PROCEEDINGS AND PAPERS

OF THE

Twenty-sixth Annual Conference of the

California Mosquito Control Association, Inc.

AT

THE FRESNO HACIENDA

FRESNO, CALIFORNIA

JANUARY 27, 28 AND 29, 1958

Edited by

C. DONALD GRANT

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California Mosquito Control Association

FIRST SESSION

MONDAY, JANUARY 27, 1958, 9:00 A.M.

Pres. Greenfield: Good morning, everyone. I would like to welcome you to the first session of the CMCA 26th Annual Conference. The announcements that should be made at this time, I would like to have held over until recess. Upon reconvening, any announcement will be made that is necessary.

So, if I may at this time, I would like to get under way by introducing to you our first speaker—Mr. Jess Rodman, who is a very well known cattleman from Fresno County. He is the gentleman who did so much towards starting mosquito control in Fresno in 1940. He has served as President of the Board and is now President-Emeritus of the Fresno Board. Mr. Rodman.

Mr. Rodman: President Greenfield, folks interested in mosquito control, and—I see at least one lady—Lady and Gentlemen: We, in Fresno, are always happy to welcome groups of this kind to our City. This morning I am speaking on behalf of the Trustees of the Fresno and the Consolidated Mosquito Abatement Districts of Fresno County, and wish to extend to all of you greetings and a warm welcome to our City.

You people are engaged in what I think is a very important work. That the mosquito is the greatest pest of mankind, has been true, I'm sure, through the ages. It has only been in recent years that great progress has been made in their local elimination and control. This work is, and has become, so popular with the people and the public officials, that you folks have had ample financing to do the job that was so necessary to be done. Because of the outdoor living so popular in California, modern homes are being designed with this in mind. On these occasions people wear less clothes than they normally would because of the warm weather, and this makes them direct targets for any mosquitoes that may be about. There is another reason why mosquito control is becoming more popular all the time. Some mosquitoes have spread, in past years, certain of our most critical diseases; hence, their control is popular with everyone. You Trustees from the various districts throughout California, and I understand there are many people here from out-of-state—some on the program and otherwise—you folks also have quite a responsibility to see that the money to do the job in your district is economically and well spent. Because the movement is so popuar with the general public and with most officials, does not justify any Trustee or Manager of any District to engage in wasteful practices with public money just because it's available to him. I think that is the responsibility you have.

We raise a lot of mosquitoes here in Fresno and adjacent areas because we use almost the entire waters of the Kings River and a good portion of the waters of the San Joaquin River irrigating our very fertile fields; and as you know, where there is a lot of water, there is wastage, puddles, and breeding grounds for mosquitoes. So we have had quite an experience with mosquitoes here. Effective control has been obtained. We have, as most districts have, very capable men heading the Districts as Managers plus capable staffs. I've seen that situation develop in this area and I'm sure it's developing everywhere in the world where organized control work is being done.

You didn't come here to listen to me talk about mosquitoes. I want to welcome you folks to Fresno. We are proud of Fresno. We are now in the number one agricultural county of the United States—we are in the San Joaquin Valley, the Garden of Eden spot in the world. I've heard it said many times that no other place in the world has the diversity of crops that we have here in the Valley. Even Fresno County alone produces more agricultural products than many States in the Union, and we have many high producing counties in our valley. That's where you are, in this fine country. You are welcome and we hope you have a pleasant occasion here the next few days and will want to come back again sometime. Thank you.

Pres. Greenfield: Mr. Rodman, in behalf of the Association, I'd like to thank you for those kind remarks and to acquaint some of the people I saw last night with where they are supposed to be. I was not too sure last night whether they knew.

Next on our program is Mr. Norman Foley. Mr. Foley is Chairman of the Board of Supervisors of Fresno County (which is also the Raisin Center of the world). So if I may, I'd like to call on Mr. Foley.

Mr. Foley: Thank you, President Greenfield. Mr. Chairman and Ladies and Gentlemen, it is certainly a pleasure for me, on behalf of the Board of Supervisors—the governing body of this great county of ours—to add to the welcome of my good friend, Mr. Jess Rodman. As Mr. Rodman has so aptly informed you, we are very, very proud of one of the greatest communities of the State—we believe, without question, it is one of the best in the State. As you see, I speak rather modestly, but I can't help it when I talk about this great community of Fresno, and to have you select our city as your convention center is very pleasing to us. We certainly hope and feel that you will enjoy yourselves here and that many good things will come out of your convention.

I would say this without any question whatever: that to you people represented here, so many throughout the county, owe a great deal, too, because most certainly you have taken a great bite out of the mosquito. Throughout the past years he has thrived very nicely, but you have cut that bite down a bit yourself, I'm sure.

I can look back at my own experiences, and I'm sure many others can. I realize the fine job you have done and I commend you for your efforts.

As I say, we have one of the greatest little communities here, and I know your work will be hard. There will be many things before you, but we do hope that you will have time to enjoy some of the very nice spots we have, and spend a few of those hard earned dollars, because Fresno can always use a little bit more. (laughter)

We have a great many good people within our community and I would say, for your information along with those, that we have one of the nicest Chiefs of Police in the State, one of the best Sheriffs there is in the State; and I would says this: that in the event that should any of our police stalwarts happen to pick you up for some minor infraction and confine you in our Sheriff's Hotel, if you would just let me know, I'm sure I could speak to him and perhaps get you a room with nice hot and cold running water. (laughter)

So enjoy yourselves, and I know that many good things will come out of the Convention which will be a continued credit of the various Associations which you represent, and we do hope that sometime in the future we may again have the pleasure of welcoming you to our fair city. I thank you very much. (applause)

Pres. Greenfield: Well, fellows, I don't think I can say one thing more than Mr. Foley has just said. You have had the word! We have a hospitality hour coming up this evening—take care.

The next part of our program is something that is important to each and every one of us. Senator Hugh Burns is going to speak on some of the problems of water and its effects on us, mosquitoes, etc. in California. Senator Burns, for some of those who are not familar with the 20th District, has represented the area for 22 years. He has for many years devoted his interests to mosquito control problems and problems of water. It gives me great pleasure to introduce Senator Hugh M. Burns. Senator Burns, please.

Senator Burns: Mr. Chairman, my dear friends and guests:

Jess Rodman and Norman Foley have just about stolen all my thunder on Fresno County. I, too, like Fresno County. I like it better all the time, because it seems to like me pretty well. I profess total ignorance about the love-life of the mosquito and practically anything else about them. I was invited very generously to come down and make a talk this morning, so I have seized the opportunity of giving you a little information, I hope, that may prove beneficial to you to learn about some of the Legislative problems entwined about the distribution and use of our water resources of the state.

I'm going to show you a picture. It's the lazy man's way of making a 20 minute speech. Its narration and background will show you some of our water development projects. As you know, the State of California has never engaged in the development, directly, of any of our water projects. All of our projects have been built either by Districts formed for that purpose or by the Federal Government. The great influx of population in the State in the past 10 years has created problems, along with many others as you know, and especially so in the field of water resources. The day is here, and we are all convinced of that, when the State will have to participate, in some degree, in this field. Now I appear a couple of times in the picture and there are some self-serving statements made in it. I hope you will forgive, and trust you will, inasmuch as 1958, pardon the expression, is an election year. It's not an impartial presentation, nor unbiased nor non-partisan. Speaking of non-partisan, when Democrats and Republicans get together at meetings like this they iron out mutual difficulties. I think it works pretty good, for during my political career, I have been in meetings that certainly were other than impartial and non-partisan.

For the third time, if you don't mind digressing a moment, I'll tell a little story that may be amusing to you. For the third time I was elected delegate to the Democratic National Convention, all three of the meetings I attended were held in the city of Chicago. If none of you has ever attended a National Convention of any major party, it's an amazing transpiring of events. It's an archaic and much out-moded system of nominating candidates for the highest office in the land. But in wandering around the convention floor, with sound and fury at its highest, I ran into a young lady who seemed to have nothing particular to do, so I spoke to her and said, "How do you do?" She smiled back and said, "How do you do?" I said, "Where are you from?" She says in a very slow Southern drawl, "I'm from Georgia." I asked her "What do you do down in Georgia?" She said, "We farm mostly, yeah, we farm, I guess." I said, "What do you raise?" She said, "We raise watermelons." I said, "How was the crop?" She said, "Terrible! We planted the seed, the birds came along and ate up the seeds. The plants started coming up and the drought hit us. The plants didn't amount to very much and when the melons started to form, the bugs got on them. You know, mister, when those melons grew up they were teeny-weeny things; dog-gone that Eisenhower. (laughter)

Well, this viewpoint that I'm going to discuss with you in this film is the Northern California viewpoint. You who are from the Southland, I hope in your charity, will learn our position and maybe spread the gospel of the Northern viewpoint down south of the Tehachapis. So without further to-do, I'll ask the young man, our operator here today, to start the film. (film)

Pres Greenfield: I'd like to say that Senator Burns has just served as Governor of California for a short period of time, and is Speaker of the House.

Senator Burns: Governor for three days. Thank you very kindly, you have been very attentive. Traditionally, water has been allocated in California on the principle of "First in time, first in need, and on the basis of flow." And that is the meat of the coconut as far as our controversy regarding water is concerned.

You may well ask, at the present time, just what is being done to straighten the entire matter out? We have three committees of the Legislature working on this problem. Considerable progress has been made. I doubt very much whether anything will be accomplished at this Budget session coming up in February and March. However, I have hopes, as has everyone else, that at the General Session in 1959, this matter will be adjudicated or compromised to such an extent that the State can go ahead with its water plan.

I think it was in the 1945 session when I handled a bill to remove the formation of MAD's from the District Investigation Act, facilitating the formation of various abatement districts throughout the State. I never will forget my colleague from Merced County, the late Senator Hatfield. He said, "When you take this bill upon the floor, don't talk about the Investigation Act, you aren't a lawyer and you'll get all tangled up. Talk about mosquitoes." So I got myself a book on mosquitoes and boned up on the subject. When I got on the floor, I took up about 20 minutes pointing out and viewing with alarm the menace of uncontrolled mosquito pests, including malaria, yellow fever and encephalitis, and what have you. The advice was very good, because we were successful in suppressing the Act which actively aided somewhat the formation of mosquito abatement districts. We are considering the Budget beginning Monday, February 2. We probably will be in session for three days, then recess until March 3, and the Budget of the State will be worked on and passed by the Legislature. So if your organization has an interest in State appropriations, which I assume you have—most everyone does—that would be the time to get in touch with your representatives at Sacramento.

I do want to thank you for this opportunity of coming before you. If this picture has been of any help to you in informing you of our legislative problems relating to water, my mission has been accomplished. Thank you very much.

Pres. Greenfield: This is a pleasure, not only to know our water problems, but to know that a man as capable as Senator Hugh Burns is on the commission to see that the problems are worked out to their ultimate conclusions. You know, it's a very strange thing here. We are actually on time, as far as our program is concerned. I hope everyone is taking note of that. Gordon, are you satisfied now?

Our next speaker this morning is Dr. Robert Metcalf. Bob has spoken before to this Association on the problems of insecticides, the problems of resistance, and I see that again he is going to present more information on that very same problem. Dr. Metcalf—

Dr. Metcalf: Thank you Mr. Chairman, members of CMCA:

It's always a pleasure to participate in your meetings and I'm happy to be able to discuss the problems of insect resistance to insecticides. I don't think I need to say to this group that I consider this the most important problem facing economic entomology today. You have had concrete experience with it and know exactly what it means in terms of your own activities. On a world-wide basis, it is gratifying that resistance is also being recognized and particularly WHO, which is the largest organization attempting to do something about solving the problem. That is what I want to talk to you about this morning.

Last summer, it was my good fortune to be asked by WHO to spend a month visiting labs where they have cooperative research projects underway in various countries throughout the Mediterranean area. It was hoped that I would be able to survey research which was in progress and make suggestions which would stimulate more work with new insecticides, in particular the organo-phosphorus insecticides as possible agents for the control of insect vectors of disease which have become resistant to the Chlorinated-Hydrocarbon materials.

As some of you know, WHO proposes to eradicate malaria from the earth. Malaria is generally considered the most important of human diseases. There are perhaps 250 million cases a year and it has been estimated by people like Dr. Fred Russell that two to three million deaths may result annually. It is a tremendous problem and WHO's program calls for an expenditure of one-half billion dollars in this eradication step. This is to be carried out largely by the use of residual house sprays of DDT, BHC, dieldren. And therefore, it was with a great deal of alarm that WHO began to view a few years ago the statements being made about the resistance of such insects as the housefly to these materials. Their concern rose sharply when it was shown that a few species of *Anopheles* had this ability to circumvent the lethal action of these insecticides.

As matters stand at present, Dr. A. W. A. Brown, who is in charge of the resistance work in WHO, has calculated that about 65 species of insects have shown a measurable degree of resistance to insecticide action. Of these, about one-half, or around 30, are insects of public health importance. These include 8 species of Anopheline, 12 species of *Aedes* and Culicine mosquitoes, several species of *Musca*, 2 species of Hemiptera or bedbugs, *Cimex lectularius* and *C. hemipterus*, the human body louse, but very strangely not the human head louse, and a few other miscellaneous species which I won't deal with at the present moment. This is a list which is very alarming, obviously because included in it are vectors of some of the most important human diseases, outside of malaria; such things as typhus, yellow fever, etc. WHO has had the foresight to recognize the importance of this problem to their scheme and have been organizing on a global basis to combat it.

They have been encouraging research work in all parts of the globe on a particularly basic and fundamental basis to find out the nature of this resistance so that they can attack it intelligently. The biggest problem at the moment is that there are far too few people and far too few laboratories engaged that can contribute directly to this.

At the Conference which I attended in Geneva last summer, we calculated that there are not more than 12 laboratories in the world which are staffed or equipped to satisfactorily deal with all the phases of the resistance problem; particularly, those relating to toxicology, physiology and bio-chemistry where it is necessary to find out what is happening in the insect's body that is producing the resistance to insecticidal action. WHO has made the very significant proposal that any group or body establishing a large insect control project in chemicals should automatically reserve a small percentage of their total cost for basic research leading to the possible effects of this treatment program on the insect, resistance and possible adverse affects on other living organisms.A program which comes to mind along this line is the Gypsy Moth program by the USDA in the Eastern part of the United States; also the Mediterranean Fruit Fly eradication program of Florida, etc. This is one of the most sensible proposals I have heard and it doesn't take much mathematics to figure that if we could spend 1% of this half-billion dollar eradication program on fundamental research of the chemicals that we propose to use on our insect populations, we could certainly carry out a large amount of fundamental research which certainly wouldn't be wasted.

I left Los Angeles on the Polar Route of SAS, which gave me a unique opportunity to fly over the north country which I had never seen. When I got to Geneva, I hadn't slept in 24 hours for the scenery was so fascinating to me. I got in touch with Dr. Brown and found I had 1½ hours to get all my tickets, itineraries, and papers, etc. from WHO.

(Dr. Metcalf then proceeded to show excellent slides of his trip, a travelogue of his journey to 12 countries in studying their insect control problems.)

Pres. Greenfield: I knew for many years that Bob was a fine research entomologist, but I didn't know you had that beautiful technique of photography at your command. It now gives me pleasure to declare a recess.

Jay Graham: I want to put in a plug here for the AMCA Bulletin No. 3, "Mosquito Culture Techniques." The AMCA still has a lot of them left, and it's worthwhile having. You can get it from Mr. C. T. Williamson, 16 Orwalk Avenue, Islip, New York, or write to me in care of the Biology Department at the University of Utah. The price is $2.00, and you can't spend a better $2.00, I'm sure.

Pres. Greenfield: Thanks, Jay! Please give your formal papers to our good Secretary, Ed Washburn, so they will be ready for the Proceedings. That completes the announcements.

It gives me a great deal of pleasure at this time to introduce one of the foremost mosquito men in California, an Honorary Member of the CMCA, Harold Gray.

Mr. Gray: Well, this is now 28 years since the CMCA has been organized and our 26th meeting. I well remember the first one we had in 1930 in December at the University of California. We had about 30-35 people present, and a good many were teachers in the University itself. There are very few of us left who were at the first meeting. I think the only one present besides myself is Stan Freeborn. This organization has come a tremendous way since that time. It has been a great pleasure for the "Old Man" to watch how all of you youngsters have come along and taken over and have made a very fine organization out of this Association. It really does the heart good to see the enthusiasm, the hard work, and the tremendous interest you have put into it. I sincerely congratulate you on the job you have done, are doing and will do in the future. Now so far this morning we have had a Waterlogue, and a Travelogue. I don't know what kind of a log this will be, but maybe it will be an Idealogue. Sometimes you can mix idealism with practicality and that is what I have tried to do this morning; whereas, you know, I usually speak to you extemporaneously, this time I am going to read, and as I go along I think you will see why. I have entitled the talk "What, How and Why."

WHAT, HOW AND WHY

Harold Farnsworth Gray, G.P.H.
Honorary Member, California Mosquito Control Association

Preface

Whether it is a business, or a professional practice, or a governmental agency, the individuals or the group involved must of necessity ask themselves, at the inception and periodically as time goes on, three pertinent questions—"What are we to do?"—"How are we to do it?"—and "Why is it to be done?"

It is essential that the questions be asked, and that they be answered with integrity, for life is something more than merely holding or doing a job for the sake of making a living. It is necessary and legitimate to make a living, but even if financially successful it will be a poor living indeed if it has no purpose or validity aside from the making of money. If one cannot feel that he has in his life's work done something of value to others than himself, he has indeed lived a barren existence.

Since public servants in general cannot expect that they will earn legitimately, in terms of money or property, any appreciable wealth, their incentives and rewards must be found in a large degree in a belief that their work is of real value to the public. To ensure that this real value is attained, they must ask these questions of "What" and "How" and "Why," and answer them adequately. For assuredly if YOU do not ask and answer them, the people you serve will ask them, and possibly their answers may not be to your liking.

What?

Limiting this discussion to mosquito abatement agencies, the first question we must ask and answer is "What is to be done?" A glib answer is "Abate mosquitoes." But all of you know that a glib answer is not enough. The answer is much more complex, particularly when you are starting a new project. Of course, the applicable sections of the Health and Safety Code of California prescribe the powers and duties and limitations of mosquito abatement agencies, and you must operate within the law. But there is a wide diversity of problems involved, and a wide variety of means with which to solve them. There is also a wide variety of difficulties to be encountered.

Mosquito abatement agencies are organized in response to a public demand to abate an appreciable public nuisance or to control a mosquito transmitted disease. In the early years of this century the control of malaria was of first importance in the central valley of California. In contrast, in the San Francisco Bay region the control of pest mosquitoes was important. So the "What" was definite in each area. However, conditions have a propensity to change. Districts in the central valley, such as Durham, and Los Molinos, and Oroville and Fair Oaks were organized to control malaria. Today, except for Fair Oaks, after malaria was controlled, they are continued to control pest mosquitoes which became recognized as a nuisance after the disease vanished. So the "What" may change, and a certain flexibility to meet changing conditions is necessary.

The "What" to be done is a matter of policy, and the determination of policy is the prerogative and duty of the Board of Trustees of the District. A trained and experienced Manager can assist the Trustees in the determination of policy, but he must always keep in mind the fact that the Board of Trustees determines policy, and once a policy is determined it is the duty of the Manager to carry it out faithfully and effectively. If he cannot in good conscience carry out that policy, the Manager must resign.

How?

The next question to be asked is "How is the policy to be carried out?" This is the primary province of the Manager, and the Board of Trustees must hold him responsible for doing the job efficiently within the means provided. The Manager must keep the Board of Trustees fully informed as to the methods being used, and he must particularly report regularly on costs and expenditures, and on work performed, and on results obtained wherever results can be measured quantitatively. The Board of Trustees must examine and evaluate these reports, and may properly make suggestions or issue directives.

But (and this is an important BUT) these suggestions and directives must come from the Board of Trustees as a BOARD, and by Board action. It is both improper, and destructive of morale and efficiency, for any individual member of the Board of Trustees to take upon himself the function of a supranumerary manager, and to mess around in the operational phases of the work, or in the administrative details. I have seen this done with poor results, and I have seen it attempted but stopped by a Manager with self-respect. If Board members do not have confidence in the ability of their Manager, they should, at a Board meeting, present their charges and try to remove the Manager by majority action of the Board of Trustees. If they fail to do so, the dissenting Trustees should either loyally accept the decision of the majority, or should themselves resign.

One important point to be decided at the start of operations involves both the "What" and the "How," and should be decided jointly by the Board of Trustees and the Manager. The question is "Shall we try to obtain immediate and spectacular results at the start by palliative methods, with a probable sacrifice of long-range economy and effectiveness, or shall we sacrifice immediate results in the interest of eventual economy and effectiveness?" Unfortunately this question is seldom considered carefully in all its implications. It is also a question which must be asked again if conditions change. Sometimes the change is so gradual that we fail to recognize it promptly.

My personal opinion is that the Board of Trustees should definitely and positively tell the public that comparatively slight results can be expected in the first several years of operation. Any experienced person knows that the first year or two must be concerned mainly with organizational problems: obtaining and training an operating staff and crews: obtaining equipment: setting up depots: purchasing materials: getting acquainted with the territory and its people and problems: mapping the mosquito producing areas: measuring mosquito production: determining the mosquito species present, their seasonal prevalence, and their relative importance as disease vectors and pests: setting up the office and administrative routines: and other matters of importance.

That is a lot of work. It takes time. It takes a lot of thought and analysis. Of course one can start out fairly soon spraying insecticides at random over the landscape, and putting out a lot of smoke screen (aerosols if you prefer) to make the public think you are doing something. But are you spending the taxpayers' dollars to the best advantage? Will these methods get the results in the long run? I doubt it. But as I have previously said much on this theme, I consider it to be unnecessary to elaborate further. But I again call your attention to the fact that from time to time you should review your operations and critically re-examine them in the light of these questions of "What" and "How." Have conditions changed so that changes in procedure and methods are advisable or necessary? DON'T GET IN A RUT!

WHY

The final question of basic importance is the "Why" of the operation. Obviously this question can be answered in part by referring to the local conditions which brought about the initiation of the project—an endemic or epidemic disease, or a serious pest, or an economic loss to the community caused by mosquito prevalence. But there are other "Why's" of importance.

Not only does the general public ask "Why" do we pay taxes to have this service performed for us, but the public may from time to time ask "Why" do we not get better results for less money. I do not think we need to go into details on this point, for it is concerned with public relations and public information. We have had many interesting papers and discussions about it at previous meetings, and they have been printed in our Proceedings.

But there are two other "Why's" which I believe have been somewhat neglected in practice, at least in some agencies, and have been discussed seldom at our conferences. One is the "Why" the Trustees may ask; the other is the "Why" the employee, consciously or unconsciously, may ask.

Trustees may ask "Why am I a Trustee?" If he can in good conscience answer that he is performing a valuable public service, which is well administered and in which he can take pride, no further answer to that question may be needed. But I submit to each Manager the propostion that few Trustees ever receive public recognition for the valuable and unpaid services they render, and some Managers fail to make the effort to let their Trustees know that their efforts are appreciated. It is not difficult to say sincerely as occasion warrants that the work of the Trustees is appreciated by the Manager. Why not do so, now and then?

The other "Why" goes to the root of successful management, and this is the "Why" asked by the employees. "Why" is this being done?" "Why should I be doing it?" "Why" does the public pay for it?" "Why" this and "Why" that in relation to the various operations.

The successful answering of these questions is the basis of that intangible "esprit de corps" of a successful organization. Either a district has it, or it does not have it. I do not know that I can tell you how to obtain "esprit de corps," but I can give you a few ideas.

First, if you want loyalty you must be loyal. You must be completely sincere, and you must be as fair and just as possible in your relations with the employees. Ask yourself "If I were in his place, how would I like to be treated?" Try to be sincerely interested in each employee *as a person*, and in his well being and advancement. These are essential qualities in a Manager. But there is more.

The employee should be constantly helped to understand his job better. He should also be given opportunity to train for advancement. This means a continuous in-service training program. I cannot over-emphasize its importance. There should also be incentives in better pay and in promotions for those men who show the most interest and do the best work. There are also such matters as a retirement system, and group medical and hospital insurance for the employees and their families. I think these things are obviously desirable, but sometimes they are neglected.

But no man can take a real interest in his job unless he understands its larger implications and believes he is doing something worth while in this world. Too many people have jobs which are merely jobs. When they go home they forget them. They are merely a means of making a living. They "live" outside their jobs. But a skilled Manager can do much to make the employees understand that mosquito abatement work is a valuable public service, of which, when well performed, they justly can be proud.

I believe that much more can be done by our Managers and Trustees to develop this "pride of workmanship" and this interest in the job of mosquito control. Not only must it be done for the regular employees, but something can also be done along this line for the seasonal employees.

I suggest that at your next annual meeting you hold a symposium on methodology and philosophy in this phase of the art of management. Pending that time, I suggest that you do some real hard thinking on it, and try out various ideas. You may be surprised at the results you will get.

Above all, constantly remember and sincerely believe that you are performing a valuable public service. Have faith in it—have pride in it—find satisfaction in it—and do it as Kipling said

"Not as a ladder from earth to Heaven,
not as a witness to any creed,
But as simple service simply given
to his own kind in their common need."

Pres. Greenfield: Thank you, Harold, I enjoyed that. Next on the program will be a report from Utah by Glen C. Collett.

Mr. Collett: Ladies and Gentleman:

It is indeed a pleasure to be here today representing the Utah Mosquito Abatement Association, and certainly we, in Utah, are appreciative of the help and support we have had from this Association in California, and we feel that although our Utah Association is small, we are a very active group and much of its success can be attributed to the California group. It is gratifying for me today to see this crowd, and we do have from Utah at this meeting four District Managers, Board Members of these districts. We also claim as Utahans Dr. Hess and Louis Ogden in addition.

REPORT FROM UTAH

Glen C. Collett
Manager, Salt Lake City MAD

AND

Lewis T. Nielsen, Ph. D.
University of Utah

Mosquito control in Utah is now being carried on chiefly by six organized districts in four counties, Boxelder, Davis, Salt Lake and Weber. All of these counties border the east side of Great Salt Lake and contain approximately 530,000 people or 64% of the state's total population.

The Utah Mosquito Abatement Association continues to be a very active group and is now preparing for its eleventh annual meeting to be held at Weber College, Ogden, Utah, March 14-15, 1958. We would like to extend a personal invitation to each one of you to attend.

We should also like to report that the Utah Association, the Logan Field Station and the Training Branch, CDC Public Health Service of Atlanta, Georgia, are sponsoring a Mosquito Control Conference to be held at Farmington, Utah, February 4-8, 1958. This school, under the direction of Dr. Harry D. Pratt, Chief of the Insect and Rodent Control Training Section of the CDC, Public Health Service was first presented in Utah in 1955. Dr. Pratt has prepared another excellent program. Our association is most appreciative of the opportunity of having this excellent training available again to mosquito control workers in the state.

Closely associated with the mosquito abatement work in Utah is the research in progress at the Logan Field Station, Technology Branch, CDC of the Public Health Service under the direction of Dr. Archie D. Hess. Dr. Hess and his staff have done much to further effective mosquito control in Utah. Also working closely with the Utah Association is the Department of Zoology and Entomology of the University of Utah under the direction of Dr. Don M. Rees. Dr. Rees, who is well-known to most of you, has also served for the past fifteen years as a member of the Board of Trustees of the Salt Lake City District and has rendered invaluable service. He is now on a year's leave of absence and at present is teaching medical entomology and mosquito taxonomy at the University of Indonesia at Djakarta, Indonesia.

Some interesting events occurred in Utah during 1957. The state legislature passed a bill which enables the creation of mosquito control districts by county commissions. Such districts are then automatically placed under their control. This bill, as far as we can determine, does not affect the districts that are now in operation.

Considerable interest in the organization of new mosquito abatement districts has been shown by Utah and Cache counties during the past year. A series of meetings, consisting of mayors and county commissioners were held in Utah County in 1957. Just prior to the end of the year the mayors of this county decided that a survey should be conducted during 1958 to determine the extent of the mosquito problem and the feasibility of organizing an abatement district. The committee contacted Drs. Vasco Tanner and Eldon Beck of the Brigham Young University, Department of Zoology and Entomology who agreed to work with the county on such a project. Approximately $5,000.00 has been contributed by the cities in Utah County to cover this survey.

In Cache County there has been increased interest on the part of the county commission as to the need of mosquito control, but no surveys have yet been definitely planned. However, it appears likely that both Utah and Cache counties will eventually organize mosquito abatement districts. When this occurs at least

80% of the people of Utah will be receiving the benefit of mosquito control operations.

During 1957 an outbreak of Western equine encephalitis in horses occurred in northern Utah. Thirty seven positive cases and a considerable number of presumptive cases were reported. The State Health Department also reported two positive human cases with one resulting in death. One other death, that of a 12 year old girl, was caused by a possible encephalitis infection.

In general, the mosquito nuisance in the organized districts was very low during 1957 even though there was above normal precipitation during March, April, May, and June and very heavy spring run-offs occurred in the valleys of northern Utah. Effective water management and timely mosquito control practices were responsible for the small adult mosquito populations which resulted. For the first time in many years there was no major migration of *Aedes dorsalis* into Salt Lake City. Several counties not carrying on mosquito control reported increased annoyances during the year.

Tremendous strides have been made in bringing about good relations between mosquito control districts and the Utah State Department of Fish and Game. Much of the credit for this was due to J. Perry Egan, late director of the Fish and Game Department. His recent death was deeply regretted by mosquito workers throughout the state.

Maintenance of existing drains in Salt Lake County by the cooperative drainage policy between the Salt Lake City Corporation, Salt Lake County, and the Salt Lake City Mosquito Abatement District was continued in 1957. The drainage of the entire county has been improved by this program and considerable progress in water management has been made each year since its inception in 1952.

Pres. Greenfield: Fellows, I hope you had a good chance to see these gentlemen from Utah, and make the opportunity of getting better acquainted with them, because they are quite a gang.

Our next will be a panel discussion on mosquito control, their environment and changes. Panel moderator is Dr. Stanley B. Freeborn, Provost of the University of California at Davis. Dr. Freeborn will introduce the subject and then ask the audience to participate.

Dr. Freeborn: Gentlemen, this is an audience participation session. I hope there will be a lot of $64,000 questions and answers—no prizes—and it's just one of those kinds of meetings where we "talk shop" about the problems we have met in the changing conditions producing changes of patterns in our mosquitoes and their methods of control. It's a place where we can talk our own language of mosquito identification and control; and that brings me up to a story—but first, Ed, cut off that machine. (laughter)

Having set the tone for the meeting, I'd like to start this discussion. Perhaps the earliest history of mosquito control goes back to the mistake of Sir Malcolm Watson where he found in one area if he cut the trees and did away with the shade that the particular malaria carrier that was in the area couldn't breed because of lack of shade, so he made a reputation by cutting down all the trees. He was invited to repeat his success in another area a short distance away, which he did but the worst malaria species in the world came in and throve in the sunshine. Now, that's a condition we are meeting all of the time in our practical control work. Most of you here have seen *Aedes nigromaculius* replace *Aedes dorsalis* in California. Purely, probably, due to irrigated pastures from the old type of irrigating waste lands of the older days.

All of you must have problems along that line. Who has a question?

Mr. Stage: For the past two weeks, I have been going up and down the Valley visiting some of the MADs here, and I've been impressed by the numbers of those - - - you mention—*nigromaculis*, and I've been wondering if those things are going to be able to come up into the arid section of Washington and take over there as they seem to have taken over here in the Valley?

Dr. Freeborn: I think they were up there long before they got to California. (laughter)

Mr. Stage: Do you have any idea of how to prevent it? We have no irrigation at present, but do have some row crops and alfalfa.

Mr. Graham: We haven't had the changeover yet to *nigromaculis*, but we apparently are getting it. At least records in the control areas seem to indicate that.

Dr. Murray: We have seen a change favoring *nigromaculis*, in our source reduction program which causes us some consternation. Many of our irrigated pastures are extensive swamps at times of the year, and as we introduce a drainage program we reduce the swamp part by perhaps 90%—as we do that, we still have water standing over parts of the field for four or five days. We are, thus, changing *Culex tarsalis* breeding areas to *nigromaculis* breeding areas, creating a more severe problem than we had before.

Bob Peters: I might say we have *nigromaculis*, but it's a matter of keeping peace with them. Before the MAD was established, the area of Lodi had a WPA project on the river and it was assumed that this would help clear out the malaria vector. This pick and shovel work managed to develop a condition so desirable that they produced the greatest malaria outbreak in their history. This occurred because of insufficient knowledge of the mosquito. Since the district has been in existence, control still involves the same general river area. At that time, we had a situation which was primarily an *Aedes* problem of *sticticus* and *vexans*, *vexans* primarily. We cleared these areas and were very pleased with our results. Up until 1952, we had cleared several hundred areas. It appeared that we had licked the problem of the *Aedes* mosquitoes. We had the complete answer as far as control of *Aedes* mosquitoes were concerned. But, it so happens, we were fooled. As you all know, 1952 was a year of record or history as far as California goes. We had a snow melt situation where the release from Pardee Dam carried this water down through a 33-mile stretch of the District. This produced a seepage condition which was an entirely different situation, causing a tremendous population of *Culex tarsalis* in the Mokelumne River bottom in the Lodi area. I never realized before that a mosquito could adapt itself so rapidly and completely as it did that year. This was true in other MAD's, I'm sure, as it was in ours. We have actually run into a new situation as a consequence of this work we have undertaken which now involves some 1,100 acres of cleared land. We have really opened the door for this species which is perhaps the No. 1 mosquito of concern in California. This change of conditions has taught us all a lesson, so we now are attempting to keep a careful watch on the *C. tarsalis* potential.

Dr. Freeborn: Did the same thing happen in Bakersfield? *Vexans* used to boil out of the river bottom down there. Do you want to talk, Frank?

Mr. Stead: One form of change which I think we should keep our eyes on is the change in water quality that is put on the land—the organic and mineral content changes, I mean. Last week, at Davis, there was a Water Quality Conference held and two or three farmers from the San Joaquin Valley stated that they had been supplying water to their land from wells which ran perhaps 700 PPM solids, on fairly sandy loam soils which would have been good for 15-20 years. They switched to canal water with actually a lower sodium ratio, about 40%, resulting in the soil tightening up so that water penetration became a real problem. The water stayed on top. You can all see the potentialities of this situation.

Mr. Raley: I'd like to relate some of my experiences in the Marysville area based on drainage done by MCWA. If you are familiar with the Marysville-Yuba City area, you will know that the Feather River is a very slow moving body of water, nearly a lake. In our MCWA work, we "unwatered" a large area of pasture land, several miles from the town. In the course of events, we encountered an infestation of *nigromaculis* in the town area. We soon found that we transported the *nigromaculis* larvae and pupae through our excellent drainage system approximately seven miles to the populated center of that area. We created a problem that did not exist before, but the drainage was excellent. We moved those mosquitoes seven miles in less than 18 hours. (laughter)

Mr. Gray: I think some may have read the History of Malaria in California that Russ Fontaine and I wrote, published in the last Proceedings. One of the things in there is of interest today as regards environmental changes which affect the malaria picture in California regardless of control measures. It actually began before we knew very much about the mosquito and probably began before we knew much about the cause of malaria. It's been due to environmental changes we have done considerable speculation as to just what those changes have been which had influence upon the gradual reduction of the disease. I doubt very much wehther there has been any reduction in the numbers of Anopheline species, there probably was some environmental change which had some influence on the mode of transmission of the disease itself. So, I think, in this relationship of the environment we must take into consideration not so much the effect upon the vector mosquitoes, but if you are dealing with the disease problem, the environmental situation which produces change upon the transmission of the disease. It takes a lot of hard thinking and observation to learn what these changes are—but right now we don't know. We may find that out about encephalitis. There may be some change in environment which will minimize the disease aside from actual prevalence of *tarsalis.*

Dr. Freeborn: Yes. Dick Peters—

R. F. Peters: I'm going to raise a question which I don't propose to have the answer to. I'd like to capitalize on the presence of Bob Metcalf and others of Southern California who have some acquaintance with *Psorophora confinnis.* How is it that *P. confinnis,* being as close to the Valley as it is, has not made entry into the Central Valley? What is there different about the requirements of *P. confinnis* that so far has not led to its being established here? I ask this with all due respect to the potential of this mosquito. Perhaps there is someone here who can answer this question. It's a real menace to the Valley area.

Dr. Freeborn: Because where *Psorophora* occurs, people can't afford to stay out at dusk to be bitten by Anophelines.

Mr. Anderson: It may be that one species in a niche cannot compete with another species in that niche without great adaptation. This is evolution and of course does not take place in a short time. It looks like what has happened here is that you have eliminated one species from the niche and another has taken its place. This has happened in Utah. *Nigromaculis* has taken over where *dorsalis* were. *Dorsalis* apparently can't compete with *nigromaculis* in the same niche. Certainly, if we change the niche, the species best adapted to that niche will spring up and take over.

Mr. Husbands: I have a bit to add to this. Some time ago I gave a paper on this problem. From our work, etc., I don't think there is actually competition between *dorsalis* and *nigromaculis.* The competition for food is apparently not a limiting factor. The places to live in irrigated pastures are extensive, so actually, I don't believe that *dorsalis* or *melanimon* is being replaced by *nigromaculis.* I don't believe *dorsalis* has the biotic potential and adjustability to environment that *nigromaculis* has. *Nigromaculis* has certain advantages in these respects. I believe the environment is ideally suited to *nigromaculis.* This points up the need for much more study and work along these lines.

There is another factor here, too. As pastures change due to time or aging, the aging leads to several significant changes to the surface of the field. Aging usually produces greater areas of water and consequently greater mosquito production. As this goes on, it benefits *nigromaculis,* and still later benefiting *C. tarsalis.* This is primarily theoretical, so I don't want to stick my neck out too far on it. We haven't pinned it down by actual fact, but our studies do indicate this action.

Mr. Mulhern: I don't have any theoretical consideration, but a very practical consideration. Early this summer at the BVC, we got an SOS from San Diego County. San Diego County was rapidly establishing some light trap records on *tarsalis* in the vicinity of the coastal marshes, so Harvey Magy made arrangements for me to go down and spend a week or so to find out what had happened. Briefly, the small coastal communities which had disposed of their sewage effluent by discharging it into the ocean had their plants become more and more loaded as their population increased and some of their outfall lines had become ruptured, and they found it was cheaper to partially oxidize the effluent in the sewage plants and then dump it into these little coastal marshes. This, I think, is a trend of the times in many local communities, and had in this instance caused a switching over from a salt-marsh *Aedes,* to a *C. tarsalis* problem by making the water fresh enough for them.

Dr. Freeborn: I notice on the program a discussion of log-pond mosquitoes; there were two log-pond problems which came up before NIH for grants-in-aid. I took a very dim view on both of them, for I didn't think there was much difference from a log-pond mosquito problem from any pond problem. I'd like to know what the problem is?

Mr. Warren: I'm Jack Warren from Eugene, Oregon. I'm glad to see this log-pond problem come up, as I have several in our area. I have some questions on the subject relating to temperatures, types of insecticides, etc.

Dr. Freeborn: What happens when logs are added to a pond?

Mr. Warren: They increase, but I don't know why. I'd like to know. We have a very serious problem up there of about 900 acres of log-pond and sloughs. Most of the mosquitoes are *C. tarsalis* in July.

Mr. Maynard: We, in the BVC, have been looking at log ponds all this last summer. Actually all that we do know now is that they are very heavy, 2,000-3,000 per dip, (standard dipper). Even last month, the breeding was very heavy of *C. stigmatosoma*. We have had very few of any other species.

Mr. Smith: I've been wondering if there isn't some material which comes from the logs and bark which makes the usual insecticides nearly impossible to use for any control. Can anyone enlighten us on that point?

Mr. Maynard: Several problems are involved. Plywood mills cannot use any oil base insecticides because of staining. I saw one pond treated with enormous quantities of Malathion by a hand sprayer. The man merely walked the logs and did a good cover job. The larvae were killed but three days later 1st and 2nd stage larvae were found, showing that there was absolutely no residual effect of the insecticide. One pond was treated with large quantities of crank-case oil, but no control was obtained. They were putting it in where the logs were dumped from the trucks, but no month went by without mosquitoes being present—even when temperatures were very low, around 28° F. I certainly don't know the answers.

Dr. Murray: We have had several log ponds in the Delta MAD with one still in existence. Last summer a mill bought the timber from a burned over area and stacked them over several acres of pond. We had *C. quinquefasciatus* there until the middle of December, when we could pick up hundreds per dip from the frozen water. Early in the spring, we get a lot of *stigmatosoma*, but as the season warms up the *quinquefasciatus* take over.

Dr. Freeborn: I've been amazed that no one has brought up the problems resulting from the breaking up of pasture area into row-crops. I've understood that mosquitoes breed in the rows between crops. This is a difficult situation to treat, I know. Has anyone any ideas on this subject?

Mr. Greenfield: I haven't had that problem, but I do have one that hasn't been brought forth. The particular problem has to do with the Spreckles holding ponds for the effluent from the mills. In the past years we have obtained good control, but last year the processes of making sugar were changed, new equipment added, etc. Certain changes have resulted from these new processes which have made mosquito control nearly impossible. We even applied as high as 13 pounds of Toxaphene per acre but got no control whatsoever. The changes have resulted in chemical changes in the effluent which, so far, we haven't been able to correct.

Mr. Grant: I think that the problem is that when the chemicals are exposed to the high organic materials, they are going to suffer a breakdown through oxidation. The processes involved have never been completely explored; although, Dr. Metcalf did give us a talk on it at one time. It's a problem which affects all districts at one time or another and one which does need careful study to overcome the problem of insecticide inactivation through oxidation by organic matter or other factors.

Dr. Freeborn: I promised to bring this session to a close on time, and since we have caught up with our program, this patricular panel is adjourned.

Pres. Greenfield: Thank you, Dr. Freeborn. As many of you know, Dr. Freeborn has been a long time interested in mosquitoes and the CMCA. We are proud to have you with us. From the many questions posed to this panel, it is quite evident that much more basic research is needed. The meeting is adjourned until 2:00 P.M.

SECOND SESSION

MONDAY, JANUARY 27, 1958, 2:00 P.M.

A PROGRESS REPORT ON THE MOSQUITO CONTROL INVESTIGATIONS OF THE LOGAN FIELD STATION

A. D. HESS

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Logan, Utah

Logan, Utah, is headquarters for some of the Communicable Disease Center's research activities on encephalitis and other vector problems associated with Federal water resource development projects. The major activities which involve mosquitoes are: (1) studies on the natural history and control of St. Louis and western equine encephalitis; and (2) investigations on the ecology and control of mosquitoes and other arthropods of public health importance which breed in aquatic habitats created by irrigation and other impounded water projects. Some of the more important of these investigations are carried out by the field units at Chinook, Montana, and Bakersfield, California. The Chinook studies include a cooperative project with the Agricultural Research Service of the U.S. Department of Agriculture, and the Bakersfield studies are carried out in cooperation with the University of California School of Public Health at Berkeley.

Some of the more significant research developments of the Logan Field Station during the past year are as follows:

1. Clarification of some of the basic interrelationships between encephalitis vectors and hosts.
2. Additional evidence on the survival of western equine encephalitis virus for extended periods in mosquitoes and avian hosts.
3. New knowledge on the comparative ecology of log pond mosquitoes.
4. Additional information on the relation of plant ecotypes to the production of *Culex tarsalis* and associated mosquitoes.
5. Development of improved techniques for the quantitative measurement of populations of mosquito larvae.
6. Further demonstration of the effectiveness of pre- and post-flood residual larviciding with dieldrin, heptachlor, and DDT for the control of irrigation mosquitoes.
7. Detection of low levels of resistance to chlorinated hydrocarbons in *C. tarsalis* populations in the Weber Basin area of Utah.
8. Determination of residues of dieldrin resulting from the application of residual larvicides to irrigated pastures and hay meadows.
9. Further development of soil and water management practices mutually beneficial to mosquito control and crop production on western wheat grass hay meadows.
10. Determination of the mosquito production potentials of sewage stabilization ponds in the North Central States.

CHEMICAL CONTROL OF MOSQUITOES IN UTAH

JAY E. GRAHAM
South Salt Lake County Mosquito Abatement District

AND

DON M. REES
University of Utah

During 1956, field observations in the Salt Lake City Mosquito Abatement district indicated resistance to heptachlor developing in mosquito populations. In 1957, similar observations were made in South Salt Lake County and Weber County districts. Laboratory tests confirmed that resistance was indeed becoming a problem to mosquito abatement in Utah (Reid, in press). The development of resistance requires a re-evaluation of the chemical control of mosquitoes in Utah.

The background of the development of this resistance explains some of the factors that have contributed to it.

The first evidence of resistance was reported from the Salt Lake City district, which, for many years, had operated an effective mosquito abatement program, but was surrounded by extensive, uncontrolled areas. Migrations of *Aedes dorsalis* from the uncontrolled areas into the Salt Lake City Mosquito Abatement District were not uncommon and it is probable that many of the larvae developing in areas controlled by the Salt Lake City district were descended from mosquitoes that had never been exposed to DDT or other insecticides. In 1953 the Davis County Mosquito Abatement District expanded operations north of Salt Lake City and the South Salt Lake County Mosquito Abatement District began operations. Salt Lake City was relieved of control operations in some of the areas to the north and south and was able to concentrate more effort on the marshes north and west of the City. Airplane spraying was greatly expanded in 1954 and supplemented by sprays and fogs along routes that migrating mosquitoes might use. Salt Lake City was able to experience some summers nearly free of *Aedes dorsalis* for the first time in its history and when mosquitoes did move into the city, their numbers were generally less than in other years.

This expansion of operations and the more complete control that followed resulted in more and more of the larvae being descendents of survivors of spraying operations, and contributed to the development of resistance to the chlorinated hydrocarbons in this area of Utah.

