,000
Chlordane	1:1,000,000	Systox	1:1,000
Endrin	1:1,000,000	Trithion	no sig. action
Toxaphene	1:10,000,000	Thimet	no sig. action

Discussion and Conclusions

There is little doubt that the chlorinated hydrocarbons tested possess considerable bactericidal power. Contrasted with this is the relative ineffectiveness of the organic phosphates in achieving a kill of naturally occurring microorganisms. These findings are understandable since many compounds of chlorine are effective germicides.

It is entirely possible that treatment of natural mosquito breeding places with chlorinates may alter these environments in such a manner as to render them even more attractive for mosquito breeding.

During 1955 and 1956 the author completed some experiments relating the effects of insecticide treatments on invertebrate predator populations and mosquito larvae in breeding water. In view of these new findings it seems that the data presented on the predator-insecticide relationships cannot be interpreted directly. Reexamination of the data collected during 1955 and 1956 has indicated that the unusually high mosquito populations encountered after treatment with DDT were due to exaggerated oviposition responses rather than to a lessening of predator pressure.

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RESISTANCE OF MOSQUITOES TO INSECTICIDES IN CALIFORNIA: A REVIEW

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This review was undertaken as a project of the Research and Development Committee of the American Mosquito Control Association. The objective of the Committee was to compile a list of susceptibility levels of mosquitoes of North America to various insecticides as an aid for mosquito control workers. The present paper is a compilation of all published susceptibility levels which have been measured in California. It includes some unpublished material of L. L. Lewallen and references to all pertinent work on insecticide resistant mosquitoes in California as well as comments on insecticides presently in use, and the results of a survey of experience by local mosquito abatement agencies. My thanks are extended to L. L. Lewallen, D. C. Mengle and C. M. Gjullin for aid in compiling the material, and to the mosquito abatement workers who aided in the survey. Wherever possible dosage mortality lines were replotted from published data and standard errors of the LC_{50} were estimated by the method of Litchfield and Wilcoxon

(1949). Except when standard errors are given, all LC_{50}'s have been rounded to one significant figure.

The use of modern, synthetic insecticides for mosquito control in California dates from 1945 when DDT was first used (Gjullin and Peters 1952b). Prior to that time oils, Paris green, pyrethrum, cresylic and phenolic acids, and copper sulphate had been used to kill mosquitoes but dosage-mortality data for that period are lacking. DDT and, to a lesser extent, other chlorinated hydrocarbons were the most commonly used insecticides in California from about 1946 until resistance problems vitiated their use. Organphosphorous larvicides were first used in 1952 and have since become the most commonly used insecticides for mosquito control in the state although chlorinated hydrocarbons are still used to a certain extent. Mosquito control in the state can thus be divided into three eras: the pre-DDT era, the DDT era, and the organic phosphate era, with the DDT era extending from about 1946 to 1952.

Insecticide Resistance in Mosquito Abatement Agencies

Chlorinated Hydrocarbon Insecticides—DDT

A questionnaire was circulated to all local agencies engaged in the control of mosquitoes to learn how much testing for resistance had been done. There were 35 responses to this questionnaire of which 18 indicated resistance problems. No agency reported having used WHO test kits for larvae or adults and only 7 indicated that laboratory testing had been done on mosquitoes from their control area. The surprising finding was that only half of the agencies reporting had experienced control problems having to do with resistance. The geographical representation of these agencies is shown in Table 1. It will be noticed that most agencies in the San Joaquin Valley reported resistance problems but less than half of the agencies in other areas have had this difficulty. This is in accord with the prevailing belief that control has been most intensive and of longest duration in the San Joaquin Valley.

Summary of Reported Susceptibility Levels

As previously noted, DDT was first used in California in 1945. It was the principal insecticide in use from 1946 to 1949 after which it began to be replaced by other chlorinated hydrocarbon and phosphate insecticides. The first published report of resistance to this insecticide in Californian mosquitoes was by Smith (1949); laboratory confirmation was provided by Bohart and Murray (1950). DDT failures were commonly experienced in the Central Valley in 1950-51. Replacement insecticides began to be used in the San Joaquin Valley in 1949 and in the Sacramento Valley somewhat later. DDT is still fairly widely used in mountainous and coastal areas and in southern California.

TABLE 1.
Agencies Reporting Resistance Problems by Geographical Area

Area	No. Reporting	No. with Resistance	Percent
Coastal	5	2	40
Sacramento Valley	11	5	45
San Joaquin Valley	11	9	82
Southern California	8	2	25
Totals	35	18	51

Aedes nigromaculis (Ludlow). Early susceptibility tests of Bohart and Murray (1950) indicate LC_{50}'s of .004 to .008 ppm (Table 2). Later tests by Gjullin and Peters (1952b) indicated that larvae from untreated areas had susceptiblities of .01 to .04 ppm, and by Gjullin (1956) .04 to .07 ppm. The natural susceptibility to DDT of this species seems to have been .005 to .01 ppm although such LC_{50}'s have not been encountered in recent years. Much of this resistance is undoubtedly due to agricultural pest control since it also occurred in areas where mosquitoes had not been controlled (Gjullin 1956). Taking .01 ppm as a base line, resistant strains have LC_{50}'s of .03 to 0.3 ppm and have been demonstrated in Tulare (1949, 1951, 1955), Kern (1951, 1956), Kings (1951), Madera (1951), Merced (1951, 1955), and Fresno (1951, 1956) Counties. Bohart and Murray (1950) stated that resistant strains were also resistant to TDE but could be controlled with toxaphene.

Aedes melanimon Dyar. Gjullin and Peters found that strains from untreated areas had an LC_{50} of .03 ppm (Table 3). Strains from treated areas had LC_{50}'s of .09 to .3 ppm. These resistant strains were from Kern and Merced Counties.

Aedes squamiger (Coquillett) and *A. dorsalis* (Meigen). LC_{50}'s .031 (.028-34) and .0056 (.0051-62 ppm respectively according to Bohart (1948a,b).

Culex tarsalis Coquillett. The most susceptible strains yet encountered have LC_{50}'s of .009 to .03 ppm (Table 4). Such strains were originally tested by Gjullin and Peters 1952b) but have also been found in recent years (1958) by Lewallen in Fresno, Madera and Butte Counties. A range of LC_{50}'s has been found extending from .009 to .2 ppm. Two highly resistant strains have been studied, one from Kern Co., by Isaak (1956) and one from Santa Clara Co. by Lewallen in 1959. If .01 to .03 ppm is taken as the original level of susceptibility (Gjullin and Peters 1952b), resistant strains have LC_{50}'s extending from .04 to 3 ppm and have been found in Fresno (1951, 1956, 1957), Kern (1951, 1955), Tulare (1955), Merced (1955), Madera (1957), Solano (1958), Butte (1957), Monterey (1957, 1958), Yolo (1957, 1958), and Santa Clara 1958, 1959) Counties.

