PROCEEDINGS AND PAPERS

OF THE

Thirty-fourth Annual Conference of the

California Mosquito Control Association, Inc.

AT THE

CASA MUNRAS GARDEN HOTEL

MONTEREY, CALIFORNIA

JANUARY 30 - FEBRUARY 2, 1966

Proceedings Committee

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CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

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CALIFORNIA MOSQUITO CONTROL ASSOCIATION
FIRST SESSION

MONDAY, JANUARY 31, 1966, 9:30 A.M.

CALL TO ORDER

WILLIAM L. RUSCONI, *President, Presiding*

I would like to welcome you to the Thirty-fourth Annual Conference of the California Mosquito Control Association. This conference is now in session.

WELCOMING ADDRESS

JOHN M. PATTULLO
Mayor, City of Seaside, California
Presented by Howard R. Greenfield

On behalf of the cities represented by your host district, I wish to extend a cordial welcome to the Monterey Bay Area. I hope your stay here will be enjoyable and your deliberations fruitful.

From personal knowledge, having lived here before my city joined the Northern Salinas Valley Mosquito Abatement District, I can state without equivocation that we have a better place in which to live because of the efforts and accomplishments of you and your associates. Members of this association can take pride in having made life more enjoyable throughout our state.

CHANGING PROGRAM PERSPECTIVES IN ENVIRONMENTAL QUALITY MANAGEMENT[1]

FRANK M. STEAD[2]
State Department of Public Health
Berkeley, California

The "keynote" role is always a difficut assignment. At least to me, it always presents a special challenge. It seems that the audience, with one accord, is saying, "I dare this presumptuous character to keynote me." So I'm not going to try to keynote you. If, however, you will consider that the three speakers this morning —Senator Farr, Mr. McFarland and I—really represent the three major parties and interests in the field of mosquito control in California, and bear in mind that we are trying to explore our relative roles of mutual support of a joint program, *this* is the keynote. Now, having the keynote obstacle out of the way, we can get on to sharing some thoughts on program perspectives.

It is trite to say we are living in a time of tremendously rapid change—change so rapid that the transformations we witness now in the course of ten years' time are actually greater than those of the preceding century. This rapid escalation of the rate of change is well known. What we do not always stop to take into consideration, however, is that as a consequence of this change the basic assumptions upon which most of our programs have been based—in fact, the foundations of our individual and collective professional development —are shaken. In some cases they are no longer valid. It becomes imperative, therefore, that we frequently stop and take stock of our objectives and the knowledge and resources upon which our programs are based.

You and I, during our own professional careers, have taken an active part in two fundamental periods of California development, and we are just about to embark on a third. Seldom has it been the privilege, or the dilemma, as the case may be, of a group of men to be the product of a recently extinct technological era; to be struggling with awesome complexities of a distinctly new era; and to be making hasty preparations for another period yet to come. In the context intended here, these three periods are identified with environmental quality—our attempts to influence the quality of the human environment in California.

ENVIRONMENTAL SANITATION ERA

The first of the three periods would include the years from 1900 to about 1940. We might refer to this as the period of environmental sanitation. What were some of the characteristics of this period? In the first place, the period of environmental sanitation was characterized primarily by a single objective, that of disease control. While certainly not exclusive, this was the predominant concern that gave character to this period. We were preoccupied during this period with a quality of the environment very close to the point of direct utilization by human beings. Our concern with water was restricted almost exclusively to features and functions of domestic water systems, and even here the focus of interest was on the last few hours before human beings consumed the commodity. Our concern with food likewise was restricted in time and space to those events that took place in the processing and serving of food. Most of our environmental control measures were taken at this last link in the environmental chain—to break the cycle of infection of any communicable disease that might represent a potential hazard. Our concern with air sanitation was almost entirely restricted to industrial hygiene—the quality of air in a man's place of work, the source of contamination usually being only a few feet from the respiratory intake of the workers in question. In addition, this period was marked by an environmental system which we visualized to be made up of waste loadings. These loadings, put on the environment in the form of wastes, were identifiable as single individual points of discharge. There came, therefore, into our program a concept of point sources, emission of adverse commodities into the air, the water, or onto the land. A

[1]Keynote address: Thirty-fourth Annual Conference, California Mosquito Control Association, Monterey, January 30, 1966.
[2]Chief, Division of Environmental Sanitation.

corollary to this point source concept was a very small group on the receiving end. If you would visualize, for example, a clearly identifiable source of smoke, or dust, or odor, then usually downwind over a small area of possibly a few square blocks one would find the penalized segment of society. With this two party system both parties clearly understood who the other was. It was a classical situation where some types of environmental impairment could actually be abated in civil court by one injured party suing one offending party.