Although DDT and some other chlorinated hydrocarbons are still in use in most mosquito abatement districts in Utah, other toxicants will probably he required in the future. Mosquito abatement in Utah can either shift to the organic phosphate insecticides, as has been done successfully in Caifornia (Geib, 1955), or it can select some toxicant used successfully in the past as Vannote (1957) states New Jersey would do if resistance developed there. The most suitable course of action for Utah can best be determined by a study of the toxicants and procedures of the past and comparing them with the new insecticides in relation to the mosquito control problems, as they exist in Utah.

Organized mosquito control in Utah, before World War II, was limited to the Salt Lake City Mosquito Abatement District. Fortunately, excellent records of the activities of this district were kept and included in the annual reports prepared at first by R. V. Chamberlain and Don M. Rees, and later by Rees and supervisors of the district. The information reported here is from these reports, unless otherwise cited.

Oil and oil mixes were the first materials used by the district for larviciding and adulticiding. Several oils and oil mixes were tested by Rees in 1929 and 1930. Some of these were Culmer's mosquito oil, which was a mixture of 90% fuel oil and 10% pressure stilled tar, light distillate oils used alone or mixed with naphalene or turpentine, three grades of oil then in use for mosquito control in California, crank case oil and other oils. None of these proved to be wholly satisfactory. In 1930, a material drawn from distilling tanks used in the manufacture of creosote and called cre-naph, was obtained from Columbia Steel. Cre-naph was mixed with fuel oil in different concentrations and the resulting formulations tested in the field against mosquito larvae. The most satisfactory mix was 90% fuel oil and 10% cre-naph. This proved to be more effective than any of the other oils or mixes and was used for several years. Crank case oil was not satisfactory when used alone for mosquito larviciding, but was found useful for thickening formulations for longer residual action when wind or storms disturbed the water surface.

Approximately 50 gallons of oil per acre was applied by power equipment and almost that much by knapsack sprayers. The cost of oil at this concentration is excessive when compared with the cost of larviciding with DDT or parathion. In addition, oil will discolor vegetation, is apt to be more toxic to wildlife, is unpleasant when spilled on the skin of the operator or, when mixed with cre-naph, is painful.

Paris green was adopted in 1930 for the control of *Anopheles freeborni* larvae. When mixed at the rate of one part Paris green to two parts hydrated lime and applied to the water surface with a California Beauty Dusting Machine, it was found to be both effective as well as economical and no injurious effects were reported.

Ginsberg (1930) and Vannote and Ginsberg (1931), reported that a pyrethrum mosquito larvicide was used effectively in New Jersey and could be used to supplement oil. This larvicide was used in 1931 by the Salt Lake City Mosquito Abatement District to treat areas where the use of oil was objectionable. This formulation was economical, but did not prove to be effective for the larger mosquito producing areas in Utah. Careful field testing showed kills as low as 33% in some areas. This larvicide was effective on small areas and was used for many years to treat small pools in residential areas.

A pyrethrum formulation for the control of adult mosquitoes was reported by Ginsberg in 1936 and adopted in Utah in 1938.

DDT was tested in 1945 by the Salt Lake City District and became the principal insecticide for mosquito control in Utah for several years. DDT was applied at 0.2 lb. per acre for the control of larvae. Adults were controlled by a spray containing 0.5% DDT and 5% thanite in kerosene. Fogs containig 8% DDT in fuel oil were dispersed first by a venturi arrangement on a truck and later by a TIFA and both appeared to be effective.

Other chlorinated hydrocarbon insecticides were tested in Utah for mosquito control and many appeared to be both effective and economical, but no adequate reason was found for changing from DDT until heptachlor was tested. Rees and Graham (1953) found heptachlor to be effective against the common pest mosquitoes in Utah at 0.04 lbs. per acre. The South Salt Lake County Mosquito Abatement District adopted heptachlor as its principal insecticides in 1953, because it seemed best suited for the particular problems of the District (Graham, Rees and Edmunds, 1954). Dieldrin was also extensively used at the same concentrations as heptachlor. Dieldrin has a longer residual action than heptachlor but in most of the areas where it was used, in Salt Lake County, conditions were such that little or no residual effects could be obtained.

After 1953, other districts in Utah used heptachlor and it became as commonly used as DDT for mosquito larviciding. Heptachlor was also used as a 1% oil solution for fogging.

DDT and dieldrin have been tested as pre-hatch sprays, but the results have not been uniform. Tests currently being conducted by Glen Collett indicate this type of larviciding can be effective in Utah, if the proper insecticides are applied in sufficient quantities.

Rees and Nielsen (1952) reported that tossits, small gelatinous capsules containing 12% DDT and 4½% BHC, were used to treat small areas and, in some cases, lake margins. They were used effectively in mountain areas that were difficult to treat with knap-sack sprayers and apparently had good residual effect. The major disadvantage of tossits is the tendency of the capsule to break when heated or carried for any length of time. Good dispersion of insecticide was obtained on continuous water surfaces but areas with numerous cow track or similar situations could not be effectively treated with tossits.

Granular formulations with several insecticides have been tseted and used extensively for mosquito control in Utah. Graham and Rees (1955) conducted tests with several granular carriers and concluded that panacalite, an expanded aluminum silicate, was a superior carrier for hand application. The cost of treatment with attapulgite or bentonite was approximately four times as high as with panacalite. Both bentonite and attapulgite granules obtained for testing in 1954 contained excessive quantities of fine dust while the panacalite granules submitted for testing did not. Since these tests were conducted, there have been some changes that require a new evaluation.

Attapulgite granules are now available in Salt Lake City at about 40% of their price in 1954 and improvements in methods of formulation have eliminated the fine dust. All of the panacalite granules that have been used since the test material, have contained considerable quantities of dust. Attapulgite granules are now in use in most mosquito abatement districts in Utah.

The use of granules for the hand application of insecticides has been very effective in Utah. They are used primarily to treat small areas at the time of inspection. Several different sizes have been used, but most districts prefer 20-40 mesh size or larger.

Graham and Rees (1956) concluded, on the basis of their own tests and the results obtained in California, that malathion and parathion could be safely and effectively used for the control of mosquitoes in Utah. Both were used by the South Salt Lake Mosquito Abatement District in 1956 and parathion became the preferred insecticide used by that district when resistance developed in 1957. It is applied for the control of larvae at 0.05 lbs. per acre. The cost of material for larviciding at this concentration is less than 20¢ per acre. Malathion can be used effectively for the control of mosquito larvae at 0.4 lbs. per acre, which makes it more expensive than parathion. Parathion, properly used for the control of mosquitoes, is not a threat to other organisms.

Summary and Conclusions

The development of resistance to the chlorinated hydrocarbon insecticides in mosquito populations in Utah makes a re-evaluation of control procedures desirable.

Many of the oils and oil mixes used during the first years of mosquito control in Utah were unsatisfactory, but a formulation of 90% fuel oil and 10% cre-naph was very effective. The cost of oils applied at rates approaching 50 gallons per acre is excessive when compared to the cost of mosquito control with DDT or parathion. In addition, oil is apt to be more destructive to wildlife, discolors vegetation and is often unpleasant to handle.

Pyrethrum larvicides were found to be unsatisfactory for many mosquito producing areas in Utah, but a pyrethrum formulation for the control of adults has been used effectively.

Granular carriers have been used effectively in Utah to treat small mosquito producing areas by hand at the time of inspection. They are superior to tossits because they give better dispersion of insecticides in many of the situations encountered and they can carry organic phosphate insecticides.

Additional data obtained since 1954 shows attapulgate or bentonite to be superior carriers of insecticides for mosquito larviciding in Utah instead of panacalite as was formerly concluded.

Parathion and malathion can be used safely, economically and effectively for mosquito control and are the most satisfactory solution to the problem of resistance in Utah.

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PRELIMINARY NOTES ON LIGHT TRAPS AND *CULEX QUINQUEFASCIATUS* (SAY) DISPERSAL IN HAWAII[1]

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Introduction. Breeding sources of *Culex quinquefasciatus* (Say) are normally found as relatively small, scattered water catchments throughout more or less developed areas. The adult flight range is usually considered to be rather limited. In the Pearl Harbor area of Hawaii, where this species is the only serious mosquito pest, the most intense breeding occurs in concentrated areas associated with sugar cane wash water where used for irrigation or soil reclamation. The adult population densities produced are more characteristic of irrigation, flood water, or salt marsh mosquitoes than of the familiar house mosquito. These special conditions have provided an opportunity to study *C. quinquefasciatus* dispersal by the use of light traps over a period of several years.

Background. Figure 1 is a diagrammatic representation of the area involved. The circles represent one mile intervals. The major source area is on Waipio Peninsula which is utilized largely for sugar cane production. Pipe lines which carry wash water from the mill are indicated by broken lines and four reservoirs used for storage and distribution are represented by the small black circles. The wash water contains dissolved sugar and supports a considerable amount of fermentation.

Exceptionally heavy breeding occurs in this area during the sugar cane harvest season from March to October while cane wash water is used for irrigation. During the non-harvest season from November to February relatively little breeding occurs in this area. Another, but less productive, settling basin area is located about four miles to the southwest of the Waipio source area and is referred to as the Ewa or secondary source. Mosquito production which is NOT associated with sugar cane harvesting procedures normally occurs in significant amounts only during the wet months from November to April. The important sources during this period are ground pools in pastures, dairy wastes, run off, or other low areas, although scattered container-type catchments may add significantly to local mosquito populations during periods of frequent rains. The most important ground pool type sources are indicated in Figure 1 by the symbols for marshland and are located for the most part to the north and east of the Harbor area.

Civilian and military population centers extend along the north and east shores while Waipio Peninsula and areas to the west and southwest are sparsely settled. Intense illumination at night occurs to the east and southeast of Waipio in contrast to the almost total darkness to the west and southwest. Prevailing winds are normally constant northeast trades.

Trap locations are also indicated on Figure 1. Trap A is the nearest (0.5 miles) to the heaviest breeding sources on the upper portion of Waipio Peninsula. Trap B is just across the channel from the tip of Waipio, two or three miles from upper Waipio. Trap C on Ford Island is about the same distance from the major breeding sources. Trap D (Makalapa) is three to four miles from the Waipio sources but within about 0.5 miles of ground pools which are flooded and become mosquito sources only during wet weather. Trap E (West Loch) is one to two miles southwest of the Waipio source area and about three miles from the Ewa settling basins. Trap F (Receiving Station) is located three to four miles from Waipio and about one mile from the Makalapa sources. Trap G (NHA3) is four to five miles from Waipio and about 1.5 miles from the Makalapa sources. Trap J (Rifle Range) is about four miles from Upper Waipio and about 2.75 miles from the Ewa settling basins. Traps H and I at Barbers Point are not shown on the map but are located about 2.5 and 0.5 miles from the Ewa source respectively.

Light Trap Data. Light traps were the standard New Jersey type with automatic timers and were operated nightly except for occasional power or mechanical failures. When traps were inoperative for less than 10 days monthly totals were estimated by interpolation, otherwise the trap is indicated as out for the month. Results are given as total females caught. It should be mentioned at this point that the number of males caught was relatively high even at trap locations two miles or more from the nearest breeding source. Ratios of from one to two females per male were common, indicating a dispersal range in this area considerably greater than generally expected for *C. quinquefasciatus* males. This occurred even during very dry periods when the only possible sources were the sugar cane wash water locations at a distance of one to two miles.

The monthly total female indices of traps A, B and D are shown in Figure 2 along with rainfall in inches from January 1954 to August 1957. Each interval on the right hand scale for trap A indicates 800 mosquitoes while all other traps are shown on a scale of 150 mosquitoes to each interval. The most obvious point to be noted in Figure 2 is the extremely high index obtained at trap A from 1954 through 1956 as compared with traps B and D. Another outstanding feature is the cor-

[1] The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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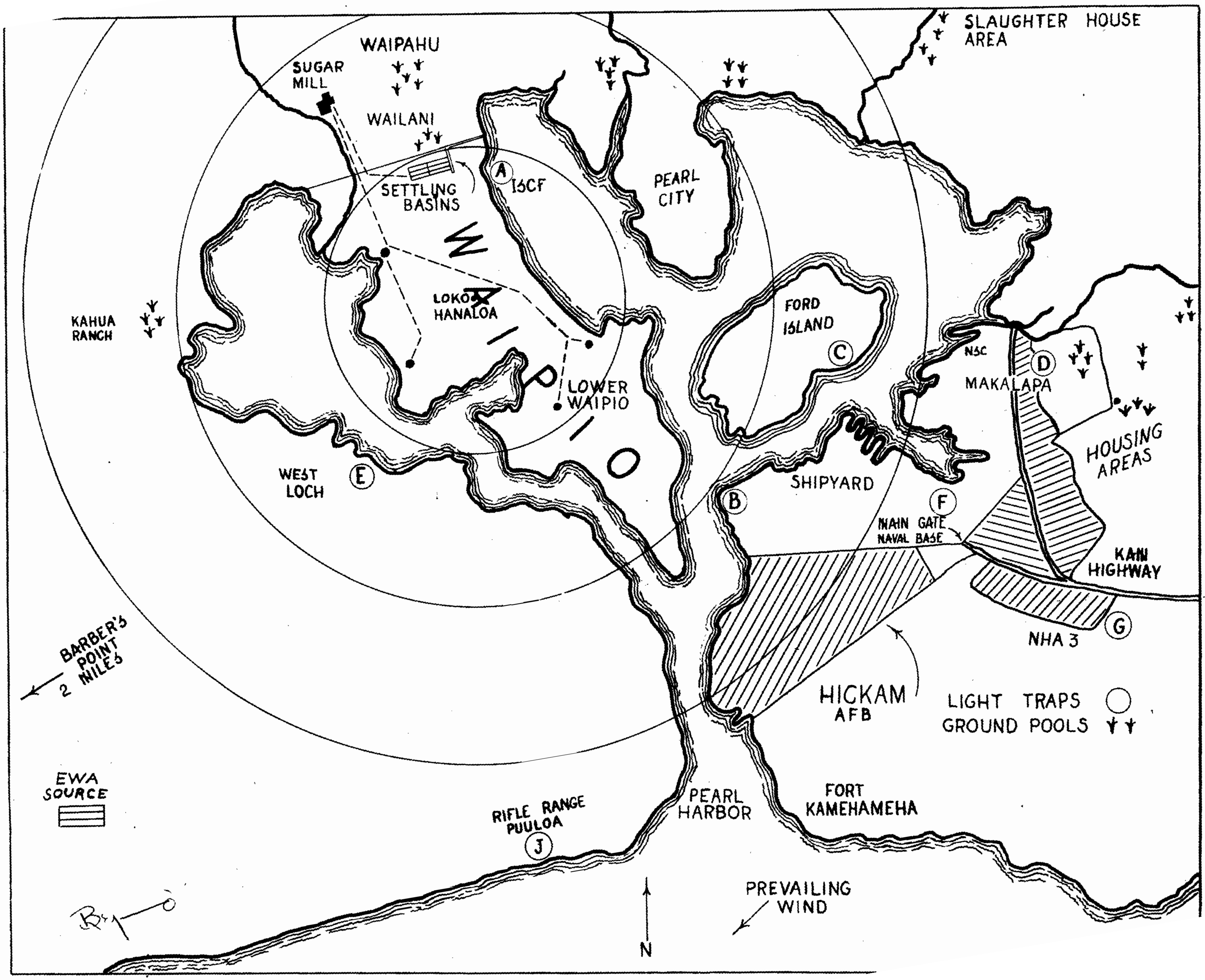
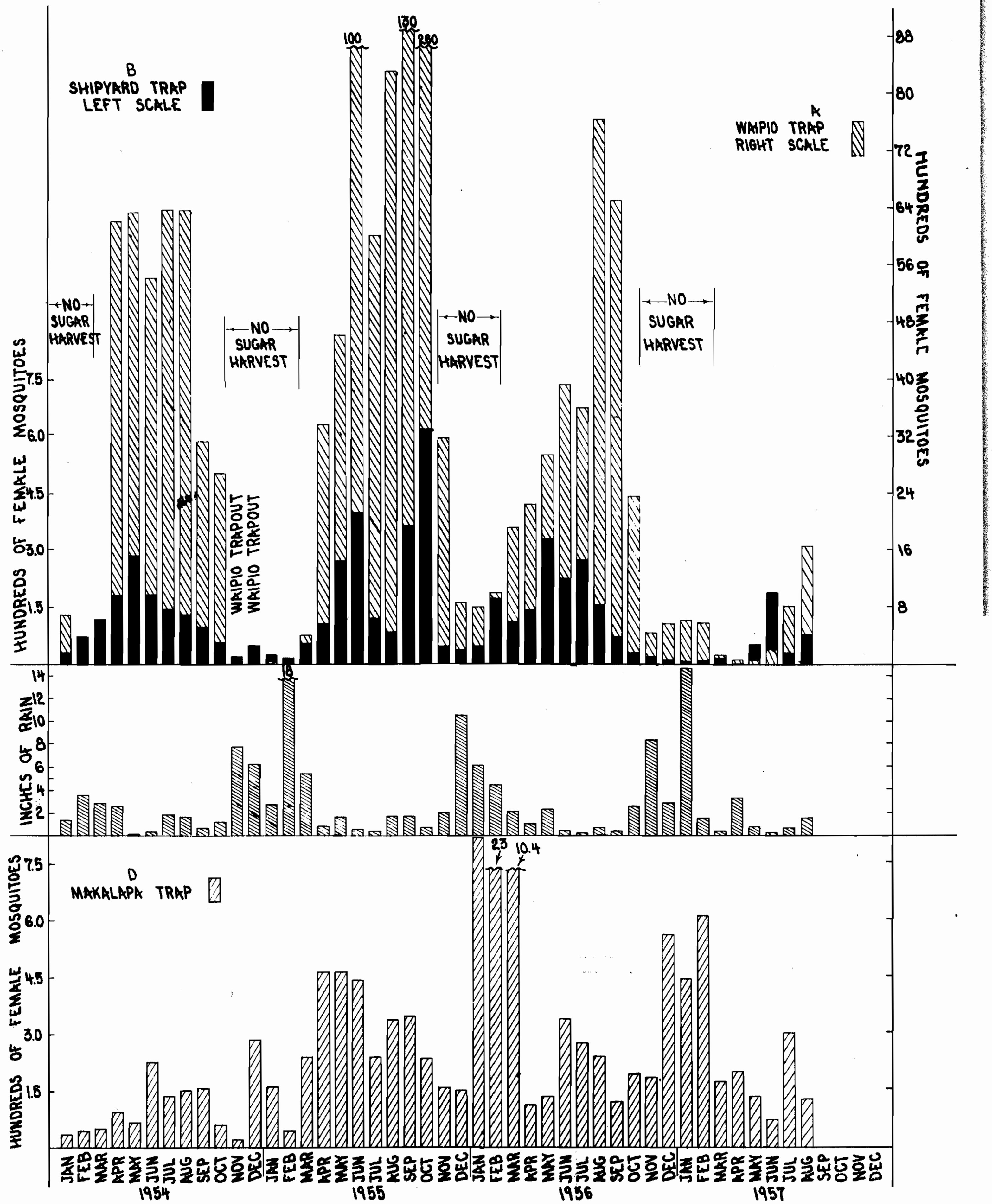
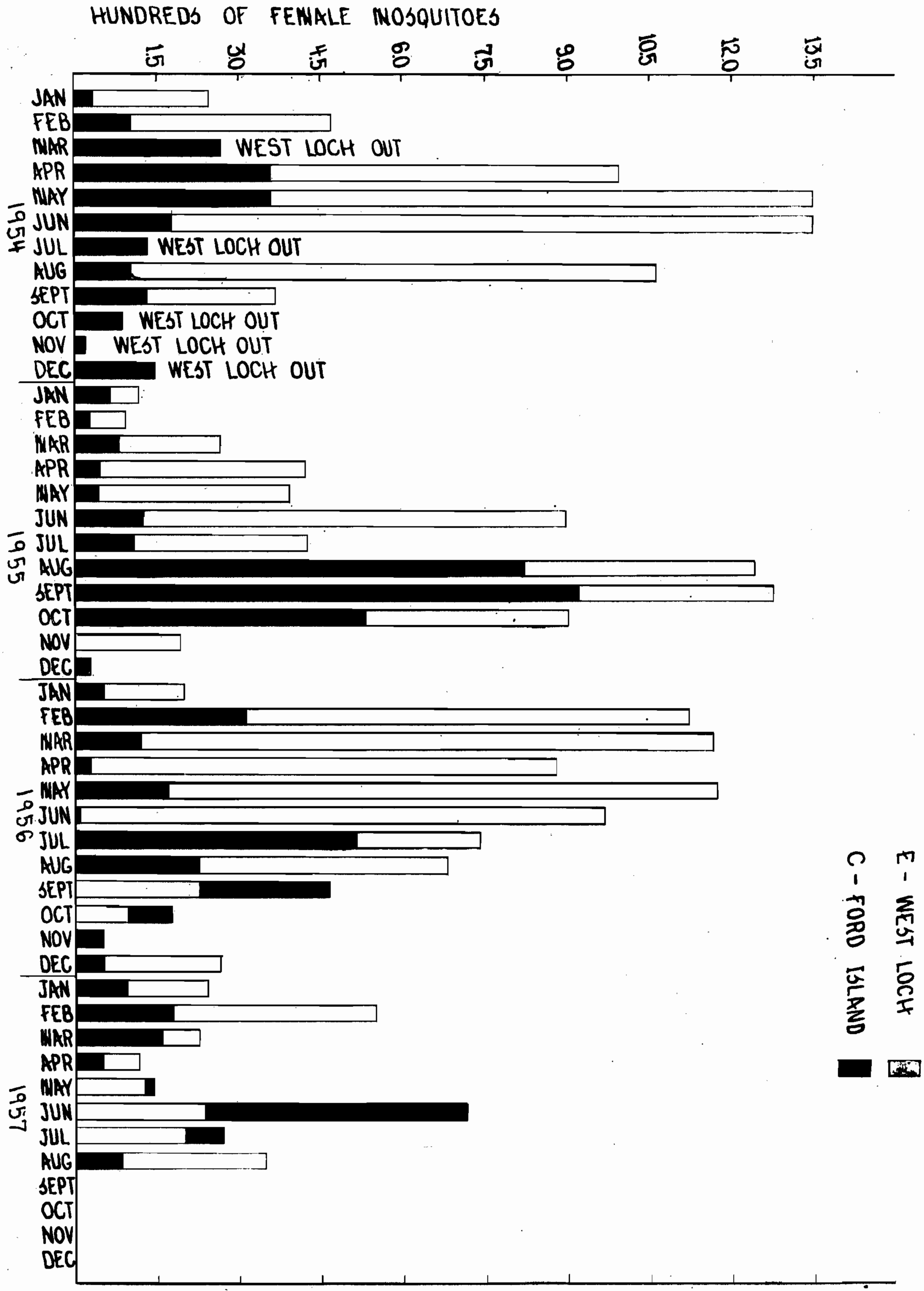
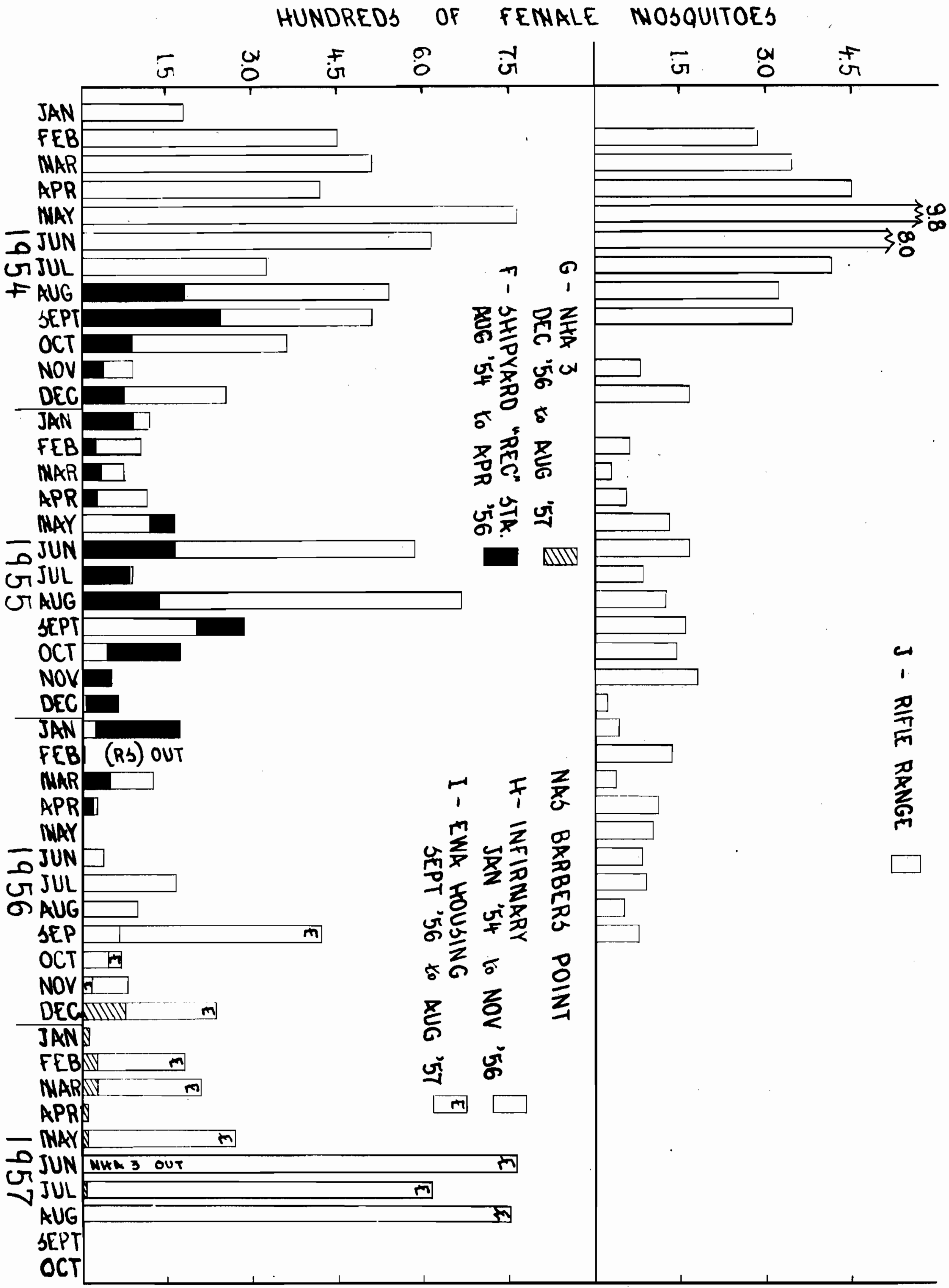

SLAUGHTER HOUSE AREA
WAIPAHU
SUGAR MILL
WAILANI
SETTLING BASINS
A
ISCF
PEARL CITY
WAIPIO
LOKOA HANALOA
LOWER WAIPIO
KAHUA RANCH
WEST LOCH
E
FORD ISLAND
C
NSC
MAKALAPA
D
HOUSING AREAS
SHIPYARD
B
F
MAIN GATE NAVAL BASE
KAM HIGHWAY
NHA 3
G
BARBER'S POINT 2 MILES
HICKAM AFB
LIGHT TRAPS
GROUND POOLS
EWA SOURCE
RIFLE RANGE PUULOA
J
PEARL HARBOR
FORT KAMEHAMEHA
PREVAILING WIND
N



B
SHIPYARD TRAP
LEFT SCALE
A
WAIPIO TRAP
RIGHT SCALE
NO SUGAR HARVEST
NO SUGAR HARVEST
NO SUGAR HARVEST
NO SUGAR HARVEST
WAIPIO TRAPOUT
WAIPIO TRAPOUT
100
130
280
HUNDREDS OF FEMALE MOSQUITOES
HUNDREDS OF FEMALE MOSQUITOES
1.5
3.0
4.5
6.0
7.5
8
16
24
32
40
48
56
64
72
80
88
INCHES OF RAIN
2
4
6
8
10
12
14
18
D
MAKALAPA TRAP
23
10.4
HUNDREDS OF FEMALE MOSQUITOES
1.5
3.0
4.5
6.0
7.5
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1954
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1955
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1956
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1957


HUNDREDS OF FEMALE MOSQUITOES
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
1954
1955
1956
1957
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
WEST LOCH OUT
WEST LOCH OUT
WEST LOCH OUT
WEST LOCH OUT
WEST LOCH OUT
E - WEST LOCH
C - FORD ISLAND


HUNDREDS OF FEMALE MOSQUITOES
1.5
3.0
4.5
6.0
7.5
9.8
8.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
1954
1955
1956
1957
(RS) OUT
NHA 3 OUT
E
G - NHA 3
DEC '56 to AUG '57
F - SHIPYARD "REC" STR.
AUG '54 to APR '56
NAS BARBERS POINT
H - INFIRMARY
JAN '54 to NOV '56
I - EWA HOUSING
SEPT '56 to AUG '57
J - RIFLE RANGE

relation between high mosquito catch and the sugar harvest season. It is also significant that there is an apparent negative correlation between mosquito population density and rainfall. This does not mean, however, that the normal increase in rainfall between December and March does not support mosquito production in the Waipio area but merey that the breeding which results from this rainfal is completely overshadowed by the tremendous production which occurs in the sugar mill wash water from March to October. The relatively low trap A levels from March to August 1957 is the result of intensified control operations in the Waipio area during this period. The trap B index follows the trend of trap A but at a much lower magnitude throughout the three year period and since rainfall was not a factor during periods of highest mosquito production it follows that the lower trap B index is a result of distance from the only active source in the area. The approximately equal indices of traps A and B during May and June 1957, are most likely due to the fact that relatively good control was obtained throughout most of the major breeding area during this period and the few broods which did emerge developed in foci at approximately an equal distance from traps A and B. The pattern of the Trap D index (lower portion of figure 2) for 1954 through 1956 also shows a tendency for peaks during the sugar harvest season; the picture is complicated however, by increased mosquito production during the wet season in less prolific but nearby breeding sources and consequently higher winter index levels.

Indices for traps E and C are shown in Figure 3. Here again we see the general correlation between summer peaks and sugar harvest season. The higher catch at trap E, relative to trap C, for 1954 through 1956 is correlated with its location nearer to the major sources; a reverse condition appears from May to July 1957 when an area nearer to trap C was the primary active source. Data for traps located at greater distances from the Waipio source area are shown in Figure 4. In general the magnitudes are lower but there is the same tendency for higher levels to occur during the sugar harvest season. A secondary source, the Ewa settling basins and adjacent areas, where sugar cane wash water was sometimes utilized, influenced the index of traps E, J, H and I during periods when it was producing large mosquito populations.

Theoretical Considerations. Detailed study of this trap data in conjunction with the significant source areas reveals a pattern in which the magnitude of the trap index is related both to intensity of production and distance from source. Discrepencies may be explained in most cases by known secondary or local sources, unusual rainfall, or control operations. It appears that dispersal is random since approximately equal catches at locations in various directions from a concentrated source were frequently obtained. Also mosquito annoyance and high adult concentrations were commonly observed at various distances in a complete circle around the only active significant source area. Prevailing winds during most of the year are constant northeast trades and population centers and night illumination occur only to the north, east and southeast of the major Waipio sources. Therefore, it does not appear that these factors exert any great influence on ultimate dispersal. It has been reported by Afridi and Majid (1938) in India that in the case of *C. quinquefasciatus* (fatigans), wind direction has no influence on direction of flight but that flights do not occur at wind velocities greater than 16 miles per hour. Stage, Gjullin and Yates (1937) report the dispersal of *Aedes vexans* and *Aedes aldrichi* in all directions both with and against the wind. Bidlingmayer and Schoof (1957) found that *A. taeniorhynchus* (Wiedemann) eventually distributed itself in a random pattern.

It is useful to distinguish between this type of dispersal in all directions without an apparent directional or attractive force and migratory flights characterized by dispersal over considerable distances in more or less definite directions. The former may be thought of as a kind of diffusion or aimless spreading from a center or source. It might be expected that the density of a mosquito population which was randomly distributed in all directions from a single source would decrease in proportion to the increase in area over which it was dispersed. Since increase in area of a circle is proportional to the square of the radius it follows that the population density, in theory, should decrease in an amount inversely proportional to the square of the radius. Assuming that the light trap index for this species bears a constant, even if only approximate, relation to the mosquito population density, the index should also decrease to a similar degree. The expected trap index at each distance when for example, 0.5 miles is the base trap distance, would then be: at 1 mile, one-quarter of that at 0.5 miles; at 2 miles, one-sixteenth of the 0.5 mile index; at 3 miles, one-thirtysixth, etc. Table 1 is designed to illustrate the theoretical decrease in trap indices to be expected at various distances from one trap to a more distant trap in relation to a single source area. The first column gives the distances of traps from the estimated center of a breeding area. The expected dispersal factors shown in column 2 are merely the number of times the area at each distance exceeds the area at each distance exceeds the area at the first trap location: dispersal factors are given for cases in which the first trap is located at 0.5, 1 and 2 miles from the center. In other words the dispersal factor is the square of the indicated distance divided by the square of 0.5, 1 and 2. We see that the rate of decrease is greater nearer the source and becomes progressively smaller with increasing distance. The remainder of the table indicates expected trap values at increasing distances when the index of the trap at 0.5 miles ranges from 320 to 5. Values less than 1 are not shown although they may be obtained when average indices are used.

At this point a further implication of table 1 with reference to flight ranges should be mentioned, which is that the probability of recovering individual mosquitoes at 1 mile, when the density at 0.5 miles is indicated by an index of 5, would be the same as the probability of recovering them at a distance of five or six miles when the 0.5 mile index is 160. In other words, reference to a flight range for a species which followed this theoretical dispersal pattern would be meaningless except for individual specimens, unless related to density of population at the source.

This theoretical relationship between distance and

TABLE 1

Distance from Source	Dispersal Factors			Theoretical Nightly Trap Index						
0.5	1			320	160	80	40	20	10	5
1.0	4	1		80	40	20	10	5	2.5	1.2
1.5	9	2.26		36	18	9	4.4	2.2	1.1	
2.0	16	4	1	20	10	5	2.5	1.2		
2.5	25	6.5	1.56	13	6.4	3.2	1.6			
3.0	36	9	2.2	9	4.5	2.3	1.1			
3.5	49	12.8	3	6.5	3.3	1.7				
4.0	64	16	4	5	2.5	1.2				
4.5	81	21	5	4	2	1				
5.0	100	26	6.2	3.2	1.6					

$$B = \frac{d^2A}{D^2}$$

A = index of trap A
B = index of trap B
d = distance from source to trap A
D = distance from source to trap B

trap magnitude shown in Table 1 may be expressed as a simple equation, $B = \frac{d^2A}{D^2}$, where, for any two traps, A is the trap nearer to the breeding source area; d is the distance from the source center to trap A, and D is the distance from the source center to trap B. It now becomes a matter of considerable interest to determine to what extent the trap data obtained fit this hypothesis. Trap locations were selected and maintained, or changed, entirely for the purpose of routine surveillance of mosquito populations in the vicnity of naval activities and were not placed for the purpose of testing this concept, which was only developed from study of the trap data long after termination of the trapping period. Therefore the number and locations of traps are far from adequate or suitable for a proper test of the inverse square relationship. Trap location is particularly important because distance from the center of the breeding area is an essential feature of the equation. It is probably not applicable where breeding occurs in many small scattered sources over a large area but only where a major part of mosquito production takes place relatively uniformly over a concentrated, definable area. The situation may be analgous to the application of the inverse square law to gravitational or nuclear forces where the attraction between two bodies of large mass may be accurately calculated while disregarding the effect of many relatively very small bodies or those at very great distances. Trap A should be located no closer to the center than the outer margin of the breeding area. Otherwise the distance between the first and second traps will include an area of mosquito production which will add to the density of the population as it is dispersing from the first trap, and alter the decrease expected with increasing distance. Also a trap located very close to the center of production might capture considerably fewer mosquitoes than expected if a lag in development of light attractivity, such as reported by Nielsen and Nielsen (1953), Provost (1952) and Bidlingmayer and Schoof (1957), were present. Finally, the theoretically infinite number of mosquitoes expected at zero miles obviously makes the equation inapplicable for a trap located at the center.

Comparison of Expected and Obtained Trap Indices. Despite the number of variables, the fact that the data was sufficiently consistent to suggest a constant relationship in the first place indicates that a closer examination may be worthwhile. In view of the well known fluctuations often obtained in light trap catches from day to day, or even week to week, average values for months or entire seasons have been used in the following analysis. This also eliminates for all practical purposes the time element requirèd for dispersal from production areas but also conceals any short term directional flights which may have occurred within the overall dispersal pattern.

Table 2 shows the obtained average nightly trap indices for the indicated periods compared with expected indices as derived from the equation. The estimated center of the breeding area during 1954 and 1955 is a point 0.5 miles from trap A and distances to other traps are measured from this point. Trap A is used as the base for calculation of indices expected from the primary source. Trap H is used as the base for calculating the effect of the secondary source on traps E and J. The other traps were not located close enough to the secondary source to expect any significant catch from it. In 1956 the secondary source was not sufficiently active to require consideration. Trap locations were the same in 1956 but the estimated center of breeding is changed as a result of control operations to a point 0.66 miles from trap A. It should be noted in comparing expected and obtained indices that those for traps A and H are identical merely because they are used as bases for calculation of expected values for the other traps. The obtained index in general decreases with distance from

TABLE 2

	April-October 1954			April-October 1955		April-September 1956		
Trap	Distance from Source Center (miles)	Expected Index	Obtained Index	Expected Index	Obtained Index	Distance from Source Center (miles)	Expected Index	Obtained Index
A	0.5	174	174	337	337	0.66	140	140
E	1.5 primary	19		37				
	3 secondary	11		4				
		30	34	41	26	1.3	36	26
B	2.3	8	6	16	10	2	15	7
C	2.6	6.5	7	12	13	2.3	11.6	8
D	3.5	3.5	4.5	7	10	3.5	5	6.4
F	3.5			7	5.2			
J	3.7 primary	3		6				
	2.75 secondary	13		5				
		16	17	11	4	3.5	5	3.3
H	5.5 primary	1.4		2.7				
	2.5 secondary	15.6		6.3				
		17	17	9	9			

the source in approximately the expected degree. Discrepancies are greatest for traps B and E for which values are in most cases below expected in amounts of from 25 to 53%. Trap B was located in a sheltered spot within 50 feet of a road traversed by the fog applicator; this was in a housing area which received nightly fog treatments during periods of annoyance. None of the other traps received as intense, close or frequent treatment as trap B although traps E and J were also in areas where fog applications were applied more or less routinely. Perhaps not much significance should be attributed to these comparisons although it is interesting to recall that several published reports on evoluation of the effectiveness of fogging have indicated maximum average trap reductions in the 30 to 65% range. The obtained index at trap D is somewhat greater than expected in all years and could be the result of small, local sources which could have been present but easily overlooked in this type of area.

The relatively good control obtained throughout the major breeding areas on Waipio during 1957 resulted in quite different centers of mosquito production. During May and June breeding was concentrated in poorly drained areas within the cane fields of lower Waipio and the center was estimated as a point 1.3 miles from trap C: traps C was used as the base because it gave the highest catch during this period. Expected and obtained indices are shown in Table 3. Breeding also occurred in the secondary source but its magnitude, based on trap I, was not sufficient to affect trap E to a significant degree.

July and August, 1957, presented a different problem. During these months no concentrated heavy breeding center could be located on Waipio Peninsula which might account for the catch at traps A, C and E although scattered mosquito production was found at various points. At the same time a very severe problem developed at a small naval activity located about two miles to the northwest of trap A. Surveys of the area failed to reveal any active major source such as had been noted in previous years. It was suspected that the source of this outbreak was an undiscovered location within inaccessible cane fields or that a large brood or broods had already emerged before inspection and the source had then become inactive due to some change in irrigation procedures. In any case there remained the strong suspicion that some very productive source had existed in that area during July. At the time the inverse square relationship had not been conceived but it now becomes pertinent to ask whether a major source northwest of Waipio could account for the trap indices obtained. Since the trap A index for July and August is approximately four times that of trap E it would be expected by hypothesis that the distance from trap E to the source center would be about twice the distance from trap A to the same center. The intersection, in the suspected area, of an arc of 1.5 miles radius from trap A with one of three miles radius from trap E was therefore taken as the assumed center of the breeding area. Distances to the other traps were measured from this point. Expected and obtained trap indices are given in Table 3. The obtained trap E index, of course, falls close to expected value because estimation of the center was based on that value. The trap C correlation is excellent but traps B and D are considerably out of line. Estimation of breeding centers during the wet seasons was more difficult and few traps were located within effective range but a comparison of obtained and expected indices for two traps, G and F, with trap D as base, for two winter periods is also shown in Table 3.

In general the degree of correlation between obtained and expected indices for 1957 is equivalent to that found in the three previous years. Trap B reveals a deficiency below expected values (75 and 56%) similar to that found in Table 2. Again, fogging was con-

TABLE 3

Trap	Distance from Source Center (miles)	Expected Index	Obtained Index
	May-June 1957		
C	1.3	14.8	14.8
B	1.2	17	4.2
A	1.5	11	5.8
E	1.8 primary	8	
	3 secondary	0.5	
		8.5	6
D	2.8	3.2	3.8
I	5 primary	1	
	0.5 secondary	16	
		17	17
	December, January, March 1955-56		
D	0.5	22.3	22.3
F	1	5.6	3.4
G	1.5		

Trap	Distance from Source Center (miles)	Expected Index	Obtained Index
	July-August 1957		
A	1.5	42	42
E	3 primary	10.5	
	3 secondary	0.5	
		11	9.7
C	4	5.9	5.8
B	4.3	5	2.2
D	5	3.8	7
I	5.4 primary	3	
	0.5 secondary	20	
		23	23
	December-May 1956-57		
		11.5	11.5
		1.3	1.4

ducted nightly in the vicinity of trap B during several periods in the summer of 1957.

DISCUSSION. Up to this point it has not been contemplated that the inverse square hypothesis would be at all applicable to species which are generally thought of as exhibiting long range and directional flight characteristics. However, Bidlingmayer and Schoof (1957), reporting on a study of *Aedes taeniorhynchus* dispersal based upon light traps and released radioactive specimens, suggest that the original population of this species, while initially displaying a somewhat directional movement, eventually distributes itself in a random pattern. They also found that the recovery of marked specimens decreased inversely with the distance from the release point. Table 4 shows the expected and obtained trap catch at two mile intervals when the inverse square equation is applied to their data. The catch at the two mile point is used as the base for calculating the expected catch at other distances. Again we see a tendency for trap indices to approach values which would be expected from the inverse square relationship. It is questionable whether this tendency, observed in the case of both *C. quinquefasciatus* and *A. taeniorhynchus*, is sufficiently pronounced and consistent to be of practical significance, but the data suggest that further investigation with suitable controls on these and other species and in other areas is desirable. It may be that very large numbers of mosquitoes must be trapped over considerable periods of time before significant comparisons are obtainable. In any case the light trap data obtained in the Pearl Harbor area was invaluable for demonstrating to the sugar plantations concerned, the mosquito problem created by their operations and in obtaining their cooperation in modification of procedures which were the cause of such intense mosquito production. Also, information derived from light traps was responsible for saving many thousands of dollars through elimination of unnecessary fogging operations. However, more efficient methods for measurement of mosquito population density which would at the same time provide some index of annoyance levels for each species are required. Attempts to correlate frequency of complaints with trap levels were not entirely satisfactory in the Pearl Harbor area because of the number of deviations from normal. In general, after allowance for exceptions, a nightly index of from one to five females was associated with complaints from unscreened barracks or ships, whereas an index of from 10 to 20 was required before complaints at outdoor evening activities became frequent. According to Table 1 an index of 10 to 20 would be expected at two to three miles during a period when the 0.5 mile index was running over 300. This is roughly the distance at which complaints were significant during similar periods. Also when the 0.5 index was only five or 10, annoyance was rarely reported beyond one mile. This suggests that the inverse square relationship, if shown to be applicable in a given area, might be useful in estimating the distance to which a particular major breeding site could be judged responsible for mosquito annoyance.

CONCLUSION. In conclusion, it appears that *Culex quinquefasciatus*, in the Pearl Harbor area, ultimately disperses in all directions without detectable influence of those factors such as wind, food, water barriers, illumination, population centers, etc., which are often expected to control or affect mosquito dispersal. On the other hand there is evidence which suggests that average adult mosquito population densities over a period of time, at any two distances from a single major center of mosquito production, tend to approach magnitudes which are inversely proportional to the squares of the distances from the center.

ACNOWLEDGMENTS. The author wishes to express his

TABLE 4

Expected catch compared with recovery of radioactive female *A. taeniorynchus* as reported by Bidlingmayer and Schoof (1957)

Distance (miles)	Dispersal Factor	Expected Catch		Obtained Catch	
2	1	100		100	
4	4	25		27	
6	9	11		17	
8	16	6.25		7	
10	25	4	Av. 2.9	2	Av. 3
12	36	2.8		4	
14	49	2		3	

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Titles of Figures and Tables

Figure 1—Important sources of *C. quinquefasciatus* and light trap locations in the Pearl Harbor area.

Figure 2—Monthly totals of female *C. quinquefasciatus* caught in list traps A, B and D, and monthly rainfall for Pearl Harbor area. 1954-1957.

Figure 3—Monthly totals of female *C. quinquefasciatus* caught in light traps C and E. 1954-1957.

Figure 4—Monthly totals of female C. *quinquefasciatus* caught in light traps J, G, F, H and I. 1954-1957.

Table 1—Dispersal factors and expected trap indices based on dispersal equation.

Table 2—Expected and obtained trap indices. 1954-1956.

Table 3—Expected and obtained trap indices. 1955-1957.