Isaak (1952) found that resistant *C. tarsalis* were not controlled with heavy applications of dieldrin. Gjullin (1954a,b) also demonstrated DDT-resistance in adults of *C. tarsalis* but found they were killed by EPN or malathion. Lewallen (1960) found that when a Fresno strain lost its resistance to malathion it also showed a normal susceptibility to DDT.

Culex pipiens Linn. subsp. Most figures for this species probably pertain to *C. p. quinquefasciatus* Say. The lowest LC_{50}'s encountered in California have been about .03 ppm (Table 5). The most resistant strain reported had an LC_{50} of 1 ppm. A strain having an LC_{50} of .3 ppm was found, after 8 to 10 generations in the laboratory without selection, still to have an LC_{50} of .3 ppm (Lewallen 1960).

Culex peus Speiser. Only one LC_{50} noted, .05 ppm

TABLE 2. LC_{50}'s of DDT to *Aedes nigromaculis*

Locality	Further Identification	Year	LC_{50}	History	Ref.
County					
Tulare	Field 1	1949	.004	uncontrolled	4
Tulare	Field 2	1949	.004	uncontrolled	4
Tulare	Fields 1 & 2	1949	.007	uncontrolled	4
Tulare	Field 3	1949	.008	uncontrolled	4
Kern	Sargent Ranch	April 1951	.01	uncontrolled	15
Kern	Sargent Ranch	Aug. 1951	.01	uncontrolled	15
Kings	— —	May 1951	.01	uncontrolled	15
Fresno	— —	July-Aug. 1951	.01	uncontrolled	15
Tulare	Field 4	1949	.03	DDT control	4
Tulare	Field 5	1949	.03	DDT control	4
Kern	Peacock-Canfield	April 1951	.03	DDT control	15
Kings	— —	Sept. 1951	.04	uncontrolled	15
Tulare	Fields 4 & 5	1949	.04	DDT control	4
Tulare	— —	1955	.04	uncontrolled	11
Merced	— —	1955	.05	DDT control	11
Tulare	Delta & Tulare Districts	May 1951	.06	DDT control	15
Tulare	Tulare District	Sept. 1951	.06	DDT control	15
Kern	Canfield	Aug. 1951	.07	DDT control	15
Merced	— —	1955	.07	Uncontrolled	11
Madera	Madera MAD	May-June 1951	.08	DDT control	15
Kern	Lane-Trout	April 1951	.08	DDT control	15
Kern	Peacock-Canfield	Aug. 1951	.09	DDT control	15
Merced	Merced MAD	July-Aug. 1951	.09	DDT control	15
Madera	— —	July-Aug. 1951	.09	DDT control	15
Tulare	— —	1955	.09	DDT control	11
Tulare	Delta Alkali Flat	Sept. 1951	.1	DDT control	15
Fresno	Consolidated & Fresno MAD's	May-June 1951	.1	DDT control	15
Fresno	Fresno MAD	1956	.1	DDT control	12
Kern	— —	1956	.1	DDT control	12
Kern	— —	1956	.1	uncontrolled	12
Merced	Hilmar	July-Aug. 1951	.1	DDT control	15
Merced	— —	1955	.2	DDT control	11
Tulare	Field 6	1949	.3	DDT control	4

(.041-.081) for a strain from Tulare Co. in 1959 (Lewallen, unpublished).

Culiseta incidens (Thomson). LC_{50} .018 (.015-22) ppm according to Bohart (1948b). Soroker (1951) found LC_{50}'s of .06 and .07 ppm with DDT in xylene and acetone, respectively. When Lethane 384 was combined in equal proportions with DDT or at 1 part to 3 of DDT the LC_{50}'s were .05 and .04 ppm, respectively. DDT dissolved in Lethane 384 had an LC_{50} of .03 ppm for this species.

A summary of susceptibilities of Californian mosquitoes to DDT is shown in Table 6. Findings have been reported for eight species but numerous determinations are available for only four. In these four species, *Aedes nigromaculis, A. melanimon, Culex tarsalis,* and *C. pipiens,* resistance of 10 to 333 times has been found. Natural susceptibilities seem to range from .004 to .05 ppm and the most resistant form yet examined is a strain of *C. tarsalis.*

TABLE 3.
LC_{50}'s of DDT to *Aedes melanimon.**

Locality	Further Identification	Year	LC_{50}	History
County				
Kern	Sargent Ranch	1951	.03	uncontrolled
Kings	— —	1951	.03	uncontrolled
Kern	Greenfield Ranch	1951	.09	DDT control
Merced	Merced MAD	1951	.1	DDT control
Merced	Hilmar	1951	.3	DDT control

*From Gjullin and Peters (1952b).

Toxaphene

This insecticide was used fairly widely in 1949 and occasionally after that time. It is still used by some agencies, especially in combination with DDT. Bohart and Murray (1950) reported that DDT resisant *Aedes nigromaculis* could be controlled with toxaphene.

The LC_{50}'s which have been established for Californian species are shown in Tables 7 to 10. In addition, Soroker (1951) reported an LC_{50} of .2 ppm for *Culiseta incidens.* These data are summarized in Table 11 from which it is apparent that resistance has been demonstrated in *C. tarsalis* and possibly *A. nigromaculis* and *C. pipiens* as well. It is questionable whether resistance has been demonstrated in *A. melanimon*.

Lindane

This insecticide has never been widely used in a program in California although it has been used occasionally in most agencies. LC_{50}'s which have been determined for various species are shown in Tables 12 to 15. In addition, Soroker (1951) reported an LC_{50} of .2 ppm for *Culiseta incidens*. Gjullin (1954) found that *Culex tarsalis* adults were resistant to residues of all chlorinated hydrocarbons tested except lindane; such adults were also susceptible to EPN and malathion.

A summary of the susceptibilities is given in Table 16 from which it can be seen that *C. tarsalis* and *C. pipiens* have been shown to be resistant as also probably *A. nigromaculis*.

Aldrin

This insecticide has never been widely or intensively used for mosquito control in California. Susceptibilities of several species are shown in Tables 17 to 20. Soroker (1951) reported an LC_{50} of .007 ppm for *Culiseta incidens*. A summary of these data is shown in Table 21 from which it can be seen that a high degree of resistance has been found only in *C. tarsalis*. A low degree of resistance may be indicated for *A. nigromaculis* as well.