The responsibility for environmental management during this period of environmental sanitation was assigned almost exclusively to the State Department of Public Health, working to the extent possible in collaboration with the local health departments. It was only a very few years ago that these circumstances prevailed. Thus, a single agency was armed with an authority given to it by common consent by the Legislature—which in fact was a total assignment of the police power—an authority seldom if ever before given to a single agency of government in a democratic society. This police power enabled the Department of Public Health to take actions without the usual concept of due process associated with going through the courts. The reason, of course, was that this was a period of preoccupation with disease control and communicable diseases, and the consequences of a failure in the environmental control machinery could be catastrophic, taking the form of vast epidemics that might actually decimate a community. These consequences were so grave that it was not necessary to stop and weigh the cost of a protective measure against the benefits. By tacit consent it was agreed that any measure the health department judged necessary was well worth any cost that might be entailed—any cost in infringement of liberties of the individual, any cost in dollars. This, then, was the period which perhaps you have already forgotten, a period when the ground rules only faintly resembled those we see in operation today.

Pollution Control Era

About 1940 there was ushered in a distinct, new period, a period which I confidently predict will end by 1970. This confidence is based on the fact that one can already see the beginnings of its successor. This period from 1940 to 1970 I think we might call, at least in my frame of reference, the period of pollution control. During this period a whole new set of concepts has entered into the management of environmental quality in California. In the first place, two new objectives took their places alongside the objective of disease control that marked the earlier period. These objectives were nuisance control and the control of property damage.

Our concepts of public nuisance have been handed down through our Anglo-Saxon heritage. They are written into the common law of England and their basic structure has not changed for hundreds of years. We usually identify a nuisance as something which interferes with a comfortable enjoyment of life or property. Many people have died to defend and sustain this principle. It is a strange feature of our culture and of our governmental and public service concepts that we tend to deprecate this question of nuisance as though it were something beyond our sphere of understanding and responsibility.

One would not ordinarily consider identification with nuisance abatement to be a position of high status. Certainly white collar professional people are apt to consider themselves above dealing with problems of the neighbors' chickens or problems of single isolated petty acts resulting in offense to a neighboring group. Yet if you will think about this—this concept of nuisance and the right to be free of nuisance is one of the very fundamental rights of our culture. It was quite logical, therefore, for nuisance abatement to become a prominent feature of this period of pollution control. Carrying our definition a bit further, nuisance abatement is the defense against those impairments of environment that tend to destroy basic comforts of life, usually identifiable as offenses to the senses of sight, or smell, or hearing, or actual physical impairment to the systems associated with these primary senses. Closely linked with the concept of nuisance, as mentioned previously, is the full enjoyment of life and property, or in some instances, the question of actual property damage.

Thus it was during this period of pollution control that the concept of control of loadings on the environment to prevent unreasonable damage came into clear focus. Our problems of water quality were concerned with man's adverse influence on the aquatic components of his environment and the degree of control required to prevent unreasonable impairment of water and its manifold beneficial uses. Our concept of air pollution was the concern for man's well-being and the damage to living property. The biggest measurable toll which air pollution has taken in California is, of course, the damage to growing crops. The second level is perhaps the damage to living animals of economic concern. Probably third in magnitude is the damage to physical property—beginning with ladies' nylon stockings back around 1938 and subsequently extending to many other things.

It is also significant that with the onset of this period of pollution control we almost completely abandoned the concept of an offending party and a victim. We suddenly realized that there are so many discharges into the environment—into the air, into the water, or onto the land—that it is virtually impossible to identify precisely their origin or the resulting level of pollution at any given point. People are now breathing air, using water, and occupying land to which there has been applied the burden of wastes by literally thousands of different parties—including very likely the potential complainant. Thus, the simple concepts which in the past made a remedy in court possible—namely, an identifiable villain and an identifiable group of victims—has disappeared. With this we suddenly realized that we must apply an entirely new concept of management.