Table 4—Expected catch compared with recovery of radioactive female *A. taeniorhynchus* reported by Bidlingmayer and Schoof (1957).

REPORT ON COOPERATIVE MOSQUITO RESEARCH IN CALIFORNIA IN 1957

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1. Larvicide Tests

A number of new materials were tested as mosquito larvicides in Fresno and Tulare Counties during the season from April 26 to August 23, 1957. Most interesting of these were the chrysanthemumic acid esters. From the structure of these compounds they should have a relatively low toxicity to warm-blooded animals.

Against *Aedes nigromaculis* some of these materials (Table 1) were effective at 0.4 pound per acre and their effectiveness was increased by the addition of piperonyl butoxide. Tests on *Culex tarsalis* indicate that they may be less effective against this species (Table 2). However, heavier grass growth and floatage may have been partially responsible for the reduced mortality in these tests.

American Cynamid 12008 was the most effective of the various materials tested. Released data indicate this compound to be slightly more toxic than parathion to warm-blooded animals.

2. Aerosol Tests

Information on the effect of adding Lethane and pyrethrins to malathion aerosol was obtained in tests against *Culex tarsalis* adults in Farmington, California, through the cooperation of the San Joaquin Mosquito Abatement District. Tifa machines operated by district personnel were used in these tests.

The solution applied on July 30 contained 2.7% Lethane 384 and 5% malathion (wt./vol.) in diesel oil. The malathion used was 5-lb. emulsion concentrate. The aerosol was applied at the rate of 20 gallons per hour by these machines as they moved at a speed of

Acknowledgment: Field assistance was provided by David M. Hawbecker, student research assistant with the Bureau of Vector Control.

TABLE 1

THE EFFECTIVENESS OF SEVERAL INSECTICIDES AGAINST 4TH INSTAR *AEDES NIGROMACULIS* LARVAE IN FIELD TESTS. AVERAGE OF 2 OR 3 TESTS.

INSECTICIDE	MORTALITY AT INDICATED DOSAGES IN POUNDS PER ACRE					
	0.4	0.3	0.2	0.1	0.05	0.025
Chrysanthemumic Acids						
6-bromopiperonyl ester (ENT 21195)	97		86			
Piperonyl ester (ENT 20274)	56		75			
6-chloropiperonyl ester (ENT 21557)	98		91			
ENT 21557 plus piperonyl butoxide (1-5)			97			
ENT 21195 plus piperonyl butoxide (1-5)			98	98	85	
ENT 21170 plus piperonyl butoxide (1-5)			99	98	82	
ENT 21559 plus piperonyl butoxide (1-5)				86	69	
Organic Phosphorus						
American Cyanamid 12008 (EC)					97	69
Korlan (ET 14) (EC)		100	80	72		
Trithion Flowable 4 (EC)				62	46	

TABLE 2

THE EFFECTIVENESS OF ENT 21195 AND ENT 21557 AGAINST 4TH INSTAR *CULEX TARSALIS* LARVAE IN FIELD TESTS

Insecticide	*Mortality at Indicated Dosages in Pounds Per Acre* 0.4
6-bromopiperonyl ester (ENT 21195)	82
6-chloropiperonyl ester (ENT 21557)	44

about 3 miles per hour. The dial settings during the application were varied from numbers 9 to 10. The machines produced particles having a mass median diameter of approximately 17 microns at the number 10 setting.

Farmington is a small town with two complete blocks and several partial blocks of buildings. The population is about 275. Aerosol was applied in swaths ranging from 100 yards apart in the central portion of town to a maximum of about 300 yards in the outlying areas where fewer roads were available. A radius of from ¼ to ½ mile around the center of town was covered by the three machines from 4:30 to 6:30 a.m. One hundred and forty gallons of solution were applied during this period. The wind was from the northwest and did not exceed one mile per hour. Fog was distributed vertically from 10 to 30 feet or more. Slight changes in air currents occurred in some areas. Coverage was considered good in most places.

Four New Jersey type light traps were operated in the town and 10-minute suction tube collections were made in five buildings for several days before and after the application of the aerosol. Collections from 14 light traps operated in other areas in the county were available to indicate general population trends during this period.

Counts were also made of adults emerging from the recesses of partially exposed tree roots and one rodent hole in the edge of a dry water course adjoining the town. These natural habitats were sprayed with chloroform to drive out the adults and counts were made as they emerged.[1]

A 48% reduction of *Culex tarsalis* females in buildings and a 38% reduction in traps (Table 3) occurred after the aerosol application. Flight counts of adults as they emerged from the natural habitat locations indicated a 30% reduction. Collections in 14 traps in other areas in the district showed that the female *tarsalis* catch had dropped from 15 per night during the three-day period from July 26 to 28 to six per night during the four-day period from July 29 to August 1. This suggests that some of the reduction in numbers of adults taken in traps in the Farminton area after the aerosol application may have been due to a general down trend in the number of adults taken in traps during this period. However, the closest of these traps was several miles away and since local conditions in the Farmington area may have influenced the number collected, no definite conclusions can be made.

[1] These natural resting places were brought to our attention by Mr. E. C. Loomis of the Vector Measurement Unit of the Bureau of Vector Control.

TABLE 3

THE EFFECTIVENESS OF AEROSOL APPLICATIONS AGAINST *CULEX TARSALIS* ADULTS

	FEMALES			MALES		
SOLUTION USED	Before spray	After spray	% Reduction	Before spray	After spray	% Reduction
		Building Collections				
Lethane 384-malathion[1]	135	77	43	44	18	59
		Trap Collections				
Lethane 384-malathion	188	177	38	73	30	60
		Natural Habitats[1]				
Lethane 384-malathion	123	173	none			
		Building Collections				
Pyrethrins-malathion	119	116	3	42	23	45
		Trap Collections				
Pyrethrins-malathion	53	35	34	47	34	23

[1] Males plus females

Culex tarsalis was the predominating species in both trap and building collections in the Farmington area.

The second test in the Farmington area was made on August 21. The solution used contained 5% malathion (wt./vol.) and 0.076% pyrethrins (vol./vol.). In this test two machines were used and 61 gallons of solution were applied. The aerosol was applied from 5 to 6:50 a.m. The fog remained at ground levels until about 6:30 but was carried along by a four- to five-mile wind.

Three New Jersey type traps were operated in Farmington and 10-minute collections were made in five buildings for two days before and after the application of the aerosol. Counts were also made of adults present in natural resting places.

There was a 3% reduction in the number of females taken in buildings after this aerosol application (Table 3) and no reduction in numbers of adults observed in natural shelters. Trap catches indicated less than 35% reduction.

The poor results obtained in this test were probably due to a relatively high wind for aerosol application and to the low volume of solution released by the machines for this two-hour period. The machines used a below-normal amount of solution for the two-hour period. This would indicate that the particle size was small. No conclusions regarding the value of adding pyrethrins to aerosol solutions can be made from this test.

3. Bioassay of Aerosol Solutions

Insecticidal solutions used in Tifa aerosol machines are subjected to a momentary exposure of about 1000° F. before they are blown out as aerosol particles. To determine if exposure to heat would have an effect on pyrethrins or Lethane 384, a 0.3% solution of the former and 4% solution of the latter in diesel oil were collected after passing through the machine and tested on mosquito larvae.

Tests of the solutions taken before and after passing through the machine were made on 4th instar *Culex quinquefasciatus* larvae at 74° F. In three replications of 0.3% pyrethrins solution a 56% mortality of larvae occurred 24 hours after the application of the non-exposed solution and a 92% mortality after the application of the exposed solution. The 4% Lethane 384 in diesel did not increase the toxicity of the diesel oil sufficiently to make a comparison of the exposed and non-exposed solutions against larvae.

The samples collected after passing through the machine were considerably darker in color than the original solutions. Both malathion, which was tested in the same manner in 1956, and the pyrethrins tested this season gave higher kills against larvae after being exposed in the Tifa machine. This suggests that a small portion of the diesel oil may have been volatilized to produce a slightly higher concentration of insecticide in the solution that was recovered.

4. Residual Sprays

Four insecticides—AC 4124, malathion, Dipterex, and diazinon—were tested as residual sprays on plywood panels against *Culex* females. The panels were sprayed with a xylene-Triton X-100 emulsion of the toxicant at the rate of 200 milligrams per square foot. Half of the panels were placed in the open facing south in order to expose them to a maximum amount of sun. The other half was placed in a shelter comparable with a chicken coop or shed.

Culex females[1] were exposed to the panels at intervals during the next month by placing them inside a ring of plastic tubing laid on one-half the panel and covering them with the other half. After exposures for predetermined periods they were placed in clean containers and mortality counts were made after 24 hours.

Results of these tests (Table 4) are somewhat erratic. The mosquitoes may have rested on the plastic ring between the panels and avoided contact with the toxicant in some of the tests. Malathion appeared to be somewhat better than diazinon and both were more effective than the other two insecticides. Panels placed

[1] A mixture of *C. pipiens, stigmatosoma,* and *tarsalis* from larvae collected in dairy drains.

in the sun lost their effectiveness more rapidly than those placed in the shade.

TABLE 4

MORTALITY OF *CULEX* FEMALES AFTER EXPOSURE TO PLYWOOD PANELS SPRAYED WITH 200 MG./ SQ.FT. OF INSECTICIDE

Insecticide	*Mortality After Indicated No. of Days*				
	1	7	14	20	35
			Panels Held in Shade		
			15-minute exposure		
4124	60	100	50	73	62
Dipterex	100	87	41	33	18
Malathion	80	100	71	100	94
Diazinon	100	100	100	75	10
			60-minute exposure		
4124	------	100	------	83	11
Dipterex	------	100	------	90	22
Malathion	------	100	------	100	100
Diazinon	------	100	------	100	17
			Panels Held in Sun		
			15-minute exposure		
4124	84	15	25	40	8
Dipterex	------	87	61	30	45
Malathion	71	100	53	58	43
Diazinon	100	74	14	13	17
			60-minute exposure		
4124	------	100	------	20	9
Dipterex	------	100	------	0	7
Malathion	------	100	------	63	50
Diazinon	------	100	------	100	17

5. Malathion Pellet Residues

Malathion resistance in *Culex tarsalis* larvae was found to be somewhat higher in one particular pasture in the Fresno Mosquito Abatement District than in others in 1956. This pasture was heavily treated with malathion pellets in August 1956 when the regular malathion spray application began to fail. Normal spray applications of 0.5 pound of malathion was again found to be effective for the remainder of the 1956 season after the application of the pellets.

Larvae collected in this pasture in September 1956 died in this water when left overnight in the laboratory. Samples of this water which were tested on 4th instar *Aedes nigromaculis* larvae caused 100% kill. In December 1956 the pasture was fertilized with nitrogen-phosphate fertilizer. No malathion pellets were used in 1957.

Water collected from this pasture in June 1957 and held in the laboratory for five and nine days caused 100 and 36% mortality, respectively, of 4th instar *C. quinquefasciatus* larvae in 24 hours. There was no reduction in the effectiveness of this water against larvae when the water was passed through a porcelain bacteriological filter before the larvae were added. Larval mortality was reduced to 73% in 24 hours when the water was boiled 10 minutes before the larvae were added and no mortality occurred in water that had been boiled for 20 minutes.

No disease was found in water or larvae examined by C. G. Thompson of the U.S. Department of Agriculture Insect Pathology Laboratory at Beltsville, Maryland. Mr. Thompson was of the opinion that mortality of larvae was due to chemical poisoning.

Soil samples collected in the pasture in June 1957 were thoroughly dried and then reflooded with tap water. The water from three of these reflooded samples taken near the lower end of the pasture gave kills of 31, 50, and 100%, respectively. In these locations the bottom was muddy and partially covered with grass. Water from samples at higher elevations within and beyond the flooded area caused mortalities of less than 5%.

The persistence of malathion residue in this pasture indicates that malathion pellets may have a long residue under some conditions and should, therefore, be investigated further.

FIELD TRIALS OF OUTDOOR SPACE DUSTING OF BHC AND DDT FOR ADULT MOSQUITO CONTROL

V. I. Miles[1]

During the summer of 1957, field trials were made in the Milk River Valley, Montana, to evaluate the effectiveness of outdoor space dusting of BHC and DDT for controlling adult mosquitoes in urban and rural areas. These trials were made in areas where large populations of *Aedes vexans*, *A. dorsalis*, and *A. nigromaculis* were present as a result of poor irrigation and drainage practices.

Methods

In the small towns of Harlem (population 1,100) and Chinook (population 2,300), six areas, each three blocks square, were dusted between June 27 and September 4. The two rural sites were a 20-acre farm feed lot treated on July 10, and a 20-acre area at the village of Zurich treated on July 24.

Commercial dusts, consisting of 5 per cent DDT and 3 per cent gamma isomer BHC in a talc carrier, were used in all of the trials. Using a truck-mounted Buffalo Turbine, Model VG-4D, Type TT, the dusts were applied in the evenings, after sunset, during peaks of mosquito annoyance. The turbine was operated at full speed and at maximum rate of dust discharge, which was about 18 pounds per minute. In the initial trials, the truck was operated at speeds that would provide actual toxicant dosages of about 0.5 pound BHC and 1 pound DDT per acre. These approximate dosages were applied in three trials with BHC at 5.3 to 6.5 pounds of dust per 100′ of travel at 3.6 to 3.9 mph, and in three trials with DDT at 7.0 to 7.6 pounds per 100′ of travel at 2.3 to 3.4 mph. In two additional trials, BHC was applied at dosages of 4.0 and 4.5 pounds per 100′ of travel at 5.7 and 4.5 mph, respectively.

In treating the urban areas, the dust was applied

[1] Entomologist, Logan Field Station Section, Communicable Disease Center, Bureau of State Services, Public Health Service, U.S. Department of Health, Education and Welfare, Logan, Utah.

TABLE 1

Control of Adult *Aedes* Mosquitoes by Outdoor Space Dusting of BHC and DDT at about 0.5 and 1.0 Lbs./Acre Respectively, Milk River Valley, Montana, 1957

Date Dust Applied	Acres Treated	Pounds Dust per 100' of Travel	Average Temperature During Dusting, °F.	Average Wind Velocity During Dusting, MPH.	Avg. No. Mosquitoes per Min. before Dusting 1/	Percent Reduction in Mosquito Populations: Night of Dusting (15-min. periods)		Days Following Application of Dusts: Daytime Collections (1-hour duration, between 8:00 A.M. and noon) on Days Indicated after Treatment									Evening Collections (1-hour duration, beginning at sunset) on Days Indicated after Treatment								
						First Period 2/	Remaining Periods 3/	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
3% BHC																									
6/27	25	6.5	60	0.6	8.7	0	93	99	98		60		14				19	8		0		79			
7/10	20*	5.3	73	2.2	11.2	85	91	100	100	99		88	41	25	48	0	83	0	93			66			
7/16	25	6.5	70	1.2	3.2	89	97	100	100	73			37			0	80	77	58			62			65
8/1	33	4.5	61	2.7	3.0	76	91	100	85		96	63	83				53	90		86					
8/8	21	4.0	66	1.2	2.9	72	82	100	92	51		39	65	72	0	0	92	0							
5% DDT																									
7/24	20*	7.0	60	0.6	1.4	0	0	100	99	95		83	73	76	83	50	58		64		0				
8/21	33	6.7	70	3.4	1.4	87	97	61	62	0							75	44	93						
9/4	24	7.6	59	1.6	0.8	100	97	100	82	25		88	89				61	20	72		89				87

*Rural Area.

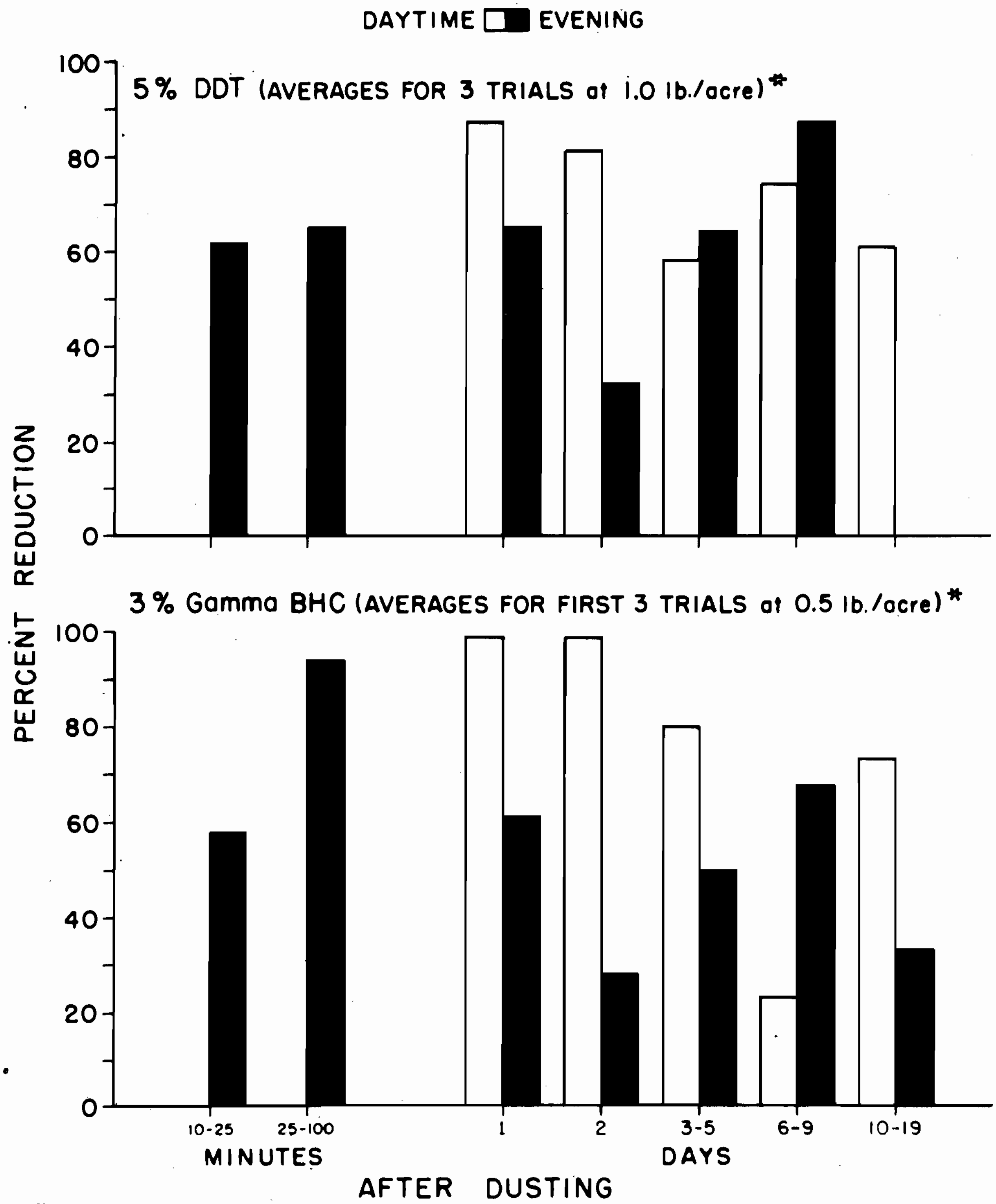
1/ Based on ½ to 1-hour collections, beginning at sunset, taken on 2 or 3 evenings prior to dusting.

2/ Beginning within 10 minutes after dust reached collecting site.

3/ Average for 2 to 5 subsequent periods.

FIGURE 1

COMPARISON OF BHC AND DDT OUTDOOR SPACE DUSTING IN REDUCING ADULT *Aedes* MOSQUITO POPULATIONS MILK RIVER VALLEY, MONTANA, 1957



*SEE TABLE 1 FOR COLLECTION DATA ON EACH TRIAL

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TABLE 2

Per Cent of Mosquito Species Comprising Evening Collections Made Before and After Space Dusting of BHC and DDT, Milk River Valley, Montana, 1957

Time of Collection	BHC, 4 trials, June 27 to August 1						DDT, 3 trials, July 24 to September 4					
	Aedes vexans	*Aedes dorsalis*	*Aedes nigromaculis*	*Aedes trivittatus*	Other Species*	Number identified	*Aedes vexans*	*Aedes dorsalis*	*Aedes nigromaculis*	*Aedes trivittatus*	Other Species*	Number identified
Before dusting:												
24 hrs.	72	13	11	2	2	1101	77	4	7	9	3	307
30 to 45 min.	65	12	21	1	1	1000	68	3	10	15	4	137
After dusting:												
30 to 75 min.	86	4	2	0	8	78	84	11	5	0	0	18
24 hrs.	74	15	9	**	2	490	77	2	13	5	3	99
48 hrs.	80	9	9	**	1	794	87	3	9	1	0	100
3 to 6 days	68	8	18	1	5	756	53	20	9	10	9	148

* Includes *Aedes idahoensis*, *A. increpitus*, *A. spencerii*, *A. cinereus*, *A. campestris*, *Culex tarsalis*, *Culiseta inornata*, and *Anopheles earlei*.

** Less than 0.5 percent.

from the streets along two opposite sides of each block, which provided good coverage across the 300′ wide blocks. The same general pattern was followed in dusting the two rural areas. The dust stream, which was at a right angle to the line of travel, was manipulated vertically as needed to insure best coverage. Wind velocities, determined by a cup-type anemometer located outside the treated areas, varied from 0.6 to 3.4 mph during the dusting periods. Even at the higher wind velocities there was little drift of dust outside the designated treatment areas.

The effectiveness of the dusting was evaluated by simultaneous mosquito collections made in treated areas and in untreated check areas during evenings and in the daytime. Evening collections, begun at sunset, were made by aspirating the mosquitoes which alighted on a 2 × 2 foot square of unbleached cotton muslin stretched over a wood frame which was placed across the knees of the seated collector. The mosquitoes taken during each of four to eight consecutive 15-minute periods were recorded and kept separately. In daytime collections, the mosquitoes were taken which alighted on the collector during a one-half hour period while walking among grass, shrubbery, and other vegetation. Repeated collections at any given site were usually made by the same individual. All post-treatment collecting sites were located near the centers of the dusted areas in order to provide the maximum amount of treated buffer zone.

The effect of the dusts in mosquito populations was determined by using the average number of mosquitoes collected per minute in the following formula which was adapted from Abbott's formula (1):

% Reduction =

$$100 - 100 \frac{\text{(Post-dust, Treated Area)}}{\text{(Pre-dust, Treated Area)}} \div \frac{\text{(Post-dust Check Area)}}{\text{(Pre-dust Check Area)}}$$

The pre-dust mosquito densities used were the average for the collections made during two or three days preceding the dust applications (including the 15-minute periods just prior to dusting).

Results

The effectiveness of individual dusting trials in reducing adult mosquito populations is shown in table 1. Both BHC and DDT gave satisfactory control of adult mosquitoes that were present in the area at the time of treatment; however, freedom from evening annoyance was limited primarily to the night of dusting due to re-invasion of mosquitoes from outside the treated areas. With one exception, mosquito populations were reduced on the evening of dusting by 82 to 97 per cent using BHC and DDT applied at dosages of 0.5 and 1.0 pound per acre, respectively. On the evening following dusting, the reduction averaged about 65 per cent in both BHC and DDT treated areas. In two to four nights the evening attack rates in the treated areas usually returned to pre-treatment levels. Daytime mosquito populations, on the other hand, were reduced greatly for four or five days by both BHC and DDT, indicating that the treatments provided enough residue to kill the mosquitoes that re-invaded the treated areas.

There were wide variations in evening reductions of mosquitoes during the post-treatment period. Notations made of evening wind conditions indicated that these variations might be due to differences in wind velocities. On calm evenings mosquitoes moved into the treated areas and attack rates approached pre-treatment levels; however, on windy evenings, less movement apparently took place, and since most of the day-resting mosquitoes had been killed by the dust residues, attack rates were very low.

The average reductions in mosquito populations, as indicated by evening and daytime collections for the three trials with DDT and the first three trials with BHC, are summarized in figure 1. It will be noted that the reduction in evening mosquito populations was greater after three or more nights following dust applications than for the second night. As indicated by the daytime collections, mosquitoes that invaded the treated areas each night were killed by the insecticidal residues. This finding suggests that mosquito populations in the immediate vicinity of treated areas may have been depleted progressively by the residual action of the dust deposits. The delayed killing action of both chemicals is shown by the increased reduction of mosquitoes after the first 15-minute period of collection following dust application (figure 1).

The results were not greatly different with applications of about one-third pound of BHC per acre (4.0 and 4.5 pounds dust per 100′ of travel, table 1) as compared with 0.5 pound per acre. BHC appeared to be somewhat more effective than DDT at the dosages applied, particularly when the dates of the various trials and the mosquito densities are considered (table 1).

The species composition of mosquitoes collected in the treated areas before and after dusting is summarized in table 2. The increased proportions of *A. vexans* in post-dust collections on the night of dust applications suggests that this species was more successful in surviving both BHC and DDT treatments than were the other species present. The apparent increase in the relative abundance of *A. dorsalis* in the DDT-treated areas was not significant due to the small number of specimens collected. The increases in subsequent post-dust collections largely reflect mosquito species migrations into the treated areas.

Summary

In the Milk River Valley, Montana, urban and rural areas of 20 to 33 acres were dusted with a Buffalo Turbine using 3% gamma BHC at about 0.5 pounds per acre (five areas), and 5% DDT at about 1.0 pound per acre (three areas). The dusts were applied after sunset during peaks of evening annoyance by *Aedes*, principally *A. vexans, A. dorsalis,* and *A. nigromaculis.* Both BHC and DDT treatments reduced attack rates during the evening of application by 82 to 97 per cent, with but one exception. In two to four nights, the evening attack rates in treated areas usually returned to pretreatment levels. However, daytime mosquito populations were reduced greatly for four or five days by both insecticides. *A. vexans* appeared to be more successful in surviving the dust treatments than the other species present.

Reference

(1) Abbott, W. S.
1925. Journal of Economic Entomology 18:265.

A PRACTICAL EGG SAMPLING TECHNIQUE FOR SURVEYING FLOODWATER MOSQUITOES

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AND

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The South Cook County Mosquito Abatement District includes some 340 square miles of Cook County, Illinois located south of 87th Street. It was readily determined during the first season of the District's activities (1955) that the principal problem is associated with floodwater types of mosquitoes, especially *Aedes vexans*. Most of the area is a relatively flat and poorly drained former lake bed containing numerous floodplains of both large and small streams and some 40 thousand acres of undeveloped and untended forest lands, a large part of which is a wildlife conservation area. It was apparent that mosquito source location, relying solely on the dipped method would require a considerable amount of time and, depending on the frequency of spring and summer rainfalls, might have to include several seasons before important floodwater mosquito producing areas could be located.

Early in 1955 we learned of a technique being used in the laboratories of the Department of Entomology at the University of Illinois to separate mosquito eggs from the soil.[1] Through the cooperation of Dr. William R. Horsfall we were able to secure a copy of the hand-operated separator and to secure training in separation procedures for members of our laboratory staff. We will not presume to describe the separator or technique in detail as Dr. Horsfall has done that, but would mention here that we did mechanize the hand-operated model to expedite the mechanical separation process.

There are three general stages represented in the use of this technique. The first, or mechanical stage, consists of agitating the soil sample in a water bath, then removing most of the debris, leaves and larger soil particles by a series of sieves. The second or flotation stage requires passage of the remaining part of the sample containing the eggs through additional water baths, where the eggs and egg-shells are separated by flotation and additional debris is sedimented. In the third, or identification stage, the eggs extracted from the soil sample are identified and counted under the microscope.

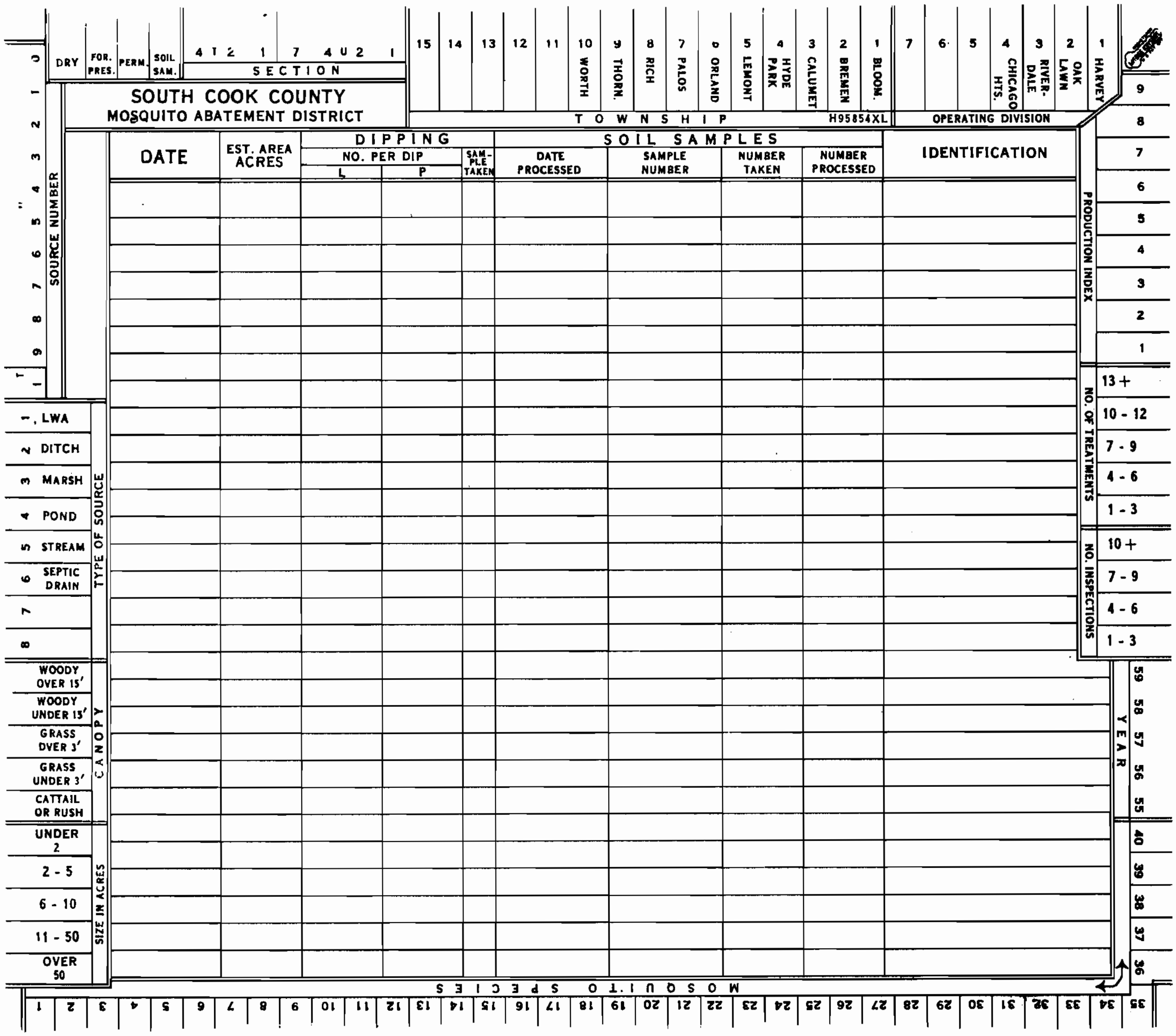
After three years using this technique in our closely integrated field inspection and laboratory programs, we are convinced that it serves a most excellent purpose for an organization concerned with defining a floodwater mosquito problem. We feel that there are several advantages to be derived from the use of this process, most important of which is the advantage of forecasting potential mosquito populations in sampled areas. We have found this forecasting to be extremely valuable to us because we have an enormous number of depressions of varying sizes distributed throughout the District which are favorable flood-water mosquito oviposition sites, and consequently, we do a considerable amount of prehatch treatment of such areas when weather and ground conditions are favorable. Obviously, the more of these sites or potential sources that we can evaluate in time for application of prehatch treatment, the greater assurance we have of more effective anti-larval work.

The following experience exemplifies one of the many reasons why we feel that this technique has proved to be of value in our District. In Cook County there is a tax-supported body known as the Forest Preserve District, which has under its jurisdiction over 40 thousand acres of naturally preserved areas including lakes, streams, sloughs, and numerous situations subject to transient inundation. Naturally, the Forest Preserve officials are apprehensive of anyone using insecticides unnecessarily in their areas because of the possible detrimental effects on wildlife.

Two years ago, in the winter of 1954, a large slough of approximately 360 acres in size was drained to eliminate the rough fish, and it was the plan of the Forest Preserve District to refill the slough and re-stock it during the summer of 1955. The bottom of the slough developed numerous cracks upon drying and a dense growth of vegetation sprang up immediately. Investigation of the area revealed the presence of numerous *Aedes vexans* adults in the vegetation and we began to wonder if they weren't there for the specific purpose of depositing eggs. Of course, we all recognize that the typical *vexans* source is one containing a considerable amount of surface debris, such as grass, leaves or branches, but in this recently drained slough we found practically no such debris. However, we did find numerous moist cracks two or three inches wide at the top, and extending down in some cases 30 inches or more in depth. We measured off a representative area five feet square on the bottom, and then measured the lineal feet of cracks present in the enclosed 25 square feet. We came up with a figure of 37½ feet of cracks, and since each crack had two side-walls, that made 75 lineal feet of vertical walls on which the mosquitoes were finding favorable oviposition sites, particularly on the top six inches of the cracks. On taking soil samples from the sides of these cracks at varying depths over a considerable amount of this area we concluded that a conservative estimate of the number of *vexans* eggs in that extensive slough would be at least 1000 eggs per square foot. In addition, there was some slight deposition of eggs on the surface of the lake bottom.

According to our estimate, there were upwards of 14 billion *Aedes vexans* eggs deposited in this slough. Having good reason to believe that much of our District would be swamped with floodwater mosquitoes if the Forest Preserve officials carried out their plan to refill the slough during the summer, that District was contacted and informed of our findings with the advice to postpone filling the slough until cold weather when the mosquitoes would be unable to develop, or unable to survive if they emerged. They agreed to wait to fill the slough until after the first killing frost. Our warning proved to be accurate, for a period of warm weather occurred immediately after the mid-October flooding and an enormous number of mosquitoes hatched out,

1. Horsfall, Wm. R., 1956. A Method for Making a Survey of Floodwater Mosquitoes, Mosquito News, 16(2):66-71.



but before they could complete their development and emerge, ice formed on the water and the entire crop was destroyed.

In addition to its value for forecasting potential mosquito populations, use of the egg sampling technique also extends the time over which population sampling can be done. With the dipper method, in the case of floodwater mosquitoes, we are limited to dipping for larvae when precipitation occurs in sufficient amounts to create pools or flooding. In our District that is usually during April, May and August, however, by the use of soil sampling we are able to collect and process samples during the dry months and thus determine, frequently far in advance, where to plan for application of pre-hatch treatment, or at least know where we will have to be on the alert for mosquitoes that undoubtedly will appear when inundation occurs. Not only can the sampling time be extended throughout most of the year, but the soil samples themselves can be stored in cellophane bags for many months in a cold room and processed at convenience.

We estimate that field pickup, separation and identification for each sample requires about one man hours. This is somewhat higher than is required for pickup and identification of larval specimens, but a principal advantage resulting from the use of this technique lies in the more effective utilization of manpower. Obviously an important prerequisite to the operation of an efficient mosquito control organization is the maintenance of experienced personnel employed on a year-round basis. We have found that by taking the soil samples at times when the field men are not pressed by other duties, and by storing and later processing the samples when laboratory personnel are not busy with seasonal operations, we can utilize our manpower to a much better advantage throughout the entire year.

Not only can the present production potential of a site be ascertained through the use of the egg sampling technique, but to a certain degree, the past production history can be revealed. At one stage in the operation of this process, the egg shells can be collected, or as is generally done, they can be counted. Thus it is possible to count and identify not only the viable eggs present in a soil sample, but also to obtain a working knowledge of the egg shells that are present, thus indicating the past record of that particular site in the production of floodwater mosquitoes.

In addition to the advantages which have been listed, we feel that the accuracy and reliability of the mechanical egg separator are quite remarkable. On several occasions, to test the accuracy of the machine and the efficiency of the laboratory crew operating it, we have taken five samples of soil which contained no mosquito eggs and have introduced one exotic egg into each soil sample which was then processed. In four out of five tests we have recovered the one introduced egg, using the routine technique. We feel that any process that can consistently provide us with 80 per cent or better reliable results is a valid one for use in an operational program.

The attached form entitled "Egg Source Description" is used for recording the data pertaining to the suspected source from which a soil sample is taken. This form, initiated at the time the sample is collected, furnishes detailed information regarding such items as location and size of the area, general land use, type of source, kind of ground cover and amount of shade present. On completion of processing the counts of eggs and shells are recorded and the identifications indicated. Coding of this information onto the attached punch card presents us with readily available and satisfactory working knowledge regarding any suspected site requiring surveillance and control.

On the basis of information presently available to us from field observations, we have been unable to detect any direct correlation between egg counts and dipper counts on the same areas. We believe that variations are influenced by several factors including the relationship between mortality or survival of larvae versus eggs under natural conditions; mechanisms involved in maturing and actual hatching of the eggs; the location and number of samples taken; the accuracy of dipping at various times, especially as related to larval concentrations as influenced by evaporation, transpiration, percolation or other conditions affecting drawdown of the aquatic habitat. Until the influences of these and other factors are better understood, we have selected an arbitrary basis for differentiating between light, medium and heavy production sites as indicated in the following table:

Table 1

SUMMARY OF EGG SAMPLING RESULTS FOR 1955-57

2109 Suspected sources sampled in all 10 townships.
3394 Total number of soil samples examined.

(60%) 1271 Sources positive on basis of eggs a/o shells.
(40%) 838 Suspected sources negative.

(64%) 807 in range of 1-100 eggs a/o shells per square foot.
(25%) 318 in range of 101-500 eggs a/o shells per square foot.
(11%) 146 in range of 501 and over, eggs a/o shells per square foot.

(66%) 835 of the 1271 positive sources had whole eggs.
(34%) 436 of the 1271 positive sources had shells only.

Table 1 shows the summary of our egg sampling results obtained during the past three years. Of the 2109 potential mosquito production sources surveyed by the collection and processing of 3394 soil samples, a total of 1271 (60%) of the sources were confirmed as positive sources by the finding of either eggs or shells or both. Consequently, we are of the opinion that the egg sampling technique provides sufficient additional knowledge concerning mosquito production to make it highly practical for adoption in a mosquito abatement program.

THE SOUTH COOK COUNTY MOSQUITO ABATEMENT DISTRICT

EGG SOURCE DESCRIPTION

Township..... Section Number..... Source Number......

I. *Land Use.**
   1. Town Lots
   2. Thicket
   3. Woods
   4. Meadow
   5. Cultivated
   6. Other
   * Always indicate Forest Preserve property by "FP" before number circled.

II. *Type of Source.*
   1. Temporary rain pool
   2. Semi-permanent woodland pool
   3. Floodplain
   5. Slough
   6. Lake
   7. Pond
   8. Stream bed
   9. Marsh
   10. Other

III. *Type of Sample.*
   A. Ground Shade.
      1. Amount
         a. Total
         b. Partial
         c. None
      2. Type
         a. Woody plants over 15′ high
         b. Woody plants under 15′ high
         c. Weeds or grass over 3′ high
         d. Weeds or grass under 3′ high
         e. Cattails
         f. Other
   B. Debris on Ground.
      1. Log jam in watercourse, under log......inches in diameter
      2. Brush pile, under log......inches in diameter
      3. Brush pile, under matted branches
      4. Leaves with very few twigs
      5. Leaves with many twigs
      6. Grass matted close to ground

7. Cattails matted close to ground
8. Leaf mold
9. Other

IV. Number and Species of Eggs present:
A. Total number of eggs________________
B. Number of *Aedes vexans* eggs________________
C. Number of other species (specify)________________
D. Total number of shells________________

V. Remarks: Approximate area of potential source:
____
____
____

Sample taken by:
________________ Date________________

A MOSQUITO ABATEMENT BUILDING PROGRAM—SAN JOAQUIN MOSQUITO ABATEMENT DISTRICT

L. R. Brumbaugh
Manager, San Joaquin Mosquito Abatement District

The basis of any building program is a serious and honest appraisal of the facts; facts about building needs, finances, and services performed by the organization. The subject of building covers many fields, which makes it impossible to touch upon all phases with any degree of thoroughness in the time allowed It is our intention, therefore, to concentrate only upon one or more of the fundamental aspects. The reasons for building, methods of financing, selection of property and the procedures to be used in starting a project of this nature.

There is no set of blueprints that will serve as a guide to evaluate the needs of all organizations. One agency's duties, functions and services may be quite different from another's; therefore, the needs vary between each group. The analysis will have to be on an individual basis if it is to serve any one organization. There is a standard set of questions that may be used in appraising an agency's needs. Perhaps the first question should be: Why is this building program necessary? This is a good and logical question and one must have justifiable answers before considering any program. Is the agency paying too much rent? Is the building adequate for good operations? Are maintenance costs high? Is there a possibility of the property being sold? Does the agency feel justified in making repairs on rented property? There are probably many more questions which could be asked; however, there is one psychological factor we would like to mention, the working conditions of the agency's personnel. Good buildings are a matter of pride to the employees, and people like to work in good surroundings. It has been proven many times that happy employees generally perform their duties with greater efficiency. If an organization is interested in improving the morale of its personnel, good facilities are a must. Unfortunately, but true, the general public seems to judge an organization by its housing. A poor exterior will give a bad first impression to any visitor. He immediately assumes that the interior and the operations are probably as shoddy as the place looks. Perhaps this program should be considered only from an economic basis. If an agency is renting, and paying $300.00 per month over a period of 20 years, this would amount to $72,000.00. This alone should be enough to justify building. After a complete and thorough study has been made of the needs, and the facts have been established, the agency is now ready to consider the next step—the financing. This step is probably the biggest stumbling block for any one who is interested in new housing.

Financing must be planned, and this may be accomplished in many different ways. The first method, and the most practical one, is to set aside a reserve fund over a period of years. Another method is to borrow money from private parties, local government or federal sources. An agency can also make arrangements with private individuals to finance a program, without making any capital outlay expenditures. Another method, or last resort, is to finance by bond election. This method is possible, if not too practical. The only sound way, of course, to finance a building project is to have the funds available. It is certainly a lot easier to set aside a fixed reserve each year, so that when you are ready to build, the money is there. Some will say, "This is impossible," which it might be. However, it is certainly a poor practice not to build a reserve fund for the future. A savings fund is a must in any organization if it expects to advance on a sound economic basis. However, if it is impossible to build this reserve, and the agency believes its needs are great enough, there is always the possibility of borrowing funds from private institutions or from local government sources. Of course, with this method, certain rules and regulations will have to be followed regarding the amount borrowed and the length of time for which the loan is to be made. It is quite surprising the number of persons that are interested in arranging financing for a building program. We were approached by three different individuals who were willing to buy the land, construct the buildings according to our specifications, and allow the rent paid to apply to the purchase price. Of course, interest would be included in the rent payments and a lease would have to be made for five to 15 years, depending upon the amount of money involved. Even with the disadvantages of paying interest, it is possible for an organization with no working capital to start a building program.

After an agency has established which method of financing is to be used, they are now ready to consider the selection of a land site. This is an important step, for many reasons. The property should be centrally located, accessible to utilities, and large enough to accommodate future expansion. Obviously, it should be located where the public will have easy access—not buried on some side road. In many areas, there are zoning laws, which should be carefully studied. Just imagine what would happen if home sites should suddenly spring up all around the agency plant. All places of business have to get along with their neighbors, and in our general course of business we can be pretty much of a nuisance to a home owner. The property should be large enough to allow any organization to grow. Many companies have made the sad mistake of thinking only of today, and find themselves suddenly "bursting at the seams" with no place to go.

Perhaps, at this point, the organization should seek the services of an architect. This is important when long range planning must be considered. It is impossible for the average layman to prepare the necessary plans and specifications required, or to envision adequately what may be needed in the future. A good architectural firm will make these necessary studies and plan the type of buildings most suited to the organization. Selection of an architect is a matter of personal preference, but there are a few things which should be considered; his qualifications, experience, record of past accomplishments, the length of time required to perform his duties, and the cost of his services. This last has been mentioned because there seems to be a wide range as to what constitutes a fair fee. The general recommendations by the American Institute of Architects is: 8% for office buildings, 5% for shop facilities and 3% for sheds, or similar buildings of simple construction. A general average would be approximately 6% of the total building cost. The majority of the people in the building trade recommend the services of an architect.

A good building program is largely a matter of using good common sense, and in order to accomplish one's goal a program must be planned, the needs established and the necessary financing obtained.

There is an old saying, "A wheel has to move to go places." By looking ahead, planning ahead and moving ahead, any agency can possess its own buildings.

Pres. Greenfield: Our next presentation will be a panel discussion. Will Dr. Reeves come forward and assemble his panel members for the discussion of "Where are we going in Mosquito Control?"

PANEL SESSION

* * *

WHERE ARE WE GOING IN MOSQUITO CONTROL?; CHEMICAL, PHYSICAL AND BIOLOGICAL CONTROL—WHAT AND HOW

William C. Reeves, Ph.D., *Moderator*

Panel Participants

W. J. Buchanan
Glen C. Collett
Gaines W. Eddy
A. D. Hess, Ph.D.
Richard T. Holway, Cmdr., USN
R. L. Metcalf, Ph.D.

Dr. Reeves: Will the members of the panel please come forward—Buck Buchanan, you should have stayed up here—Glen Collett, Gaines Eddy, Archie Hess, Dick Holway and Bob Metcalf. Will each of you find yourself a chair and leave one for me, please? If you stay up here, Howard, I'll call on you, too.