Heptachlor

This insecticide has been infrequently used for mosquito control in California. The LC_{50}'s which have been determined are shown in Table 22. The high resistance of *C. tarsalis* was probably induced by lindane or some other cyclodiene insecticide (Gjullin and Peters 1952b). The *C pipiens* from Kings County may also have been resistant.

Other chlorinated hydrocarbons

TDE, dieldrin, and Perthane have also been used to a limited extent in California. Bohart (1948a) determined the LC_{50}'s of TDE to *Aedes squamiger* and *A. dorsalis* to be .0092 (.0077-110) and .0018 (.0016-20) ppm, respectively.

Soroker (1951) reported the following series of LC_{50}'s to *Culiseta incidens* from Solano Co.: dieldrin (497) .05 ppm, Perthane (Q 137) .3 ppm; TDE .5 ppm, and HE-761>1 ppm. Herms (1946) reported an LC_{90} of TDE of less than .2 ppm for this species.

Bohart (1950) mentions LC_{50}'s of aldrin, TDE, chlor-

TABLE 4. LC_{50}'s of *Culex tarsalis to DDT*.

Locality	Further Identification	Year	LC_{50}	C. L.	History	Ref.
Kern	Poso Creek	Apr. 1951	.009	— —	uncontrolled	15
Fresno	— —	1958	.01	(.008-.018)	— —	25
Madera	Berenda	1958	.02	(.012-.024)	— —	25
Kern	Poso Creek	Aug. 1951	.02	— —	uncontrolled	15
Butte	Biggs	1958	.02	(.019-.033)	— —	25
San Diego	Del Mar	1957	.03	(.021-.041)	— —	25
Kern	Pintail Duck Club	Aug. 1951	.03	— —	DDT control	15
Kings	— —	Aug. 1951	.03	— —	uncontrolled	15
Riverside	Thermal	1957	.03	(.022-.049)	— —	25
Madera	Berenda	1957	.04	(.026-.058)	— —	25
Solano	Dixon	1958	.04	(.026-.067)	— —	25
Butte	Biggs	1957	.05	(.026-.083)	— —	25
Fresno	Fresno & Consol. MAD's	June 1951	.06	— —	DDT control	15
Kern	Paloma Field & Stockdale Road	Aug. 1951	.06	— —	DDT control	15
Kern	Peacock Ranch	Apr. 1951	.08	— —	DDT control	15
Fresno	Consolidated MAD	Apr. 1951	.08	— —	DDT control	15
Monterey	Salinas	1958	.08	(.074-.089)	— —	25
Yolo	Davis	1957	.09	(.064-.14)	— —	25
Kern	Klipstein Duck Club	1951	.1	— —	DDT control	17
Tulare	— —	1955	.1	— —	DDT control	11
Santa Clara	Palo Alto	1958	.1	(.06-.18)	— —	25
Yolo	Davis	1958	.2	(.10-.26)	— —	25
Monterey	Salinas	1957	.2	(.14-.23)	— —	25
Fresno	— —	1957	.2	(.19-.23)	— —	25
Kern	Ware Duck Club	Aug. 1951	.2	— —	DDT control	15
Tulare	— —	1955	.2	— —	Uncontrolled	11
Merced	— —	1955	.2	— —	DDT control	11
Fresno	Fresno MAD	1956	.2	— —	DDT control*	12
Santa Clara	Palo Alto	1959	3.	(2.1-3.5)	— —	25
Kern	— —	1955	3.	— —	DDT control*	18

*(Relaxed several years)

dane, DDT, lindane, and toxaphene for *Aedes squamiger, A. dorsalis, A. nigromaculis, Culex peus, C. tarsalis*, and *Culiseta incidens*. His overall results were that aldrin was the most effective insecticide tested, with TDE and chlordane next, and DDT, lindane, and toxaphene poorest. He also mentioned that *Culiseta incidens* and *Aedes squamiger* were the most difficult species to kill and *Aedes nigromaculis* was not especially difficult.

Organic phosphate insecticides - malathion

This insecticide was first used for mosquito control in 1953 and 1954 and has since been widely used. There have been notable failures with *Culex tarsalis* (Gjullin and Isaak 1957), *Culex pipiens quinque fasciatus* (Isaak 1961), and *Aedes nigromaculis* (Lewallen 1961).

A. nigromaculis. LC_{50}'s of susceptible strains range from .003 to .04 ppm (Table 23). The highest LC_{50} measured is .1 ppm; this resistant strain is discussed by Lewallen (1961).

C. tarsalis. The lowest LC_{50}'s encountered are in the range .004 to .01 ppm but a graded series of LC_{50}'s has been found up to .09 ppm (Table 24). The malathion resistant Fresno strain has proved to have LC_{50}'s as high as .3 ppm (Gjullin and Isaak 1957). This strain appears to convert malathion to malaoxon as does the susceptible strain (Lewallen and Nicholson 1959b). Lewallen (1960) tested samples from the field where resistance was originally found in 1956 at intervals during the summer of 1959 and found susceptibilities of .004 to .03 ppm which must be considered in the range of normal susceptibility.

Gjullin *et al.* (1953) established that less malathion was required to kill larvae at 90° than at 70° F. Gjullin (1954) found that DDT resistant adults could be controlled with malathion. Gjullin and Isaak (1957) (also in Geib *et al.* 1957) showed that the resistance of the Fresno strain extended to adults as well as larvae. Lewallen (1960) found that in the absence of selection in the laboratory the resistance of the Fresno strain decreased from .2 ppm to normal susceptibility.

Culex pipiens subsp. Isaak (in Geib *et al.* 1957) reported an LC_{50} of .1 ppm for a susceptible strain from Bakersfield. Mulla *et al.* (1961) and Georghiou and Metcalf (1961b) reported LC_{50}'s of .07 and .08 respectively for the same strain. Mulla *et al.* (1961) reported failures with this insecticide in Kern Co. in 1959. Lewallen (unpublished) reported an LC_{50} of .003 ppm (.0023-.0038) for a Fresno strain in 1958.

Culex peus. Lewallen (unpublished) established the LC_{50} of a Tulare strain collected in 1957 to be .05 ppm (.029-85).

A summary of susceptibilities of various species to this insecticide is shown in Table 25. Resistance has been demonstrated in *Aedes nigromaculis* and *Culex tarsalis* and may occur in *Culex pipiens* as well.