The panel has been brought together today for the first time to discuss the timely topic of "Where are we going in Mosquito Control; Chemical, Physical and Biological Control, Research—What and How?" This is quite a title, but a very distinguished panel to discuss the subject. I would like to add to the "What and How" the very important, and maybe the key point, of "Who" is to do this research. Before calling on the first member of the panel, I must admit that the basic key problem that we have to discuss today is the term "Research." I'm certain that each one of us would have a completely different definition of what "Research" means. I know there have been some meetings of Health Department personnel going on this past week in Berkeley, and they spent the first day trying to define what "Research" meant to them. This is not easy.

It will, perhaps, help us a little bit if I give you one illustration of what I mean by interpreting research. This deals with the young lady who was going to be married, and in getting her trousseau ready she picked out a very nice pattern to make herself a negligee. Having picked out the pattern, she went down to the dry goods store to pick out the material. She very definitely knew what she wanted. She found the bolt of material she wanted. She took the pattern from her purse and asked the sales girl, "How many yards of this material do you think I need?" The sales girl looked at the pattern and said, "I think four yards will be enough." The bride-to-be said, "I'll take 15 yards." The sales-girl then said, "You don't need 15 yards. You are only going to make one negligee aren't you?" The girl said, "Right, but I'll take 15 yards." The sales-girl said, "Well, all right, I'll sell it to you if you'll tell me why you want 15 yards." The bride-to-be said, "I'm marrying a research man, and he'd much rather look for it than find it."

I don't mean this as any reflection on the distinguished panel here, but I'm sure that from the discussions this morning we have spent a lot of time looking for the answers to some of the research problems—many answers haven't been found yet.

I took the prerogative, as panel moderator, of circulating amongst the several members of the panel to find out what each one had in mind to do on this panel. They just looked at me and said, "What did you want us to do?" However, it turns out that each member does have a particular cudgel which he would like to brandish in your face or a soap box which he would like to get on for a few minutes at least to bring to you a philosophy or viewpoint regarding research. I'll call on each panel member, then I hope we may have time for questions from the floor which can be directed to each panel member.

I'll call on "Buck" Buchanan first. He's all warmed up—since he just left this platform, and I know that Buck has been very concerned with some of the problems he has dealt with in the realm of availability of trained personnel, particularly in the area of research, also the problems of personnel in attempting to carry out a good mosquito control agency program. So, "Buck," take over.

Mr. Buchanan: Thanks, Bill. I'm not a philosopher, so I'd better confine my remarks to simply a point of view. In Illinois, we do have a problem, and I think it's pretty general throughout the Mid-West with respect to the recruiting and training of personnel for abatement jobs. I believe the title of the panel refers to the future—and I'm very much concerned about where we will get our trained personnel in the future. The ones that we have now, we are stuck with. And believe me, it's a real problem to be an expert in all facets of this work. To be an entomoligist, toxicologist, hydrologist, irrigation engineer and goodness knows what else, is asking an awful lot from one person, it seems to me. Perhaps we can learn from the agricultural people, who established short courses to train and upgrade their personnel. I believe we have a big job to do in that area in the Mid-Western States. I simply bring that out for some future possibility as a means of utilizing much of the information that has been obtained by the research people. I may not have touched on the points Bill had in mind, but it may at least start the discussion.

Dr. Reeves: Thanks, "Buck." I'm glad to hear that you didn't come out from Illinois with the purpose of picking up people from California where we have this large group of trained people. This might have "shook" us up quite a bit if you had offered them a job at this time. There is no question about it that, in carrying out the research findings and in the research itself of the districts, trained personnel add materially to the ease of doing a good job. I happen to know that another member of the panel, Dr. Metcalf, is greatly concerned with the problems of research, not only in our field, but others. He is concerned with where it might be done, who it might be done by and he has some ideas with regards to the future of where we will go with the problems of resistance. Bob has already had an opportunity of telling us something about this this morning, but I hope he will expand this somewhat. Bob—

Dr. Metcalf: Thank you very much, Bill. I think that one of the big problems in this era of rockets, etc., is to attract promising young men into the field of biological research. Certainly the problem of insect resistance to insecticides is one of the most challenging ones with which biologists are faced and its satisfactory solution will be one of the greatest scientific achievements of all time. There isn't nearly enough work going on in this field. We need a lot of bright college boys who have new ideas and won't follow the same old patterns so many of us have trod. There are many good leads which could be followed which might contribute to the total problems as well as to the particular mosquito control problems. I don't need to belabor the point that despite what other methods we may foresee which will provide satisfactory mosquito control under California conditions we will have to depend on insecticides for many years, which will need to be used in conjunction with any other methods of control or cultural control which may be devised. The work that Dr. Kearns of the University of Illinois has done on the DDT dehydrochlorinase is very interesting and has been extended to mosquitoes. Working through the WHO and the London School of Hygiene and Tropical Medicine, he was able to show with selected strains of *Anopheles sundaicus* that DDT dehydrochlorinase levels are very well correlated with levels of resistance and segregation between resistance and non-resistance with Mendelian genetic ratios. This greatly strengthens the view that DDT resistance is due to this intriguing enzymatic mechanism.

There is much interesting work in progress which will account for the similar resistance of other insecticides. Perhaps the biggest hope today is the organophosphorus field. There are hundreds of these compounds that are toxic enough to use for mosquito control, and intriguingly enough, resistance to one doesn't necessarily mean resistance to another. In our laboratories, Dr. Ralph March has found that Malathion resistance is comparatively easy to build up in house flies. You all know this, for it's quite common here in California and Florida, but, perhaps surprisingly, these flies do not have appreciable resistance to parathion. Even more intriguing is the fact that a strain resistant to Chlorthion which has been built up quickly in some 30-40 generations of selection, is not resistant to parathion and yet resistant to compound 4124, which is an analogue of Chlorthion with one chlorine atom moved from the *meta*-position on the benzine ring to the *ortho*-position. Now it's awfully difficult to speculate just how this could be, but the solution would be a very interesting biochemical problem and may have a lot of practical importance. We have found that selection by parathion in over 200 generations of house flies does not raise the tolerance above a level of five to seven times. This is quite the contrary to the case of malathion and the chlorinated hydrocarbons, where resistance of 100-fold has been obtained in some 30-40 generations. There are many extremely interesting problems of this kind which offer a great challenge to bright young students and whose solution would be very valuable to all of us here. I take the optimistic view that the insect toxicologists and chemists are going to keep far enough ahead of the resistance problem so that we are never going to run out of new materials for mosquito control. The pyrethroid-type compounds that Dr. Gjullin mentioned this morning are good examples of some of these materials, which, if satisfactorily used, can control even malathion-resistant mosquitoes. Thank you.

Dr. Reeves: Thanks a lot, Bob. I think this very firmly puts before us the problems of research as seen by a person who has certainly been involved very strongly in trying to keep ahead of the insects in their development of resistance. Another member of the panel, Mr. Collett of Utah, has been very much involved in problems of duck club management in which they have been bringing people of the University into some of the research activities. The Fish and Game people are trying to look ahead and come up with various ways of approaching this important problem in the Salt Lake area. I'd like to have Glen now take a look at the problems from the point of view of this panel.

(NOTE: Mr. Collett requested that this portion of the panel be deleted from publication.)

G. Eddy: Where are we going in mosquito control?—well, we may not be going anywhere unless we find a better solution to the problem of insecticide resistance in insects. In fact, that we may be losing ground was voiced in a recent article appearing in *Mosquito News* (September 1957). The author, in speaking of the advances made with the chlorinated hydrocarbon insecticides in the way of control of malaria and many other diseases, stated that "the social and economic gains made have been greatly diminished due to the resistance now present, and that the welfare of millions of people depends upon the solution to the problem." The author was none other than Dr. Wright of the World Health Organization. Dr. Wright is one of the most traveled persons I know of and is certainly in a position to see the problem in its true perspective in various parts of the world.

I would like to go on now to the problem of mosquito resistance in Oregon. As far as I know there has been no resistance to the phosphorus compounds. The resistance of mosquitoes to DDT in the State is not of a general nature but rather isolated in only a few areas. Aside from DDT, Jack Warren, in charge of the Eugene Mosquito Control District, ran into a bit of resistance this past season in *tarsalis* involving heptachlor. So far as I know, most of the control units are getting along just fine from the standpoint of the other materials. However, I know that Dr. Hess' group has been engaged in certain activities in the southern part of the State and it may be that he will have some news from that area. I might mention that a recent communication from our Orlando, Florida laboratory indicated that they had not run into any marked resistance of mosquitoes to phosphorus compounds such as has been found here in California in one or two areas.

Some of you may remember that in last year's meeting Gjullin and Isaak reported resistance in *tarsalis* to be about 25 times or so. In talking with Dr. Lewallen of the Vector Control laboratory in Fresno regarding this I gathered that he had not run into any greater resistance to malathion in other areas. However, just before Mr. Gjullin left California last August to go on his WHO assignment, he brought up some *tarsalis* eggs from an area not too far from here where resistance to malathion had previously been encountered. We reared the larvae through and now have a colony of this particular strain. Laboratory tests indicate resistance of this strain to be in the neighborhood of two decimal places over compared with the normal colony, or, in other words, about 100 times more resistance to malathion than our laboratory colony. Our non-resistant laboratory colony is very similar to those you would find here in California in that the differences have not been greater than about two fold.

Our experience in establishing this particular strain might be of interest to some of you if you are maintaining laboratory colonies. At the start the colony did exceptionally well and reproduced in sufficient numbers for considerable experimental work. However, all of a sudden the colony then took a turn downward, decreasing at about the same rate at which it had originally increased. For several weeks we struggled with the colony in an attempt to hold on to it and simply had no extra specimens available for experimental use. However, the colony has now apparently recovered and is doing well again. This same situation with respect to reproduction has occurred in other insects and appears to be in some way more involved with insecticide-resistant strains than with nonresistant ones.

Now in connection with further research needed—I should think that studies on the mechanisms of resistance is without question one of the most important. It was of interest to me to note in some of the recent WHO communications that Dr. Clyde Kearns had turned some of his attention from house flies to mosquitoes. I was glad to see this because such a reputable individual as he should help to throw more light on mosquito resistance. The obvious lack and need of information on mosquito resistance is quickly noted by anyone taking the time to review the subject. For instance, in going through the recent WHO supplement on the subject of resistance I noted that there were some 150 references or so. Although I could not read many of the foreign languages in these references, I was able to at least detect most of the subject matter and could not help but be impressed that the biggest share of the references were on house flies. Some of them were on *Drosophila,* a very few on the scale insects, and some on roaches. There was, I believe, only one or two which dealt with mosquitoes and these did not involve research which would throw much light on the problem of resistance in mosquitoes.

As I recall, resistance in house flies was first noted in about 1946 and in the case of mosquitoes about three years later but a quick glance at the literature would clearly indicate that we are more than three years behind in research on mosquitoes.

Aside from the resistance problem itself I think that the proper development and selection of new compounds is a must. We need also further study on synergists and combinations of compounds. Although this may seem futile to some, it seems that about the only thing we can do is to take an optimistic viewpoint.

On another subject of investigation, I am sure many of you noted one of Dr. Kearns' recent communications to WHO on the subject of the "reverting or breaking down" of resistance in house flies by the use of a phosphate material. In a short period of three generations the exposed group of flies reverted back to normal. I believe in the population he was working with only about 5% of the individuals were susceptible. Although I understand that there has been some difficulty in confirming his work, this phase of research certainly warrants extensive investigation.

To hurry on now, I would like to mention some of the log pond work being conducted by Mr. Lewis of our laboratory. He has about 15 ponds presently under observation which were treated with DDT, heptachlor, and malathion. These particular compounds were selected simply to get in tests with chlorinated and phosphorus type compounds. Before showing the slides of the results obtained with these materials I would like to make a few other comments with respect to the use of materials in log ponds. One important point concerns the stability of the preparation. A perfectly good insecticide may appear to be ineffective when used in log ponds due to this factor. I know, for instance, that certain mosquito control agencies bought emulsifiable DDT last year that gave very poor control of the larvae. This was due to the preparation itself rather than the insecticide or rates used. I know that some emulsion preparations which we ourselves tested were good in distilled water, did well in tap water, and I suppose they would have worked well even in salt water, but they simply were no good in log pond water. Some companies put out DDT preparations, for instance, that are intended for use on foliage and these are often cheaper than those that are needed for larvicide work. In getting insecticide supplies on bids, therefore, these are the ones which are obtained. In other words, the bidders get their materials cheap but they in turn get a cheap material. I believe in last year's Proceedings Milt Beuhler of the Eugene, Oregon mosquito district mentioned some of their troubles with various formulations. I mention the formulation problem because I think this factor may be involved in some of the troubles being encountered by some of you who have log ponds in your district.

Another factor involved in the control of mosquito breeding in log ponds is that of temperature coefficient of insecticides. This has been especially noted in Oregon. As many of you know, the temperature coefficient of a lot of the chlorinated insecticides is negative, whereas the phosphorus compounds are positive, so in cold water log ponds, for instance, what do you get but an increase in the effectiveness of say DDT and a decrease in the effectiveness of phosphorus compounds as, for example, EPN or parathion. This, in turn, would therefore put the effectiveness of DDT on par with the phosphorus compounds which otherwise would be more effective. The temperature factor and the point of formulations should be kept in mind when attempting to conclude or judge on the effectiveness of larvicides in log ponds. We know also that there is a tremendous difference in log ponds themselves, such as in turbidity, pH, organic content, etc. Each log pond, therefore, is a problem in itself and what may work in one pond or in one area may well not work in another.

Before showing the slides I would like to mention an interesting observation in connection with the breeding of *tarsalis* in log ponds. In most of the ponds in the Willamette Valley of Oregon this species can be found but is neither alone nor predominating. However, there are two ponds, in one of which this species represented about 95% of the population and the other pond was practically 100%. In both instances the larvae from these ponds were by far the most resistant that could be found anywhere. Whether this was due to the fact that the other species had been killed out leaving only *tarsalis* is not known. It does, however, represent an interesting observation on which further data may be gathered. (Slides were shown with comments by Mr. Eddy.)

Adulticides—I could skip over most of this since it follows the pattern of the larvicides for the most part, but Mr. Gjullin has some information from last year's research that might be of interest. This work was on effectiveness against adult *Culex* females of malathion, Am. Cyanamid 4124, Dipterex, and diazinon. The slide shows that malathion is very good against adults and confirms the work done in Florida against *Anopheles quadrimaculatus*. The tests were made on plywood panels sprayed at the rate of 200 mg./sq.ft., some of the panels being aged in the shade and others in the sun. Although Mr. Gjullin subjected the mosquitoes to varied time exposures, I selected only the 60-minute exposures since these data appeared to be representative of the effectiveness of the materials tested. Malathion was the best of the shade exposures and almost the best of those exposed in the sun. However, it is pointed out that the data could possibly be misleading in that had the exposures been a little longer, diazinon may have proved to be as good or even better than malathion.

I see that the time has run out. Thank you for your kind attention.

Dr. Reeves: Thank you very much, Gaines. I think that it is certainly obvious from this presentation, that there is one thing that we must always have in mind, and that is when research work is done under a certain set of circumstances and then taken into the field in your own District, you may run into trouble. The circumstances are different and it is going to take some manipulation, some review, some retesting. If you will, we can actually apply the term, here, "research"—relooking at the problem—because there was some reason the research work was effective originally. It is a matter of adapting the original suggestion to the circumstance where you are attempting to apply it. Frequently, many of the very promising leads are discarded without any attempt to modify them to a particular local situation. I think this is frequently a mistake.

The next member of our panel is Dick Holway, and I know that he has a philosophy on where we are going in mosquito control, particularly with regard to the relative ways of physical, chemical and biological control approaches. This is based on some of his experiences that he has had in various situations with the navy, and he has seen how these various approaches actually pay off in the end. I would like to have Dick speak to you now. Dick.

Cmdr. Holway: I have only one point that I want to bring out. It may be an old story and I would have hesitated to bring it up if it had not been for Mr. Gray's reference this morning concerning the use of spectacular or dramatic palliative measures, instead of getting down to fundamentals, such as source control. First, I think we all realize that there are times when the palliative or adult control measures are essential, but I feel that we have too often over-sold the public on some of these measures and this has tied our hands, or at least made it more difficult to get the support for some more basic applications of a less spectacular or dramatic nature. Here, perhaps we could trust the public a little more by not trying to oversell them, particularly in regard to one example, the use of fogs.

Out in some of the areas west of here, particularly Guam and Hawaii, there has been in the last 10 years, a tendency to rely a great deal on fogging to the detriment of everything else. A couple of years ago I had an occasion to spend a short time on Guam where, during the period from 1945 to 1948, many of the mosquito control people well known to you (Dr. Reeves, A. W. Morrill, or any number of others) had done a great deal of work. There was the elimination of *Aedes aegypti*, for example. A lot of basic information had been forgotten and the control programs had been dropped, primarily I think, due to the fact that there were no longer any full time mosquito control people left there. As a result, the control procedures consisted almost entirely of getting the fog machine out every night and the more the complaints, the more they would run it. It is very difficult to put across to the powers that be, whether it is commanding officers or the public, that some of these less dramatic procedures will pay off. One example which I think is an old story to all of you, still helps to emphasize this;

The Civilian Contractor's Camp on the Barragada side of Guam had been using this fogging regularly for their control and we were still able to obtain high bite counts on *A. albopictus* and *A. pandani* which were the primary offenders in the area. These were breeding in coconut shells, excess war materials and various trash collections in the surrounding groves as well as in the pandanus trees. After our survey, the sanitarian of the Contractor's Camp was sufficiently interested in the results to attempt application of the recommendations, which were merely the same recommendations which had been made years before. They did put on a campaign and cleaned up an area from one to three hundred yards around the camp, removing coconut shells and other water-holding items and cutting out the pandanus trees. Within a few weeks they were able to abandon fogging entirely, and later gave figures to show that the $3,000.00 they had spent on the cleanup would be more than recovered in the cost of fogging within six months time.

A similar situation occurred in the Pearl Harbor area where routine fogging had been employed for about 10 years up until 1956. It is still going on but has been cut down tremendously with the increased attention to major breeding sources which result from sugar harvesting operations. We trust that emphasis along these lines will be continued.

Again, I say these are old stories but we seem, in many cases, to forget them. Or, even when they are not forgotten, sometimes a problem is caused by over-emphasis of the spectacular, which makes it that much more difficult to obtain funds, or to use available funds, for the less obvious but more effective basic control measures which are, of course, the only final answer.

Dr. Reeves: Talking about the situation on Guam brings back some rather nostalgic memories for me. It is very frustrating to suggest that they cut down Pandanus and have them run the fog machine instead; although, I will never forget one Colonel who said: "I'll do whatever you tell my men to do. It is alright. Just tell them." And the next thing you knew, a whole row of ornamental Pandana had been cut down that were right down the main road on his air-base—and these were his pets. But it took care of the problem in a very practical way.

I think the main thing to remember is that when we are using chemical means ostensibly, the main thing is to look and see if there is an alternative, more permanent method that we have basic knowledge on. It is at least worth evaluating to see if permanent measures won't replace the continuous process.

The next speaker on our program, Dr. Archie Hess, from Logan, has given me a tip-off as to what he is going to bring to your attention and where he thinks we may be going in mosquito control. It may be away from mosquito control—I'm not sure; but I'll let him explain to you his viewpoints. I don't think there are any tomatoes out in the audience, Archie, so, I think it is perfectly alright to go ahead and throw your idea out just the way you have it.

Dr. Hess: It is obvious from the comments of the others, that in the future we are going to have to make more and more use of research and be research minded. As Bob pointed out, if malathion doesn't work, we've got to find something else that will; and through research, I agree with him, we will find it. Just as an industry, which is research minded and invests part of its funds in research pays better dividends, a mosquito abatement district which keeps up with research developments and adapts its program accordingly, will pay better dividends in its expenditure of the taxpayers' money.

This research, also, must be a good balanced program of fundamental research as well as applied research. As Bob said in his talk this morning, this problem of resistance requires some pretty fundamental work in the fields of toxicology, physiology and biochemistry. That applies, I believe, to the source reduction type of measures, naturalistic control, which most of us feel must be more and more relied upon in the future. We will always have a need for insecticides, but, looking into the future, I am sure that the only answer on a long range basis is more source reduction. That means we must adapt to the changing conditions in this world. We heard earlier this morning that here in California you are going to soon have more people than New York—I don't know why they all come out here, I think Utah is a lot better place, and they ought to stop there. If this keeps up, instead of having rural mosquito control, you'll all be carrying out urban mosquito control. Maybe you'll be working on *quinquefasciatus* instead of *nigromaculis* or *tarsalis.* You must, therefore, adapt your programs not only to changing methods and materials, but also to the changing needs in a community—to man's continuous change in his way of living. In this respect, I think that more and more mosquito control must be integrated with other interests; not only with interests outside the field of vector control, such as agriculture and wild-life, but with other vector control problems more directly related to mosquito control, such as the control of flies, rodents, *Hippelates,* and *Culicoides.* Most of you know that in Florida, many of the districts are just as much concerned with sand-flies, or *Culicoides,* as with mosquitoes.

So, I predict, looking into the future, (and some may throw those tomatoes which Bill mentioned) that more and more we will see a translation of mosquito control districts into vector control districts, whether we like it or not. I think it is the direction we will go, and, eventually, we will be applying our research and operations facilities and personnel to solving more problems than just mosquito control, just as we changed from disease vector to general mosquito control. I think we should and will expand out into the whole field of vector control. We might as well look realistically into the future and be prepared to adapt ourselves for such a change.

Dr. Reeves: Thank you very much, Archie, for presenting the potentiality for broadening out activities beyond mosquito control, as well as intensifying and applying further of our present means.

There is one point which I would like to make on where we are going in mosquito control. This point was brought to my attention this afternoon when Ed Davis brought me up for an interview with someone at the radio station. In discussing things with this man, it came out of our discussion that we are dealing with a public today that is quite a different public than the public that we were dealing with 10 years ago. We are dealing today with a scientifically informed public, and this they definitely were not in the relatively near past. This is very well attested by looking at your newspaper, seeing the number of articles on science which are now in every copy of a newspaper, or the number of articles in magazines that are on science research. The public has come to expect to be informed of developments in science and what they can do for themselves. This is very well exemplified in many of our disease problems, in which the public wants to know "What can I do to help myself and my family." They are eager for such information.

I think that the public, perhaps, doesn't know enough about much of the research that is going on today, and the various problems as far as mosquito control is concerned. They do not get the information passed on to them as completely as it might be possible.

I appreciate that we are not ignoring this problem in any districts, as far as I know. However, I think that we might make a more intensive effort to pass research on in a more palatable form to the public because they are quite receptive to it today.

It has been very obvious from the discussions of the various panel members that there is a great deal of research going on today that is directly applicable to mosquito control problems. It has been very obvious that the biological approach is being applied to this problem, very widely. It is also obvious from the reports given by the various districts and agencies. I think that this is very encouraging. It reminds me of what happened a very short time ago when a group of Russian scientists visited the University in Berkeley. These were leading scientists from Russia and one of these men was in charge of a great deal of the biological research that was being done on physiology in that country. While sitting in the office, an opportunity came up to discuss things very informally with this individual. This was right after the second Sputnik had gone up, which we call Muttnik. He was very concerned with how we came to get this name; and, after it was explained to him, he thought this was very hilarious. Then the question was asked him, in this very free atmosphere, "Well, you know, as a leading physiologist in Russia, what went into this idea of putting a dog in the second Sputnik?" He said, "I really don't know anything about it. I really don't." I asked him if he was not asked for advice on this, since it was a biological problem; and he said, "No. The physicists handle all this." We asked him again: "Isn't this a biological problem?" He laughed and said: "Yes, I know this is a biological problem, but that physicist surely didn't." He thought this was very amusing. He wasn't particularly upset. He thought this was sort of matter of course.

We know we are dealing with a biological problem. I think we are all well oriented in this direction, and we are going to approach it in a biological way in the future. It is obvious to us that if we are to do anything in the way of physiological control in the future, we are going to have to approach them as biological problems.

It is a quarter past five. We have used up an hour. I think that we will draw the panel to a close at this time, and certainly would encourage you to discuss further with the various members of the panel, any questions or any further ideas that you may have on the things that they discussed. I am sure that they would be very willing to do so.

I thank you very much for your very kind attention.

Pres. Greenfield: I want to thank you, Bill, and your panel, for a very, very fine presentation on "what" and "why"—but, I don't recall hearing anything about "how."

A Voice: "You tell him."

Pres. Greenfield: No, I will not take that time now, because that could be a long and difficult subject. I do think that what Bill and his panel have said today really typifies, or exemplifies, the entire spirit that I have noted in this Association's activities today. The why, the what, and I hope, very soon, the how of it. It is evident that we are not going to be concerned only with mosquitoes—but other insects and other arthropods of public health significance, agriculturally or otherwise.

It is time to adjourn. I want to thank each and every one of you for being such a very fine audience today. To those that have already participated in the program, I wish to thank you on behalf of the officers and the Association for being here with us and to be able to present your thoughts to the group.

Harold, would you please come up and make that statement you mentioned a moment ago.

Mr. Gray: On Wednesday of last week, there died one of the early workers in the field of malaria control in California. Probably comparatively few of you knew him in that particular light, because he had been in recent years the Health Officer of Berkeley and a lecturer in the School of Public Health in the University of California. I am referring to my old friend, Frank Kelly, who in the early days was in the old Hygienic Laboratory of the State Health Department in Berkeley. With Dr. Freeborn, Dr. Geiger and others he was concerned with studies on malaria in the central valley of the State in the period 1915-1925. He did a great deal of investigational work, for example in the area around Redding, and the interior, in measuring the amount of malarial infection. He went with us, for example, on some of the trips with out of the State people like Louis Williams of the Public Health Service. He always did have a research interest in many of these problems, and he was always to a certain extent interested in the work that we were doing. In view of his past record in our particular field, I would like to ask that when we adjourn this meeting, we adjourn out of respect for his memory.

Pres. Greenfield: Thank you, Harold. We will now adjourn out of respect to the memory of Frank Kelly.

Please, everyone, remember that there are other things to come; I now declare this meeting adjourned until the hospitality hour this evening.

THIRD SESSION

TUESDAY, JANUARY 28, 1958, 8:45 A.M.

ANNUAL BUSINESS MEETING OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION

The annual business meeting was called to order by President Howard Greenfield, who presided throughout this session. Pres. Greenfield first called upon Dr. W. Donald Murray, Chairman of the Ways and Means Committee, for his Committee Report in regard to the proposed revisions of the Association's bylaws. Dr. Murray summarized the proposed alterations and, since copies thereof had been previously given to the members present, action on the adoption of the proposed bylaws was requested by President Greenfield.

BYLAWS OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

Article I. Name

The name of this Association is the California Mosquito Control Association, Inc.

Article II. Objects

The objects of this Association 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 of this field in California and elsewhere.

Article III. Membership

Section 1. Membership in this Association will consist of four classes: Corporate Members, Associate Members, Sustaining Members, and Honorary Members.

Section 2. Corporate Members will be Mosquito Abatement Districts, Pest Abatement Districts concerned principally with mosquito control, and other local governmental agencies directly engaged in mosquito abatement in the State of California. Each Corporate Member will have one vote, to be cast by its designated representative.

Section 3. Associate Members will be individuals, agencies or other organizations interested in or concerned with mosquito abatement. Associate Members have no vote in this Association.

Section 4. Sustaining Members will be those individuals or organizations who desire to contribute to the furtherance of mosquito control through this Association. Sustaining Members have no vote in this Association.

Section 5. Any individual who has performed some outstanding service in the interest of mosquito control in the State of California or elsewhere will be eligible for election to honorary membership upon recommendation of three or more Associate or Corporate Members to the Board of Directors. The Secretary of the Association will submit the name in writing to all Corporate Members at least 35 days before the Annual Meeting. Honorary membership will be conferred if the person receives two-thirds of the votes cast at the Annual Meeting. Honorary Members have no vote in this Association and pay no dues.

Section 6. At all meetings of this Association, all members, irrespective of type of membership, will be permitted to take part in the discussion and proceedings.

Article IV. Officers

Section 1. The Officers and Board of Directors of this Association are a President, a Vice-President, a Secretary, a Treasurer, the immediate Past President, one member of a governing board of a Corporate Member, and a Regional Representative from each of the five geographical regions of the State as follows: Sacramento Valley, Coast, Northern San Joaquin Valley, Southern San Joaquin Valley, and Southern California. At the time of his nomination and election, each officer and director will be either a member of a governing board or a manager of a Corporate Member. The offices of Secretary and Treasurer may be held by the same individual.

Section 2. The President is chairman of the Board of Directors and has the usual duties which pertain to the office, subject to the authority of the Board. He is empowered to:

1. call a meeting of the Board of Directors when he believes such is necessary.
2. select the chairman and members of standing and special committees, except nominating, subject to approval by the Board of Directors.
3. be an ex-officio member of all committees except nominating.
4. execute with the Secretary or Treasurer legal and fiscal documents.

Section 3. The Vice-President, a member of the Board of Directors, will exercise the powers and perform the duties of the President in the absence or disability of the President or in case of a vacancy in that office. He is empowered to execute with the Secretary or Treasurer legal and fiscal documents.

Section 4. The Secretary, a member of the Board of Directors, will:

1. keep minutes of all general meetings of the Association and meetings of the Board of Directors.
2. issue notices of all general meetings and Board meetings, on direction of the President or Board of Directors.

3. conduct correspondence of the Association, on direction of the President or of the Board of Directors.

4. execute, with the President or Vice-President, legal and fiscal documents.

Section 5. The Treasurer, a member of the Board of Directors, will:

1. bill and collect for all dues, and will receive any other funds made available to the Association for services rendered, from sales, donations, etc.

2. execute with the President or Vice-President legal and fiscal documents.

3. maintain all records on a budget account basis as determined by the Budget Committee and the Board of Directors.

Section 6. The Board of Directors:

1. will manage the affairs of the Association between Annual Meetings.

2. may prescribe the duties of officers and committees.

3. may censure, suspend or expel an officer from office for cause.

4. may fill a vacancy in the office of Vice-President, Secretary, Treasurer, Trustee Member, and it may request a Region to fill a vacancy in the office of a Regional Representative.

5. may appoint or employ an Executive Secretary, Attorney-at-Law, or other paid help, and define his duties.

6. will appoint the Nominating Committee.

7. will have an annual audit of the accounts of this Association made by a qualified public accountant and the written report of the account given at the Annual Meeting.

8. may prescribe the boundaries of the Geographical Regions.

9. will set the dues for the Associate and Sustaining Members, and the Contractual Payments for Corporate Members. All payments will be on the basis of a calendar year, from January 1 through December 1.

10. may determine the number and price of each publication which will be distributed to the various members and others.

Section 7. Nomination and election of Officers.

1. At least 90 days before the Annual Meeting, the Board of Directors will appoint a Nominating Committee consisting of a member of a governing board or a manager of a Corporate Member from each of the five geographical regions.

2. The Nominating Committee will select nominees for the elective offices of the Association, except Regional Representative, at least one for each office. It will, at least 35 days before the Annual Meeting, send to each Corporate Member, through the Secretary, the names of the nominees selected. Nominations may be made from the floor at the Annual Meeting, but only if the proposed nominee has given prior consent to serve if elected.

3. Regional Representatives of the Board of Directors will be elected, one from each geographical region, by a meeting of Designated Representatives of the Corporate Members of each respective region, prior to the Annual Meeting or before its conclusion.

4. Officers and Directors of this Association will be elected at the Annual Meeting and will serve until the next Annual Meeting or until the election of their successors.

Section 8. As soon as possible after the Annual Meeting, the President will select, subject to approval of the Board of Directors, Standing Committees, excepting nominating, with their chairmen. At any time during the year, special committees may be formed by this same procedure.

Article V. Meetings

Section 1. Annual Meeting. There will be an Annual Meeting of this Association for the election of Officers, the presentation of papers, discussions on mosquito control and related subjects, and such other business as properly may be brought before it. This meeting will be held at such time and place as the Board of Directors selects. At least 35 days prior notice in writing will be given to all Members, announcing the time and place of the Annual Meeting.

Section 2. Special Meetings.

1. The Board of Directors will call a special meeting of the entire membership whenever it believes such is necessary, or when it receives a petition signed by the designated representatives or five or more Corporate Members. A petition requesting such a special meeting will indicate the topic for disposition or the reason for the special meeting. The Board will be bound thereby to set a place and date no sooner than 35 days nor greater than 60 days after the receipt of the petition.

2. Special meetings of the general membership for consideration of technical subjects, field demonstrations, local problems or similar matters may be held at times and places selected by the sponsoring group or committee.

3. Regional meetings of an informal nature may be called by the respective Regional Representative at any time.

Section 3. Board of Directors' Meetings. The Board of Directors will meet upon call of the President, or upon request of three or more Directors directed in writing to the President. At least 10 days prior notice in writing will be given by the President to all members of the Board announcing the time and place of Board meetings.

Section 4. Voting.

1. A simple majority of designated representatives of Corporate Members will constitute a quorum for the transaction of business at any Annual or Special Meeting.

2. Five members of the Board of Directors will constitute a quorum at a meeting of this body. If one person occupies the positions of both Secretary and Treasurer, he will have but one vote.

Article VI. Parliamentary Authority

The rules contained in Robert's "Rules of Order, Revised" will govern in all cases in which they are not inconsistent with these Bylaws. Other texts or references may be used as supplements, so long as they do not conflict with Robert's. The president is authorized to appoint a Parliamentarian to assist in interpretation of parliamentary procedures and to compile and maintain for reference the standing rules of the Association.

Article VII. Amendments to Bylaws

Section 1. These Bylaws may be amended or revised only at the Annual Meeting. Previous notice of the proposed amendment or revision will be submitted to all Members in printed form by the Secretary at least 35 days before the Annual Meeting.

Section 2. Amendments or revisions may be prepared by the Ways and Means Committee, or by a special committee appointed for that purpose. Individuals wishing to recommend amendments should route their request through the appropriate committee. Amendments will be submitted in writing to the Board of Directors, via the Secretary, at least 60 days before the Annual Meeting.

Section 3. A vote of two-thirds of the Members present and voting at the Annual Meeting will effect the amendment or revision.

Pres. Greenfield: It has been moved by Don Murray that the Bylaws be accepted with the changes indicated. Gardner McFarland has seconded the motion. Ready for the question? We will have a roll call vote for the adoption of the Bylaws. We will take that then as the first item. It has been moved and seconded that the revisions, as incorporated in the Bylaws, be accepted. May we have this by a show of hands. All those in favor raise their hands. Those opposed, please raise your hands. Now then, it has been moved and carried that the revisions be incorporated into the Bylaws. Now we are ready for the Bylaws motion as amended, and that will be, of course, by roll call vote. We have the motion on it.

No! It need not be by roll call vote. I just thought it might make it easier. Then all those in favor of the adoption of the Bylaws please say "Aye." Those opposed? So carried.

Next is, as you would say, the "so-called" Presidential Address.

PRESIDENT'S REMARKS

Howard R. Greenfield
Manager, Northern Salinas Valley Mosquito Abatement District

Gentlemen:

Custom dictates that I furnish you with an account of the Association's activities during the past year. Rather than discuss at length those activities with which you are all familiar, I will confine my remarks to certain probems which were encountered during the year. It is my opinion that, if a solution can be found to these problems, the position of all mosquito control agencies in this State will be strengthened.

I am sincerely pleased to know that this Association has accepted the challenge of revising the Bylaws. That, in itself, is testimony that we can accept responsibility firmly; know that, when the dust of arguments both pro and con has settled, the decision will be the voices of the majority. We have all heard, too many times, the expression, "the organized minority rules the unorganized." That expression certainly cannot be applied to this group in attendance today. With a set of new Bylaws, I know the incoming Officers and Board Members will have an effective tool with which to work.

During the past year, a few member agencies requested this office and the Board of Directors to examine the income of the Association to determine whether or not it would be possible to effect a reduction of the dues paid by Corporate Members. This question apparently was raised through the knowledge that the Association supposedly had a reserve fund which could be reduced by a reduction in Corporate dues.

The Directors acknowledged these requests and appointed a Special Finance Study Committee to make a report on the Association's financial position and to make any recommendations necessary to bring about a more comprehensive structure which would guide the actions of future officers and Directors of this Association. The results of the actions taken by this Special Financial Study Committee have received general distribution. I wish to ask that you give special consideration to these recommendations as they will play a vital role in the future of this Association. It should be remembered that if the initiative of your Officers, Board Members, and Committees is nullified or killed by throttling restrictions, this Association, founded for the dissemination of knowledge about and for the advancement of mosquito control and subjects related thereto, will cease to exist.

Now I will present, as precedent dictates, my challenge. It seems as though it has become necessary for those about to be retired to hurl a challenge to the incoming Officers.

Many years ago, March 26th, 1920, to be exact, a paper with the title "Mosquito Control—An Important Factor—The Development of the State's Resources and the Necessity for Coordinated Action" was presented at the first Conference of Abatement Agencies. I want you to note the title. Some of you in the audience today attended that Conference when Professor Herms delivered his opening address in which he pointed out the need for *Coordinated Effort*.

Later, 30 years later in fact, Mr. Ed Washburn in his Presidential Address, given before the 18th Annual

Conference, pleaded to have the Association join together to develop a coordinated Operational Research Program. Complete ecological knowledge concerning the habits of *Aedes nigromaculis, Aedes dorsalis,* and the *Anopheles* species was lacking at that time. However, his pleas fell on deaf ears, no hands were joined in a common cooperative effort, and no common voice of the Association advocated a continuing program of basic, operational, or applied research on mosquitoes during 1950.

True, through the years there has been developed, within the California Mosquito Control Association, a program of operational investigations which has, under the guidance of Ed Washburn and Ted Raley, helped tremendously in gathering information valuable to all in this Association.

Today, however, we find the complexities of mosquito control increasing instead of diminishing. The problems of application rates and the effectiveness of insecticides differ from one general area to another. We find that many Districts have not only responsibilities in mosquito control, but have assumed responsibilities in flies, gnats, and other insects of Public Health significance.

Each year we also see an increasing Public awareness of the work being done by Mosquito Abatement Districts. We also see Public awareness being turned from mosquitoes to other insects such as flies and gnats. This Public awareness eventually will demand answers to such questions as "why must we put up with these pests?" We, in this Association, must be prepared to accept this challenge if District positions are to be strengthened instead of weakened. The answers, which will be needed, can come only through proper channeling and coordination of programs that now exist as separate and distinct entities. We must have an agency that can assemble the information from these separate projects and dispense the information to all interested Districts.

Much more could be said on this subject and much has been said during the past years, however, I believe the time is ripe now, when even the world is recognizing the need for more scientific activity, to declare ourselves openly and publicly to be fully and unanimously in support of a program which would provide each and every one of us with a place to state our problems and receive the vital information necessary to discharge our obligation to the people who support us—the Taxpayer.

Let us set the example, which we know to be right, by advocating an expanded and continuing program of basic research in California.

Dr. Murray: As you members have seen, the Conference program has been discussing research, many of the talks yesterday did so, and the present address of our President, plus our program this afternoon, as well as a number of talks on our program tomorrow morning.

Regarding research—too often we listen to something that sounds good. We sit on our bottoms and listen and do nothing—this has happened quite a few times as Howard mentioned, and to which Ed Washburn gave a little bit of a challenge; yet, somehow, it just fluttered and died out. Perhaps, if at the risk of some objections—but who ever gets anywhere if he doesn't take a few chances—it might be appropriate at this time to make a motion that our Association go on record as favoring a stronger research program, both operational or applied and basic. To this part of the motion, I am sure there is no difference of opinion. Now I am going to get controversial, but I think it is necessary to make a decision. I also move that the State Department of Public Health be assigned the responsibility of (1) coordination and stimulation of research by other agencies, universities, colleges, private agencies, the United States Public Health Service, and such other agencies that do research. Likewise, (2) the Bureau of Vector Control should be the central or coordinating agency to receive requests for research and to channel those requests out to agencies which are able to start those research programs or projects. And, likewise, (3) that the Bureau of Vector Control should continue on its present program but on a greatly expanded basis; and, as you will see this afternoon, the Bureau of Vector Control has a considerable program in research. This afternoon, I hope you can listen to some of the developments which part of this motion, that this program be expanded, put on a sound basis. The basis it is now on is "by luck and by gosh"—let's make it sound. Enough money to make it grow. Enough personnel to make it work. Further, I move that the incoming President appoint a committee to study this project, to work with the State Health Department in arriving at a research program that will make California stand out, as Archie has mentioned yesterday; not taking a back seat, not necessarily spending the most money, but doing the real program to help us all; and, as Howard said, to help our taxpayers.

Pres. Greenfield: It has been moved and seconded that the Association adopt the motion as presented by Don Murray. Ready for the question? Yes? . . .

Mr. Glikbarg, Salinas: Perhaps not being a professional mosquito abater, I am presumptuous in commenting on this; however, there are certain phases of this problem with which I have had some experience. We, of course, as a group cannot assign the research function, or any other function, to the State, to the Bureau of Vector Control, or to any of these other organizations. However, I am sure that the purpose is well stated; but, perhaps, it should be done in a slightly different fashion. I am quite impressed with the—from a layman's standpoint and with my limited knowledge just from what I have observed in the meetings I have attended—I am quite impressed with the need for research. I was fortunate to go to Miami this last year, I was quite impressed with the research program some other states had that was indicated in the program there. Yesterday, one did not have to be a skilled observer to recognize that there were more questions asked than there were answers given. This indicated a need for research. I for one, certainly the Board of which I am a member, have always favored local autonomy. I for one do not like State control, local areas have local problems. I like decentralization, I think mosquito abatement districts are well set up in that regard, however, there are exceptions. Research certainly is one such exception. When Salinas Valley has a problem with a pond from a sugar mill, when Oregon has a problem, or the northern part of the state has a problem with log ponds, sometimes these things are related; sometimes local districts are not set up to do the amount of research that is necessary to solve the problem; there isn't any co-ordination; there is a duplication of effort; it is just an inefficient way of doing the thing. It seems to me that research, to be effective should be on a more centralized basis, so that questions could be asked, research could be done, there would be no duplication of effort, and there would be proper dissemination of information. I think, possibly that I am not talking about anything different than the motion contemplates; however, I think it might be more effective if, instead of doing it in quite the fashion presented, that more leeway be given. This is a legislative problem, and because there are State Funds that would have to be forthcoming, State agencies would have to be involved. I think the more effective way of handling the program might be for this group to have a committee appointed with certain broad powers and certain objectives stated, then the thing might be worked out one way or another without the necessity of the group as a whole spelling out the details. In other words, if you are in accord on the objective that there should be more research, that research should be centralized under some central agency, why don't you state your objectives in that fashion and have a committee to try and carry it out; then it is a question of—if you will pardon the expression—"lobbying" to accomplish your purpose. It requires legislative action, it requires the cooperation of State administrative agencies, and you may end up in one place or another, but the thing you would strive to end up with would be a centralized research facility, and in that fashion you might accomplish it. There has been in informal meetings much discussion, some of which I have listened to on State aid for subvention. There is a need for State funds if you are going to have an effective research program. This should be done in coordination with the subvention, part of that program too, I think. One reason individual districts have problems of economy and budget is that they are doing a lot of things that possibly could be done better elsewhere, and the strain on individual districts could be relieved. So, I am not arguing with the concept that has been presented, I am just suggesting that possibly a little different tactic might be more effective. Thank you.

Mr. Greenfield: Is that an amendment to this motion? Perhaps it would help clarify things if I read the motion by Don Murray as he has it written, and then would you please give me your comments on it. (Pres. Howard Greenfield then read the prepared resolution in regard to the expanded program for research, which is as follows):

RESEARCH RESOLUTION

In the interest of technological progress and economy of operation in meeting the increasingly complex problems of mosquito control in California, the CMCA hereby goes on record stating the imperative need for continued and expanded research, both basic and applied.

The CMCA believes that the California SDPH is the most logical agency to assume the major responsibility for this program. Such a delegation of responsibility envisions frequent joint research projects by the Bureau of Vector Control and other agencies prepared to participate; it further indicates the active encouragement and coordination as necessary by the Bureau of Vector Control of related research efforts undertaken through the State University and other interested public and private agencies.

In order to accomplish these objectives, an augmented program of research within the Bureau of Vector Control, supported by substantially improved facilities and increased manpower resources must be provided.

It is urged that adequate financial provisions be made to develop a comprehensive research program as an integral and continuing part of the SDPH budget.

It is further moved that the incoming President of the CMCA be directed to appoint an ad hoc committee to work with the SDPH and to explore all means available to facilitate and expedite the accomplishment of these objectives.

Mr. Glikbarg: Now having heard the entire motion, I find it is exactly what I had in mind. Thank you. (Laughter)

Pres. Greenfield: We can proceed with the motion. Is there any discussion anyone would care to make on it? Those in favor of adopting this motion say "Aye." (Ayes) Those opposed. So carried:

. . . In recognizing that our days of mosquito control as a simplified, non-technical, effort is no longer with us, I am very happy to see this Association taking this step. It makes me feel better that my year has been with a group that is moving forward. Believe me, I have enjoyed this immensely, and I have enjoyed the entire year. Especially with the culmination of the work we just have seen to this point. But we have a lot of other activities to get over; so, if I may, I would like to ask for the reports of the standing committees. The first committee report will be the Treasurer's.