Parathion

This insecticide came into use about 1954 and has been widely used since, especially in the San Joaquin Valley.

Aedes nigromaculis. The lowest LC_{50}'s found are .00003 to .0003 ppm (Table 26). The higheset LC_{50}'s range from .001 to .004 ppm and these strains were from Kings and Tulare Counties. The early values reported by Gjullin and Isaak (1957) ranging from .002 to .007 ppm are very high and probably due to field-collected larvae and tap water having been used; their tests were also run at a somewhat higher temperature than were those of Lewallen and their criterion of survival was somewhat more conservative. Lewallen first reported resistance in this species from Kings Co. (Lewallen and Brawley 1958) and later from Tulare Co. (Lewallen and Nicholson 1959a, Lewallen 1961). The resistant strains showed a normal susceptibility to Guthion and malathion although they seemed to show some tolerance for ronnel and possibly

TABLE 5.
LC_{50}'s of DDT to *Culex pipiens* subsp.

Locality	Further Identification	Year	LC_{50}	C.L.	History	Ref.
County						
Tulare	#2 Ranch	Sept. 1951	.03	— —	DDT control	15
Kern	Bakersfield	1959	.03	— —	uncontrolled	33
Solano	Dixon	1958	.04	(.028-.047)	— —	25
Tulare	Visalia Sewer Farm	Sept. 1951	.05	— —	DDT control	15
Fresno	Consolidated MAD	Sept. 1951	.06	— —	DDT control	15
Merced	Cannery Waste	July 1951	.06	— —	DDT control	15
Madera	Madera Sewage Plant	Oct. 1951	.07	— —	DDT control	15
Kings	McCuen Ranch	Sept. 1951	.08	— —	DDT control	15
Fresno	Firebaugh Sewage Plant	Oct. 1951	.08	— —	DDT control	15
Santa Clara	Palo Alto	1959	.1	(.08-.17)	DDT control	25
Santa Clara	Mountain View	1958	.2	(.12-.21)	— —	25
Orange	— —	1958	.3	(.28-.32)	DDT control	25
*Orange	— —	1959	.3	— —	DDT control	22
Santa Clara	Palo Alto	1958	.1	(.81-2.1)	DDT control	25

*Incorrectly reported as 3.0

Trithion (Lewallen and Nicholson 1959a). The resistant strains were controlled with a mixture of methyl and ethyl parathion (4:1) although more highly resistant straisn seem to show a tolerance for methyl parathion (Lewallen, unpublished).

Aedes squamiger. Bohart (1948b) established an LC_{50} of .0047 (.0043-52) ppm for this species.

Culiseta incidens. Bohart (1948b) and Soroker (1951) found LC_{50}'s of .0056 (.0046-69) and .008 ppm, respectively for this species.

Culex tarsalis. A graded range of LC_{50}'s from .00007 to .001 ppm has been established for this species (Table 27). The high LC_{50}'s of Gjullin and Isaak (1957) and Isaak (1961) are probably due to aforementioned conditions. Isaak (1961) mentions a 2 to 3 fold resistance of this species in Kern Co.

Culex pipiens. Lewallen (unpublished) records one LC_{50}, .001 ppm (.0009-13), in a strain from Visalia tested in 1958. Georghiou and Metcalf (1961b) and Mulla *et al.* (1961) found LC_{50}'s of .003 and .004 ppm respectively for a susceptible strain from Bakersfield. Isaak (1961) mentions a 2 to 3 fold resistance of this species in Kern Co.

TABLE 6.
Summary of susceptibilities of various mosquitoes to DDT and degrees of resistance found.

Species	Lowest LC_{50} (ppm)	Highest LC_{50} (ppm)	Ratio
Aedes nigromaculis	.004	.3	75
melanimon	.03	.3	10
squamiger	.03	— —	— —
dorsalis	.006	— —	— —
Culex tarsalis	.009	3.	333
pipiens	.03	1.	33
peus	.05	— —	— —
Culiseta incidens	.02	.07	3.5*

*Probably due to technique

TABLE 7.
LC_{50}'s of toxaphene to *Aedes nigromaculis.*

Locality	Further Identification	Year	LC_{50}	History	Ref.
County					
Tulare	Fields 4 and 5	1949	.006	DDT control	4
Tulare	Fields 1 and 2	1949	.01	Uncontrolled	4
Kern	Sargent Ranch	April 1951	.01	uncontrolled	15
Kern	Peacock-Canfield	April 1951	.01	DDT control	15
Fresno	— —	July-Aug. 1951	.01	uncontrolled	15
Kern	Sargent Ranch	Aug. 1951	.02	uncontrolled	15
Fresno	Consol. & Fresno MAD's	May-June 1951	.02	DDT control	15
Tulare	Delta & Tulare MAD's	May 1951	.02	DDT control	15
Tulare	Tulare MAD	Sept. 1951	.02	DDT control	15
Kings	— —	May 1951	.02	uncontrolled	15
Kings	— —	Sept. 1951	.02	uncontrolled	15
Madera	Madera MAD	May-June 1951	.02	DDT control	15
Merced	Merced MAD	July-Aug. 1951	.02	DDT control	15
Merced	Hilmar	July-Aug. 1951	.02	DDT control	15
Kern	Canfield	Aug. 1951	.03	DDT control	15
Kern	Lane Trout	April 1951	.05	DDT control	15
Kern	Peacock-Canfield	Aug. 1951	.05	DDT control	15
Tulare	Delta Alkali Flat	Sept. 1951	.08	DDT control	15

TABLE 8.
LC_{50}'s of toxaphene to *Aedes melanimon.**

Locality	Further Identification	Year	LC_{50}	History
County				
Kings	— —	May 1951	.02	uncontrolled
Kern	Sargent Ranch	Apr. 1951	.04	uncontrolled
Kern	Greenfield Ranch	Apr. 1951	.04	DDT control
Merced	Merced MAD	July-Aug. 1951	.05	DDT control
Merced	Hilmar	July-Aug. 1951	.05	DDT control

*From Gjullin and Peters (1952b).

Table 9.
LC_{50}'s of toxaphene to *Culex tarsalis.**

Locality	Further Identification	Year	LC_{50}	History
County				
Kern	Poso Creek	1951	.01	uncontrolled
Kern	Peacock Ranch	1951	.01	DDT control
Fresno	Fresno & Consol. MAD's	1951	.02	DDT control
Fresno	Consolidated MAD	1951	.02	DDT control
Kings	— —	1951	.02	uncontrolled
Kern	Poso Creek	1951	.03	uncontrolled
Kern	Paloma Field & Stockdale Road	1951	.04	DDT control
Kern	Pintail Duck Club	1951	.3	DDT control
Kern	Ware Duck Club	1951	1.	DDT control

*From Gjullin and Peters (1952b).