FINANCIAL STATEMENT
REVENUE AND DISBURSEMENTS
CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

January 1, 1957 - December 31, 1957

Gentlemen:

Herewith is submitted the report of the Secretary-Treasurer of this Association for the period January 1, 1957 to December 31, 1957, inclusive:

Revenue			
Balance January 1, 1957	$5,060.17		
Bank Balance Jan. 28, 1957		$2,560.17	
Building & Loan Deposit Jan. 28, 1957		2,500.00	
			$5,060.17
Income			
Contractual Membership Payments			$3,120.00
Associate Membership Dues			57.00
Sustaining Membership Dues			225.00
Publications			65.50
25th Conference Income			985.00
Refunds			35.56
Other — Exhibits			400.00
Total Revenue			$9,948.23

Disbursements

Postage	$ 129.14	
Stationery	123.76	
Stenographic Service	690.34	
1957—Yearbook	175.00	
Utilities (Telephone)	139.99	
Advertising (AMCA)	108.00	
Herms Award	50.00	
Printing 25th Conference Proceedings (750 copies)	1,440.87	
Travel to AMCA Convention	700.00	
Flowers	4.34	
Checkbook	3.30	
C.P.A.—Audit	25.00	
Addressograph	10.00	
Reprints (History of Malaria)	98.80	
Reprints (Author Index)	59.49	
Conference (Dinner Dance—Orchestra, etc.)	1,187.43	
Total Disbursements		$4,945.46
Balance on Hand December 31, 1957		$5,002.77

Respectfully submitted,
G. Edwin Washburn
Secretary-Treasurer

It has been moved that the Treasurer's Report be adopted. It has been seconded by Don Grant. Question? All those in favor say "Aye." (Ayes) Those opposed. So carried.

The next report wil be that of the Entomology Committee, Ed Loomis, Chairman. Is Ed Loomis with us?

REPORT OF THE 1957 ENTOMOLOGY COMMITTEE

The 1957 Committee consisted of eight members, one of which discontinued activities in October and was replaced by a former 1956 committee member.

A total of six meetings were held during the 1957 calendar year (see attached, Item I). A preliminary meeting of both 1956 and 1957 committee members was held in early March to make immediate plans for the entomology seminar to be held at the University of California, Davis campus, on March 29 and 30. On this latter date, approximately 50 interested workers in culicidology enjoyed an active discussion on mosquito and gnat problems (see attached program Item II). All participants attended both the open house sponsored by Dr. S. B. Freeborn and the following dinner meeting arranged by Drs. Bailey and Bohart. Fresno State College was voted as the location for the 1958 seminar to be held at approximately the same time period.

Reviews of this meeting were published in both the *Mosquito News* and *California Vector Views.*

A current list (as of December, 1956) of mosquito investigation projects in California was prepared by members of the Entomology, Operational Investigations and Toxicology committees. This list was published in the 1957 CMCA annual report, with reprints sent to educational institutions and other interested agencies in and outside of California (see attached Item III).

Efforts continued on the compilation of biological information (outside of that already in published form) for most of our common mosquito species. A questionnaire form and covering letter was mailed to interested entomologists and agencies throughout the State. Useful information has been received to date on the particular subjects of larval habitats and distribution of species. Evaluation of data will be made by each individual assigned a species, with copies of complete texts to be made available during 1958. This should be a continuing committee activity.

Plans for publishing the "Field Guide to California Mosquitoes" are to be completed by the 1958 committee. Work this year, 1957, consisted of the following: Construction of non-technical but yet workable adult and larval keys for six genera and 23 of our most common species in California, a glossary of terms used in the key and text, plus an ecological description for each species listed.

The committee was asked to prepare a subject for presentation at the CMCA 1958 meeting. Dr. S. B. Freeborn was selected to moderate the topic "Mosquitoes—their control when environment changes." Participants for panel discussion from the floor were contacted to assist in giving specific examples experienced in this state.

Respectfully submitted,
Dr. R. M. Bohart, U.C. at Davis
Dean Ecke, Santa Clara Co. Health Dept.
Jack Fowler, Sacramento-Yolo MAD
Leo Hall, San Joaquin MAD
Herb Herms, Sutter-Yuba MAD
Gerald Lant, No. Salinas Valley MAD[1]
Tom Lauret, San Mateo MAD
Ed Loomis, B.V.C. S.D.P.H., Com. Chairman
Harry Mathis, Marin Co. MAD
Embree Mezger, Solano Co. MAD[1]

Pres. Greenfield: Do I hear a motion to accept?

Mr. Grant: I move it be accepted.

Pres. Greenfield: Moved by Don Grant the report be accepted. Second? Seconded by Dick Sperbeck. All those in favor say "Aye." (Ayes) Opposed?

Report of the Education and Publicity Committee under the Chairmanship of Les Brumbaugh.

EDUCATION AND PUBLICITY COMMITTEE

In 1957, the Education and Publicity Committee's suggested projects for the year were:

(1) State Fair Booth
(2) Providing publicity for the annual conference.

At the first meeting of this committee, it was unanimously agreed that no C.M.C.A. exhibit be prepared for the 1957 State Fair. It was further decided that the goal of the committee would be to place greater emphasis on educational material. To achieve this goal, the following information was prepared for distribution to all of the agencies:

(1) Abstract of the A.M.C.A. conference.
(2) Bulletins and circulars pertaining to mosquito control.

[1] Lant replaced by Mezger in October, 1957

(3) List of books helpful to mosquito control.
(4) Collection of two by two inch slides on mosquito control, and establishment of a distribution center.
(5) Gathering and collecting films on mosquito control.
(6) Exhibiting educational material at the annual conference.

The last project was the development of an irrigated pasture mosquito bulletin for publication. (This is still in the formative stage, and will probably be ready for publication next year.)

Recommendations:

In reviewing the past year's activities, this committee would like to make the following recommendations:

(1) Complete arrangements for the publication of the irrigated pasture bulletin.
(2) Develop a procedure for the distribution of news releases.
(3) Retain at least three members from the 1957 committee.

Respectfully submitted,
Les Brumbaugh, *Chairman*
Marvin Kramer
Bob Peters
John Stivers
Eric Yoeman
Howard Dunphy

Pres. Greenfield: Moved by John Brawley to accept the report. Is there a second? Seconded by Dave Reed. All those in favor say "Aye." (Ayes) Those opposed? So carried.

Report on the Forms, Records and Statistics Committee under Jack Kimball.

FORMS, RECORDS & STATISTICS COMMITTEE REPORT FOR 1957

To Be Presented at the 26th Annual Conference
California Mosquito Control Association
Fresno, January 26-29, 1958

Two projects were completed by this Committee during the year. The 1957 YEAR BOOK was mailed on April 25th to 482 individuals and 141 extra copies were distributed to Association Officers. A new section, "List of Investigations in California—Completed, Current and Proposed" was included this year at the request of the Operational Investigations Committee, and 150 reprints of this section were furnished to this Committee. The total cost for printing and mailing the 1957 Year Book and reprints was $139.49. The Staff of the Orange County Mosquito Abatement District compiled and typed the data and statistics and assembled and mailed this Year Book. The actual printing was done by our District Entomologist, John G. Shanafelt, Jr. at his home "hobby" print shop.

A comprehensive six page statistical report "Personnel Working Conditions and Salary Schedule" was compiled, printed and distributed on August 1st, 1957 to contributing Districts by W. D. Murray, as a member of this Committee. This report, in addition to 1957-58 salary schedules reported by 38 agencies for 17 job classifications, also presented the number of employees, working hours, holidays, days of sick leave and annual leave, as well as retirement and insurance benefits which are currently in effect by each of the Agencies.

1957 Forms, Record & Statistics Committee
Jack H. Kimball, *Chairman*
John G. Shanafelt, Jr.
W. D. Murray
J. R. Walker
T. D. Mulhern
R. E. Fontaine

Pres. Greenfield: Thank you, Jack.

Mr. Glikbarg: As uncontroversial as most of these reports are, I suggest that we wait until the end and then adopt all of them, if there are no objections.

Pres. Greenfield: If there are no objections, I think that we will do just that in view of the time. The next report then will be from the Publications Committee, Don Grant.

Mr. Grant:

PUBLICATIONS COMMITTEE

The Proceedings and Papers of the Twenty-fifth Annual Conference were published and mailed by June 30, 1957, which stands as one of our earliest publication dates. Making this possible has been a coordinated effort by many people, the Program Chairman, speakers submitting papers, Publications Committee and printer, all representing an improved level of procedure.

Costwise, 800 copies of the 116 page Proceedings were printed at a favorable low bid by The Abbey Press in Oakland. Five hundred reprints of the Gray-Fontaine paper, "A History of Malaria in California," were ordered for the Association and distributed in part to sources interested in malaria work, as previously authorized by the Board.

A significant inclusion in this 25th Proceedings was the Author-Title Index prepared by John R. Walker covering the entire 24 volumes of the Proceedings. Two hundred reprints were ordered by the Publications Committee to provide for future requests for a comprehensive index to the Association's annual publication.

Mailing lists for the Proceedings and reprints were somewhat revised and a list of reference depositaries at various scientific and public health libraries throughout the world has been initially prepared for receiving the Proceedings. This should be continued and improved upon.

Editing of the abstracts and program for the current conference, as submitted by the Program Chairman, Bob Portman, was done by members of the Publications Committee and printed by the Bureau of Vector Control.

The Committee has endeavored to meet the standards for publication of the Proceedings that were recommended and adopted by the Association in the preceding year. It is here felt that such an organization as our own is in a great measure judged on a basis of quality and contents of its publications, which in turn are an outlet for this organization's contributions and inspiration to mosquito control work in many parts of the world. Numerous considerations as to policy, accuracy and standards are necessary to properly serve the interests of the Association, reflect due credit for the meritous work which is being accomplished by members of this Association, and to serve as a reliable aid for mosquito workers elsewhere, which considerations this Committee had deemed as its charge with due regard for economy.

It would appear that this concept has not been universally accepted, or at best, that gross misunderstandings have prevailed as to the basic essence of a "proceedings" and the value of at least some method of recording portions of the Conference, as reflected in a recommendation by the Budget Committee which was recently accepted by the Board of Directors. In view of the unexpected high costs presented for the stenotyped recording at the last Annual Conference, members of this Committee agree that such charges exceed the value derived from this manner of recording, but this in no way alters the need for recording pertinent portions of such conferences for inclusion within the Proceedings; especially, if it is to be considered or titled as a "Proceedings."

It is not in the province of this or any committee to determine the objectives of our Association; however, it is apparent that certain policies and definition of objectives in regard to its publications should be resolved by the Association. Until the will of the members is expressed in regard to such policies and objectives, it would be inappropriate for this Committee to make any recommendations on procedure or further action.

Respectfuly submitted by
THE PUBLICATIONS COMMITTEE
John R. Walker
G. Edwin Washburn
C. Donald Grant, *Chairman*

Pres. Greenfield: Don, there were quite a few points in your report that I think will merit discussion at a little later date.

We will now go on to the Ways and Means Committee, Don Murray, Chairman. Already presented? Fine. The next item is the William B. Herms Award under the Chairmanship of Richard Peters.

Mr. Peters:

COMMITTEE ON W. B. HERMS AWARD

The W. B. Herms Award Committee has the following to report for the year 1957:

Mr. Victor Lindblad, Executive Secretary of the Mt. Diablo Boy Scout Council, Berkeley, expresses sincere appreciation to the California Mosquito Control Association for its continuation of the W. B. Herms Award in the amount of $35 for the year 1957. Scout Larry Weikler, Troop 21, Berkeley, was sent to camp for a two-week period and also received brief employment as a deserving boy who stood to benefit from this experience. Mr. Lindblad emphasized the importance of this contribution to this cause and reiterated the appropriateness of honoring Professor W. B. Herms in this manner, since he so supremely symbolizes the Boy Scout movement.

It is the recommendation of this Committee that its function be continued in like manner in 1958 and indefinitely into the future.

Committee on W. B. Herms Award
Richard F. Peters, *Chairman*

1957 LEGISLATIVE COMMITTEE REPORT

The Legisative Committee of the C.M.C.A., upon recommendation of the Board of Directors of the C.M.C.A., assisted in securing the passage of the following bills in the 1957 State of California Legislature:

AB1015– Amends Sec. 2300 of H & S Code to delete the phrases "cash basis fund and an emergency fund" and substitute the following: "defraying district expenses between the beginning of a fiscal year and the time of distribution of tax receipts in a fiscal year. Such general reserve shall not exceed 60 per cent of the estimated expenditures for a fiscal year.

"The amount of money necessary for the district purposes may also include an unappropriated reserve for the purpose of defraying unusual and unanticipated expenses.

"Expenditures from such unappropriated reserve may be made only upon an affirmative vote of four-fifths of the members of the district board. Such emergency fund is not to exceed 25 per cent of the estimated expenditures for a fiscal year."

AB1016– Amends Sec. 2313 of H & S Code by repealing the entire section.

AB1017– Amends Sec. 2314 of H & S Code by repealing the entire section.

AB1018– Amends Sec. 2206 of H & S Code by continuing the District Investigations Act of 1933, as before, until 1959.

AB 333– Amends Sec. 2270 of H & S Code to "provide a civil service system for any or all employees of the district." This is permissive.

The Committee also assisted in having Item 432 of AB500 and SB400 (which is the item of State Subvention to mosquito control districts passed as originally proposed. This was the 15¢ tax rate requirement before operational subvention money could be received by a district. Considerable controversy over this point developed in the Assembly Ways and Means Committee hearings and at one time all State subvention was deleted. A rehearing before the Senate Finance Committee reinstated subvention as originally proposed.

The Committee was instructed to investigate having Sec. 2350 of the H & S Code repealed or amended. This section allows a portion of a city to withdraw from a district. Differences of interpretation by attorneys of the intent of the law will require further study by the next legislative committee.

The Committee was also directed to develop legislation to be presented to the 1959 Legislature covering the following items of interest to mosquito districts:

1. That provisions be made in the H & S Code for permissive legislation which would permit the board of trustees to authorize the manager or administrator of a mosquito abatement agency to sign salary warrants. This would obviate the necessity of obtaining

board member signatures and would expedite many office procedures. This is consistent with present practice in many public agencies, as well as school, city, county and state offices.

2. That Sec. 2248 H & S Code be amended to allow an increase in trustees' compensation not to exceed $25 per month for attendance at the districts' regular monthly meetings.

LEGISLATIVE COMMITTEE
E. Chester Robinson, *Chairman*
Harold Brydon
C. Donald Grant
Norman Hauret
Gardner McFarland
Thomas Sperbeck

Pres. Greenfield: There is another Committee to be heard from. I believe it comes under New Business, that of the Budget Committee. So, I'll ask for other old business at this time. That concludes the giving of the reports of the Association's Standing Committees at this time; so, I will ask for a motion to give approval of all of these reports as submitted. Oh! Yes.

The Committee on Duck Clubs, Art Geib as Chairman.

REPORT FROM THE COMMITTEE ON DUCK CLUBS

The Duck Club Committee has been functioning for a number of years. The past two or three years we have concentrated on an attempt to prepare a bulletin in cooperation with State Fish and Game relative to mosquito problems associated with the flooding of ponds. Such a bulletin woud also include data concerning water fowl management practices.

To date we have had no success in this objective through Fish and Game. Recently, however, the Federal Wildlife Service has shown an interest in working with the Duck Club Committee in the preparation of such a bulletin, and we have tentatively approved funds for publication in the event that something suitable would be developed.

The Committee recommends that next year's Committee follow up this matter and attempt to develop a bulletin in cooperation with Fish and Wildlife Service. Should funds be necessary, the Committee will request them from the Association through the Board of Directors to further this objective.

Art Geib, *Chairman*

Pres. Greenfield: Thank you, Art. I offer my apologies for overlooking the Duck Club Committee.

Mr. Portman: I would like to report on the Program Committee.

PROGRAM COMMITTEE

Mr. Portman: The Agenda for this Conference which is available at the Registration Desk constitutes the report of the Program Committee. I would like to suggest that in the future rather than having individual Committees each working alone on separate portions of the Conference, have the Proceedings Editor and representatives of the Publications, Publicity, Program and Local Arrangements Committees and perhaps the President or other officers or directors of the Association dove tailed into a joint Conference Committee for the purpose of coordinating the activities of the various committees, which should make for a better program. I would also like to comment at this time, as Chairman of the Program Committee, on the excellent response, help, consideration and hard work done by a number of the committee members. Don Grant and Jack Walker did a lot of work on this program agenda, and Dick Peters made possible its printing, in fact he had it printed twice. As for the program, well, it's up to the individuals here to judge for themselves.

Pres. Greenfield: Fine. Thank you, Bob.

INSURANCE COMMITTEE

The Insurance Committee's project for 1957 was to investigate the insurance needs of mosquito abatement agencies and to establish a standard rate on liability coverage. Information was gathered, and reports were prepared on accident occurrence and the different services performed by mosquito abatement agencies in California.

This information was submitted to the Insurance Underwriter's Association, and a committee was appointed by this group to investigate and establish a standardized liability rate for mosquito abatement agencies. It is expected that sometime next year the Insurance Underwriters will submit their final report on standardized liability insurance rates.

Recommendations:

This Committee would like to recommend that at least two members be retained on next year's Insurance Committee.

We wish to express our thanks to the members of this Association for their excellent response in submitting material for our insurance rate study.

Respectfully submitted,
L. R. Brumbaugh
Gordon Smith
Robert Portman

Gentlemen, I hesitate to ask this question, but are there any other committees I have overlooked? (Laughter)

Dr. Murray: I move that the reports of these committees be adopted.

Pres. Greenfield: Thank you, Don. It has been moved that these committee reports be adopted. Is there a second to that? Seconded by Roy Holmes. All those in favor say "Aye." (Ayes) Opposed? So carried.

Is there any other old business to come before the Association? Then I would like to move to New Business, and under the New Business, I would like to call upon Jack Kimball to bring up the question of the Budget study. Where is Jack? Jack, would you please bring forth your observations on the action that your Committee wishes to take.

Note: In that the comprehensive report of the Budget Committee had been previously disseminated and reviewed by the Board of Directors, Mr. Kimball, at this time, merely reviewed the previous action and current standing of the Budget Report as submitted by the Committee for consideration at this meeting.

Mr. Grant offered a critique covering several policies and specific recommendations and tendered an alternate proposal governing budgetary procedures for future consideration.

Pres. Greenfield: Don, you really had quite a bit there. We have, as Don has brought forth, something that requires consideration. I have, of course, received many comments through the past few months from member agencies, pro and con as to the adoption of the new Budget as it was sent forth from the Secretary's Office. While we have the entire Membership present, some decision should be made as to either adoption, tabling of it for restudy, or some action that will meet with the general feeling or concensus of opinion of the group. Quite obviously, I can't ask for the approval of the Board actions at this time, until this question has been resolved in one fashion or another.

Are there any questions that you would like to ask?

Mr. Grant: Mr. President, I would like to move that any consideration or action in regard to acceptance of the budget be put off until a future date.

Pres. Greenfield: It has been moved that any further consideration of this budget report be put off until a future date is established. Seconded by John Brawley. Are you ready for the question?

All those in favor of delaying action on the budget at this time, signify by raising their hands. Those opposed please raise their hands. Apparently it is going to be held over. The count is 15 for holding-over, four for approval at this time.

Apparently, all I can say is that it will be up to the incoming Board of Directors and Officers of this Association to see that this matter is taken under immediate consideration.

It is important—believe me it is important—that the Association have a budget established so that there are no chances of it coming about wherein expenditures are made in the heat of immediate decision or need, but rather that adequate study can be made before funds are granted. I can recall that in the history of this Association there have been only three budgets, to my knowledge, presented for actual adoption, and for the Officers and Directors to work within the limitations of those budgets. It is a very necessary part of the operation of this Association. I, therefore, wish to ask each and every one of you to give your serious consideration to it, so that it may be taken up in the near future.

Gardner McFarland: We have had the reports of several special committees that have been established in the past, and I would like to move the adoption of another special committee, one that may be a continuing thing, because of a problem that I feel may be statewide—particularly a problem in Southern California—and that is the mosquito problem raised by disposal of dairy wastes. There are some papers that have been published by several districts on their particular solutions, but I feel that it is a larger problem than that. Therefore, I will move the formation of a special committee to study the complete problem of dairy waste disposal.

Pres. Greenfield: Gentlemen, it has been moved by Gardner McFarland, that a special committee be appointed by the—that would be the incoming Officers and Directors of the Association—to study the problem of Dairy Wastes. Is that correct phrasing? Is there a second to that motion? Second by John Brawley. Is there any discussion on it?

Bob Peters: I would like to concur with Gardner's thought, here, I think that, as one who has been in the public health field in the past, as Gardner has and I have, that the point is well taken. I think that without question further study is indicated that inadequate legislation now exists as it pertains to this problem, and it may be that in due time something in the way of a modification of the dairy law, or maybe more specific legislation of some type may be forthcoming. Certainly, for any area where dairies are a problem, this is something, I am certain, for which I do not have any answers at the present time and we must bear with it.

Pres. Greenfield: Thank you, Bob. Now, those in favor of Gardner's motion please signify by saying "Aye." Those opposed. Gardner, they are behind you solidly. How is our time running here? They tell me not to dilly dally around, so, Ted, may I call upon you at this time to present resolutions?

Ted Raley: May I read them sitting down?

Pres. Greenfield: Yes, you may.

Ted Raley: The Resolutions Committee has been in continuous session since its appointment. Transcribing the results of our meeting, I have, if I may, used existing material as a guide. The following resolutions have been proposed by the committee and are herewith submitted for approval by members of the general assembly:

Resolution No. 1

WHEREAS the members of the California Mosquito Control Association are familiar with the transactions of the Board of Directors during the past Conference year, through attendance or distribution of copies of the minutes of such meetings,

BE IT RESOLVED that the actions taken by the Board of Directors during the past Conference year, as duly recorded in the minutes, be approved by the members assembled in this business meeting of the 26th Annual Conference.

Resolution No. 2

WHEREAS the program presentations and meeting arrangements of the 26th Annual Conference of the California Mosquito Control Association, held at the Fresno Hacienda, has afforded great interest and enjoyment to the audience here assembled,

BE IT RESOLVED, by the members of this assemblage at the annual business meeting of January 28, 1958, that we hereby express our deep appreciation and thanks to those persons who have contributed of their time and efforts in effecting the success of the program and conference arrangements;

BE IT FURTHER RESOLVED, that the Secretary-Treasurer of this Association be hereby directed to convey such appreciation and thanks to the principal contributors and members of the Program and Conference Arrangements Committees.

I herewith move that these resolutions be adopted.

Pres. Greenfield: What is your pleasure, Gentlemen?

John Brawley: I have a question which I think should be clarified. Is this controversial budget approval included in this resolution—or did the Board take action on this budget report?

Pres. Greenfield: The report was only accepted by the Board, not approved. It has been delayed now for further study. All those in favor of accepting the resolutions in their finalized form please signify by saying "Aye." Opposed? (Carried) So ordered.

And now, I come to that which I have been waiting for for almost a whole year. I call at this time upon the Nominating Committee Chairman, Chester Robinson.

NOMINATING COMMITTEE REPORT

Gentlemen:

The following persons are hereby placed in nomination for officers of this Association for the next ensuing year (1958) beginning January 28, 1958.

President	Robert F. Portman
Vice-President	Gordon F. Smith
Secretary-Treasurer . .	G. Edwin Washburn
Trustee Member . . .	A. Stanley Glikbarg

Respectfully,
NOMINATING COMMITTEE
E. Chester Robinson, *Chairman*
Robert H. Peters
Jack H. Kimball

Pres. Greenfield: Ed, have there been any other nominations submitted? Since there have been no other nominations for the offices, I suggest therefore that the Association cast a ballot unanimously in favor of the nominees as presented by the Nominating Committee. It is so moved by Roy Holmes, and seconded, that these men be placed in nomination. All those in favor signify by saying "Aye." Those opposed? So carried. Oh, this is going to be great. Come on up here, Bob. You have just been elected to guide the Association in the forthcoming year. Bob Portman—where's Gordon Smith? Come on up here. We have a few minutes, so I want everyone to get a good look at you, so that they can pot-shot you all year.

It gives me a great deal of pleasure to welcome you at this time, Bob and Gordie. I wish you a lot of success.

There is only one other duty I have at this time, and that is to ask that the regional representatives conduct elections of their officers and give the names of the new regional representatives to the Secretary, Ed Washburn.

Pres. Greenfield: All right. Fine. Any other regions care to report their nominees at this time?

Chet Robinson: As a member of the Bay Area, I would like to have Paul Jones stay on.

Pres. Greenfield: I think there is need for caucus in that Bay Area Region. Would you gentlemen get into the back of the hall and make your decision at this time.

Mr. Grant: Chet is our new Bay Area Representative as elected by a majority of regional constituents.

Dave Reed: I am representing the southern part of the San Joaquin Valley, and we are unanimously agreed that John Brawley should represent us.

Pres. Greenfield: How about the newly formed Northern San Joaquin District?

Bob Peters: As representative at the moment of the newest, and probably one of the best, regions of the CMCA, I would like to indicate that Mr. Lester Brumbaugh is our chosen representative for the next year.

We may take a few moments here and have a telegram read.

Marion Bew: I would like to present this to you, Mr. President, and the Secretary. From the title page you can see that this is indeed repetitious of Marysville, California, which encloses letters of Mr. Charles Cooper, Chairman of our Board of Supervisors, Jackie Stanton, our Convention Bureau Chairman, and also a more detailed letter from our mayor expressing his invitation, and also there is a letter expressing various Marysville facilities. We hope, sir, that you will give these favorable consideration.

Pres. Greenfield: Thank you, Marion. I wish that I were able, at this time, to present the Salinas bid. As you have noted, I have a little bit of advertising up here. However, I am very hopeful that that will be taken care of tomorrow. Also, I take pleasure in stating that those of you who wish to join the Salinas Chamber of Commerce and some of their very fine representatives, you might wander over to room 30 sometime today, between the hours of 4:30 and 7:30.

Gardner McFarland: I would like to convey the invitations that are from the South for 1959. Our position is that if you gentlemen are ready to hold the Conference in the Southern Region in 1959, we are ready and able to do the work. The Long Beach Chamber of Commerce, and also the Los Angeles City Chamber of Commerce have extended invitations, and believe me, if they put them in a frame, they would be fancier than the others. However, we felt that you would be tempted; so, I feel that we accomplished their request.

Pres. Greenfield: Thank you, Gardner. I am sure that the Secretary has all of these requests. Yes, Ted?

Mr. Raley: For general information, what is the room number of the Southern California delegation?

Pres. Greenfield: William Bollerud has just been elected representative for the Sacramento Valley Region.

I am not going to adjourn the meeting, rather I am going to give that pleasure to Bob Portman. He may have a few words to say; but I do want to thank each and every one of you. Sincerely, it has been a pleasure. We have had our unanimous agreements and our differences of opinion. Regardless, we are still an Association, and, believe me, that is something that I wish to see continued for many years to come. So, again, to every one of you, thanks a lot for your help this year. (Applause)

Bob Portman: Fellow workers, I want to thank you very kindly, and I know that you are itching to go. You have been sitting a long time this morning—I don't believe we have had a recess. I have been waiting for one since 10 o'clock, myself. On behalf of the new Board of Directors and your Officers, I feel sure that they will try to serve you to the best of their abilities during the coming year. Thank you.

I will hear a motion for adjournment. Thank you. All those not in favor may stay.

FOURTH SESSION

TUESDAY, JANUARY 28, 1958, 1:30 P.M.

Mr. Greenfield: I would like to introduce the new President of the California Mosquito Control Association, Bob Portman. Bob.

Pres. Portman: We are a little bit late in beginning this afternoon's session; I would now like to introduce to you, Dr. Malcolm H. Merrill, Director of the California State Department of Public Health. He is to show us, and tell us, about his part in the recent Public Health Mission to Russia.

PUBLIC HEALTH MISSION TO RUSSIA

MALCOLM H. MERRILL, M.D., M.P.H.[1]

Mr. President, members of the Association, and guests, it is an honor, indeed. to be with you this afternoon to tell you a few things about our travels into Russia last summer. I was one of a five member team organized by the U.S. State Department and the U.S. Public Health Service to look into the organization, administration, and provision of health services in the USSR.

We left this country on August 11, going by way of Copenhagen, Stockholm, into Russia through the Port of Rega, and then spent 27 days within Russia. Within that 27 days we traveled some 8,500 miles, visited 61 institutions of various kinds, and in the course of those visits, had an opportunity to meet and converse with many of our colleagues in the Russian Union. We visited nine cities, and in each instance rural areas surrounding the cities in five of the 15 republics of Russia. We were cordially received and treated throughout our visit.

When I received word of this invitation to join the team, I found I knew very little about Russian geography or really about Russia. On the faint possibility that some of you might be nearly as poorly informed about this great country as I was, it might be helpful to give a few highlights of some of the facts about the country.

Russia is of tremendous size, three times the land area of United States, extending over 6,000 miles from east to west, and in the farthest stretches some 3,000 miles from north to south. I was amazed to find that Russia is peopled by at least 150 different ethnic and nationality groups, most of whom speak their own languages. In addition to Russian, there are some 149, or 175, or some such number, different languages and dialects spoken within the Russian Union. Russia has a population of some 210 million. That is an estimate, because they have not had a census since 1939. As stated above, there are 15 republics—and I will speak just a little more about what it means to be a republic in Russia in connection with showing you one of the slides.

Our primary mission was to find out as much as we could about organization and administration of public health services. In the course of our visit, though, we tried to absorb as much information as we possibly could about all aspects of Russian life. To this end we attended ballets, operas, and puppet shows, we rode on subways, and in jeeps, and automobiles, and various types of airplanes. We visited collective farms, two state farms, recreational centers, resorts, hospitals, clinics, dairies, pasteurization plants, water purification plants—in other words, we tried to see just as much as we possibly could in the limited time that was available to us and get as accurate a picture as we possibly could as to what was going on currently in Russia.

The question is always asked: how much surveillance were you under, and how much freedom were you given? Within the nine cities that we visited, we were given, essentially, complete freedom to go any place that we chose within those cities. There was no restriction whatsoever upon picture taking, except the landing field side of airports and we were not permitted to take pictures from airplanes in flight. Other than this, we all used our cameras liberally. I brought back some 700 Kodachrome pictures. Other members of the team took almost as many, so that in the aggregate we had some 1,800 to 2,000 pictures that we took while in Russia. I assure you that I am not going to show you the 700 that I took, but you will get a sampling of them.

We found that in Russia all phases of medicine, including medical education, public health and medical care, are under the Ministry of Health. The 76 medical schools, which are called institutes, are all under the Ministry of Health. They are not affiliated in any way with the Universities. We were told that they found some years ago that it was so difficult to get through the administrative heirarchy and chains of command, and get anything done through the university structure, that they decided that if they were going to really make progress in the medical field that the only thing to do was to pull away from the universities and provide the training in separate institutes. For that reason, they told us, they have organized their schools under the Ministry of Health. They are turning out about 17,000 physicians per year, 60 per cent of whom are women. This compares to less than 8,000 graduated each year in this country. They have 350,000 physicians in the Soviet Union, one physician to 600 people as compared to our one physician to 750 people in this country.

In addition to these 350,000 physicians, they have some 900,000 "felchers," who are people with varying amounts of medical training, usually less than half the training provided to physicians. These felchers do first-aid work, medical work in rural areas, assist around the hospitals, do mid-wifery, and provide other types of medical services.

Every place that we went we found an abundance of hospital beds. They estimate that they have 8½ hospital beds per thousand of population. In our figuring of hospital bed needs in this State, we use as a base 4½ hospital beds per thousand of population. Again, they need more beds than we do because they do not have the facilities to take care of the patients in the homes,

[1] Director, California State Department of Public Health, Berkeley

due to the extreme crowding in the home situations. As a result their hospital stay averages more than twice as long as in this country.

We were interested in what goes on in their medical research which is conducted in special institutes organized under the Ministry of Health. Thus, they have also withdrawn this activity from the university setting and now have some 320 medical research institutes scattered throughout the Union. We visited five of these medical research institutes in the Moscow-Leningrad areas. The highest level of medical research, presumably, is done within the framework of the Academy of Medical Sciences of the Union. There are 26 research institutes under this Academy.

We could obtain very little and superficial information regarding the freedom of investigators to pursue their respective desires in the field of medical research. Certainly, much of it is already outlined for them, particularly by the presidium of the Academy of Medical Sciences, and the areas to be investigated are assigned to the respective institutes. As an example of how they proceed when a new problem comes along, we were advised by the Deputy Minister of Health, who was our host while there, that when they were confronted with the problem of production of Salk vaccine they immediately established a separate institute staffed by drawing trained personnel from whatever direction they needed to and some of those scientists were sent to this country to work with Dr. Salk, and others were sent to other countries of western Europe to get the latest information on the production of this vaccine. At the time we were there, they had two institutions set up for the production of Salk vaccine. They were really just getting underway, and only a limited amount of vaccine had been produced up until the time that we were there.

I am sure that those of you here will be interested to hear what were our observations with respect to mosquitoes and flies. I must tell you that I did not, as far as I knew, have a single insect bite all the time I was in Russia, mosquito or otherwise. We did find houseflies every place we went, including the restaurants and hotels in Moscow itself, and in Leningrad. Particularly in the central Asian areas that we visited, flies were in extreme abundance, to the point where one member of our team said he would be so glad when he got back to this country and be able to get away from these flies. With his usual efficiency, Dick Peters provided me with a spray that I could take along for just such occasions. Finally at Kuibyshev, on the Volga River, when our room was over-run with flies I thought well here's a chance to really do it, and I sprayed the room, I thought very thoroughly. I got a few of the flies alright, but there immediately followed a marked influx of bees. So, we had then not only flies, but bees. Somehow or other, my treatment didn't work.

Our team was an exchange mission. There were five Russians who came to this country within a month after we returned. They did spend some five or six days with us in the San Francisco Bay area, and visited some other areas of this country. I was interested to notice in this morning's *Examiner,* and in the other morning papers, in an announcement from Washington, that arrangements had been concluded, now, for something over 500 experts from our respective countries to continue this type of exchange visits. It looks as though we are now getting on the road to really exchanging information with fellow scientists from the Soviet Union. These new exchanges, it is said, will be in the various fields of industry, agriculture, medicine, art and writing, movies, music and theaters, science, education and athletics. Tourism will also be encouraged. Apparently it is to extend over a wide area of the interests of people in this country and in Russia.

I would say that in every place we went, and in almost every one of the almost innumerable toasts that were given at the banquets and dinners that we attended, there was some reference made, not only by the Russian scientists, but by ourselves, to the necessity for an accelerated exchange of personnel and information between the countries. I think the one comment that I made that was perhaps the most enthusiastically received was that it was fine for five of us to come to Russia, for five of them to come to this country, but we hoped it was just a catalyst, just a harbinger, that things would really open up, and that, perhaps, we would not really come to understand each other until literally millions of Russians came over here to see us, and millions of our people went to Russia to get acquainted with them. There was a tremendous interest, and we felt sincere interest, on the part of our medical colleagues in Russia to get acquainted with us and to get to know what we were doing and how we were doing it and to have our people come and visit them.

I have thought, since returning, of so many, literally hundreds of questions, that I wonder why I did not ask about this or that. Then, after all, I recall that we were going about 18 hours a day for each of those 27 days. Sometimes we got a little exhausted in the course of this, and maybe we can be forgiven for not having asked everything that, in retrospect, we would have liked to have found out about what is going on there. But now that we are to have additonal people going, perhaps during succeeding months and years, we will really begin to get the factual information that we all would like to know about what is going on there. But now that we are to have additional people going, perhaps during succeeding months and years, we will really begin to get the factual information that we all would like to know about what is going on in the Soviet Union.

(The slides were then shown.)

Pres. Portman: We have already had quite a number of comments, remarks, and considerable discussion pertaining to research, and now we are to hear from the Bureau of Vector Control about their research program and some of the work which they have been carrying on.

I would also like to call to your attention at this time the opportunity to visit the Field Station to which this meeting will adjourn following the Bureau's program in this room.

Now I would like to introduce to you, Dick Peters, Chief of the Bureau of Vector Control, California State Department of Public Health, who will preside over the rest of this afternoon's program.

Dick.

THE BUREAU OF VECTOR CONTROL RESEARCH PROGRAM

RICHARD F. PETERS, *Chief*

Bureau of Vector Control
California State Department of Public Health
Berkeley

INTRODUCTION

Thank you, President Bob Portman. This is an opportunity I have been looking forward to for some time with a great degree of feeling and dedication. All of you, I am sure, have, at one time or another, associated me with an unrelenting support of research. Some, undoubtedly, feel that I carry it to excess, but deep down inside, it is my conviction that we are not going to be sure about the technology needed in mosquito control until or unless we adopt a sound research program to obtain or verify it. Essentially, whatever I have tried to say or do in the past, has been founded on that belief.

The Bureau of Vector Control, in 1950, made its start in the field of research on mosquitoes and their control in cooperation with the CMCA, and it was, admittedly, a rather fragmentary start. The United States Public Health Service had a vital part in it too, having furnished the key man to the activity in the person of the late Deed C. Thurman. We, in California, owe a lot to Deed Thurman for having given us a start in this program. In addition to the Public Health Service, we also developed a fine cooperative working relationship with the USDA, which has continued to flourish to this day with their workers from Corvallis, Oregon and Orlando, Florida.

Over the years, we have earnestly tried to work out every possible avenue of research cooperation with every existing resource available. One of the most important of all, of course, is the University of California. We have effectively collaborated with the research staff on the Campus at Davis, the Campus at Riverside, the Campus at UCLA, and the Campus at Berkeley.

We have also recognized that there must be a nerve center to the mosquito control research undertaking. The Bureau Research Facility and staff have attempted, in effect, to be a coordination point, operations base, and a place for information exchange. We have been gratified by the trust the CMCA has placed in us to undertake this coordinating role on the research needs in mosquito control.

We feel that the program, itself, has got off to a good, sound start. I assure you that the staff on this stage have given the best years of their lives to research on California mosquito control. Some of them are actually still working on a basis of extreme uncertainty, because their salaries depend on a very tenuous and uncertain question—will the legislature renew subvention next year?

Over twenty years ago, Professor Herms, whom we affectionately regard as the father of California mosquito control, taught me what I understand to be the ecological attitude, or outlook, toward research. It is expressed in his own words, "know well the insect." Without an ecological attitude, a research program such as the Bureau of Vector Control is undertaking against mosquitoes would, I believe, fall flat on its face in due course of time. It is inevitable that pressures will be exerted on any type of applied research program to produce results. These results cannot come about unless first a foundation is built with continuing consideration given to what constitutes logical chronology in the schedule of research to be undertaken. We have tried to utilize this ecological principle—to do first things first; in other words, when you build a house, you build a foundation first; when you build a boat, you lay a keel first; then, every building block added to a firm research foundation enhances the prospect of each development being meaningful.

In a way, the research program which the Bureau has started might be compared with an iceberg. We have thus far had to build seven-eighths of our program below the surface. The one-eighth representing usable results will, I am certain, lead to other significant information being brought into evidence in the future.

It takes time to build a sound foundation. We do not, in any way, regret having taken an evolutionary course in this program. In the long run, we think it will pay off. Our entire research program has been identified with this ecologic concept. If this concept is wrong, then I admit to having blundered; but it will have to be proved wrong, because to me it is a logical and scientific course.

Ever since the research program began, we have had to decide carefully on the scope of effort to be undertaken because of limited funds available. It was agreed early that we have three major mosquito species in California, all of which are responding to the artificial changes taking place around us in every direction. The three mosquitoes which are thus the primary object of our research are, and I am not going to surprise anyone, *Culex tarsalis*, *Anopheles freeborni*, and *Aedes nigromaculis:* the vector of encephalitis, the vector of malaria, and the vector of misery.

We chose what we call three horizontal areas of endeavor and three vertical areas of endeavor. The horizontal areas pertain to the following generalized subjects:

(1) Toxicology studies are vital, particularly in the face of mosquito resistance to insecticides, in order to meet existing urgent control situations. Consequently, we have a toxicology project, headed by Larry Lewallen.

(2) We also recognize an area of research need not yet fully explored; that of examining the egg stage of the mosquito as a potential avenue of bringing new control methodology into being. Through research on the mosquito egg, it is hoped that Dr. Judson and Miss Rosay will be successful in finding a way to deal with mosquito development before eggs become mosquitoes.

(3) The other horizontal activity, headed by Ed Loomis [we feel to be inescapable—it hits us at every turn] is the mattter of mosquito-population measurement. We must be able to obtain objective measurement of mosquitoes since, even in our endeavors, every piece of research has to be founded upon this kind of precision.

It is thus our conviction, at this time, that these three areas of horizontal activity are the most vital elements of a continued research program.

In looking at the important mosquito habitats, it appeared obvious that there are three major categories deserving study; these we call the vertical projects. All three are artificial habitats—the most important of those produced by irrigation:

(1) First and foremost is the intermittent-flooding habitat typified by the irrigated pasture. Dick Husbands succeeded Deed Thurman as project leader for the irrigated pasture or intermittent-flooding habitat project. Dick has made continuous systematic observations since 1951, trying to reason out the causative influences upon mosquito production in the irrigated-pasture habitat.

(2) Also under study is that kind of habitat characterized by continuous flooding, exemplified by rice fields, log ponds, or oxidation ponds in sewer farms, where water maintained at a relatively constant level produces mosquitoes. The rice field has been the habitat studied most, and Dr. Gerhardt has been given responsibility to engage in intensive research toward working out the control technology indicated.

(3) In the remaining category, Dr. Markos has been assigned to research on the irrigated row crop habitats.

I am about to call on the research staff now to give you a brief review of what they have been undertaking within their respective projects. After they have completed their presentations, which are going to be necessarily brief, we have made arrangements for a convoy to take you all out to visit our research facility. We want you to see what we are doing and what we have to work with. We want you to be aware of the facts since you are the ones who will benefit in a greater or lesser way, as the case may be, by the extent or limitations of the research effort that is undertaken. We hope the experience of seeing this program will be an interesting one, and we are going to do our best out there to reinforce, with visual aids and demonstrations, the rather brief presentation that each of the project leaders is able to give at this time.

I will warn the staff now that, as much as I dislike the role, I will be an autocrat in conducting the panel. At four o'clock this panel discussion will be over and we are all going by automobile to visit the research facility.

Now, I will call on Dr. Markos, who will discuss recent work undertaken in conjunction with the habitat characterized by row crop irrigation.

STUDY OF MOSQUITOES ORIGINATING FROM IRRIGATED ROW CROP HABITATS

Basil G. Markos, Ph.D.[1]

The mosquitoes associated with row crop irrigations, a distinct and significant habitat, have been under study in the San Joaquin Valley (Central California) since 1955. Since cotton, corn, and various other row crops occupy a substantial percentage of the annual irrigated acreage, efforts have been directed toward documenting conditions of mosquito production preliminary to evaluation and development of control measures.

The three areas under study from 1955 to 1957, inclusive, were situated in three counties which are rated second, third and fourth in acreage of cotton under cultivation in California.

The results of the study conducted in West Fresno County have been published (Proc. & Papers 24th Ann. Conf. Calif. Mosquito Control Ass'n., July, 1956, pp. 39-47) and work is progressing on summation of data collected in Tulare and Kings Counties. Therefore, this presentation will only very briefly deal with several interesting observations concerning the three study areas. Detailed aspects of the latter two studies will be presented in papers to be published in the near future.

Irrigation

It was common practice years ago (prior to 1940) to give cotton fields a heavy irrigation before planting, followed by only three or four irrigations during the growing season. Approximately 20 to 30 inches of irrigation water were used then during the entire season.

Observations in West Fresno County revealed a total of 81 irrigation periods for 12 cotton fields, five of which were characterized by sandy soil and seven by clay soils. The greatest number of irrigations occurred during June, July and August. Irrigation periods ranged from three in the Franchini cotton field to as many as 11 in the Gentry B field which was characterized by sandy soil. The source of water in this study area was from deep wells.

In Tulare County, a total of 98 irrigation periods was observed for 10 cotton fields. Here, too, the greatest number of the irrigation periods occurred during June, July and August. It is of interest to note that during the month of August a total of 42 irrigation periods was observed for the 10 fields under study. The number of irrigation periods for the season ranged from seven in the Fox cotton field to as many as 12 in the Stadden field. Both well water and ditch water were used to irrigate cotton fields in this study area.

In Kings County a total of 50 irrigation periods were observed for four cotton fields and seven corn fields. The greatest number of irrigations occurred during the months of June,. July and August. The number of irrigation periods ranged from five in the Falco cotton field to eight in the Parsons cotton field and Avila corn field, respectively. In this study area, well water was used to a large extent, but a few ranchers used ditch water to irrigate their respective fields.

Species of Mosquitoes

The following species of mosquitoes have been taken from the fields under study: *Culiseta inornata* (Williston), *Aedes nigromaculis* (Ludlow), *Aedes melanimon* Dyar, *Culex tarsalis* Coquillett and *Anopheles freeborni* Aitken. *C. tarsalis* was the dominant species in all of the areas under study.

Identification of adult specimens taken in boxes (resting stations) placed in cotton and corn fields has not been completed at this writing.

Retention of Water

In West Fresno County, cotton fields retained water from 3-15 days, while in Kings County, the range was

[1] Senior Vector Control Specialist, State Department of Public Health, Bureau of Vector Control.

from 2-42 days. This problem was more prevalent in Tulare County where several cotton fields retained water for many days due to more frequent irrigations. The Serpa field held water from 5-27 days, Cooper No. 2 (80 acres) 9-56 days, Turk field 7-32 days, Cooper No. 2 (160 acres) 6-59 days and the Bailey field 4-20 days.

It is apparent from the above that many cotton fields were frequently irrigated, in spite of the fact that several contained extensive areas of standing water at the tail-end section within the field.

During the latter part of the season, irrigation laterals in West Fresno County retained water from 5-26 days. In Tulare County, the range was from 5-132 days and in Kings County from 3-41 days.

In drainage areas in West Fresno County, the range was from 6-38 days, in Tulare County from 6-61 days, and in Kings County 7-24 days.

Mosquito Production

In West Fresno County where 12 cotton fields were studied, and where we recorded 81 irrigation periods, we observed just 14 actual mosquito production sources. Of these sources, five were in cotton fields, five in irrigation laterals, two in drainage areas, and one each in pot-holes and overflow areas.