Table 10.
LC_{50}'s of toxaphene to *Culex pipiens* subsp.

Locality	Further Identification	Year	LC_{50}	C.L.	History	
County						
Merced	Cannery waste	1951	.03	— —	DDT control	15
Orange	— —	1959	.03	(.025-.030)	DDT control	25
Fresno	Firebaugh Sewage Plant	1951	.07	— —	DDT control	15
Fresno	Consolidated MAD	1951	.07		DDT control	15
Tulare	#2 Ranch	1951	.08	— —	DDT control	15
Tulare	Visalia Sewer Farm	1951	.09	— —	DDT control	15
Madera	Madera Sewage Plant	1951	.1	— —	DDT control	15
Kings	McCuen Ranch	1951	.2	— —	DDT control	15

A summary of susceptibilities of various mosquitoes to parathion is shown in Table 28. Resistance has been shown in *A. nigromaculis* and probably *C. tarsalis* as well. It is suspected in *C. pipiens* as well but substantiating data have not been published.

Other organic phosphate insecticides

EPN was used for a short while by some districts in the San Joaquin Valley especially in 1953 and 1954. Gjullin *et al.* (1953) reported LC_{50}'s of .009 and .006 ppm for *Aedes nigromaculis* and *Culex tarsalis*, respectively. Georghiou and Metcalf (1961b) established an LC_{50} of .005 ppm for a susceptible strain of *Culex pipiens* from Bakerfield. Isaak (1952) found that DDT resistant *C. tarsalis* could be controlled with this insecticide. Gjullin (1954) reported that adults of strains resistant to chlorinated hydrocarbons could be controlled with EPN.

Table 11.
Susceptibilities of Californian mosquitoes to toxaphene.

Species	Lowest LC_{50} (ppm)	Highest LC_{50} (ppm)	Ratio
Aedes nigromaculis	.006	.08	12.5
melanimon	.02	.05	2.5
Culex tarsalis	.01	1.	100.
pipiens	.03	.2	6.7
Culiseta incidens	.2	— —	— —

Metacide (4:1, methyl: ethyl parathion) has been extensively used to control parathion-resistant *Aedes nigromaculis* in Kings and Tulare Counties. Georghiou and Metcalf (1961b) and Mulla *et al.* (1961) report LC_{50}'s of .02 and .003 ppm, respectively, for methyl parathion with a susceptible strain of *Culex pipiens* from Bakersfield.

Lewallen and Nicholson (1959a) report LC_{50}'s of .01 to .04 ppm for ronnel, .006 to .007 for Guthion, and .02 to .03 for Trithion against *Aedes nigromaculis.* Gjullin *et al.* (1953) report LC_{50}'s of .06 and .02 ppm for tetra-*n*-propyl dithionopyrophosphate against *Aedes nigromaculis* and *Culex tarsalis*, respectively.

Isaak (in Geib *et al.* 1957) reported the following LC_{50}'s for a susceptible strain of *Culex pipiens* from Bakersfield: phorate .02 ppm, Guthion .03 ppm (see also Isaak 1957), DDVP .06 ppm, ronnel .06 ppm, Phosdrin .07 ppm, Thiodan .08 ppm, and ethion .3 ppm.

Other insecticides

Soroker (1951) reported the following series of LC_{50}'s for *Culiseta incidens:* Cinerin I >1 ppm, 4041 (a phosphate) >.1 ppm, *O,O*-diisopropyl nitrophenyl thiophosphate >.1 ppm, Lethane 384-xylene-Triton X-100 2 ppm, and xylene-Triton X-100>2 ppm.

Metcalf and his associates have reported LC_{50}'s of a large number of compounds (Table 29) for a susceptible colony of *Culex pipiens quinquefasciatus* from Bakersfield (Mulla 1961a, b; Mulla *et al.* 1960, 1961; Georghiou and Metcalf 1961a, b). Georghiou and Met-

TABLE 12.
LC$_{50}$'s of lindane to *Aedes nigromaculis.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Kern	Sargent Ranch	1951	.004	uncontrolled
Kern	Peacock-Canfield	1951	.005	DDT control
Kern	Sargent Ranch	1951	.006	uncontrolled
Tulare	Delta & Tulare MAD's	1951	.006	DDT control
Fresno	Consolidated & Fresno MAD's	1951	.006	DDT control
Fresno	— —	1951	.006	uncontrolled
Kern	Lane-Trout	1951	.007	DDT control
Merced	Merced MAD	1951	.007	DDT control
Merced	Hilmar	1951	.007	DDT control
Tulare	Delta Alkali Flat	1951	.009	DDT control
Tulare	Tulare MAD	1951	.009	DDT control
Kings	— —	1951	.009	uncontrolled
Kern	Canfield	1951	.01	DDT control
Kings	— —	1951	.01	uncontrolled
Kern	Peacock-Canfield	1951	.02	DDT control
Madera	Madera MAD	1951	.02	DDT control

*From Gjullin and Peters (1952b)

TABLE 13.
LC$_{50}$'s of lindane to *Aedes melanimon.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Kern	Sargent Ranch	1951	.02	uncontrolled
Kings	— —	1951	.02	uncontrolled
Kern	Greenfield Ranch	1951	.03	DDT control
Merced	Merced MAD	1951	.03	DDT control
Merced	Hilmar	1951	.03	DDT control

*From Gjullin and Peters (1952b).

TABLE 14.
LC$_{50}$'s of lindane to *Culex tarsalis.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Kern	Poso Creek	1951	.01	uncontrolled
Kern	Peacock Ranch	1951	.01	DDT control
Kern	Pintail Duck Club	1951	.02	DDT control
Fresno	Fresno and Consolidated MAD's	1951	.02	DDT control
Kings	— —	1951	.02	uncontrolled
Kern	Paloma Field and Stockdale Road	1951	.03	DDT control
Fresno	Consolidated MAD	1951	.03	DDT control
Kern	Poso Creek	1951	.04	uncontrolled
Kern	Ware Duck Club	1951	.5	DDT control

*From Gjullin and Peters (1952b)

Table 15.
LC$_{50}$'s of lindane to *Culex pipiens* subsp.