The lowest number was observed in Kings County, where we recorded 50 irrigation periods for 11 fields. From a total of 11 fields (four cotton fields and seven corn fields) we observed only nine actual mosquito production sources. Of these sources, six were in cotton and corn fields, two in irrigation laterals and one in a drainage ditch. All potential mosquito production sources in this study area were sprayed by personnel of the Kings Mosquito Abatement District. It is of interest to point out that at least one-half of these so-called mosquito production sources would not have produced mosquitoes, because the water disappeared before the mosquitoes could have completed their aquatic development. Because of the proximity of residential areas it was decided to spray these areas.

The largest number of production sources were observed in Tulare County, where 98 irrigation periods were observed for 10 cotton fields. As noted previously, during the month of August *alone*, a total of 42 irrigation periods was observed for these fields! Therefore, it is not surprising that 110 actual mosquito production sources were recorded from this study area; of which 60 were in cotton fields, 17 in irrigation laterials, 15 in drainage areas, eight in seepage areas, five in run-off water, four in drainage ditches and one in sump-holes. During the latter part of the season, one field contained 10 separate prolific mosquito production sources as a result of just one irrigation period.

As a result of these intensive irrigations, we observed areas within an irrigated cotton field environment that were productive of heavy densities of *Aedes*, *Culex* and *Anopheles* mosquitoes.

There were fields in Tulare County which, because of judicious use of water and application of good irrigation practices, produced no mosquito problem. Most of the fields in West Fresno and Kings Counties were also in this category.

In West Fresno and Kings Counties, the mosquito production sources involved small areas and could be considered minor problems, while in Tulare County, these sources were extensive and were considered major problem areas.

Mr. Peters: We now shift from the irrigated row crop habitat to the intermittent flooding habitat. Dick Husbands has been out in pastures so long and often that I am sure he is virtually "pasturized." Dick, will you take over from here?

THE STUDY OF MOSQUITO HABITATS THAT RESULT FROM INTERMITTENT FLOODING IRRIGATION

Richard C. Husbands[1]

The habitat which is represented by the project title "Intermittent Flooding Irrigation" is characteristically associated with irrigated pastures and alfalfa. In California these habitat crops utilize approximately 1,500,000 acres of land. Much of this irrigated land lies in the Central Valley of California where climate, soil and water provide favorable conditions for the development of *Aedes nigromaculis* (Ludlow) and *Culex tarsalis* Coquillett. Although other species of mosquitoes such as *Aedes dorsalis* (Meigen) and *Aedes melanimon* Dyar are also associated with these crops, this project has limited its study to factors influencing the primary pest mosquito *A. nigromaculis* and vector mosquito *C. tarsalis*. In this environment, these two species outweigh all others in relative importance insofar as their control and public health significance is concerned.

Studies which were formally initiated in 1950 to examine this habitat in detail have progressed through several phases of development. The first phase was primarily a study of fundamental biological and environmental factors and relationships which were associated with mosquito production. This included studies such as: methods of adult mosquito evaluation and the dispersal habits of *A. nigromaculis* (1).

By 1952, the project had gained sufficient information and experience to concentrate on problems of special importance. Among these was a study of pasture deterioration or aging and its influence on mosquito production. It was early recognized that the pasture abiotic environment changed constantly and provided a different set of conditions for mosquito production during the season and from year to year. The results of this study showed that the deterioration of pastures would increase the production of *Culex tarsalis* as well as result in changes in the abundance of *Aedes nigromaculis*. At the same time, it was shown that the aging process would increase ponding areas and the cost of mosquito control (2).

In 1954 a cooperative project was initiated with the United States Department of Agriculture, Soil and Water Conservation Research Branch, to study the relationship between irrigation practices and mosquito production. This was concluded in 1956, after three

[1] Senior Vector Control Specialist, Bureau of Vector Control, California State Department of Public Health.

years of effort. Some of the results of this study have been published (3) (4).

In 1957, in addition to the continuation of fundamental studies, a demonstration project was established in Tulare County in cooperation with the Delta Mosquito Abatement District. This area was selected primarily because it was adjacent to the research facility and because this district has maintained extensive records for several years on sources of mosquitoes in pastures. This study is in its infancy and is a trial operation. The future will determine its feasibility.

During the various stages in the development of this project, it was necessary to determine which investigational activities would provide the most tangible results. An objective of this project was to seek means of improving mosquito control operations through applied results of research. In order to do this, the intermittent flooding irrigation mosquito investigations program was divided into four main categories of operation. First, to provide biological and environmental information which would improve the efficiency of chemical control, or would provide information to the research toxicologist to help tailor or select chemicals suitable to the types of problems encountered in the field. In addition, this would help to bridge the gap between the laboratory test, the field trial, and the practical use of insecticides. Second, to provide information which would aid, improve or suggest methods of mosquito source reduction. Third, to develop special projects or special studies which warrant additional research. Generally these studies would be of a developmental nature which could be eventually farmed out to graduate students or interested individuals, or through agents, or other methods could be developed into new and separate projects. And fourth, to develop demonstration projects or projects that would show how research information could be applied to a mosquito control program or technical operation. These demonstrations could be developed after a foundation of basic information had been accumulated.

One of the best means of exemplifying the significance and application of research information obtained from operational research is through specific examples. These examples should point out relationships between research findings and mosquito control operations. To do this, four examples were selected for discussion.

The details of these four examples will be published at a later date. The subjects covered were:

1. Control Timing: The relative rates of development of *Aedes nigromaculis* and *Culex tarsalis* were compared. It was shown that the treatment of ponds in irrigated pastures for *A. nigromaculis* could result in the failure to control *C. tarsalis* due to control timing.
2. Irrigation Efficiency and Mosquito Production: Interesting relationships between water management and source reduction were pointed out. The control of *Culex tarsalis* by an improvement in irrigation efficiency was suggested. Details will be found in the third progress report on the relationship between irrigation efficiency and mosquito production.
3. Seasonal Changes in Intake Rates: The results of a limited number of studies in pasture with fine textured soil and hardpan showed that intake rates were reduced by the end of an irrigation season to one-fourth of the initial value. Theoretically, this can lead to the increased duration of ponding and mosquito production as the season progresses. This also implies that non-productive fields can become productive both in numbers and kinds of species produced.
4. Duration of Ponding after Irrigation: The advance and recession of water as it occurs in different parts of fields can determine the stage of mosquito development in each area. The careful measurement of water movement during irrigation and ponding shows that heavy mosquito production can occur in unsuspected areas. Casual inspection of a field will not reveal this information. The inspection or mapping of fields to determine areas requiring treatment or for the timing of control operations should take the advance and recession factor into consideration. In addition, the duration of ponds determines the presence or absence of *Culex tarsalis* production.

Much of the material mentioned in this brief review requires further development and refinement. A continuing research program will eventually perform this needed operation. The project on intermittent flooding irrigation habitats is designed to provide a foundation for that task.

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Mr. Peters: We now come to the continuous-flooding problem against which Dr. Gerhardt has been pitting his brains for the past four years. Dick Gerhardt, you are next.

PERMANENTLY FLOODED MOSQUITO HABITATS

Richard W. Gerhardt, Ph.D.[1]

Abstract

"Permanent" with regard to fresh water is at best a relative term. In the present connection, the classification may be based on vegetation: water which remains in place long enough to develop a characteristic aquatic vegetation may be considered permanent; while water

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which does not remain long enough to result in modification of vegetation is transient.

The modification of vegetation generally results from the development of anaerobic, chemically reducing conditions in the waterlogged soil of the habitat.

Permanent environments which produce mosquitoes include: rice fields, sewage oxidation ponds, log ponds, marshes and swamps.

The important California mosquitoes associated with permanent water include: *Anopheles freeborni*, *A. punctipennis*, *A. franciscanus*, *Culex tarsalis*, *C. erythrothorax*, *C. pipiens*, *C. quinquefasciatus*, *C. stigmatosoma*, *Culiseta incidens*, *C. inornata*, *Aedes squamiger* and *A. dorsalis*. Of these species, *Culex tarsalis* is currently the most important mosquito in California.

The temperature of permanent shallow water may exceed the ambient air temperature and varies widely each day.

Water movement is variable but usually minimal.

Oxygen is usually superabundant in shallow water, but may be absent in special situations such as sewage ponds.

Carbon dioxide is usually present only as half-bound or fully-bound carbonates.

Other gases which may be dissolved in the water include: ammonia, hydrogen sulfide, methane, hydrogen, and nitrous oxide.

As far as is known, mosquito larvae are unaffected by these gases as they are usually found.

Sodium chloride, calcium carbonate, magnesium sulfate, and silicon dioxide are common dissolved solids along with traces of iron, manganese, potassium and sulfur.

Organic compounds found in shallow permanent water include: polypeptides and amines, carbohydrates, fats and fat acids.

pH values ranging the full scale have been recorded in natural water. Commonly observed values range from pH 4.0 to 11.0.

In typical shallow water environments, physicochemical conditions vary daily. Dissolved gases, pH, hardness and other attributes show regular cyclic variations.

Bacteria are the dominant life form of shallow aquatic habitats. Anaerobic types are characteristic of the waterlogged soils while the soil-water interface and the water contain incalculable numbers of oxidative bacteria. The metabolic processes of bacteria control the trophic relationships of these environments.

Hundreds of species of algae are commonly encountered in shallow, permanent water. Some of the Myxophyceae excrete metabolites which influence other organisms of the environment. Their metabolism influences the environment nearly as much as that of bacteria.

Protozoa and fungi are found in permanent water but their importance is not understood.

Aquatic plants are dependable indicators of soil and water conditions. Few are known to influence directly mosquito breeding in special situations.

The influence of higher animals on shallow water environments is poorly understood; predaceous animals may be important in depleting mosquito populations under special circumstances.

Mr. Peters: Thank you, Dick. As you notice, the research staff isn't wanting for words.

We now move into the first area which I referred to as a horizontal project. We hope there will come from the activities being conducted by Dr. Judson and Miss Rosay, something new of application across the board of mosquito control. Yes, even applicable to and including the coastal counties and Southern California. Dr. Judson, you're next.

THE BUREAU OF VECTOR CONTROL'S MOSQUITO OVA STUDY

Charles L. Judson, Ph.D[1]

Underlying the whole program of the development of control techniques aimed at the mosquito egg is the knowledge that the egg represents a very complex stage in the life cycle of the organism. When the egg is laid, it consists of undifferentiated yolk and the male and female germ cell nuclei enclosed within an incompletely developed shell. Within an hour of laying, the outer portions of the shell have undergone extensive changes and within 24 hours, the shell has become waterproofed. Within two to three days in *Culex tarsalis*, and five to six days in *Aedes nigromaculis*, all of the growth and development changes have occurred which give rise to an individual capable of independent existence.

Because of the complexity of these processes in the egg, there is a good probability that one or more of these vital processes can be interrupted, resulting in the death of the organism—or, in other words, control. Our chances of attaining this control are made even better when the need for water by the aquatic stages, and our ability to manipulate water, are kept in mind. Because of this critical relation, a delay in the rate of one of these processes, rather than its complete stoppage, could effect control in many instances.

New or improved control techniques could result from the ovicidal approach. For example, water might be used as the carrier for a material which would affect the egg. This would eliminate much of the need for spray operations, as well as open up many areas presently inaccessible to control operations. Interference with normal development of the egg shell would make the embryo susceptible to adverse environmental conditions or to insecticides. Perhaps the greatest benefit to be derived from an ovicide would be its high degree of specificity. In contrast to materials affecting a wide variety of animals, a compound specific against a process almost wholly restricted to mosquito eggs, such as shell maturation, conditioning, or hatching, would allow more widespread use of this material while avoiding the danger of toxicity to other animals.

Emphasis has been placed on the use of chemicals as the agent affecting the mosquito egg, and chemicals do offer great potential in this respect. We are, however, interested in any factor which will give us control. We have, for instance, found certain fungi which destroy mosquito eggs in the laboratory. Field condi-

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tions rarely provide the environment needed for this fungal action unfortunately, but it nevertheless gives us a clue to the susceptibility of the egg. Samples of apparently diseased larvae of both *C. tarsalis* and *A. nigromaculis* have been submitted to the Insect Pathology Laboratory, University of California, Berkeley; again unfortunately, with negative results. This last example, while outside the strict limits of the egg study, indicates the type of phenomena which come up during our studies, and which are evaluated for their possible value to mosquito control.

Keeping in mind our need for more and better control techniques, three phases of the egg stage have been selected as offering the greatest possibility for the development of these techniques. These phases are: (1) maturation of the egg shell, which occurs during the first 24 hours following oviposition, (2) conditioning of the embryo for hatching, and (3) the stimulus for the process of hatching; thus we are concentrating on the first and the last phases of the egg stage.

Because of its properties, the shell protects the embyro from natural environmental adversities such as drying, or attack by micro-organisms, and from man-made adversities in the form of insecticides. At the same time, it provides an optimal environment for the development of the embryo. In contrast, at the time of hatching, the shell provides (or might be made to provide) an obstacle between the embryo and the environment it must have in order to survive. What then are these special properties of the egg shell, and more important, what can we do about them?

At the time the egg is laid, the chorion, which is produced by the female's ovary, is soft and white rather than hard and black as we usually see it. The process of "tanning" is responsible for these changes in color and hardness, and requires the hour or so immediately following oviposition. Two additional layers, the wax layer and the vitelline membrane, are soon added to the chorion. These are produced by the developing embryo, and gradually appear during the 16 to 24 hours following deposition of the egg.

The wax component functions in preventing water loss by the embryo, and both layers probably function as barriers to the entry of various molecules such as insecticides. If this impermeable property could be prevented, the embryo would be liable to destruction through both natural and man-made factors. Because too, the chorion is the outer layer of the egg, it is readily accessible to some disruptive influence, and we can avoid the formidable problem of penetrating it in order to reach an internal site of action.

Because the process of tanning results in extensive alteration of the chemical and physical properties of the chorion, the identification of the steps comprising the tanning process is important. We have found that tanning of an isolated egg shell, which will not undergo spontaneous tanning, can be simulated by placing the shell in the chemical 3,4-dihydroxyphenylalanine. Knowledge of the nature of the tanning agent, its source, the possible role of enzymes in its formation. and its reaction with the protein of the chorion, might allow us to devise methods for interrupting the tanning process and hence destroying the eggs.

The second phase of our study is that of conditioning. Conditioning is the process by which eggs of species occupying areas which are intermittently flooded are readied to hatch when suitably stimulated. By manipulation of the environment in the laboratory, groups of eggs can be produced which will show complete hatch (conditioned eggs), or which will show little or no hatch (unconditioned eggs) on flooding. The humidity of the environment, the exposure of the eggs to air, and temperature, are apparently involved in the conditioning process. Our problem is to determine the relative importance of these factors, how they influence the egg, and how this information can be applied to control operations. That conditioning has a real effect on mosquito embryos is indicated by some preliminary experiments we have made. The embryo of an unconditioned non-hatching egg can be removed from the shell without injury, but this embryo shows only feeble muscular movements, fails to rise to the water surface, and soon dies. These results indicate that conditioning has more to do than only readying the embryo to escape from the shell, but also prepares it for its independent existence following hatching.

A cooperative study is being developed with Fresno State College in which conditioned and non-conditioned embryos will be compared histologically. The existence of differences between these two classes of embryos will possibly give us a clue as to the processes involved. Physiological and biochemical differences between these two classes of embryos will also be studied.

Knowledge of these differences and the factors responsible for them will possibly allow controlled hatching by means of environmental manipulation. This ability to control hatching could be used to prevent all hatching, or to bring about hatching at pre-determined times. This would facilitate chemical control operations, or could be used to bring about hatching in an environment designed to be unsuitable by means of water manipulation.

Hatching, which is the third phase of our studies, consists of two aspects: the stimulus which initiates the hatching process, and the actual mechanism by which the embryo escapes from the shell. Work done by several investigators has indicated that a reduced oxygen content of the flooding medium is the effective stimulus for hatching in several species of *Aedes*. Our work with *A. nigromaculis*, however, has not been so clear-cut. Reducing the oxygen tension of water does bring about hatching of *A. nigromaculis* on occasion, but our results have not been consistent, and other unknown factors seem effective at times. Since conditioning is important in influencing hatching, this variability might be due to our conditioning procedures. We are currently attemptng to standardize our procedures to eliminate this variability. This will allow us to define the hatching stimulus more accurately, and to determine the action of this stimulus on the embryo, with the ultimate possibility of controlling hatching.

The second phase of the hatching process, that by which the embryo actually escapes from the shell, is also being studied. Shell rupture might be caused by internal pressure resulting from embryonic activity induced by the hatching stimulus. An understanding of this activity, and the nature of the forces could aid in the development of new control techniques. If water were ingested by the embryo prior to shell rupture (this aiding in the generation of an internal pressure) changes in the impermeable properties of the shell will have to occur. Should this occur, knowledge of the process might allow these changes to be induced at times when the environment is unfavorable for survival of the larvae. If shell rupture is due in part at least, to the physical properties of the shell alone (i.e., absorption of water with resultant stress), knowledge gained from our studies of the chemistry of tanning might be used to modify the shell in such a way as to prevent shell rupture.

It is hoped that this brief discussion will provide an insight into the Bureau of Vector Control's research program on the mosquito egg, why we feel these studies to be of value, and to what we can reasonably hope to gain in the way of new or improved control techniques as a result of these studies.

Mr. Peters: Thank you, Charlie, He had only eight typewritten pages more that he might have given you.

We now move to Mr. Measurement, Ed Loomis. Ed became identified with this particular activity after we were all "shook up" by the encephalitis experience of 1952. As suggested before, you will find that what Ed has to present is of broad application.

MOSQUITO POPULATION MEASUREMENT STUDIES

EDMOND C. LOOMIS
Bureau of Vector Control
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Mosquito population evaluation has been the chief activity of the Vector Measurement Unit since its formation in 1955. During these two and one-half years the Unit has been concerned with three specific objectives: (1) to evaluate currently recognized mosquito population measurement methods, therefrom to develop new techniques and equipment for obtaining a more accurate appraisal of mosquito control, and to provide more reliable sampling techniques for use in mosquito ecology studies; (2) to assist in establishing, as part of the State-wide encephalitis surveillance program, a standard method of measuring and reporting mosquito populations with attention focused primarily on *Culex tarsalis;* and, (3) to collect mosquitoes in four representative study areas of the Central Valley for the purpose of determining encephalitis virus levels. The need for increased effort toward these objectives became clear as a result of the California encephalitis epidemic in 1952.

A standardized adult *C. tarsalis* measurement program has now been in operation for five years. This activity has been sponsored by California Mosquito Control Agencies in cooperation with the Bureau of Vector Control. Weekly reports of mosquitoes collected by American Model light traps are submitted from March through October. This activity was expanded in 1955 to include data on the occurrence and density of immature *C. tarsalis* populations. This supplementary information has been submitted weekly by the control agencies for a four-month period, March through June. Data are obtained from sampling at fixed larval stations and from section-survey inspections.

Standardization of collection techniques and reporting procedures among the 40 participating agencies has required frequent consultation between personnel of local and State agencies. It was also recognized at the outset that certain studies were necessary in order to improve our sampling techniques, equipment and procedures. Results from some of these studies, including completed projects prepared for publication and those in progress, can be cited here:

1. An evaluation of light trap collection data showed that four trap-nights per week provided mosquito population indices which were as reliable as those obtained from running the traps every night (Loomis, 1956).
2. Light trap studies indicated that for *C. tarsalis* a four-hour collection period (7 p.m. to 11 p.m.) was as satisfactory as a 12-hour collection period (7 p.m. to 7 a.m.) for determining population trends. These four hours include the period of maximum biting activity for this species. Unfortunately, it is during this time that the greatest number of other night-flying insects are also collected; therefore, the amount of work required to process trap material is not greatly reduced.
3. The study of light trap air-displacement has shown that records from traps operating 50 per cent or more below their air-flow capacity can not be interpreted as standard trap-night collections. Development of measurement devices for simple, rapid and accurate determination of light trap air flow has shown the need for frequent cleaning of traps and the occasional realignment of fan blades. This is particularly important when traps are to be used for investigational purposes.
4. The evaluation of larval survey methods resulted in the adoption of two techniques which could be used to advantage by most mosquito control agencies. Report of a California Mosquito Control Association Entomology Committee (1956), covering the use of these two methods, is available to interested persons.
5. Light intensity and color tests indicated that rather wide variations in wave length and intensity of light do not appreciably affect the catch of *C. tarsalis* in light traps. Comparable studies by workers in the eastern United States have shown a marked selectivity on the part of *C. quinquefasciatus* for certain wave lengths. Our tests with mosquitoes of the *C. pipiens–quinquefasciatus* complex gave similiar results. Evaluation of data and *Aedes nigromaculis* showed that this species was particularly attracted to white light and that the attraction was greater with increased light intensities. Information on the development of the so-called "*nigromaculis* light trap" will be presented on tomorrow's program.

Studies on the ecology of *C. tarsalis* have been undertaken in conjunction with the encephalitis surveillance program. Work of this nature, in four virus study areas of the Central Valley, has been made possible through the cooperation of mosquito control agencies and the University of California encephalitis laboratory at Bakersfield. Results from certain of these studies are believed to have some practical value in control operations and are therefore mentioned briefly here:

1. The study on adult *C. tarsalis* resting places in

the Delta region of the Valley has supported earlier observations by Reeves, *et al.* (1948) and by Loomis and Green (1955) that this species is found abundantly in natural habitats. Both overwintering and summer populations observed in natural resting places were found to be equal to or greater than populations observed in man-made shelters. This is undoubtedly one reason why residual or aerosol-type control efforts directed toward man-made mosquito resting places have failed to give satisfactory results.

2. Light trap studies were also undertaken to determine the vertical distribution of *C. tarsalis*. In one test area, *C. tarsalis* was most numerous at 50 feet while *A. nigromaculis* was the predominant species collected nearer ground level. This difference in vertical distribution of species is compatible with results of previous studies of the feeding habits of these species and availability of preferred hosts. It is unlikely, however, that the answer is this simple, but in control areas where previous trap locations have not been found to reflect the existing mosquito population the problem may be one of trap elevation as well as location.

3. Field tests with red, one cubic-foot, wooden boxes have shown that these artificial resting units are of particular value for population measurement of *Culex* and *Anopheles* mosquitoes. The results were not unexpected since Goodwin (1942) found similar units satisfactory for collecting *A. quadrimaculatus*, and Hayes *et al.* (1958) have used such units successfully for collecting *C. tarsalis*. This device has the advantages of durability, portability, ease of inspection, and economy.

These and other studies show the need for continued research and development in the field of mosquito population measurement. We are all aware of the limitations of the best tools and techniques now available to us. The development of additional refinements in mosquito sampling methods and equipment is dependent to a large extent upon our progress in gaining a thorough understanding of the various types of environment in California and the ecology of the numerous species which must be controlled. For this reason a more concentrated effort on the study of *C. tarsalis* ecology is planned for 1958 in association with the encephalitis surveillance program. It is hoped that this will provide significant additional information on the vector-virus-reservoir-host interrelationships. The measurement of the *C. tarsalis* attack rate using bird-bait traps may, for example, give us a better mosquito population measurement technique and may provide better epidemiological information with which to interpret the occurrance of human disease. Ecological studies are planned for the entire year instead of for the six-months period previously followed. This will also provide an opportunity to acquire biological data on vectors of secondary importance as well as on species which are of public health importance in the broad sense but which have not, thus far, been implicated in the transmission of specific infectious diseases of man.

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Mr. Peters: Thanks, Ed. Now, as you can see, the strategy of this panel called for trying to keep you in your seats throughout by saving the subject the majority of people want most to hear about as the last presentation. We now bring into focus the toxicology project. I couldn't conscientiously introduce this project without paying respect to the Kern Mosquito Abatement District which, for a number of years—up to about two years ago—carried the principal load on this particular effort. We have also had a very gratifying relationship with Dr. Metcalf and the staff at the University of California, Riverside, in connection with this project. Dr. Metcalf provides technical guidance to this effort. Our project leader, Larry Lewallen, previously worked under Dr. Metcalf for some six years in a similar capacity. Larry succeeded Lew Isaak, now Assistant Manager with the Kern Mosquito Abatement District, on this project.

Larry, will you give us the final presentation.

MOSQUITO TOXICOLOGY STUDY

Lawrence L. Lewallen[1]

In mosquito control, as in most insect control operations, chemicals continue to be one of our most important weapons. Since the advent of the synthetic organic insecticides for the control of agricultural and household pests, as well as disease vector species, dramatic results have been witnessed in California and throughout the world.

In view of the need to achieve and maintain effective chemical control of arthropod pests, complicated by the development of resistance by many species, a constant search for new materials is carried on by the insecticide industry and governmental research agencies. This continuous exploration for new materials is also influenced by the need for finding chemicals that have a high toxicity to arthropod pests, a low mam-

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malian toxicity, and can be applied within a cost range that is economically feasible.

Literally hundreds of new materials have been synthesized that are purported to have insecticidal properties. These compounds must be checked by various research organizations for their efficiency in controlling a variety of pests. In addition, phytotoxicity, mammalian toxicity hazards, residues, and other inherent characteristics must be determined.

Although insecticide chemists can be guided to some extent in anticipating relative toxicities of new materials on the basis of molecular configurations, the actual merits of a candidate insecticide must still be determined by the more-or-less trial and error system commonly referred to as the "screening process."

In the development of any new material, initial consideration must be given to laboratory screening tests. If the compound looks promising on a wide spectrum of arthropod pests, field tests are then undertaken. The results of these tests must be considered in the ultimate determination of the value of the material.

In consideration of our common objective of achieving more effective mosquito control throughout California, it some time ago became evident that a laboratory and field screening program represented a major need which could only partially be met through local resources. For this reason, the Bureau of Vector Control established a toxicological research program in 1955. Cooperative projects with other agencies, including the United States Department of Agriculture, the University of California, and a number of individual mosquito abatement agencies have facilitated this program.

The primary task of the toxicology unit at this point is to determine the relative merits of new insecticides for mosquito control. Laboratory screening tests have been designed to obtain toxicological data on several of the more important vector and pest species in California. The high degree of specificity exhibited by some of the new synthetic insecticides makes it necessary to obtain laboratory data on more than a single species. Screening tests have therefore been conducted on fourth instar larvae of *Culex quinquefasciatus, Culex tarsalis,* and *Anopheles freeborni*, all of which are available from insecticide-susceptible laboratory colonies.

Since we have been unsuccessful thus far in our attempts to establish a colony of *Aedes nigromaculis* in the laboratory, data on this species must be obtained on labortary-reared larvae hatched from eggs produced by field-collected females.

The value of a laboratory screening program lies not so much in the direct application of the results obtained to field problems, but rather in that it gives the investigator a uniform method for comparing the performance of a new compound with insecticides whose properties are already well known.

In some cases, compounds that look extremely promising in the laboratory do not perform as well as anticipated under field conditions. Conversely, compounds that look only fair in laboratory tests sometimes prove to be outstanding when subjected to field trials. Bearing this in mind, the judicious selection of compounds from a laboratory screening program is of importance in carrying out effective field experiments.

Preliminary field tests in our program are carried out on small plots, usually consisting of ⅛ acre in area. A variety of aquatic habitats, in geographically and ecologically representative areas, throughout the state are utilized in evaluating new materials. Emulsion concentrate or granular formulations are used primarily in larviciding experiments. The tests are conducted on fourth instar larvae of *Aedes nigromaculis, Culex tarsalis, Anopheles freeborni,* or other species as need for study is indicated.

We are encouraged by the observation that information obtained from the mosquito toxicology study has, with increasing frequency, been of direct benefit to mosquito abatement districts. This was well illustrated during the 1957 field testing season when it became apparent that additional information might well be obtained on the performance of a new compound which appeared on the market. The initial recommendation called for a dosage of 0.1 to 0.25 lb./acre as a mosquito larvicide. Our tests revealed that although this dosage was satisfactory for the control of certain species, the material had to be applied at 0.5 lb./acre to obtain satisfactory control of *Aedes nigromaculis*. This is a graphic illustration of the importance of considering the possibility of variations in species susceptability in planning control operatons. Since one of the biggest problems in the Central Valley of California is the control of *Aedes nigromaculis*, it was economically infeasible to use this product in large scale operations. On the basis of this information, some abatement agencies were able to avert ineffective or excessively costly control efforts against *Aedes nigromaculis*.

The application of knowledge gained from mosquito ecology studies can often throw light on the reasons for chemical control difficulties in programs carried out by mosquito abatement districts. This is particularly important in accounting for failure in cases where laboratory tests have revealed no physiological basis for resistance. A case in point would be a situation where an entire irrigated pasture is treated with one chemical application directed at the larval stage. Survey techniques used by the mosquito abatement agency may indicate that treatment is needed on a certain date; as is frequently the case, the pre-treatment inspection may be limited to one portion of the pasture. Since most pastures are laid out to receive irrigation water in sections, all stages of development are apt to have been present, considering the pasture as a whole, instead of only the larval stage as indicated by the inspection. Materials that are ineffective against pupae or materials that dissipate rapidly would be ineffective from the standpoint of control throughout the entire pasture.

On the other hand, many cases of chemical control failure are actually due to the development of insecticide resistance. The seriousness of this situation has been pointed out through numerous studies, and the pressing need for fundamental research into this phenomenon on a worldwide basis has been stressed in a recent report issued by the World Health Organization.[2] The acute problem of insecticide resistance in California mosquitoes has created real concern for control agencies.

Since the Bureau of Vector Control is now in a position to undertake certain types of fundamental studies

[2] W.H.O. Technical Report Series No. 125. Expert Committee on Insecticides, Seventh Report 1957.

relating to insecticide resistance, we are obligated to devote some effort to this problem. The information gained from this approach can be of value in bringing about a better understanding of the nature of resistance and thereby aid in the solution of the problem. The ultimate objective to be achieved is to obtain more satisfactory chemical control of mosquitoes.

At this point, I should like to make brief mention of some of the specific studies we are undertaking—

1. An insecticide-susceptible strain of *Culex quinquefasciatus* has been divided into two lines. One line is being selected for resistance to DDT, while the other line is being selected for resistance to malathion. The results of such a study can accommodate three needs: (a) provide information on the time required to develop resistance to these compounds; (b) provide an easy-to-rear resistant species for physiological and biochemical studies of resistance; and (c) provide material for cross-resistance and genetics studies.
2. An insecticide resistant strain of *Culex tarsalis* collected in the field has been established as a laboratory colony for cross-resistance tests and physiological studies. This strain has also been divided into two lines, one line being maintained with malathion pressure in an attempt to increase the resistance level, while the other line is being maintained without malathion treatment. The time required for malathion resistance to decline will be of interest.
3. An insecticide resistance survey of *Culex tarsalis* collected from stations established in various parts of California has been undertaken. The response of fourth instar larvae to DDT, malathion, and parathion has been determined.
4. An analysis of resistant and non-resistant mosquito strains, employing the techniques of paper chromatography, is in progress. This is being undertaken with a view toward the possible elucidation of some of the biochemical mechanisms involved in resistance.

Occupying a very minor portion of the toxicology research effort at this time is an interest in insect hormones and the possibility of using chemicals in an attack on the endocrine system of mosquitoes as a control method. In our program, studies along this line must, of necessity, be quite restricted. As our knowledge of insect hormones increases through contributions by researchers who are actively engaged in this specialty, the potentiality for undertaking promising applied research in this field will be materially increased. This possible approach should not be ignored as long as evidence obliges us to adhere to the thesis that chemicals with varying modes of action are needed to avoid the development of resistance. A chemical rotation program can be effective in avoiding the development of resistance only if the chemicals used have widely varied modes of action. The literature is being searched for leads on chemicals that may be used in a study of this nature. The ultimate objective of this approach is to find or develop chemicals that might, for example, produce sterility, prevent molting, interfere with metabolic systems under hormonal control, or produce other deleterious effects. Experimental work will be carried out in conjunction with the egg-hatching studies of our research group since the biochemical aspects of such investigations are particularly applicable to hormone studies.

It is our conviction at this time that the three main areas of endeavor which I have attempted to outline briefly here—(a) screening of insecticides, which constitutes the major effort, (b) insecticide resistance studies, and (c) anti-hormone studies—are all vital to the achievement of more effective mosquito control. It is our aim and desire to carry out these research objectives as effectively as possible.

Mr. Peters: Thank you, Larry.

Before we depart for the research facility, I want to acknowledge and identify another very important area of research which we are proud and pleased to be helping to a limited extent—that of Dr. Reeves' encephalitis research activities at Bakersfield where Dr. Bellamy of the U.S. Public Health Service is resident project leader. That particular research activity has such important bearing to every mosquito abatement agency in California that I only wish it were possible to double the amount of support now available.

We are now at the point where it is our pleasure to invite you out to the research facility. You are encouraged to ask questions, to dig into what is actually going on and to enable us to explain to the best of our ability what we are doing. We are located opposite the entrance to Fresno Airport on Shields Avenue, near the corner of Clovis and Shields Avenues. As you approach the facility, you will see a State flag and a United States flag out front, and if we had a local flag we would put it up too.

FIFTH SESSION

WEDNESDAY, JANUARY 29, 1958, 8:30 A.M.

The assembly was called to order by President Portman, who presided over this final session. The first paper called for presentation at this session was by W. A. Delmer.

Editor's Note: This presentation is herewith published in abstraction as determined by editorial policy. The abstract by the Editor is based on the paper submitted by Mr. Delmer.

ABSTRACT: Some experimental work is being done in developing various sized containers to hold insecticide concentrates which are dispersed by means of one or more wicks into the water in various small mosquito sources, such as flower vases, meter boxes and catch basins.

It was herein advanced that the prime requisite for successful dispensing lies in the use of emulsifiable concentrate with a specific gravity close to that of water. Activity of the larvae is felt to create adequate agitation for further dispersal in the water.

It is stated that a small container designed for use in flower vases has been extensively tested in some Los Angeles County cemeteries. Such field usage was over a 10 week period by the Orange County Mosquito Abatement District and, although good results were achieved, there is, thus far, no validation to the long period of effectiveness that is suggested. Other proposed uses and dispenser forms are mentioned, but testing and results have not yet been accomplished.

WEED CONTROL WITH SIMAZIN

VERNON W. OLNEY

Research Department, Geigy Agricultural Chemicals, Fresno, California

Simazin is a relatively new herbicide, synthesized by Knüsli and Gysin of J. R. Geigy, S.A. in Switzerland, which is fast proving to be an effective material for long lasting weed control.

The chemical formula of Simazin is 2-chloro-4, 6-bis (ethylamino)-s-triazine, a very stable compound being approximately 5 ppm soluble in water. The chemically pure substance is white in color and melts at 225-227 degrees centigrade. Because of the chemical and physical properties of Simazin, it is relatively non-toxic to man, animals and plant foliage. It is a non-conductor of electricity, is non-corrosive and does not move laterally in the soil.

Simazin is most effective when applied as a preemergant, preferably when the ground is clean of weed growth. This helps to ensure a uniform coverage. When Simazin is applied to established weeds, three to six weeks are required to show toxic symptoms. An examination of the grasses, before they die, will show a necrossis of the tips of the leaves and a chlorotic pattern to broad-leaved weeds. This process continues slowly until the plants die. Results so far indicate Simazin inhibits the carbon assimilation in the plant.

Simazin 50%W is marketed for use as a residual preemergence herbicide for non-crop areas only. Tests are underway to get it cleared for specific crop use.

Rates of 2 to 4 lbs. per acre of the 50%W are usually sufficient to give seasonal control of annual grasses and broad-leaved weeds. Dosages of 20 to 40 lbs. per acre are suggested for longer residual control and to kill the deeper rooted perennial weeds. Johnson grass appears to be somewhat resistant to Simazin. Salt grass is quite resistant.

Simazin holds considerable promise for control of aquatic weeds and algae. At 10 to 20 lbs. per acre rate, duck weed and water hyacinths have been killed with no injury to fish such as carp, trout, and chub minnows. Simazin may be applied to the dry irrigation ditch. When water flows over the treated area tests indicate Simazin remains fixed in the soil.

Ornamental shrubs and trees such as roses, rhododendron, heather, evergreens and others have been sprayed with Simazin as an over-all coverage. Excellent weed control has been obtained with no injury to the shrubs or trees. Rates up to 10 lbs. per acre (5 lbs. actual) have proven safe.

Outstanding weed control has been obtained with relatively low dosages, such as 2 lbs./A of Simazin in corn. However, any rate above 4 lbs. per acre may prohibit the planting of crops other than corn the following season.

Simazin also appears to be a promising herbicide for the control of annual weeds in asparagus, grapes, cane fruits, strawberries, citrus, olives and deciduous fruit trees such as pear and apple. Stone fruit trees are more sensitive, especially in the seedling stage but may tolerate Simazin after they become established.

To summarize, tests so far indicate Simazin at 2 to 4 lbs. per acre of the 50%W has given excellent control of annual grasses and broad-leaved weeds. The sterilant rates of 20 to 40 lbs. per acre are necessary for longer residual control and for the deeper-rooted perennial weeds. Woody plants in general are resistant to Simazin.

The following weeds were effectively controlled by Simazin at dosage rates of 1 to 4 pounds per acre. In many cases control was effective at the lower rate:

Barnyard grass (Echinochloa crusgalli)
Bull nettle (Solanum elaeagnifolium)
Carpet weed (Mollugo verticillata)
Crabgrass (Digitaria sanguinalis)
Dandelion (Taraxacum officinale)
Foxtail, green (Setaria viridis)
Foxtail, yellow (Setaria lutescens)
Ground cherry (Physalis heterophylla)
Groundsel (Senecio sp.)
Knotweed (Polygonum aviculare)
Lamb's quarters (Chenopodium album)

Nightshade (Solanum sp.)
Plantain (Plantago sp.)
Purslane (Portulaca oleracea)
Quickweed (Galinsoga parviflora)
Ragweed, common (Ambrosia artemisiifolia)
Ragweed, giant (Ambrosia trifida)
Redroot pigweed (Amaranthus retroflexus)
Shepherd's Purse (Capsella bursa-pastoris)
Smartweed (Polygonum sp.)
Velvetleaf (Abutilon theophrasti)
Water hemp (Achnida altissima)
White cockle (Lychnis alba)
Wild buckwheat (Polygonum convolvulus)
Wild mustard (Brassica arvensis)
Wild oats (Avena fatua)
Witch grass (Panicum capillare)
Quackgrass (Agropyron repens)

Pre-emergence application at the rate of 10 pounds of Simazin 50%W per acre will prevent growth for about one year of the following:

Barnyard grass (Echinochloa crusgalli)
Carpet weed (Mollugo verticillata)
Chickweed (Stellaria sp.)
Crabgrass (Digitaria sanguinalis)
Foxtail, green (Setaria viridis)
Ground cherry (Physalis heterophylla)
Groundsel (Senecio sp.)
Henbit (Lamium amplexicaule)
Knotweed (Polygonum aviculare)
Lamb's quarters (Chenopodium album)
Plantain (Plantago sp.)
Quickweed (Galinsoga parviflora)
Purslane (Portulaca oleracea)
Ragweed, common (Ambrosia artemisiifolia)
Ragweed, giant (Ambrosia trifida)
Shepherd's purse (Capsella bursa-pastoris)
Smartweed (Polygonum sp.)
Redroot pigweed (Amaranthus retroflexus)
Velvetleaf (Abutilon theophrasti)
Water hemp (Acnida altissima)
Wild parsnip (Pastinaca sativa)
Wild buckwheat (Polygonum convolvulus)
Wild carrot (Daucus carota)
Wild mustard (Brassica kaber)
Wild oats (Avena fatua)
Witch grass (Panicum capillare)
White cockle (Lychnis alba)

To control the following weeds, it is generally necessary to apply 20 pounds of Simazin 50%W per acre prior to weed emergence:

Nightshade (Solanum sp.)
Quackgrass (Agropyron repens)
Bermuda grass (Cynodon dactylon)
Canada thistle (Cirsium arvense)
Cocklebur (Xanthium pennsylvanicum)
Dandelion (Taraxacum officinale)
Goosegrass (Eleusine indica)
Kochia (Kochia scoparia)
Puncture vine (Tribulus terrestris)
Russian knapweed (Centaurea repens)

A pre-emergence application of Simazin 50%W at 20-40 pounds per acre is required to control the following weeds:

Bull nettle (Solanum elaeagnifolium)
Horse nettle (Solanum carolinese)
Morning glory (Ipomoea sp.)

Pres. Portman: Yesterday afternoon, some of you gentlemen were undoubtedly disappointed that the scheduled airplane demonstration didn't take place. I have been informed by John Stivers that the Call-Air 180 plane will be available today. The spray plane demonstration which was scheduled for yesterday afternoon had to be postponed because of an automobile accident between here and the field; but arrangements have been made for the plane to be available to us this afternoon for inspection at Chandler Field, which is fairly close and to the south of this motel. Anyone interested is invited to come out, look over, discuss, and fly the plane.

Now, we will have a paper on a different method of mosquito control by Mr. David Powell of the John Bean Division of the Food Machinery and Chemical Corporation in San Jose: "Air Sprayers for Mosquito and Insect Control."

AIR SPRAYERS FOR MOSQUITO AND INSECT CONTROL

DAVID POWELL

Regional Sales Manager, John Bean Division, Food Machinery and Chemical Corp. San Jose, California

Mr. Chairman and members of the mosquito conference. If I should cough at you in the next few minutes, it is only because I was eating dinner in a Chinese restaurant in Fresno last night. I broke open one of these Chinese cookies and the slip on the inside said, "Greetings, American friend. You have now contracted Asiatic Flu."

The evolution of the air-carrier sprayer from its inception to today's rather finished design has taken place in a very few years. You, as technicians, have done much of the pioneering work in air-carrier sprayers, as other people who were in need of lower cost or higher capacity equipment. Usually one of these two facets must go together to make it profitable for you to invest in any new machines. It is with these ideas in mind, on air-carrier sprayers in particular, that I will confine my remarks.

Today, in the United States, about three-quarters of all the fruit and nut spraying is done with air-carrier sprayers. Ten or twelve years ago, only about five per cent was handled with this type of machine. These machines must have qualified for those two factors which were just mentioned, specifically a lower cost job, or an increased rate of work, or this change would not have come about.

A few owner benefits that have brought about this change are apparent to you, but are worth mentioning. Better insect control, as well as fungicide and herbicide control, have come about from better coverage of the plant itself; better coverage gives better insect control of the ground or tree, or house, or whatever is to be sprayed. A closer drop size control with better dispersion of the particle is also possible with this equipment. Combining all of these into the one machine, presents an interesting engineering task. The second reason for owner benefits and increase in use has come about through man hours saved. Abnormal high labor increases in recent years have made manufacturers, like ourselves, extremely conscious of your problems and emphasizes, as we will show in a few minutes, how extremely important this labor problem has become.

Spraying of more acres per day comes about in two ways with air-carrier equipment. The carrying power and coverage in acres or miles per day is the first reason, generally. The second comes about through less operator fatigue. Most of your equipment is designed, I have noticed, with a good eye toward the operator himself. The person that you are asking to spend your dollars and give the highest return on your investment does better work with "operator designed" equipment. New designs in this air carrier spray equipment produce tremendous amounts of work with minimum operator fatigue. This is a very important part of the air-sprayer program.

Dollar savings have come about in sprayer usage through concentrate spray programs; and we would both agree, I think, that the better the machine and operator, the better and more concentrate we can have a spray program. Air carrier sprayers make possible effective concentrate spray programs.

Lower costs per acre sprayed, then, comes about by these above reasons. Recently much pioneer work has been done in accomplishing the same type of results as by this orchard air-sprayer, in row crop, field, and shade tree spraying. These new uses bring about new machines, but use the same basic principles in almost every case. Just as many of you have converted or used a machine built for some other purpose and it has fit in well with your program. Now, air-mosquito, air-row crop, and air-shade tree equipment differ in these small ways. The machine may be operated by manual or hydraulic controls. The machine may be of different air volume sizes. The size to fit your job is as important as any other single point. I hope we can illustrate this in a minute. The proper size to fit the job assures lower spray costs per acre.

Now, the new designs, or new refinements on old designs, that brought some of these cost savings about, are as follows: Air as a carrier, is a constant source of energy, and it is extremely useful as a diluent and power to place the material where it is needed. The change in direction possible with air equipment, and the change in chemical application rates are quickly available with this equipment. Air volume will change between any two machines, from a few hundred cubic feet of air per minute to some recent machines above 65,000 cubic feet of air per minute. This entire range is being used very successfully in the work that you do. The rate of work, then, is almost directly proportional to the cubic feet of air that you displace through that machine. Now, that doesn't mean that the largest air volume is necessarily the one that you need. However, it is interesting to see that the spraying cost per acre generally goes down as the volume of air goes up.

New designs have come about, just recently, in improving spray coverage. The first is the concept of air turbulence. It is the fact that usually brings about more actual insecticide on the backside of the mosquito rather than on the front in many spray applications. The development of air discharge configurations to improve overall coverage has shown some remarkable recent successes.

New pump designs have recently helped the effectiveness of air carrier sprayers. A low cost high pressure pump is becoming more and more a common item in many parts of American life. We used to think of a high pressure pump as an orchard spray pump. Now these low cost units are a necessary part of mosquito and insect control air carrier sprayers. New designs have increased in three ways the efficiency and usefulness of this type of equipment. Power is less and fuel is saved because the efficiencies in high pressure pumps are generally over 90% at the present time. Repairs have been materially cut down through the use of new materials, such as teflon and ceramics which almost defy wear.

The last, and most important part, probably, is the possibility of using the pressure range from zero to 400-600-800 pounds pressure. This results in changing the drop size through nozzles. A well designed nozzle, commercially available, with a pump at four hundred or five hundred pounds pressure, can easily give you a ten micron size droplet in everyday activity. With filters to protect the nozzle, a machine can operate with this nozzle for hours and days without having plugging problems.