Locality	Further Identification	Year	LC$_{50}$	History	Ref.
County					
Kern	Bakersfield	— —	.03	uncontrolled	8
Fresno	Fresno MAD	1951	.04	DDT control	15
Tulare	#2 Ranch	1951	.05	DDT control	15
Tulare	Visalia Sewer Farm	1951	.05	DDT control	15
Fresno	Firebaugh Sewage Plant	1951	.05	DDT control	15
Madera	Madera Sewage Plant	1951	.07	DDT control	15
Kings	McCuen Ranch	1951	.1	DDT control	15
Merced	Cannery waste	1951	1.	DDT control	15

Table 16.
LC$_{50}$'s of lindane to various mosquitoes

Species	Lowest LC$_{50}$ (ppm)	Highest LC$_{50}$ (ppm)	Ratio
Aedes nigromaculis	.004	.02	5
melanimon	.02	.03	1.5
Culex tarsalis	.01	.5	50
pipiens	.04	1.	25
Culiseta incidens	.2	—	—

calf (1961a) reported on the synergism of carbamates by piperonyl butoxide.

Summary of demonstrated resistance

A summary of all of the demonstrations of resistance in Californian mosquitoes is shown in Table 30. Only 4 species have been tested enough so that resistance could be demonstrated and resistance to one compound or another has been shown in all four species. *Culex tarsalis* is the most tested species and resistance has been shown to all of the 7 listed compounds.

Present Insecticide Usage

The amounts of insecticides used in California in 1960 by 50 of the 55 mosquito abatement agencies were taken from the 1961 Yearbook of the California Mosquito Control Association. These figures were converted from pounds or gallons into acreages which could have been treated at reasonable rates to indicate relative usage (Table 31). Parathion was used far more commonly than any other insecticide and malathion was a weak second; these two insecticides accounted for more than three quarters of all the acreage treated.

Table 17.
LC$_{50}$'s of aldrin to *Aedes nigromaculis.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Merced	Hilmar	1951	.001	DDT control
Kings	— —	1951	.003	uncontrolled
Kern	Sargent Ranch	1951	.004	uncontrolled
Tulare	Delta & Tulare MAD's	1951	.004	DDT control
Fresno	— —	1951	.004	uncontrolled
Fresno	Consolidated & Delta MAD's	1951	.004	DDT control
Merced	Merced MAD	1951	.005	DDT control
Kern	Sargent Ranch	1951	.005	uncontrolled
Kern	Peacock-Canfield	1951	.005	DDT control
Madera	Madera MAD	1951	.005	DDT control
Tulare	Delta Alkali Flat	1951	.006	DDT control
Tulare	Tulare MAD	1951	.006	DDT control
Kings	— —	1951	.006	uncontrolled
Kern	Lane-Trout	1951	.007	DDT control
Kern	Canfield	1951	.008	DDT control
Kern	Peacock-Canfield	1951	.01	DDT control

*From Gjullin and Peters (1952b).

Table 18.

LC$_{50}$'s of aldrin to *Aedes melanimon.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Kings	– –	1951	.005	uncontrolled
Kern	Sargent Ranch	1951	.007	uncontrolled
Kern	Greenfield Ranch	1951	.008	DDT control
Merced	Hilmar	1951	.008	DDT control
Merced	Merced MAD	1951	.02	DDT control

*From Gjullin and Peters (1952b).

Table 19.

LC$_{50}$'s of aldrin to *Culex tarsalis.**

Locality	Further Identification	Year	LC$_{50}$	History
County				
Kern	Poso Creek	1951	.001	uncontrolled
Kern	Peacock Ranch	1951	.002	DDT control
Kern	Paloma Field and Stockdale Road	1951	.002	DDT control
Fresno	Consolidated and Fresno MAD's	1951	.002	DDT control
Fresno	Consolidated MAD	1951	.002	DDT control
Kings	– –	1951	.002	uncontrolled
Kern	Poso Creek	1951	.003	uncontrolled
Kern	Pintail Duck Club	1951	.1	DDT control
Kern	Ware Duck Club	1951	.6	DDT control

*From Gjullin and Peters (1952b).

Table 20.

LC$_{50}$'s of aldrin to *Culex pipiens* subsp.

Locality	Further Identification	Year	LC$_{50}$	History	Ref.
County					
Fresno	Consolidated MAD	1951	.004	DDT control	15
Merced	Cannery Waste	1951	.006	DDT control	15
Tulare	#2 Ranch	1951	.007	DDT control	15
Tulare	Visalia Sewer Farm	1951	.01	DDT control	15
Fresno	Firebaugh Sewage Plant	1951	.01	DDT control	15
Kings	McCuen Ranch	1951	.02	DDT control	15
Madera	Madera Sewage Plant	1951	.02	DDT control	15
Kern	Bakersfield	– –	.02	uncontrolled	32

Table 21.

Susceptibilities of various species to aldrin.

Species	Lowest LC_{50} (ppm)	Highest LC_{50} (ppm)	Ratio
Aedes nigromaculis	.001	.01	10
melanimon	.005	.02	4
Culex tarsalis	.001	.6	600
pipiens	.004	.02	5
Culiseta incidens	.007	–	–

Table 22.

LC_{50}'s of heptachlor to various species.

Species	Locality	Further Identification	Year	LC_{50}	History	Ref.
Culex tarsalis	Kern Co.	Poso Creek	1951	.002	uncontrolled	15
Culex tarsalis	Kern Co.	Ware Duck Club	1951	2.	DDT control	15
C. pipiens	Fresno Co.	Firebaugh Sewage Plant	1951	.01	DDT control	15
C. pipiens	Madera Co.	Madera Sewage Plant	1951	.02	DDT control	15
C. pipiens	Tulare Co.	#2 Ranch	1951	.07	DDT control	15
C. pipiens	Kings Co.	McCuen Ranch	1951	.1	DDT control	15
Culiseta incidens	Solano Co.	Green Valley	1950	.02	uncontrolled	36
*Culiseta incidens**	Solano Co.	Green Valley	1950	.007	uncontrolled	36

*"Velsicol Heptachlor"

Table 23.

LC_{50}'s of malathion to *Aedes nigromaculis*

Locality *County*		Year	LC_{50}	C. L.	History	Ref.
Kings	Blanchard Ranch	1959	.003	(.0019-.0054)	– –	25
Madera		1958	.006	– –	uncontrolled	27
Kern		1956	.01	– –	controlled	12
Kings		1958	.01	– –	controlled	27
Kings	Rocha Ranch	1959	.01	(.006-.016)	– –	25
Tulare		1955	.02	– –	– –	11
Fresno		1956	.02	– –	controlled	12
Kern		– –	.03	– –	– –	13
Kern		1951	.03	– –	– –	11
Kern		1956	.03	– –	uncontrolled	12
Madera	Pinedale	– –	.03	– –	uncontrolled	25
Fresno		1956	.04	– –	uncontrolled	12
Fresno		1960	.1	(.08-.14)	(malathion control)	25

TABLE 24.