The rate of work of these machines is a most important part to getting the cost per acre down. As an interesting fact, these figures bring to mind the saying that you and I have heard many times: "Don't try to do a vast job with a half-vast idea." This fact has been brought out many times, and perhaps we can show some of it here.

(Whereupon Mr. Powell proceeded to give figures and illustrations at the board.)

Pres. Portman: The next paper that we have is "The Feeding Habits of the Mosquito Fish, *Gambusia affinis*, in Utah, by Dr. Bryant E. Rees from the Fresno State College in Fresno.

Dr. Rees: After talking over this paper with a number of colleagues, it was decided that we should change the title to "The Attributes of Mosquito Fish in Relation to Mosquito Control."

ATTRIBUTES OF THE MOSQUITO FISH IN RELATION TO MOSQUITO CONTROL

Bryant E. Rees, Ph.D.
Fresno State College

In the past, as in the present, various mosquito control measures have been introduced, tried, improved upon, accepted or rejected. It might well be that the biological control of mosquitoes received its important impetus in 1904 when attention was first directed toward the mosquito fish. This is a report on the mosquito fish, *Gambusia affinis affinis* (Baird and Girard), in Utah.

The fish was described in the genus *Gambusia* by Poey in 1854, yet its economic value as an ally in mosquito control work was not discovered until W. P. Seal (1904), under the direction of David Starr Jordan, began his investigations of mosquito control through the utilization of natural mosquito enemies. Since the work of Seal, the fish has been distributed throughout the world by such men as Fowler, Moore, Hildebrand, Grassi, Sella, and others of more recent times.

The mosquito fish is able to survive under a wide variety of conditions, many of which would be detrimental or even fatal to fish of other species. It is able to live in ponds of water containing ice but not completely frozen over or, as recorded in Utah, in waters reaching 41 degrees C. The fish survives in brackish or fresh water, in still pools densely filled with algae, or in the quiet clear waters of streams and rivers. According to Hildebrand (1917), when the water becomes too stagnant and lacking in oxygen, the fish will project its mouth above the surface at frequent intervals, making a sucking noise as it supplements its oxygen requirements. Although a slow swimmer, *Gambusia* often penetrates plant growths too dense for other fish or skims across the surface of open water and through floating vegetation while seeking food. In most instances, the fish frequents shallow water near the shore; but it may be seen in the deeper portions of ponds and lakes.

The economic value of the mosquito fish as an ally in mosquito control, as in the case of other fish or aquatic animals, is dependent upon its food preferences, faculty to survive when desired foods are not present, feeding capacity, rate of digestion, reproductive potential, and ability to exist under various conditions, whether these conditions be limited in extent or general as with the changing of the seasons. Since the ability of *Gambusia* to survive in Utah has been given in a series of papers by Dr. Don M. Rees, University of Utah, the report here deals with the other attributes of the fish.

It is not the purpose of this paper to go into lengthy discussions of field observations on *Gambusia*, which in all probability have been observed by others interested in mosquito control, but to supplement some of these observations and to present data pertinent to a better understanding of the fish and its utilization in mosquito control work.

The presence of mosquito fish, as observed during this study, precluded the appearance of mosquito larvae in small bodies of water, such as ornamental ponds, into which the fish were introduced in sufficient numbers early in the mosquito breeding season. If fish were planted late in the season into small pools containing mosquito larvae, the larval population decreased in size and became non-existant after a period of approximately two weeks. Once cleared of mosquito larvae, the ponds remained so for the rest of the season, even in ponds containing fairly dense growths of plant life.

Of the fifty or so ornamental ponds planted with fish and kept under constant observations for a period of over one year, less than 3% continued to produce mosquito larvae and then only on a minor scale. In these instances, the larvae were located in small pockets of water completely isolated by plant growth from the remaining body of the pond and totally inaccessible to the mosquito fish. The isolated areas were small, generally ranging in size from 6 to 12 square inches and constituting only a small percentage of the total water surface of the pools in which they were located.

In large bodies of water, such as swamps and lakes, the fish congregated into schools and confined their feeding activities to certain selected areas even though they had been well distributed when first introduced. Occasionally groups of fish explored nearby areas, but they returned soon to the place from which they started. In their search for food, they appeared to select areas exposed to the sun where perhaps food was more abundant, invading the densely shaded areas only temporarily and then not for a very long period of time.

The amount of vegetation in a given body of water influences not only the efficiency of *Gambusia* as a mosquito exterminator but often their feeding and foraging habits. Petragnani and Castelli (1927) in their work with *Gambusia* in Sardina were of the opinion that one fish per square meter of water surface was sufficient for satisfactory mosquito control. At the beginning of the present study this ratio was adopted, but it was varied as the work progressed. Additional studies will be required to verify the data presented in the following paragraph.

Throughout the present work, the number of fish planted in a given body of water was computed not on the total water surface but on the surface area of water in which mosquito larvae were found to be present or assumed to be present and on the amount of vegetation growing within these areas. Through a series of field studies, it was found that one fish per square yard of water gave satisfactory control in ornamental and similar ponds in which the plant growth occupied less than 20% of the water surface; two fish per square yard were required for favorable results in ornamental pools and larger bodies of water if the plant growth covered 20% to 40% of the water surface; and three fish per square yard in waters where the vegetation occupied 40% to 60% of the water surface. The use of two fish per square yard generally gave satisfactory results in most types of water, but the ratio did not assure complete mosquito control. Whenever plant growth exceeded 50% of the water surface, the fish foraged about the edges of the vegetation; some entered it, but, being hindered in their activities, shortly moved to other and more open locations.

Important in mosquito control is the reproductive potential of the biological agent that may be used; and if the potential is high, the competition for preferred food may be greatly increased. In the instance of this study, the breeding season in Utah for *Gambusia* in pools of normal temperatures started late in May and continued into October; in thermal ponds reproduction began in March and extended into early November. Eggs and embryos in various stages of development were found present throughout the breeding season of fish taken from either type of water, indicating that while one brood was ready for birth another was awaiting or undergoing embryological development. Seal (1908), observing the fish in captivity, demonstrated that the mosquito fish produces two or more generation per summer; but in the present work, observations made throughout the breeding season of fish contained within five different ornamental ponds of normal temperatures revealed that three or four generations per season were not uncommon and that this number was exceeded by the fish in thermal waters.

Albert Kuntz stated in his paper on *Gambusia affinis* that the average number of embryos contained in the ovaries of females five to six centimeters in length, based on a limited number of counts, was 33, the maximum number removed from a single female being 76. During the course of the present study, the average number of 25 embryos was taken from the ovaries of a limited number of fish 2.7 cm. to 4.1 cm. in length, the maximum number of 85 being removed from a female 4.1 cm. in length. The specimen was collected from a thermal pool. In general, the young at birth varied from 4.5 mm. to 8 mm. in length; and the sex ratio of one male to eight or nine females appeared to be normal.

The mosquito fish is a voracious feeder; but if an abundance of food is present, the fish becomes lethargic in its foraging activities, an attitude often influencing its feeding habits and selection of food. Therefore, in order to better understand the diet and feeding habits of the fish, stomach analyses and laboratory studies on food preferences were made.

The stomach contents of 259 field specimens of *Gambusia* were analyzed. Specimens were collected, killed, and preserved in the field by making an incision into the abdominal cavity and placing the fish into vials containing 4% formalin solution. The formalin curtailed digestion and preserved the content of the stomach for later study. The volume of stomach material from each fish was measured by removing the stomach, placing it into a watch glass, opening the organ, and washing out the content. This was diluted with water to a volume of 10 ccs., the whole placed into a graduated test tube and centrifuged for one minute. The volume of the stomach material, now concentrated in the bottom of the tube, was recorded; and the substance was examined for microscopic organisms. Large organisms, when present, were removed and identified. The tube was then shaken in order to distribute the remaining material equally, and a one-tenth centimeter sample taken and placed within a counting cell. Through the use of an ocular micrometer and the examination of a given calibrated area within the counting cell, the different kinds and numbers of microscopic animal and plant life were determined. A series of multiplications gave the total number of each organism within the stomach.

The material consumed by the fish exceeded 50 different kinds of plant and animal life, with animal organisms being the preferred or selected food. In stomach specimens of *Gambusia* taken from thermal pools with their excessive number of fish, plant material exceeded animal matter from August to and including March. The diet consisted primarily of green and blue-green algae of the genera *Oscillatoria, Lyngbia, Phormidium, Anabaena,* and *Merismopedia.* Diatoms and desmids found in the stomachs were mostly of the genera *Amphora, Navicula, Pleurosigma, Pinnularia, Tropidones, Surirella, Closterium,* and *Cosmarium.* Animal material included *Cyclops, Cyclops* egg masses, chironomid larvae of the genus *Tanytarsus,* undetermined nematodes, and other small creatures that were few in number. From April to June, a period of aquatic arthropod propagation, the amount of animal material in the stomachs surpassed that of plant life, the amount being greatest during April. Throughout April, May, and June the number of fish progressively increased. Either through the increase in the number of fish and the resultant competition for animal life as food or perhaps through the decrease in aquatic arthropod propagation in these waters, plant material in the stomachs again predominated from July on. In one instance, a mosquito fish collected in June contained three small *Gambusia* within its stomach, illustrating that the fish practice cannabalism in nature as well as in the confines of an aquarium.

In pools and streams of normal temperatures, the number of fish per square yard of surface area was less than in the thermal pools; and both animal and plant life were available at all times in various amounts. In fish collected from normal water, animal substance in the stomachs exceeded plant material throughout the year except during the month of July. During July, however, aquatic animal life was found to be scarce; and the fish apparently were forced to supplement their preferred diet with an increased consumption of plant material.

In no instance were mosquito larvae or the remains of mosquito larvae found within the digestive tracts of fish collected from either thermal pools or waters of normal temperatures. This is explainable on the fact that *Gambusia* had long been established in the field, and the sources from which specimens were taken were devoid of mosquito larvae by the very presence of the fish. Furthermore, of the 259 fish stomachs examined, 66 contained no recognizable animal matter, the fish apparently surviving for unknown lengths of time on a strictly vegetable diet. The capacity of the fish to survive on such a diet was confirmed in the laboratory by keeping several specimens alive for one month in an aquarium containing no food other than plant material.

Since mosquito larvae were not found within the stomachs of fish taken from the field, a number of feeding experiments were conducted in the laboratory. Several fish from a stock aquarium were transferred into small aquaria of equal size and shape. Three fish were placed separately into balance aquaria and fed, while three were similarly placed into aquaria of clear water and starved for 48 hours. The fish were then given third and fourth stage larvae of the genus *Aedes.* Within 30 minutes, for those fish that had been fed, one, 3.6 cm. in length, ate 17 larvae; the second, 4.1 cm. in length, ate 49; and the third, 2.9 cm. in length, consumed 15 larvae. Within the same period of time, for those fish that had been starved, the first, 4.2 cm. in length, devoured 65 larvae; the second, 3.8 cm. in length, consumed 49; and the third, 4.0 cm. in length, ate 58 larvae. In a series of additional feeding experiments, one fish, 4.5 cm. in lenfth, devoured 168 third and fourth stage *Aedes* larvae within eight hours. A much smaller and younger fish, 6.9 mm. in length, ate two third stage mosquito larvae, taking 38 seconds to swallow the first one and one minute and 20 seconds for the second larva. As seen here, *Gambusia* voraciously feeds on mosquito larvae, and the predatory habit is practiced early in the life of the fish.

Field observations, stomach analyses, and feeding experiments in the laboratory demonstrated that the selected food of the mosquito fish is not always the mosquito larva. The stomach contents of fish planted in waters with mosquito larvae and small crustaceans of several kinds, principally *Cyclops*, *Daphnia*, and similar forms, often contained predominant amounts of crustaceans. When larvae and crustaceans were added concurrently to laboratory aquaria containing *Gambusia*, the fish not infrequently attacked the crustaceans first, feeding upon them in great numbers with only an occasional devouring of a larva. In a few rare instances the fish would not touch a larva until the crustaceans were completely consumed. Similar results were obtained through field observations. However, it was noted, in both the field and laboratory studies, that as long as the mosquito larvae remained quiet they were seldom molested by the fish, but when active, they were immediately attacked. The crustaceans, on the other hand, were perpetually in motion and apparently attracting the attention of the fish. Movement of the potential prey might well be a contributing factor in the selection of, but not necessarily the preference for, certain animal life in the diet of *Gambusia*.

A study of the mosquito fish in regards to its rate of digestion concluded the investigation. Twenty fish from a stock aquarium were segregated and fed 100 third and fourth stage *Aedes* larvae. The fish consumed the larvae within five minutes. Subsequently, one hour after feeding and then every two hours thereafter, two fish were removed from the aquarium, killed, and preserved in 4% formalin solution. The specimens were allowed to stand for not less than 24 hours in order to simulate conditions that would be comparable to those had the fish been collected in the field. In each case, the digestive tract of the fish was removed, placed into a watch glass, opened, and the content washed out. Food other than the mosquito larvae was disregarded.

In the fish that had been killed one hour after feeding, and in which two larvae were found, the larvae had shrunken to about two-thirds their normal size. The sclerotized head capsules and siphons remained intact, but the fleshy contents of these structures appeared to be approximately one-half digested. Muscle tissue within the thorax and abdomen showed signs of disintegration, but the muscles remained whole and retained their normal shapes and characteristics. In the fish killed two hours after feeding, one contained 23 larvae about three-fourths digested, while the other, containing only a single larva within the stomach proper, had 18 that were three-fourths digested in the upper portion of the intestines. The head capsules, siphons, and abdominal setae were entire and attached to the integument which was also entire with each larva. The muscle tissue throughout the larvae was digested to a semi-liquid state. The tracheae were entire and visible through the transparent integument.

Two fish killed four hours after feeding each contained two larvae in the lower part of the stomach and upper intestines. The larvae were more than three-fourths digested and the muscle tissue completely liquified. The integument of each was considerably wrinkled in appearance, but the head capsules and siphons were complete. Two fish killed six hours following the feeding contained 10 and 14 larvae, respectively, in the upper portions of the intestines but none in the stomach. The head capsules, siphons, and abdominal setae were distorted and tortured in appearance. In each case, the integument of the thorax and abdomen was no longer entire but appeared as white strands of material connecting the head capsule to the siphon. In the two fish preserved eight hours after feeding, the larvae were found in the middle portion of the intestines as a mass of tangled tissue consisting of the remains of the integument and distorted sclerotized structures of the larvae. The head capsules and siphons were reduced to small discontinuous pieces with the exception of a few siphons. In the fish killed ten hours after feeding, only an indistinguishable mass of tissue and sclerotized material was found in the lower portions of the digestive tracts, even the siphons being destroyed to a status where only careful study revealed them for what they were. The rapid rate of digestion undoubtedly is a contributing factor in the feeding capacity of *Gambusia*, making it possible for the fish to consume large numbers of mosquito larvae and quantities of other food in comparatively short periods of time.

The studies made during this investigation resulted in the following conclusions: *Gambusia*, widely distributed throughout the world, survive in many types of water some of which are not tenantable for fish of other species. When employed in small ponds, the fish can be effective in mosquito control if planted in sufficient numbers under conditions favorable for their use. In large bodies of water, swamps and lakes, *Gambusia* often congregate and remain within selected areas. They prefer sunlight to shade. The amount of plant growth and abundance of food directly influence the feeding activities of the fish and their effectiveness as exterminators of mosquito larvae. When vegetation exceeds 60% of the water surface area, the fish generally forage around the edges of the growth with only a small percentage of them entering it. The reproductive season of *Gambusia* is more extensive in thermal pools than in waters of normal temperatures. Eggs and embryos in various stages of embryological development are to be found within female ovaries during the reproductive season; and three to four broods per season are not uncommon under normal conditions. Animal life is the selected diet of *Gambusia*, but the fish will supplement this diet with plant material, often surviving for limited lengths of time on plant tissue alone. The selected animal life in the diet of *Gambusia* is not always mosquito larvae since small crustaceans are often consumed in predominant quantities even when mosquito larvae are present. Movement of the prey might be a contributing factor in the selection of, and not necessarily preference for, certain animal life in the diet of *Gambusia*. The fish are able to eat large numbers of mosquito larvae and digest them within eight hours, a factor contributing to their voracious feeding habits. Finally, because of the characteristics of *Gambusia*, the fish if properly employed can be an important supplementary control measure in mosquito abatement work.

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Pres. Portman: Thank you, very much, Dr. Rees. I know that everyone who has been concerned with mosquito fish learned something new this morning, and perhaps some of our doubts, or some of our wishful thinking, has been proved or disproved.

Now we will hear from Leon Hall, Assistant Manager, San Joaquín Mosquito Abatement District, who will inform us concerning Larvicide Experiments and Evaluations in the San Joaquin Mosquito Abatement District.

LARVICIDE EXPERIMENTS AND EVALUATIONS IN THE SAN JOAQUIN MOSQUITO ABATEMENT DISTRICT

Leon L. Hall

Assistant Manager, Entomologist, San Joaquin Mosquito Abatement District

The use of insecticides and oils for the temporary control of larvae constitutes the major phase of most mosquito abatement programs. This fact becomes more apparent economically, when the combined 1957-58 budgets for 14 mosquito abatement districts in the Northern California area are analyzed. Approximately 62% of these combined budgets go for salaries and wages of personnel, the majority of which are necessary for operating equipment used for larviciding or related work. Insecticides and oils call for approximately 15% with the remaining 23% set aside for other work, operations and maintenance.

To meet this importance of insecticides in the District's program, a continuing evaluation is provided through the establishment of experimental plots for testing larvicides in current use as well as those of potential use in the field. In support of the field tests, periodic evaluations of routine field applications are made regarding methods, equipment, and chemical effectiveness.

The use of these various materials as larvicides can often become so routine that the important factors associated with their use becomes somewhat clouded. Even the most effective larvicide formulation can be in such a manner as to be partially or totally ineffective. The past history of effectiveness of any formulation gives no guarantee of the desired end results. The methods of application and the applicator must be under continued guidance to insure that the larvicide actually comes in contact with the larvae. The type of equipment, application rate, dosage rate, and the form with which the larvicides are used depend on the source to be treated.

The experimental plots are not set up to reveal prolonged data, but rather to obtain usable technical information to fit our area and program. These experiments in the field were planned to determine the dosage rates of various insecticides, etc., necessary to give a near complete kill when it actually came in contact with the larvae. With this basic information, application rates and types of equipment necessary to do the job are selected.

Larvicide formulations currently in use in the S.J. M.A.D. consists of DDT, Malathion, Dieldren, Pyrenone, Lethane, Diesel and Weed Oils. These insecticides are used at approved dosage rates. The more toxic organo phosphates have not been used, however, plans to incorporate Parathion in next season's program led to its inclusion as part of the experiments.

The site for experimental plots play an important role in evaluation. They were carefully selected with uniform vegetative growth, water depth, and presence of numerous larvae as key factors, thus offering comparative conditions for various dosage rates and formulations.

The main object of these plot tests during the past two seasons has been the control of *Culex tarsalis* larvae, which due to its universal breeding habits, is our principal control problem.

Most plots have consisted of 1/20 of an acre, each completely separated from the other. A series of dips with a ½ pint porcelain dipper on a 5 ft. cane handle are made just prior to treatment. A count is made of the 3rd and 4th instar larvae and pupae collected with each dip. The count is recorded on a small plot sketch and the location of each dip is noted within the plot. The procedure was duplicated 24 hours following the larvicide application with an attempt made to dip in the same locations. The larvicides were evaluated as to the per cent kill of 3rd and 4th instar larvae and per cent reduction of pupae. All dipping, spraying, and rechecking were done by the Entomologist to insure uniform evaluation.

Results considered important to our program can be noted in the accompanying table. Briefly, DDT, Dieldren, and Perthane did not give results considered satisfactory. Malathion at the recommended dosage per acre was consistently effective and excellent results came from Parathion and Trithion at dosages tried. The formulations that proved effective as pupacides were the 5% DDT in Diesel Oil and Malathion in Diesel Oil applied from one to two gallons per acre. The practice of adding oils to emulsions (with agitation) to aid the control of late instar larvae and pupae proved ineffective in the plot tests when 5%, 10% and 20% Diesel Oil by volume was added to the emulsion.

In the support of these field tests, periodic evaluation of routine field applications are made to determine if the desired end results are obtained. The field evaluations are made by the Entomologist who enlists the help of the Division Supervisors. As in most districts, our operators fill out daily reports which list the individual places sprayed and show the type of area tested, its size, the type of material and the amount used. This information is removed periodically and is used to determine dosage rates, application rates, etc. When these areas in the field are checked, notes are made on the accuracy of the operator's report.

A variety of findings followed these inspections such as: overdosage or wasteful use of insecticides, underdosage or failure of larvicide to reach larvae due to field conditions, equipment malfunction, improper methods or poor judgment in application, and on one occasion, the treatment of a source only minutes before being checked, which was reportedly treated 24 hours earlier.

When poor larval kills are realized, the methods and materials used are checked to determine what corrective measures are necessary to obtain good control. In this manner the work done by the personnel of the District is constantly directed and useless effort or waste of expensive insecticides is reduced to a minimum.

Summary

Realizing the importance of the larviciding program and its need for constant guidance, methods for selecting effective formulations through plot tests have been devised. These formulations selected even though experimentally, are of little value unless proper methods of application are used. Periodic and unannounced evaluation of routine field work has uncovered the need for improved methods of application and thus increased the efficiency of the program.

PHYSICAL AND BIOLOGICAL ASPECTS IN REDUCING *AEDES NIGROMACULIS* (LUDLOW) SOURCES FROM CONTOUR CHECK IRRIGATED PASTURES

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Introduction

The physical and biological aspects that influence the production of *Aedes nigromaculis* in California pastures have been studied by the ecology unit, R. C. Husbands, et al., Bureau of Vector Control, California State Department of Public Health.

In the past six years some basic factors that influence the production of the species in the pastures have evolved from this ecology unit. Some of these factors were utilized in attempting to reduce *Aedes nigromaculis* sources in the contour check pastures in the Solano County Mosquito Abatement District.

In the past years, including the year 1957, the adults of the species completely dominated the contour check pasture area in the northern section of the M.A.D. Sheep growers in this area stated they were losing their monetary profits of raising sheep for market, because of the herds of the adults of the species preventing the sheep from feeding on the pasture forage. The growers said they had to supplement alfalfa and Trefoil Clover hay at an added expense to keep their flocks of sheep completely out of the area because of the hordes of mosquitoes. It was also stated by these sheep growers that the mosquitoes interrupted the irrigation cycles of their pastures by preventing the irrigators from turning irrigation district water into the fields and from starting their irrigation pumps.

To give immediate relief from the great number of mosquitoes in the contour check pasture area, the Solano County Mosquito Abatement District resorted to chemical control methods. Knowing that this type of control has no lasting effect as far as permanent control is concerned, source reduction must be emphasized in order to control mosquito production in contour check irrigated pasture area. (The M.A.D. has practiced source reduction in its salt marshes *(Aedes dorsalis* Meigen) the last 27 years.)

M. D. Miller and J. B. Brown (1950) describe contour check pastures as irregular basins formed by small levees or ridges. Location of the contour levees is determined by the use of the engineer's level and rod. Each levee is constructed on a contour, or line of equal elevation. It is also stated that this method of irrigation is only suitable on heavy soils where the land is nearly flat or gently sloping, and where large heads of water (6 to 10 cubic feet per second are desirable) must be available so that the basins can be filled in a short time. After contour lines have been established to form the basins or checks a broad shallow irrigation-drainage ditch is located through the approximate center of each check or basin. Control weir gates are placed where the ditch passes through the levees. The ditch is used for rapidly draining the basins or checks after they have been irrigated, and for carrying the water from the source of supply to the lower basins. The fields are irrigated from basin to basin, with the water being drained from the upper to lower basins successively. Excess water from the last check is discharged to waste ways or to lower lands.

Labor costs for this type of irrigation are lower than for any other system of irrigation, probably not exceeding $3 per acre per year. Construction and planting costs on the average is about $30 per acre. This is about $20 per acre less than for the strip check method of irrigation.

J. C. Marr (1954) states that by using this method (contour check) of irrigation, it reduces the need to grade or level the land. Frequently this irrigation method is employed to avoid altogether the necessity of grading the land.

The Solano County Department of Agriculture in their annual agricultural crop report for the year 1956 states that there was a total of 21,400 acres of irrigated permanent pasture in the county of Solano, of this total acreage it is estimated that 63% are irrigated by the contour check method.

Physical and Biological Aspects

Observations of many contour check pastures in past years have shown that the physical and biological aspects that influence the production of *Aedes nigromaculis* in any given contour check pasture must be known before source reduction of the species can begin. R. C. Husbands (1955) states that the interrelationship between soil factors, climatic factors, water management practices and larval densities and larval distribution must be taken into consideration at all times when planning the source reduction program. Thus from the basic principles set down by S. Davis and R. C. Husbands (1955), R. C. Husbands (1955) and the author's own observations, an analysis was made of the aspects that would influence the source reduction of the species.

Four influencing factors were found to predominate in the contour check pasture fields. They were: field layouts and structures, irrigation applications, climatic factors and larval development, densities and migration.

In analyzing the field layouts and structures factor it was found that in the construction of contour check pastures mosquito oviposition sites were built in the pastures during the construction process. Disk ridgers that form the levees or ridges that make the irregular checks leave a shallow depression (colloquially known as barrow pits) on both sides of the levees. These depressions retain irrigation water, thus making an ideal mosquito oviposition site. With the lack of any appreciable land leveling or grading in this method of irrigation, natural depressions are found in most any check. The irrigation-drainage ditch which supplies and drains the irrigation water to and from the pasture was found to be in most instances ½ to ¾ ft. higher than the checks bordering it. Thus the irrigation water could be backed into the checks since control weir gates in the ditch are closed on each check during irrigation and are opened only when the check is set to drain. Water could not be drained off sufficiently to prevent mosquito oviposition because of the high section of the irrigation-drainage ditch and of the silted condition of the shallow depressions (barrow pits) bordering the levees.

Irrigation applications play a very important part in the solution of source reducing the species *(Aedes nigromaculis)* from contour check pastures. There are usually two sources of supply in irrigating the pastures, canal water supplied by the irrigation district and irrigation pumps supplied by the pasture grower. If a contour check pasture is irrigated from an irrigation pump it will usually take from 7 to 12 days to irrigate the field. (Size of pasture, 80 acres—flow from pump 900-1200 G.P.M.) It has been observed many times that when a contour check pasture is irrigated from a pump, adult emergence takes place while the pasture is still being irrigated. If the contour check pasture is irrigated from a canal (size of field 80 acres, flow from canal—4 to 10 cubic feet per second), it will usually take from 3½ to 5 days to irrigate the pasture. Adult emergence in this irrigation application has been observed to take place only after the pasture has been irrigated, and the field is set to drain. Thus the number of days required to irrigate a contour check pasture is influenced by the irrigation application rate. This is a very important aspect to be considered in the contemplated source reduction program of *Aedes nigromaculis* from contour check pastures.

The climatic factor strongly influences the irrigation application factor, by influencing irrigation cycles. Numerous observations have shown that when the air temperatures are high (85-95 degrees fahrenheit) the pasture growers will irrigate their pastures regardless if the soil in the pastures is still saturated from the last irrigation. This additional irrigation does nothing but scald their forage plants (the Trefoil and clover) and promote water loving weeds, water grass *(Echinochloa crusgalli)*, broom sedge *(Andropogon virginicus)* thus inducing pasture deterioration. The climatic factor (temperature) also influences larval development of the specie, (R. C. Husbands 1955), where it is of a major importance in source reduction program involving the contour check pastures.

Larval development, larval migration and larval densities are very closely interrelated in the analysis of the specie source reduction program. It has been observed when contour check pastures are irrigated from irrigation pumps, the checks are flooded and drained separately. Not more than one or two checks are irrigated at the same time. When the first check is flooded to its maximum depth, first stage larvae *(Aedes nigromaculis)* appear after about one hour. The water in this first check is allowed to drain (by opening the weir gate in the irrigation-drainage ditch) into the irrigation-drainage ditch and flow into the second or next lower check, taking with it a fairly high percentage of the first stage larvae. This is larval migration induced by water movement. When the second check is flooded another egg hatch takes place producing first stage larvae. Then when this second check is completely flooded to its maximum depth, the water is allowed to drain into the irrigation-drainage ditch, taking with it larvae that were hatch in the first check, (some are in the second stage of their larval growth) and larvae that were hatch (first stage) in the second check down into the third check to be irrigated. This process of larval migration is repeated check by check until the pasture is completely irrigated.

If contour check pastures are irrigated from a canal, larval migration takes place only to a limited degree. This is because of the high intake rate (4 to 10 cubic feet per second) of irrigation water coming from the canal into the pasture. With this high intake rate from four to five checks are flooded at the same time, and if the contour pasture has only fifteen checks, the irrigation water is drained only three times into the irrigation-drainage ditch, thus creating a condition whereby the larvae migrate only three times before they are drained off into the drainage canal.

Larval development (growth rates) is taking place continuously in the contour pastures, and is especially important regarding the larval migration process. When the temperature is high this increases the larval development process, and when the larvae are being transported by the irrigation water movement down to the lower end of the pasture, they are usually in the third and early fourth stage of their larval growth. By the time the larvae have passed the center of the pasture, the high temperatures have increased the larval growths to the pupa stage, with some adult emergence taking place. Adult emergence then occurs (on the fifth or sixth day of irrigation) approximately from the first check irrigated to the center of the pasture, which is approximately the seventh check in the field. There are usually only fifteen or sixteen checks to an average size contour check pasture field.

Larval densities are important in the overall analysis because they indicate which pasture would produce high adult densities (R. C. Husbands, 1955). By the larval sampling, a ratio can be obtained showing the percentage of each stage of larval growth. Thus, theoretically, if a given contour pasture had 33.0 per cent fourth stage larvae, 37.0 per cent third stage and 20 per cent second stage, this pasture could be classified as a high mosquito producer, thus indicating which pastures should be considered in the contemplative source reduction program.

An Indicative Methodology in Source Reducing *Aedes nigromaculis* from Contour Check Pastures

When all of the factors that influence the production of *Aedes nigromaculis* in the contemplated source program are analyzed there is usually one factor that is the key in reducing such sources. This key factor would also limit, to a great degree, the other influencing factors on the production of the species. In the contour check pastures this key is the irrigation-drainage ditch of the field layout and structures factor. This ditch is usually ½ to ¾ ft. higher than the checks bordering it, thus preventing to a great degree adequate drainage of the irrigation water from the checks into the irrigation-drainage ditch. By lowering or deepening this ditch so that the ditch pad is at the same height as the checks, and by cleaning the shallow depressions (barrow pits, the depressions are usually silted and plugged) next to and on both sides of the levees that form the checks, so that the irrigation water could adequately drain into the ditch. This would help remove the water from the checks in a shorter period of time. The shallow natural depressions located throughout the center of most checks might be filled with any available soil, so preventing them from being a mosquito ovipostion source, or by digging a shallow ditch from these natural depressions to the barrow pits next to the levees and thus have the water drain from the barrow pits into the irrigation-drainage ditch, and into the main drainage wasteway or canal. This would prevent (theoretically) adult emergence of the species in the contour check pastures. R. C. Husbands (1955) describes prevention based upon the removal of all water from the pastures four days after application. Theoretically this can be done whether the pastures are irrigated either from an irrigation pump or canal water, by constructing the irrigation-drainage ditch as previously mentioned.

Annual maintenance is of a prime importance in the prevention process. Once a pasture has been reduced of practically all of the existing oviposition sites, and then is allowed by neglect to go back into production of the species, is a needless waste of taxpayers' money and time and energy of the people doing the source reduction work. Only by annual surveys of the pastures can the maintenance part of the source reduction program be made to continue to exist.

The Solano County Mosquito Abatement District have decided to continue on with the source reduction program of *Aedes nigromaculis* from contour check pastures by negotiating with local sheep growers who have problem pastures. The district has influenced them to contract with a local drag line operator who has a hydraulic shovel which is very efficient in constructing or lowering the irrigation-drainage ditch to the proper level in the contour check pastures. The district also is negotiating with local implement companies concerning the purchase of a light weight track-layer type tractor. The district wishes to develop a plow to dig and clean the barrow pits next to the contour levees and to dig the shallow ditches from the shallow natural depressions located in the center of most checks.

It is anticipated that this equipment (tractor and plow) will be rented to the pasture growers on a cost basis.

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RECENT DEVELOPMENTS IN THE BIOLOGY AND CONTROL OF *HIPPELATES* EYE GNATS

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Public Health Importance

Hippelates eye gnats are a major public health problem in localities where these pests attain high population levels. Since eye gnats are attracted to and have a predilection for eyes, ears, nose, mouth, wounds and sores, they constitute a constant source of annoyance to man and his domesticated animals. In addition to being a nuisance, they have also been incriminated in the transmission of several infectious human diseases, such as, conjunctivitis—prevalent in many parts of the globe, yaws—endemic in the tropics, and mal de pinto or spotted disease—endemic in parts of Mexico and other sections of tropical Americas.

Eye gnats or eye flies have been shown to transmit Naga Sore in Assam (Graham-Smith, 1930) and bovine Mastitis in this country (Sanders, 1940).

Research Program Expanded

Research project on the biology and control of eye gnats in southern California is a cooperative effort pursued by the Coachella Valley Mosquito Abatement District and the Department of Entomology, Univer-

[1] The assistance of L. D. Moore, Gerry Latham, Art Cavanaugh and Bart Williams of the C. V. MAD, in parts of this work is greatly appreciated.

TABLE 1

Eye gnat bait trap comparisons in pairs using grided versus non-grided cones. *Hippelates collusor* was the only species counted.[a]

Pair	Trap No.	Trap with	Date and number of gnats caught								Total	
			3-30	4-2	4-4	4-6	4-7	4-11	4-13	4-16	Grid	Non-grid
A	10	G[b]	71		414		1240		140		1865	2774
		NG[b]		222		1566		186		800		
	20	NG	107		1495		2848		204		1862	4654
		G		139		1080		219		424		
B	12	G	37		417		616		49		1119	1023
		NG		109		392		170		352		
	21	NG	67		676		1008		45		879	1796
		G		26		183		275		395		
C	13	G	105		47		2251		46		2449	2419
		NG		203		1704		248		264		
	22	NG	91		380		1200		53		307	1724
		G		73		153		34		47		
D	14	G	43		164		1160		58		1425	1816
		NG		59		1040		37		680		
	23	NG	35		83		824		36		914	978
		G		28		667		30		189		
E	19	G	72		91		1027		27		1217	2191
		NG		112		1784		100		195		
	33	NG	452		1427		3768		459		2817	6106
		G		294		1832		275		416		
										Total	14,854**	25,451**

[a] Raw egg (4 in a quart of water) was used as the bait.
[b] G = With Grid, NG = No Grid.
** Significantly different from each other at .01 level.

sity of California, at Riverside. Extensive research undertakings on eye gnats have been made possible, by a grant-in-aid from this District to our Department.

Recent studies on the biology of eye gnats in southern California, particularly those in Coachella Valley, have unfolded some interesting facts about the niches, behavior, breeding grounds, dispersal and seasonal population fluctuations of five species of eye gnats. Successful laboratory colonization of the most predominant eye gnat species (i.e. *H. collusor)* in the southwest, has made it possible to carry on basic studies on the biology of this pest under controlled environmental conditons. Laboratory trials with various insecticides against eye gnat larvae and adults have been made easier with the availability of laboratory populations of the various life stages of the insect.

Biological Observation

The eye gnat species encountered in the desert areas of southern California, breed mainly in cultivated soils. Loose soil with ample water and organic matter content when accompanied by optimum weather conditions and cultivation result in a large number of eye gnats. It is therefore obvious that the type of crop, as far as we know, does not influence eye gnat production to a great extent. It should be mentioned here that non-cultivated areas such as certain alfalfa fields, household gardens, and golf courses also breed gnats, but the number of gnats contributed by the latter is relatively negligible as compared to cultivated croplands.

After the ground has been disked, gnats swarm over the disturbed ground and deposit their eggs, presumably at the surface of the soil in protected niches. The larvae after hatching work down into the soil and probably feed and develop below the five to six inch depth level. Upon completion of development the larvae work back up toward the surface of the soil and pupate. The majority of the pupae have been recovered from the 3-6″ depth level. The vertical distribution of pupae and larvae will unquestionaby depend on the water and organic matter content of the soil as well as atmospheric conditions.

This biological information has certain implications insofar as the distribution of the larviciding chemical in the soil is concerned. Maximum exposure of the larvae to the insecticide will be attained only in cases where the maximum distribution of the insecticide and the larvae is in the same depth level.

Adult eye gnat populations have been heavy during the past two seasons all over the Coachella Valley. Increased gnat activity was observed in the months of March and April, and the peak of population density was reached either in September or October. Population density during the summer months was main-

TABLE 2

Some proteinaceous materials tested as attractant baits against *H. collusor* (Townsend) in bait traps.[a]

No. of Gnats Captured by Each Material for the Duration of the Test					
TEST A (Duration 18 days)					
Egg	Brewer's Yeast	Staley's Sauce Base 2	Blood Meal	Partially hydrolyzed Yeast	Protein Hydrolysate
11865**	158	2795	3662	8382**	545
TEST B (Duration 16 days)					
Egg	Hy-Case	Soy Peptone	Lactalbumin Peptone	N-Z Amine E	Peptonized Milk
6699**	1406	98	9585**	3910	223

[a] Raw egg (5% weight/weight basis) was the standard bait used. All the other materials were also made either into 5% solutions or suspensions and placed in the traps. In order to minimize positon effects the materials were rotated in one direction each servicing time. The volume of the solutions or suspensions was kept constant by adding water to them.

** Significantly different from the rest at .01 level but not different from each other.

tained at a constant level with no dip in the population curve. This finding is rather in contrast to what was observed by workers in the early thirties. Studies conducted on eye gnats 25 years ago (Burgess 1951) showed the seasonal population curve to fluctuate to a low level during the summer months. The prevalence of high populations during these months at the present time is more likely to be due to the availability of an ample supply of water for irrigation, increased cultivated acres under farming and various types of crops grown in the Valley now.

Sampling Adult Eye Gnat Populations

In sampling adult eye gnats, large numbers of other dipterous flies are caught in the collecting jars. These flies, like *Hippelates* are attracted to the egg bait used in the trapping operation and cause inconvenience in counting and segregating the tiny gnats. The exclusion of these flies is desirable and much time can be saved in counting and determining eye gnat species.

In order to exclude the larger flies, a window screen (16 mesh) grid was placed in the screen cone of Tinkham bait traps. Five pairs of these traps were compared in different locations and the screen cones were interchanged each time the gnats were collected. The results of this experiment (Table 1) indicated the grid hampered movement of the gnats through the screen cone into the collection jar, and therefore fewer gnats were usually caught in the traps with the grid. The data analyzed by crossover design,[2] showed significant difference in catch between the two types of traps.

Insofar as baits are concerned, there are several materials that attract eye gnats in large numbers, by their decomposition products. Among these, ground liver and meat, fish meal and raw egg are the ones that are well-known and used by other workers. Along this line, two preliminary field tests were conducted on the use of some other substances as lures to the adult gnats. The standard bait used for comparison with materials was a 5% suspension of raw egg in water.

In Test A (Table 2), egg and partially hydrolyzed yeast were significantly superior to the rest of the materials. Brewer's yeast, Staley's Sauce Base No. 2, blood meal and MRT protein hydrolysate were not significantly different from one another. In test B (Table 2), the standard egg bait and lactalbumin peptone gave significantly better catches as compared to the other materials. Hy-Case and N-Z Amine E were not as effective as egg and lactalbumin but they were slightly better than Soy Peptone and Peptonized milk.

Eye Gnats Found to Fly Appreciable Distances

During the past season, two experiments on the flight range of *H. collusor* (Tns.) were performed in the Palm Desert and Indio areas of the Coachella Valley. In each experiment, well over 37,000 gnats were labelled with P^{32} incorporated in their food. The radioactive gnats were released in locations where extensive breeding activity of gnats had been observed. Conditions for roosting of gnats in these places were also favorable.

The tagged gnats released in the Palm Desert area were trapped as far as 4.15 miles from the release point. This point was reached on the 4th day following the release. The radioactive gnats gave anywhere from 500 to 20,000 counts per minute when they were placed at a distance of ½ inch from the Geiger Müller tube. Therefore, the detection of a labelled gnat among thousands of other gnats was a simple matter.

Similar results were obtained from the release in the Indio area. Here, labelled gnats were captured as far as 4.3 miles from the point of release.

In both these experiments the eye gnats traveled with and against the general direction of the wind.

[2] Statistical analysis of the data were performed by Dr. Morris J. Garber, University of California, Citrus Experiment Station, Riverside.

They consistently flew toward residential areas which were one to three miles away from the release points.

Larviciding treatments for the control of eye gnats were previously confined mainly to farms in the proximity of towns and residential subdivisions. This was based on an assumption that eye gnats would not fly into the residential sections from distant gnat producing land. However, in the light of the present information obtained on the flight activity of eye gnats, the perimeter of the area to be treated for gnat control should be expanded.

More Effective Control Measure Developed

The first larviciding control measure against eye gnats in the Coachella Valley was developed by the Coachella Valley Mosquito Abatement District about six years ago (Tinkham 1953). This control consisted of treating the soil primarily in date gardens and citrus groves with two or three pounds of actual Aldrin per acre and then disking this chemical under soon after treatment. This treatment was claimed to yield control of eye gnats for two to three years. Therefore, a certain piece of cultivated land was treated every other year, or in some cases every third year, up to the end of the 1957 larviciding program.

However, information obtained during the past two seasons indicated Aldrin to provide a poor degree of initial control when applied at two to three times the recommended dosage. Initial control ranged anywhere from 26 to 79% when 2.2 to 5.5 pounds of actual Aldrin was applied per acre—higher degree of control does not necessarily correspond to heavier dosage. Similarly, Dieldrin, Endrin, Toxaphene and Heptachlor when used at relatively higher dosages, resulted in poor initial control. The long-term effectiveness of Aldrin, Dieldrin, and Heptachlor when applied at higher dosages was found to be low against the gnats. These materials, in a number of tests failed to provide control of eye gnats, eight to ten months after application. Results of trials on the long-term effectiveness of Toxaphene and Endrin are not available as yet, but it looks as though these two materials by themselves alone would not provide a desirable degree of control of eye gnats for any length of time, when used at practical dosages.

Present indications are that the tolerance of eye gnats to Aldrin does not seem to be a case of resistance. Aldrin as was found recently has a fair degree of initial biological activity against the gnats, but in its residual effectiveness, it falls short of its expected persistence and longevity in the soil. The amount of acreage treated every year for gnat control constituted a small portion of the total cultivated land that could produce gnats. This fact and the fact that eye gnats can fly long distances, lead to the belief that resistance to Aldrin could not have been developed under these circumstances.

As Aldrin was shown to yield poor control of gnats, preliminary trials were then undertaken, using DDT and DDT-Toxaphene combinations. DDT alone when used at 8.5-17 pounds actual per acre as sprays gave 77 to 99% initial control of the emerging gnats. At the same time DDT-Toxaphene combination applied as sprays (DDT 5-7 pounds actual plus 6-9 pounds actual of Toxaphene per acre) effected 94-99% control of emerging eye gnats. Four months after application, both these treatments yielded almost the same degree of control as they did initially. Studies on the long-term effectiveness of these materials are not final as yet and will be continued into the future.

Currently, two large areas in the Coachella Valley are being treated by the Coachella Valley M.A.D., with 12-15 pounds actual of DDT per acre. These areas because of their isolation from the rest of the Valley are primarily treated for the purpose of evaluating the effectiveness of DDT treatments on an area basis. Although information on the effectiveness of granular formulations of DDT versus sprays is lacking, nevertheless, due to their ease of application, low cost, less residue hazard on food crops and faster application method; the granular formulations have been mostly employed in these treatments by the District.

Difficult to Control

Reducing eye gnat populations to a low level with larviciding means alone is a difficult proposition. Even with an effective larvicide on hand, there are situations where it could meet with failure. Some of the factors that would lead to less effectiveness of a larviciding program are as follows:

(1) Large amount of organic matter turned under at disking time provides niches for the larvae where they would not be exposed to the contact action of insecticides. This practice of turning under large quantities of green manure is fairly common in the Coachella Valley. In addition to providing protected niches, large amounts of organic matter in the soil may also adversely affect the longevity of an insecticide.

(2) Exposure of an insecticide applied to the soil for longer periods will reduce its effectiveness. There are instances where farmers fail to disk the treated grounds soon after treatment or the same day.

(3) Treatment of a small portion of the total acreage that can produce gnats. At the present time in the Coachella Valley, 50,000 acres of farm land is estimated to breed gnats at some time or another during the year. From this total acreage, only a small portion (5000-8000) acres can be treated with the current available funds.

(4) Certain gnat producing grounds are not possible to treat at the present time. Dense date gardens interplanted with citrus, alfalfa fields, golf courses and others belong to this category.

(5) Dislocation of an insecticide at a treated surface by normal farming operations such as furrowing, bordering and moving soil from one portion of the field to another during leveling work.

It should be pointed out that eye gnats as a general rule are a post-agricultural problem. With a constant disturbance of the natural balance, eye gnat populations will tend to increase in favorable areas. With a tendency toward an increased utilization of water and intensive farming practices in the desert regions of southern California, eye gnats will pose more and more a challenging problem than ever. This problem should be met with sound research program and constant vigilance practiced by the responsible agencies.

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CORRELATION OF SOIL TYPES WITH BLACK GNAT BREEDING SOURCES IN SAN MATEO COUNTY

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Introduction

The initial study of the *Leptoconops torrens* problem in portions of San Mateo County was started in 1956. The review of the findings has been previously disseminated.

Based on the original study, a three point outline for the 1957 season's work within the San Mateo County Mosquito Abatement District on the biting black gnat problem was proposed. First, a comprehensive survey of breeding sites be made through the utilization of emergence traps in all suspected black gnat producing sites. Second, initial experimental control work be done on a limited scale in those known gnat producing sites as previously determined. And last, that further work be done in studying the life cycle and habits of *L. torrens*, especially in regard to larval migration and longevity.

Soil Survey of the District

A complete survey of the District for all adobe soil was begun before black gnat emergence. The size of the areas and their locations were recorded and plotted on a large map of the District and immediate area. A total of about 2000 acres were found to be composed of heavy black clay or adobe. This does exclude much of the valley along the Crystal Springs Lakes where adobe is present; but adult gnats have not been collected nor has the District received complaints from the area. A great percentage of the total adobe areas lie on hillsides or where there is a definite slope to the land. In the southern portion of the District some rather moderately flat ground exists.

The adobe soils are of several derivations, and although resembling each other in appearance and texture, they are slightly different in formation. In the very southern part of the District and in the Stanford University area the Sweeny adobe series appears to be the common type. Behind Menlo Park, in one of the *L. torrens* producing areas, the Colma series is present. In the rolling knolls behind Atherton, the Dublin series predominate, this is also a gnat producing area. The Dublin clays persist along the Woodside road into Redwood City, but gnats are not known to occur, at present, much more than a half mile east from the Alameda de las Pulgas. The Emerald Lake area of Redwood City and the northern-most area, Hillsborough, possess still another type of adobe which was formerly called the Olympic series but is now referred to as the Montara series.

The adobe soils present in every case appear dark gray or black in color and fissure extensively upon drying. The surface fissures extend deeply into the soil, often exceeding 20 inches, and then divide into numerous smaller fissures and continue downward as the summer progresses.

The dark adobe is not uniform in depth, but may vary from a few inches to very deep pockets. In the Montara series a calcareous gray subsoil appears at varying depths, and this is underlaid with a light sandy loam. The Dublin series also exhibits a calcareous subsoil. The Sweeny series does not appear to have any calcareous material in its complex composition and is homogeneous in composition. The Colma series does evidence small amounts of calcium inclusions in the thin layer of yellowish clay immediately below the dark adobe.

Adult gnats were trapped from the Montara, Dublin, and the Colma adobe series, but as yet the Sweeny series is negative. Also, a change in subsoil at about 25″ to 28″ in depth from the black adobe to a clay subsoil, is present under all positive traps. The calcareous clay subsoils gave way to a sand at about 40″ in the Montara series (Plate I & II), but persisted to a depth of greater than 50″ in the Dublin series. The Colma series was slightly different in its formation, the adobe layer was between 23″ to 27″ in the positive trap sites. The yellowish clay subsoil varied between 4″ to 8″, underlaid with a yellow sand of the Merced series (Plate III).

Where negative trap sites were cored to ascertain the soil composition beneath them, the composition of the subsoil was considerably different or did not appear to change in our maximum cores of 50 inches. In some instances the adobe gave way to bed rock. In the large meadow type of situations the adobe does not evidence a change, nor is a subsoil encountered within a 50″ depth.

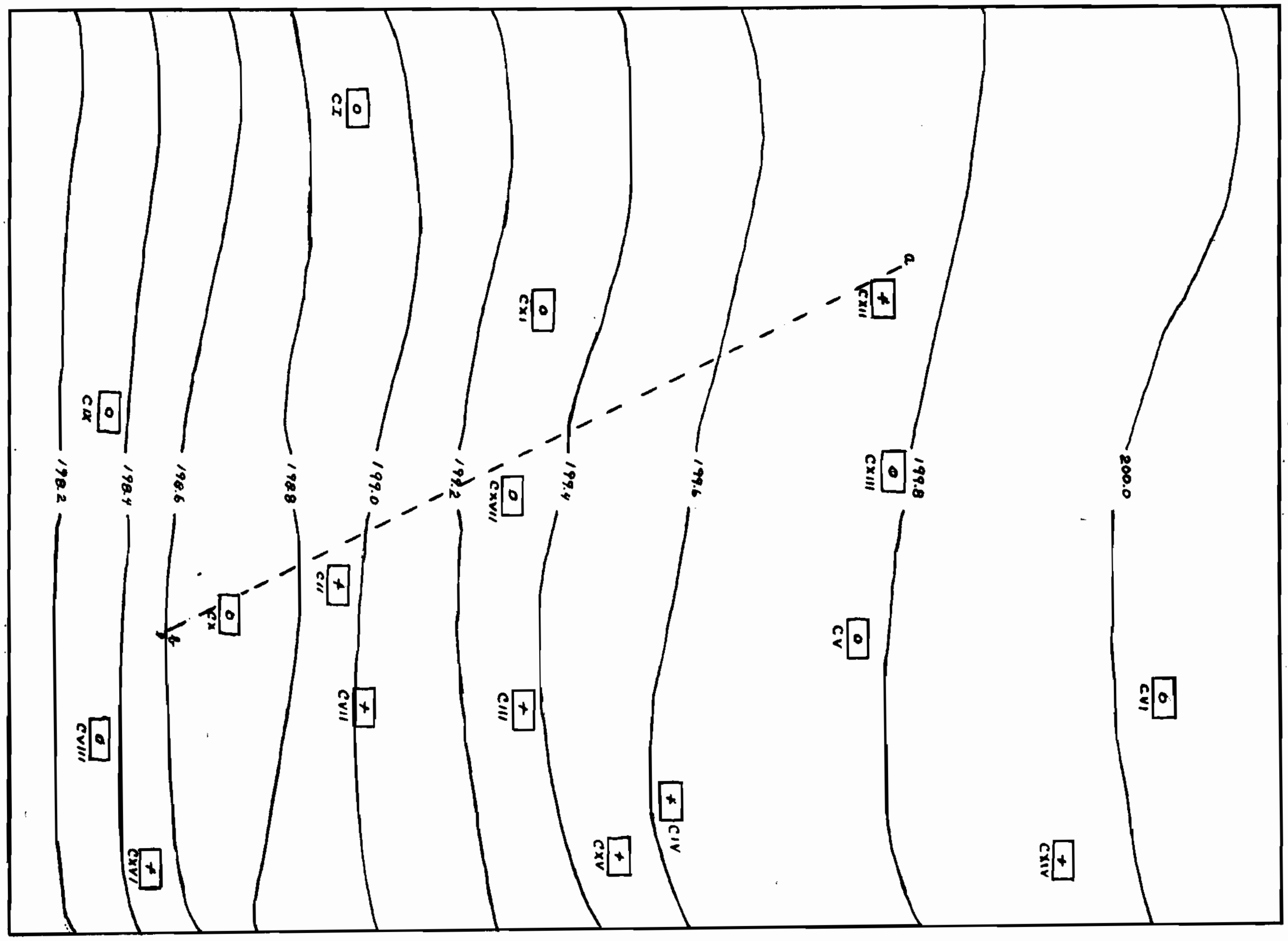
Black Gnat Emergence

Before the black gnats began to emerge, traps were placed on known positive areas. These traps would ascertain the first date of adult appearance. The physical features of the positive areas, as well as the plants and their state of development, were noted| It was hoped that there might be a correlation of soil drying and the development of specific plants might be an aid in determining positive black gnat producing areas. Unfortunately, there were no species of plants that were representative of the positive sites that could not be found over much of the adobe ground.

Upon the first collection of adult *L. torrens*, emergence traps were placed on predetermined areas. Collections were taken from the traps every two days and the information was recorded. If a trap failed to collect any gnats, it was relocated. Because of limitation of time and personnel, the traps were moved if gnats failed to appear in the traps after four or five days. When possible, traps were moved over an area to sample as many situations as possible. A total of 49 traps were used in the trapping program.

As gnat producing areas were ascertained, a program of trapping the area was established to determine more precisely the locations that were producing gnats. The Sharon Estate area, Menlo Park, which was established as a study point in the preceding year, was extensively trapped to determine the exact delineation of the gnat producing area (Plate IV). In Hillsborough, our trapping was not as complete, unfortunately, because of vandalism on several occasions; however, a fairly good

Control Area Sharon Estate Menlo Park, Calif.



Contour Interval 0.2' PLATE IV Scale 1cm=10'

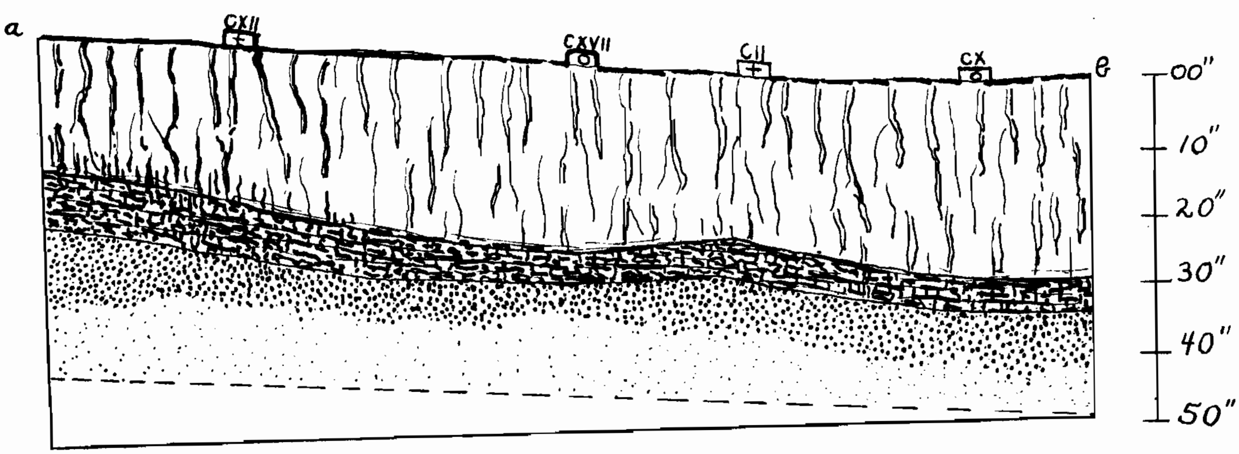


PLATE III

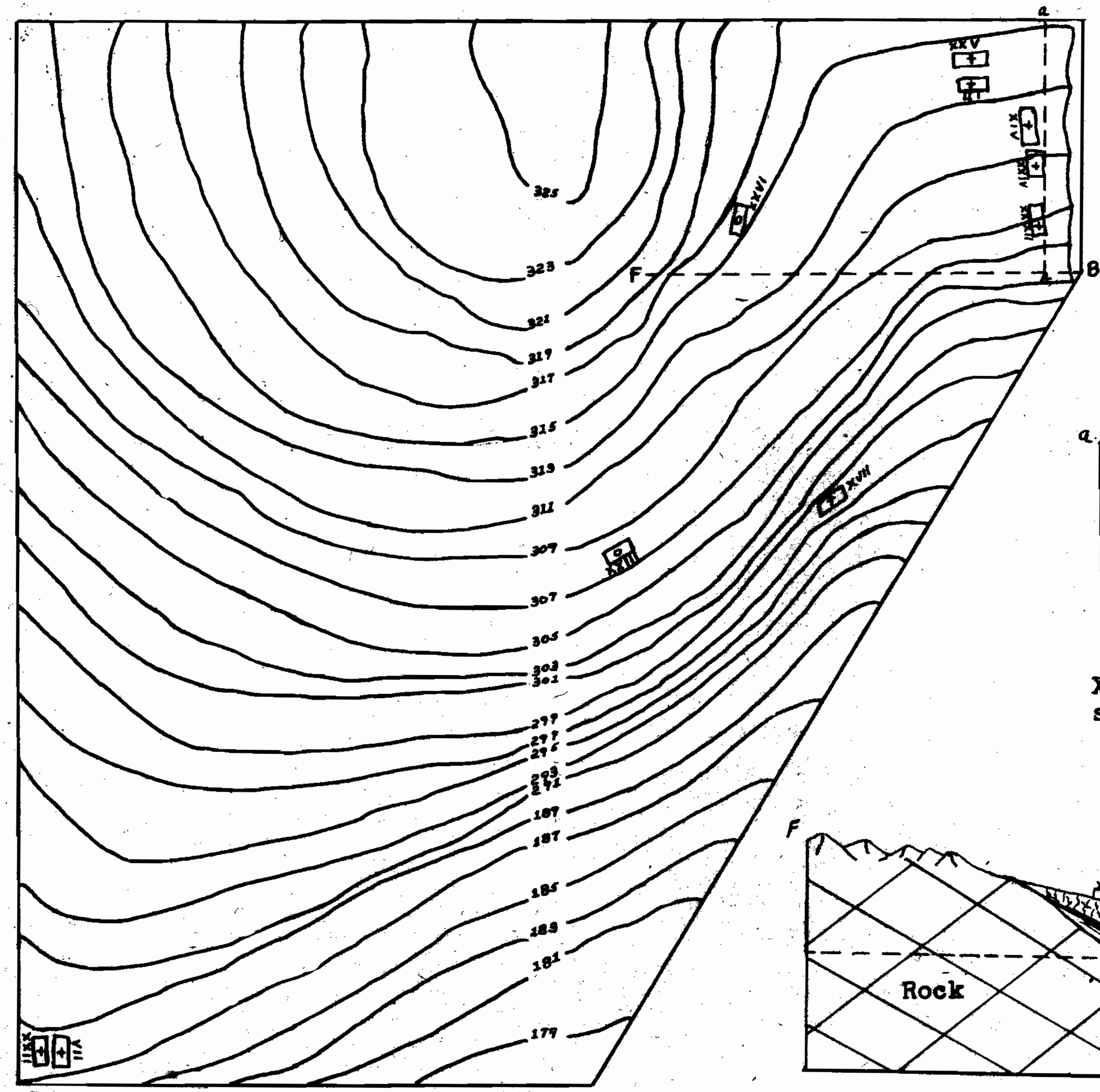
KEY

CRACKED ADOBE

CLAY

SAND

SHARON ESTATE CONTROL AREA
X-SECTION THROUGH TRAP SITES
C X, C II, C XVII, C XII



Contour Interval 2.0' PLATE V Scale 1cm=15'
Control Area Hillsborough, Calif.

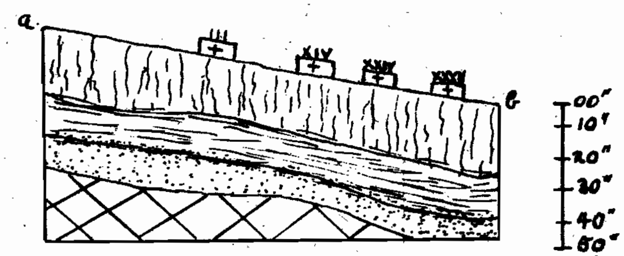


PLATE II
X-Section of black gnat producing sites, Hillsborough, Calif.

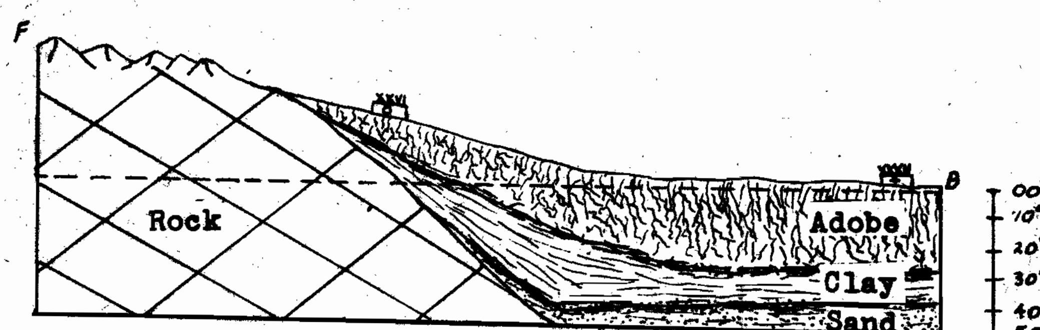


PLATE I
X-Section of suspected black gnat producing soils.

picture of the *L. torrens* producing area was achieved. (Plate V)

Because of the information previously gathered by the District, which was in opposition to the "sink hole" situation existent in other known gnat producing areas of the Central Valley, traps were placed on flat areas and the adjacent slopes. As the gnat season progressed, it was apparent that the producing sites were found on sloping ground.

This past season, only those sources that appeared most likely to be positive and of large extent were trapped in areas where the adult gnat population was heavy. Due to limitations in time and the number of emergence traps, many of the lesser areas were trapped by only one trap which was moved about in the area.

Larval Recovery

Larvae of *L. torrens* have been recovered only at one source. The search for larvae and the recovery of same is a very difficult and time consuming task. Three methods in all were tried.

The first method used was the screening of the material through two screens of 40 and 80 mesh. The 40 mesh screen removed most of the plant roots and other organic debris; the 80 mesh would catch the larvae. The residue on the 40 mesh screen presented a time consuming job just to examine the debris to ascertain the presence or absence of larvae. The 80 mesh screen retained a large amount of sand which also was quite laborious to examine.

The second method tried, to speed up the collection of larvae, was to first dissolve the adobe into a thin slurry and stir the mixture. The top fraction was then analyzed for the presence of larvae, but none were found. The bits of roots and other organic material collected in either process are the same color as the larvae for the most part and present a need for close observation of each root hair that is present, which is time consuming.

The third method was probably as slow as the other two processes, but did produce larvae. The mechanical breaking of the soil into very small fractions and visually observing each fraction for larvae. The larvae were recovered from the subsoil of the Dublin series which is an adobe with large amounts of calcareous material present. This soil structure becomes quite hard to break up when exposed to incandescent light and air. It was found that working under a fluorescent lamp retarded drying of the soil samples and also gave good light in which to work.

Larvae were recovered at 30, 34 and 36 inch levels. Larvae were only found in the subsoil which was quite high in calcareous materials and organic debris. No larvae were recovered from the hard upper sections of the adobe blocks. After the winter rains had softened the surface adobe, a search of the soil failed to produce any larvae.

Determination of Soil Composition and Formation in Regard to Gnat Producing Sites

With the use of emergence traps, four areas in the District were extensively trapped to ascertain the exact area of gnat occurrence within the suspected adobe areas. Care was taken to locate each trap site with a reference stake for further study.

To get a uniform sampling of the areas to be surveyed, the soil was sampled to ascertain the minimum depth need to fully cover all the soil changes that would occur. Fifty inches appeared to be a sufficient depth to enable all the soil changes that would be present in all the areas to appear. Two types of instruments were used in taking the samples. The first was a post hole type with a two-inch diameter. The second was an auger type also with a two-inch diameter. The second instrument proved to be more effective, both on the hard adobe and on the sandy base encountered.

Soil cores were secured from the positive areas and recorded. It was then quite evident that, although three soil series were represented (Colma-Menlo Park, Dublin-Atherton, Montara-Redwood City and Hillsborough), the adobe top soil gave way to a change in subsoil at about 30 inches in positive sites. Beneath the clay subsoil is found a sand formation. The Dublin series did not have a sand formation, but the subsoil became very heavily laden with calcareous salts.

The Dublin series and the Montara series both show the presence of high quantities of calcareous salts present in the subsoils. The Colma series does not have such a high degree of salts present, but small inclusion of calcareous material may be found.

The pH of the soils of the positive gnat producing sites were all in excess of pH 8.3. The calcareous salts are obvious in the Dublin and Montara series, but do not show up as white striations in the Colma series where they are present in small scattered pockets and not homogeneous throughout.

The organic content of all three soil types is high. The wind and water borne debris that filters down the crack, plus the strong root systems of the hardy plants living on the adobe, affords the soil with a high organic content.

The subsoil below the adobies is quite different in moisture holding capacity. The adobe, once it becomes saturated, is tenacious and impossible to break apart, whereas the subsoil does not show this same tendency when saturated, being friable when the adobe above it is still saturated. The subsoil in the Dublin series also demonstrates good moisture holding tendencies, but it also does not remain completely saturated for long periods of time, such as the surface adobe. Beneath the layer of clay in the Colma and the Montara series there is a layer of sand which probably is a major factor in removing excess water from the subsoil.

Experimental Chemical Control

Two areas were selected for the testing of insecticidal control. The largest positive gnat producing area was in the Menlo Park area on the Sharon Estate. Records of gnat production from the previous year's work indicated a fairly high population emerging from the soil. The area of infestation was laid out in strips 20 feet wide and 100 feet long. Traps were placed on the strips to enable adequate sampling of the test strips before treatment with insecticide so as to determine positive emergence and approximate rates.

The problems involved in securing chemical control are: first, the introduction of the insecticide into the cracks of the adobe in large enough concentrations to effect a larval or adult kill, and second, to use the formulation which will be the most effective against *L. torrens*. A high volume of spray was used to permit sufficient amounts of spray to enter the cracks even after the loss of insecticide spray collected by the grass cover. The soil itself will absorb a large portion of the sprayed material and thus will cut down on the run-off that enters and drips down into the deeper fissures. These fissures often go deep into the soil, 20 inches or more, and a coating on the walls of such cracks would appear to provide a barrier of insecticide for adult gnats leaving the cracks and to migrant females when entering to oviposit. The larvae which are deep in the soil must migrate to a crack to enable the adult form to escape. It is hoped that if the larvae migrate to the larger cracks a lethal dose of insecticide will be present.

Dieldrin was used on the Sharon Estate site. The insecticide was water emulsifiable 8 pounds per gallon concentrate. The rates of application were .5 lb. per acre dispersed in 150 gallons of water per acre, 1.0 lb. per acre in 300 gallons of water, and 1.5 lbs. per acre in 500 gallons of water per acre.

The chemical was applied with a boom spray mounted on the rear of a four wheel drive Jeep. A four gallon per minute Bean pump was used at 150 psi. Tee Jet nozzles giving a flat spray pattern with the two outer spray nozzles having a 90° pattern were used. The spray boom was mounted 18 inches from the ground with the nozzles directed down, thus affording the greatest possible force of the spray to penetrate the cracks in the soil.

The emergence traps had been removed before the application of the insecticide, and the same traps were replaced shortly after treatment. The emergence traps were initially placed on the Sharon Estate test sites on June 15. The first 24 hour collection was discarded and so the first recorded collection was June 17. The last gnat collected from this test area was on July 2. Emergence trapping was continued until July 29. Application of insecticide was on June 22, 1957.

.5 pound Dieldrin applied in 150 gals of water per Acre

Trap	Dates				
	6-17-21	6-24	6-26	6-28	7-2
XLV	2	0	0	0	0
XVI	1	0	0	2	0
XV	3	0	0	0	0

1 pound Dieldrin applied in 300 gals. of water per Acre

Trap	Dates				
	6-17-21	6-24	6-26	6-28	7-2
IV	4	0	0	0	0
VII	5	0	0	0	0
VIII	0	0	0	0	0

1.5 pounds Dieldrin applied in 500 gals. of water per Acre

Trap	Dates				
	6-17-21	6-24	6-26	6-28	7-2
XII	5	0	0	0	0

Control traps

Trap	Dates					
	6-17-21	6-22	6-24	6-26	6-28	7-2
CII	25	6	5	0	3	0
CIII	2	1	0	0	0	1
CV	0	0	0	0	0	0

The collection jars, which were mounted on opposite sides of the emergence traps, were collected and changed every two days. After the spray was applied the gnat count from traps in the treated plots dropped to zero and no further gnats were collected except in one plot (trap XVI) which received the minimal treatment of .5 lb. dieldrin in 150 gals. of water/Acre. A total of 17 traps were placed in and about the control area.

The other test area was on a hillside in the Hillsborough area. The chemical was heptachlor, which was obtained as a 4 lb./gal. emulsifiable concentrate.

Hand application of the insecticide was used in this test area because of the difficult terrain and limited amounts of positive black gnat producing areas. Due to vandalism, larger areas could not be adequately sampled before treatment.

Heptachlor was applied on test plots at the rates of 1 lb./Acre in 150 gals. of water/A., 1.5 lbs./A. in 300 gals. of water/A, and 2 lbs./A in 300 gals of water A. The applications were made July 10, 1957. This late date was due to the retarded emergence of the adult gnats and the difficulty in maintaining emergence traps in the area.

The treatments with Heptachlor would appear to have given 100% control in each instance; however, the results are inconclusive since several of the control traps were damaged and records of the controls are not complete. However, adult gnats were recovered from two control traps on July 15 and July 24. The traps were maintained and the collections were examined up to July 30, 1957. Adult gnats were still in evidence in sheltered areas on July 30.

A third test plot was established in the Atherton area. This test is in progress and is aimed at larval control. While the network of cracks were open, before winter rains, granular dieldrin 2.5%, 10-20 mesh, was applied to the area at the rates of 1 lb. and 2 lbs. per Acre.

This test area has been a high gnat producing source. Collections with emergence traps have been continued on the ground for the past two years. Thirty adult black gnats were recovered from one-half square yard area this season.

It is hoped, that with the winter rains, enough of the granules will be carried down into the larval zone to release sufficient toxicant for a larval kill. Before gnat emergence next spring, emergence traps will be established to evaluate the control effected.

A definite effort was made to keep up a continuous routine in collecting the trapped insects and determining the presence of adult *L. torrens* on an every other day schedule. When a trap was established in an area the jars were collected and examined 24 hours after being placed and recorded. The first day collections were recorded, but they were not included in the report of the traps because of the possibility of capturing harboring gnats.

When the traps were moved from one location to the next, the emergence traps were carefully inspected before being placed at new locations. Any necessary repairs were made and the traps were cleaned of all spider webs and spiders.

The collecting jars were removed from the emergence traps with the paper cones in place to eliminate possible loss of black gnats in field handling. When replacing clean jars on the traps, new paper cones were inserted and care was taken to see that the cone was properly installed in the jar and set firmly on the jar ring which had been fitted to the emergence trap.

It would appear by the field tests of the two chemically sprayed plots that chlorinated hydrocarbons are effective against the adult *L. torrens* when sprayed into the cracks of the soil. It still remains to be demonstrated if possibly the treatment of the test plots will depress the incidence of gnats in the coming season. If the control was effective then there should be no new eggs laid; but, since the larvae are believed to have a larval cycle of two or more years, there still should be gnats present. If the chemical sprayed into the cracks penetrated the soil and contacted the larvae as well, then the optimum will have been reached. This, of course, can not be ascertained until the coming gnat season.

Adult Black Gnat Prevalence and Distribution

The adult black gnats first appeared about June 1, 1957 in the Menlo Park area. The build-up of the adult gnat population was not until a week later, June 6th. The earliest trapped adult gnats were from the Atherton area on Dublin adobe on June 7. Adult black gnats were first recovered June 10th from the Menlo Park traps on Colma adobe. The area in the hills above Redwood City appeared to be two weeks behind the lower elevations, for adult black gnats were not collected from the emergence traps until June 21st. The first records of collected adult gnats from the Hillsborough traps were on June 12th. Both Hillsborough and Redwood City gnat producing areas are located on Montara adobe.

The latest date that an adult black gnat was recovered in an emergence trap was July 24th in Hillsborough. Adult gnats were present in the area at least a week after the traps were removed on August 1st.

Adult male *L. torrens* swarms were observed in only one area. Small swarms of 5 to 20 male *L. torrens* were observed in Huddart Park, a heavily forested area. A survey of the location did not uncover any potential gnat producing area within the confines of the park. Further survey work will be attempted to locate the source of the gnats in the area.

The adult gnat counts taken in the field did not appear to be as high as the previous year for the most part. Many of the residents, in normally heavy gnat infested areas, did not complain of great annoyance from the gnats as in past years. It would seem that the gnats were in heavy populations only in the Menlo Park area, and this was somewhat limited to the open areas immediately adjacent to the gnat producing sources.

Sweeping areas with insect nets failed to produce any numbers of male *L. torrens* even over positive locations. Sweeps were made at different times of the day by several different persons, but no significant numbers were collected.

Summary

The correlation of certain soil formations with positive black gnat producing areas indicates a means by which the prediction of new positive gnat producing sites is possible on a practical basis. Further work with other soil types present in the district will be necessary. The basic work has been directed at adobe, but evaluation of heavy clay soils adjacent to black gnat producing areas must be further examined to ascertain whether these soils are potential gnat producing areas. A definite effort should be made in conjunction with the evaluation of adobe soils to determine all non-producing soil types so that they may be eliminated from further study.

Chemical control of black gnats is possible in limited areas. Much work is needed, however, to find the most practical formulation and insecticide for use in extensive treatment. Before further tests can be made, additional gnat producing locations must be determined and their limits established. If, by prediction of positive soil formations, further gnat producing locations can be found and the limits of gnat infested soil established, then more trials of insecticide formulations and applications methods can be made.

Continued research on the biology of *L. torrens* immature stages should be continued. As yet, the pupae of this species has not been observed. Many of the facets on migration of the larvae while they are developing still have to be determined. The better understanding of larval behavior of the black gnat will probably aid in determining the best type of control for the species.

Study should also include adult biology; longevity of adult female black gnats, with and without a blood meal, flight ranges and normal migrations, sheltering habits, egg deposition and reproductive potential are only some of the many points which would aid in determining control measures for *Leptoconops torrens* on a cosmopolitan basis.

A POTENTIAL *AEDES NIGROMACULIS* LIGHT TRAP

Edmond C. Loomis*

Review of the literature on light traps used for collecting insects revealed that Frost[1] reported the Minnesota light trap and the New Jersey model trap collected mosquitoes in approximately equal numbers. Numerous types of light traps, all based on modifications of the original Minnesota trap design and utilizing many different combinations of baffles, funnels and lamps, were tested over a ten-year period by Frost.[2] In view of its simplicity of design and ease of operation, a modified Minnesota trap was built and tested against an American Model trap (motor and fan driven)[3] for efficiency of attraction and collection of the two most common Central Valley, California mosquitoes: *Aedes nigromaculis* (Ludlow) and *Culex tarsalis* Coquillett.

Minnesota Trap Design

The Minnesota trap was originally designed and used by the University of Minnesota to capture adults of the European corn borer, *Pyrausta nubialis* Hübner. The trap operates without a motor and fan and consists of a light source placed between four reflector plates (baffles) contained within a top hood and funneled bottom. The hood and bottom are separated by a distance of one foot. This provides a wide horizontal light beam in contrast to the light pattern of the American trap which mainly illuminates a small, circular area of the ground beneath the trap. Insects are collected by the Minnesota trap in a killing jar which is attached to the funnel-shaped bottom. An electric timer switch may be bolted to the top if desired. A figure of this trap has been published by Frost.[4]

Field Tests

Limited tests were conducted from August to October, 1957 in one urban and in two rural locations in the Central Valley of Caifornia. At each location, a Minnesota trap was operated simultaneously with an American trap. All traps were placed five feet above ground and operated a standard 12 hours each night, beginning at 6:00 to 7:00 p.m. The traps were operated with Sylvania inside-frosted "vibration service" white lamps. With the exception of tests at the second rural location, the positions of the traps were interchanged at regular intervals.

Evaluation of results was made with female mosquitoes since they amounted to 75 per cent or more of the total mosquitoes collected in all tests. The American trap collected a greater variety of species than did the Minnesota model. The collection efficiency of the motor and fan-driven trap was also superior to that of the Minnesota model in terms of numbers of specimens taken. The Minnesota trap collections, however, showed a greater variety of Lepidoptera and Coleoptera than collections from the American trap. This can be accounted for, in part, by the presence in the American trap of a one-quarter inch gauge wire screen surrounding the light source which was absent from the Minnesota trap.

At the first rural location, both traps were operated with 25-watt bulbs and 24 trap night collections consisted predominantly of *A. nigromaculis*. The number of *C. tarsalis* collected in the American trap (95) was much greater than that in the Minnesota trap (1). Since the *C. tarsalis* population at this location was extremely low, 20 trap nights were run at an urban location where previous light trap records indicated a larger *Culex* population. In this test, a 25-watt bulb was used in the American trap and a 100-watt bulb in the Minnesota trap. The Minnesota trap again collected predominantly *A. nigromaculis* (227 of 240 total specimens), while the American trap collected *A. nigromaculis* and *C. tarsalis* in almost equal numbers (83 and 62, respectively of 157 total specimens). The greater total catch by the Minnesota trap can, in part, be attributed to the fourfold larger wattage of the bulb in that trap. A final test was conducted for eight trap nights at a second rural location and 50-watt bulbs were used in both traps. The American trap collection excelled in numbers of *A. nigromaculis* and *C. tarsalis* (340 and 283, respectively), and the Minnesota trap collected entirely *A. nigromaculis* (61).

The limited results indicate the overall inferiority of the Minnesota to the American type trap under the conditions stated. That the factor of suction in the American trap increases the total collection of mosquitoes and especially of *C. tarsalis* is fairly evident.

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The repeated collection of solely *A. nigromaculis* by the Minnesota trap, particularly when the light intensity was increased, is worth further study. Additional tests are being undertaken to confirm these results and to determine whether or not the Minnesota trap will approach the efficiency of the American trap when both are operated at high light intensities, when the motor and fan are removed from the American trap, and under various other modifications of trap design and operation.

The author wishes to acknowledge the assistance of J. R. Holten in the construction of the trap and E. J. Sherman and M. S. White in conducting the field tests.

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LARVICIDING TESTS AGAINST MOSQUITOES IN IRRIGATED PASTURES OF THE SAN JOAQUIN VALLEY, CALIFORNIA

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The persistent problem of insecticide resistance in mosquitoes necessitates a constant search for new materials to replace those that become ineffective in chemical operations. In California this problem has been exemplified by the development of resistance to chlorinated hydrocarbons by *Aedes nigromaculis* (Ludlow) (Bohart & Murray, 1950), *Culex tarsalis* Coquillett (Gjullin & Peters, 1952), and *Culex quinquefasciatus* Say (Gjullin & Peters, 1952). In addition, a report of resistance to malathion by *C. tarsalis* (Gjullin & Isaak, 1957) further complicates the resistance problem.

The principal factors that are taken into consideration in our search for more effective chemicals for

[1] The help of Mr. L. M. Nicholson, student research assistant with the Bureau of Vector Control, in carrying out field tests is gratefully acknowledged. Cooperating agencies providing field plots for experimental use included: Tulare Mosquito Abatement District, Kings Mosquito Abatement District, Merced County Mosquito Abatement District, Consolidated Mosquito Abatement District, and Kern Mosquito Abatement District. Several of the materials tested were made available through Dr. R. L. Metcalf, University of California, Riverside. Thanks are due the several chemical companies supplying materials for testing.

TABLE 1

Tests With Mosquito Larvicides in Irrigated Pastures Against Fourth Instar Larvae

COMPOUND	RATE APPLICATION LB/ACRE	24 HOUR PERCENT MORTALITY	
		Aedes nigromaculis	Culex tarsalis
Thimet[a]	0.025	56	75**
Thimet	0.05	88	100
Thimet	0.1	91	
Thimet	0.2	99	
Guthion[b]	0.05	90	75**
Guthion	0.1	94	100**
Guthion	0.2	96	
Guthion	0.3	100	
Trithion[c]	0.05	57	
Trithion	0.1	85	92**
Trithion	0.2	93	
Phosdrin[d]	0.1	79	77*
Phosdrin	0.2	82	82*
Diazinon[e]	0.1	95	
Diazinon	0.2	77	100*
Diazinon	0.4	100	
Di-Syston[b]	0.1	54	27*
Di-Syston	0.25	43	
Di-Syston	0.5	94	
Thiodan[f]	0.1	54	
Thiodan	0.2	65	60**
Thiodan	0.25		100**
Thiodan	0.4	88	
Korlan[g]	0.1	48	75*
Korlan	0.2	84	100*

COMPOUND	RATE OF APPLICATION LB/ACRE	24 HOUR PERCENT MORTALITY	
		Aedes nigromaculis	Culex tarsalis
MGK Pyrocide[h]			
Richfield Larvicide Oil	0.1 (Pyrocide)	51	
Triton X-100			
Co-Ral[b] (Bayer 21/199)	0.1	47	98*
Co-Ral	0.2	96	85**
Dylox[b]	0.2	77	60
Dylox	0.4	84	100*
Chlorthion[b]	0.1	30	69*
Chlorthion	0.2	98	
Chlorthion	0.3	96	100*
DDVP[i]	0.1	30	50*
DDVP	0.2	80	70*
DDVP	0.4	97	
Delnav[j]	0.1	35	20*
Delnav	0.2	26	100*
Delnav	0.3	87	
Toxaphene 4[k]	(.160 Tox)		
DDT 2 Spray	0.25 (.09 DDT)	57	80
Toxaphene 4	(.33 Tox)		
DDT 2 Spray	0.5 (.17 DDT)	91	99
Toxaphene 4	(.52 Tox)		
DDT 2 Spray	0.8 (.28 DDT)	91	
Dicapthon[a] (Am. Cy. 4124)	0.1	10	65*
Dicapthon	0.2	13	100*
Dicapthon	0.3	57	
Pyrenone #20[l]			
Richfield Larvicide Oil	0.5 (Pyrenone)	64	
Triton X-100			

* Based on 1 plot (not replicated).

** Average of 2 plots.

Source: Materials supplied by: a. American Cyanamid Co.; b. Chemagro Corp.; c. Stauffer Chemical Co.; d. Shell Chemical Co.; e. Geigy Chemical Co.; f. Niagara Chemical Division, Food Machinery and Chemical Corp.; g. Dow Chemical Corp.; h. McLaughlin-Gormley-King Co.; i. Alco Chemical Co.; j. Hercules Powder Co.; k. Fresno Agricultural Chemicals; l. Fairfield Chemical Division, Food Machinery and Chemical Corp.

mosquito control are: (1) high toxicity to mosquitoes, (2) low mammalian toxicity, and (3) moderate cost.

Several new insecticides were field tested in California on mosquito larvae during the period May to October 1957. In addition, tests were carried out on some materials that have been previously tested by other workers in order to obtain additional data on their performance. All tests were conducted on ⅛ acre plots in irrigated pastures of the San Joaquin Valley. Pre-treatment and post-treatment counts were made by taking twenty dips in each plot with a six-inch dipper equipped with a three-foot handle. Various dosage levels of emulsion concentrates were diluted with tap water to give one gallon of finished spray. Dylox and Phosdrin were applied as directly water soluble preparations, rather than as emulsions.

The gallon of finished spray was applied to the water surface of each plot by means of a one to three gallon, portable, hand can, spray tank with 30 pounds per square inch pressure. Usually about four swaths were required to cover each plot, the walking pace being gauged to insure complete coverage of the water surface.

The materials were evaluated for efficacy in 24 hours against fourth instar larvae. Each test was replicated three times unless otherwise indicated. No attempt was made to avoid testing in areas where insecticide resistance in mosquito larvae is known to occur. The results obtained are indicated in Table 1.

The materials that performed best as mosquito larvicides are organo-phosphates that unfortunately have a rather high toxicity to warm-blooded animals based on acute oral toxicity data on rats. Thimet, Guthion, Trithion, and Phosdrin are in this category. Di-Syston is also highly toxic to warm-blooded animals but did not perform exceptionally well as a mosquito larvicide, considering its high mammalian toxicity. The residual activity of Guthion and Trithion is worthy of consideration in control operations.

Materials that gave good control of larvae at reasonable dosage levels, and which are considerably less toxic to mammals on an acute oral basis than the aforementioned group, included Diazinon, Thiodan, Korlan, Pyrocide, Co-Ral, Dylox, Chlorthion, DDVP, and Delnav. Thiodan is a cyclodiene type of insecticide; Pyrocide is a synergized pyrethrin; the remainder are organo-phosphates. Unfortunately, Chlorthion will not be available commercially due to production difficulties.

Materials with rather low mammalian toxicity that gave only fair performance as larvicides included Toxaphene 4-DDT 2 Spray, Dicapthon, and Pyrenone No. 20. Dicapthon is an organo-phosphate, Pyrenone No. 20 is a synergized pyrethrin, and Toxaphene 4-DDT 2 Spray is a mixture of chlorinated hydrocarbons which is purported to be highly effective against resistant species.

Even though a material may exhibit desirable characteristics for mosquito control, there are several factors that tend to determine its real potentialities for general field use. Cost of producing the compound, use in the control of agricultural and household pests, residual qualities, formulation ease, and safety factors in handling are important in determining the commercial production of a compound.

Insecticides currently in use by mosquito abatement districts in California include DDT, toxaphene, lindane, heptachlor, malathion, and parathion. Satisfactory control is still being achieved in a few California agencies with chlorinated hydrocarbons. A growing number of agencies, after experiencing the development of resistance to chlorinated hydrocarbons, have switched over to either malathion or parathion. Although to date there has been no indication of resistance to parathion, the possible widespread development of resistance to malathion poses a problem. A backlog of alternate chemicals is available however in case a widespread resistance problem develops. From the data presented, it is evident that there are several materials that can be used as substitutes for malathion that exhibit a fairly low degree of mammalian toxicity. Costs in most cases will be substantially higher, however, than for materials presently in use.

In the final analysis, the actual selection of materials should be at the discretion of the control agencies since the performance of several of the insecticides tested are in the same category of efficiency as larvicides in current use, have similar ranges of mammalian toxicity, and are within the same range.

Many of the compounds tested in this evaluation of mosquito larvicides will not be immediatey available since they have not been registered for this use, or they are still in the experimental or developmental stage.

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Note: Dr. Gerhardt's paper, entitled "The Influence of Soil Fermentations on Oviposition Behavior of Mosquitoes," was presented at this time, but is being published elsewhere.

Thomas D. Mulhern's illustrated presentation on "Principles Involved in the Use of Mist Blowers for Mosquito Control and Practical Methods of Calibration" has not been submitted for publication.

The following paper by Mr. Mapes was not presented at the Annual Conference but has been submitted for publication in this Proceedings and Papers.

BRIEF HISTORY OF THE MATADERO MOSQUITO ABATEMENT DISTRICT AND MOSQUITO CONTROL ON THE SAN FRANCISCO PENINSULA

Gordon W. Mapes
Superintendent, Matadero Mosquito Abatement District

The original Mosquito Abatement District Act of 1913 passed the California Legislature but failed to become law, having been vetoed in that year by the Governor. This Act, known as the Guill Bill, made its way through the Legislature by effort of the malarial Counties (Sacramento Valley) in the interests of public health.

The second major effort toward Mosquito Abatement came in 1915 from a very different source—that of the real estate interests and land owners of the San Francisco Peninsula to further their interests. The dense hordes of mosquitoes arising from the bay marshes retarded the population increase of the Peninsula and also in Marin County. In 1915, therefore, a second Mosquito Abatement District Act was passed by the Legislature, which became law.

Very quickly thereafter developments toward mosquito control took place on the San Francisco Peninsula. The Three Cities Mosquito Abatement District was organized in 1915, The Pulgas Mosquito Abatement District (Redwood City) in 1916 and the Matadero Mosquito Abatement District (Palo Alto) in 1918.

The early figures of the struggle of men for mosquito control on the Peninsula embrace such names as Quale, Doane and Stover. The efforts of Prof. Quale of the Zoology Department, Stanford University, date back as far as 1903. Prof. Rennie Doane carried on his efforts to further mosquito control in the early teens and his later work in the Matadero District in the twenties and thirties of the present century. To further the work carried on by these distinguished Entomologists, a third name should be added in the field of Engineering, that of Nobel Stover, the creator of the automatic flood gate which since has gone around the world (but which unfortunately does not bear his name). He is reputed to have had a background in South America before coming to the Peninsula. (Earnest Campbell, present Manager of the Contra Costa Mosquito Abatement District was assistant to this great man).

(To complete the picture of man's efforts toward mosquito control in the early part of the present century in California, mention should be made of the monumental work carried on by the great team of Herms and Gray to reduce the incidence of malaria in the Sacramento River Basin through abatement of Anopheline mosquitoes).

It will be seen therefore, that in these early days of man's struggle for mosquito control in California, it was for the most part a combination of Entomologists and Engineers working together. Quale and Doane, Entomologists and Stover, Engineer on the San Francisco Peninsula—and Herms, Entomologist supported by Gray, Engineer in the Sacramento River Basin.

Other early names on the San Francisco Peninsula include the late Carl Pittard, veteran of World War I and successor to Nobel Stover in the Three Cities District. Mention should also be made of T. L. Murray, orignal superintendent of the Pulgas Mosquito Abatement District. This very capable young man in 1918 devised a sprayer consisting of a main compressor and a receiver which was used as pressure oil tank mounted on a truck and provided with a long hose and nozzle. The career of this promising young man was cut short by pneumonia and he was succeeded by the late capable and memorable Joseph Dickey.

Coming to the Matadero Mosquito Abatement District, Palo Alto, we find Dr. Rennie Doane, Entomologist, Stanford University, to be a dominant figure in its organization in 1918 and the early years of its operation.

As his Superintendent, Robert Hackley, a young Engineer from Stanford University carried on an effective drainage program of marshes in the Mayfield and Charleston Slough areas of San Francisco Bay. This excellent work had barely been accomplished with outstanding results when installation of the great salt ponds in the southern portion of the San Francisco Peninsula upset the tidal pattern and changed the entire environment. Loss of tidal flow resulted in tidal siltage and obstruction of main drainage channels.

To help meet this situation, Dr. Doane obtained the services (for several years on the Board of Trustees) of the late Dr. Leon B. Reynolds, former Professor of Hydraulic and Sanitary Engineering, Stanford University.

Also, into this new picture came another Engineer, the late Donald Steel, of world reputation, to work out the complicated drainage problems confronting the area.

The great urban growth of the present decade plus the ever present problem of tidal silt has still further complicated the general drainage situation. Flash flooding from hard surfaced upland areas quickly fill the low lands and marshes in storm periods further increasing mosquito problems.

Professor J. B. Wells, Engineer and President of the Board of Trustees of the Matadero Mosquito Abatement District, and retired Professor of Engineering, Stanford University, has given unstintingly of his services to the Community in meeting the growing problems of mosquito control confronting Northern Santa Clara County.

The rapid urban growth and improvement of land has altered drainage and has produced changes of environment calling for adjustment of Flood Control (protection of populated areas in times of flood) with low level drainage (mosquito control in normal periods).