LC_{50}'s of malathion to *Culex tarsalis.*

Locality	Further Identification	Year	LC_{50}	C. L.	History	Ref.
County						
Santa Clara	Palo Alto	1958	.004	(.0027-.0045)	— —	25
Fresno	— —	Apr. 1959	.004	(.0031-.0052)	malath. control	22
Fresno	— —	May 1959	.004	(.0031-.0052)	malath. control	22
Madera	Berenda	1957	.005	(.0054-.0059)	— —	25
San Diego	Del Mar	1957	.006	(.0043-.0084)	— —	25
Fresno	— —	Mar. 1959	.008	(.0073-.0088)	malath. control	22
Fresno	— —	Sept. 1959	.01	(.0077-.013)	malath. control	22
Yolo	Davis	1958	.01	(.009-.013)	— —	25
Fresno	— —	July 1959	.01	(.0083-.012)	malath. control	22
Fresno	— —	Aug. 1959	.01	(.0083-.012)	malath. control	22
Kern	— —	1956	.02	— —	uncontrolled	12
Riverside	Thermal	1958	.02	(.012-.018)	— —	25
Butte	Biggs	1957	.02	(.012-.021)	— —	25
Orange	Brea	1958	.02	(.015-.035)	— —	25
Kern	— —	— —	.02	— —	— —	13
Fresno	— —	1956	.03	(.019-.033)	uncontrolled	12
Fresno	— —	June 1959	.03	(.027-.033)	malath. control	22
Fresno	— —	1958	.03	— —	— —	25
Butte	Biggs	1958	.03	(.024-.043)	— —	25
Kern	— —	1956	.04	— —	malath. control	12
Monterey	Salinas	1957	.04	— —	— —	25
Monterey	Salinas	1958	.04	(.039-.047)	— —	25
Yolo	Winters	1957	.04	— —	— —	25
Madera	Berenda	1958	.05	(.035-.060)	— —	25
Kern	Bakersfield	1958	.06	(.047-.067)	— —	25
Fresno	— —	1957	.09	(.75-.11)	— —	25
Fresno	— —	1958	.2	— —	malath. control	22
Fresno	— —	1956	.3	— —	malath. control	12

TABLE 25.

Susceptibilities of various species to malathion.

Species	Lowest LC_{50}	Highest LC_{50}	Ratio
Aedes nigromaculis	.003	.1	33
Culex tarsalis	.003	.3	75
pipiens	.003	.1	33
peus	.05	—	—

TABLE 26.
LC$_{50}$'s of parathion to *Aedes nigromaculis.*

Locality	Further Identification		Year	LC$_{50}$	C. L.	History	Ref.
County							
Tulare	— —		1960b	.00003	— —	parath. control	25
Madera	Pinedale		1958	.00004	— —	uncontrolled	27
Fresno	Kerman		1958	.00004	— —	uncontrolled	27
Madera	Pinedale		1959	.00005	— —	uncontrolled	24
Kings	Hanford		1959	.00008	(.000053-.00012)	parath. control	27
Kings	Riverdale		1959	.00009	(.000043-.00017)	— —	25
Tulare	Tulare		1959	.0001	— —	parath. control	27
Madera	Pinedale		1961	.0001	— —	parath. control	24
Kings	Hanford	July	1959	.0002	(.00017-.00024)	parath. control	22
Kings	Lemoore		1961	.0002	— —	parath. control	25
Kings	Hanford	Sept.	1959	.0002	(.00015-.00026)	parath. control	22
Kings	Hanford	Mar.	1959	.0003	(.00025-.00036)	parath. control	22
Kings	Hanford	May	1959	.0005	(.00038-.00065)	parath. control	22
Tulare	— —		1960a	.001	(.0008-.0015)	— —	25
Kern	— —		1956	.002	— —	parath. control	12
Kern	— —		1956	.002	— —	uncontrolled	12
Tulare	— —		1958	.003	(.0026-.0044)	— —	25
Fresno	— —		1956	.004	— —	parath. control	12
Tulare	Traver		1960	.004	(.0033-.0056)	— —	25
Fresno	— —		1956	.007	— —	uncontrolled	12
Tulare	Visalia		1960	.02	— —	parath. control	25

TABLE 27.
LC$_{50}$'s of parathion to *Culex tarsalis.*

Locality	Further Identification	Year	LC$_{50}$	C. L.	History	Ref.
County						
Fresno	— —	1958	.00007	(.000043-.00011)	— —	25
Madera	Berenda	1958	.00008	(.000070-.000085)	— —	25
Madera	Berenda	1957	.00008	(.000065-.000094)	— —	25
Monterey	Salinas	1958	.0001	(.00010-.00014)	— —	25
Orange	Brea	1958	.0002	(.00020-.00024)	— —	25
San Diego	Del Mar	1957	.0003	(.00019-.00043)	— —	25
Kern	Bakersfield	1958	.0004	(.00030-.00059)	— —	25
Riverside	Thermal	1957	.0005	(.00048-.00058)	— —	25
Butte	Biggs	1957	.0006	(.00047-.00067)	— —	25
Fresno	— —	1957	.0006	(.00052-.00074)	— —	25
Butte	Biggs	1958	.0008	(.00057-.0011)	— —	25
Yolo	Davis	1957	.0009	(.00076-.0011)	— —	25
Yolo	Davis	1958	.001	(.0010-.0017)	— —	25
Monterey	Salinas	1957	.001	(.0010-.0017)	— —	25
Kern	Klipstein Duck Club	1951	.002	— —	parath. control	20
Kern	Klipstein Duck Club	1953	.002	— —	parath. control	20
Kern	Klipstein Duck Club	1955	.002	— —	parath. control	20
Kern	Klipstein Duck Club	1960	.002	— —	parath. control	20
Kern	— —	1956	.002	— —	uncontrolled	12
Tulare	Traver	1961	.002	— —	— —	25
Kern	Klipstein Duck Club	1958	.003	— —	parath. control	20
Kern	Klipstein Duck Club	1959	.004	— —	parath. control	20
Kern	— —	1956	.004	— —	parath. control	12
Fresno	— —	1956	.004	— —	uncontrolled	12
Fresno	— —	1956	.005	— —	parath. control	12

TABLE 28.
Susceptibilities of various species to parathion.

Species	Lowest LC_{50}	Highest LC_{50}	Ratio
Aedes nigromaculis	.00003	.02	667
squamiger	.005	—	—
Culiseta incidens	.006	.008	1.3
Culex tarsalis	.00007	.005	71
pipiens	.001	.004	4

TABLE 29.
LC_{50}'s of various insecticides to *Culex pipiens*

	Georghiou & Metcalf 1961b	Mulla et al. 1961
Bayer 37343	.002	— —
Bayer 29141	.002	— —
Bayer 38108	.003	.003
Bayer 30468	.003	— —
Bayer 38107	.003	— —
parathion	.003	.004
Bayer 30237	.003	— —
Bayer 34042	.004	.01
Bayer 38104	.004	— —
EPN	.005	— —
Baytex	.005	.01
SD 4402	— —	.005
Bayer S-5660	.006	— —
ethyl dicapthon	.006	— —
dieldrin	.008	.009
G-30494	— —	.008
Bayer 32384	.009	— —
n-propyl parathion	.01	— —
Bayer 33333	.01	— —
Bayer 29492	.01	.02
methyl parathion	.02	.003
Dow *O*-methyl *O*-(2,4,5-trichlorophenyl) ethylphosphoramidothioate	.02	— —
Dow *O*-propyl *O*-(4-nitrophenyl) methylphosphoramidothioate	.02	— —
Bayer 25198	— —	.02
aldrin	— —	.02
endrin	— —	.02
Cyanamid EN 18133	— —	.02
lindane	.03	— —
Guthion	.03	.02
Bayer 34098	.03	— —
Dow *O*-methyl *O*-(2,4,5-trichlorophenyl) isopropylphosphoramidothioate	.03	— —
Dow *O*-ethyl *O*-(2,4,5-trichlorophenyl) ethylphosphoramidothioate	.03	— —
Chlorthion	.03	— —
dicapthon	.03	.02***
Bayer 30554	.03	— —
ronnel (Korlan)	.03	.03
Dow K-6951	.03	.03
Dow *O*-isopropyl *O*-(2,4,5-trichlorophenyl) methylphosphoramidothioate	.03	— —
RE-5305	.03*	— —
Bayer 38156	— —	.03
Ethyl Guthion	— —	.03
Bayer 22408	— —	.03
G-30493	— —	.03**
Bayer 24882	.04	— —
Dow *O*-isopropyl *O*-(2,4,5-trichlorophenyl) ethylphosphoramidothioate	.04	— —
Dow K-6882	.04	.04
Dow *O*-isopropyl *O*-(2,4,5-trichlorophenyl) isopropylphosphor-amidothioate	.04	— —
phorate (Thimet)	— —	.04
Bayer 30749	— —	.04
G-28029	— —	.04
Hercules AC5727	.04*	.04
Bayer 25141	— —	.05
GC-3582	— —	.05
Methyl Trithion	— —	.05
Co-ral	— —	.05
Dow *O*-methyl *O*-(2,4-dichlorophenyl) ethylphosphoramidothioate	.06	— —
GC-4072	— —	.06
DDT	.07	.04
Bayer 22684	.07	— —
Trithion	— —	.07
DDVP	.08	.07
malathion	.08	.07
LB-95-61	.09	— —
Bayer 38920	— —	.09
Bayer 16450	.1	— —
Dibrom	.1	.05
allethrin	.1	— —
Zytron	— —	.1
GC-3583	— —	.1
Dow ET-15	— —	.1
RE 5030	.2*	— —
Delnav	— —	.2
VC-13	— —	.2
B-8999-S (ASP-51) (NPD)	— —	.2
Bayer 37344	.2	— —
ethyl malathion	.3	— —
Bayer 39007	.4*	— —
Zectran (Dowco 139)	.5*	.6
Bayer 39731	.6*	— —
ethion	— —	.9
Dekafos	— —	1.0
Sevin	1.0*	— —

*Georghiou & Metcalf 1961a
**Mulla 1961b
***Mulla *et al.* 1960

TABLE 30.

Demonstrations of insecticide resistance by species and compound.

Compound	*Aedes nigromaculis*	*Aedes melanimon*	*Culex tarsalis*	*Culex pipiens* subsp.
DDT	+	+	+	+
toxaphene	?	—	+	?
lindane	?	—	+	+
aldrin	?	—	+	—
heptachlor			+	?
malathion	+		+	?
parathion	+		+	?

TABLE 31.

Approximate amounts of insecticides (expressed as acres) used for mosquito control in California, 1960.*

parathion	1,100,000	56.5%
malathion	390,000	20.0%
DDT	130,000	6.7%
oils	110,000	5.7%
methyl parathion	64,000	3.3%
TDE	52,000	2.7%
Baytex	25,000	1.3%
lindane	22,000	1.1%
toxaphene	19,000	.9%
Perthane	17,000	.9%
Metacide (methyl parathion)	8,000	.4%
Lethane	6,000	.3%
dieldrin	2,000	.1%
heptachlor	1,000	.1%
	1,946,000	100.0%

*Some compounds (Ureabor, malagren, DDVP, dibrom, borax, etc.) were omitted because of the small amounts used and, in some cases, insufficient information concerning application rates.

Summary

Testing for resistance has been done chiefly by workers at the University of California at Davis, the United States Department of Agriculture, the Kern Mosquito Abatement District, and the Bureau of Vector Control, and such testing has not been standardized among the various laboratories. World Health Organization test kits have not been employed.

The prinicpal insecticides which have been used for mosquito control in California are DDT, malathion, and parathion. A wide variety of other chlorinated hydrocarbons and organic phosphates have been used less frequently. Resistance has occurred to all three of the major insecticides in *Aedes nigromaculis* and *Culex tarsalis* and probably in *Culex pipiens* (mostly subsp. *quinquefasciatus*) as well. Resistance has also been demonstrated to toxaphene, lindane, aldrin, and heptachlor even though these insecticides, especially the latter two, have been used only infrequently.

The principal species which have been tested are *Culex tarsalis, Aedes nigromaculis*, and *Culex pipiens*. No laboratory testing has been reported with most species, even *Anopheles freeborni*, a major pest.

About half of the mosquito control agencies contacted reported no resistance problems in their areas although most of these agencies have changed insecticides for various reasons. The use of chlorinated hydrocarbon insecticides is declining, owing in part to residue problems, and the principal insecticides now in use are parathion and, to a lesser extent, malathion. Resistance to each of these insecticides has been demonstrated but such problems are not yet widespread.

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