The new concept has taken shape as a belief that there are permissible loadings for air, land, and water that could be borne without society as a whole being unduly penalized. The present period of pollution control has been marked by an effort to so manage the discharge of wastes that this assimilative capacity of air, land, and water would not be overtaxed and, therefore, in a sense we could have our cake and eat it, too.

We could proceed on the basis that the rivers of the world are the sewers of the world—that the atmosphere is the logical place to discharge all of the gaseous and particulate wastes which we have been in the habit of discharging, ranging from cigarette smoke to motor vehicle exhaust—that this is a logical system and it would be unreasonable to think of modifying it.

The next matter for consideration here, however, is this question of property, with its concepts of economics. It is no longer possible to discount this fiscal or economic impact of controls as we did when only human health was at stake and when costs were more or less academic considerations. As it is now, in addition to determining costs, one must weigh these costs against the benefits. In this period of pollution control we no longer strive for absolute correction of the faults as we did in the period of disease control. We expect to have some impairment of the air, land, and water and the limit of this impairment is a judicial matter that we entrust not to the courts but to a new type of governmental function called regulation. Regulation is a way of dealing with control when it is no longer possible to identify a guilty party—you merely make some ground rules.

Regulations are interesting things. A regulatory program usually follows a biological S-shaped growth curve with a decay on the far end almost like one would expect of any typical biological phenomenon. Regulations are first conceived as regulations of convenience. It is assumed that if everyone is reasonably responsible, then certainly this will be enough; but as the loading increases, as it did during the 1940's, it becomes immediately apparent that regulations of convenience are not nearly enough. As a result, we strive for tougher and tougher regulations until we get regulations of feasibility, then regulations of attainability. "Attainability under present technology"—surely this is the ultimate. If we ask every party to do the very best that our technology permits him to know how to do, surely this is enough—or is it enough? When the electorate of this state embarked upon the California Water Plan it discarded a concept of natural lakes and rivers which would receive and dilute the treated wastes that are discharged in liquid form. This concept became obsolete over night because south of the Sacramento-San Joaquin delta all of the waterways are man-made conduits and it is no more logical for a community to discharge its wastes, treated or not, into that conduit than it is for you to discharge the wastes from your household into the water main in the street. Thus this concept of treatment to the point of technical feasibility became obsolete.

In 1959 the State Department of Public Health, at the behest of the Legislature, enunciated air quality standards, for the first time in the world, describing good air and describing two levels of less than good air. The first point of interest is that all of our communities by their actions, and all of our counties by their actions, elected to take on what was closest to the good air standard. The Legislature then asked us to establish motor vehicle exhaust standards. These are emission standards, not on the basis of what is technically feasible but on the basis of what is needed to meet the established air quality standards. We computed these standards as directed, and in 1960 enunciated the motor vehicle exhaust emission requirement. It was not until the current model of cars—those that are just now coming out—that technology caught up. This is a new concept, as you can see, of going beyond the technologically feasible in establishing a standard. This projects us into the new era which I say will be here with a vengeance by 1970.

Another strange, or perhaps not so strange, but very important consequence of this shift from environmental sanitation to pollution control is that the Health Department is no longer the sole agency of authority; in fact, it is not always the central party on the control team. First of all, we have a proliferation of governmental regulatory agencies in various forms. These may take the form of line departments of government or they may appear as new instruments of government, often in the form of special districts. These are districts with appointed officers operating in a quasi-legislative manner. Thus, we have air pollution control districts, water pollution control districts, and regulatory districts of various kinds. These regulatory districts perform no direct service comparable to the operations of mosquito abatement districts. These are the sheer instruments of regulation, established to enunciate and enforce the rules within their respective jurisdictions. This brought into view then another kind of agency: the operating agency.

Water pollution control regulatory agencies govern the actions of a wide variety of special service districts, private and public water companies (in a sense by determining the quality of their raw product), a wide variety of sanitation and sanitary public utility districts, and other districts that engage in a wide spectrum of liquid waste disposal activities; in addition, they regulate those line functions of government which are engaged in similar operations, such as a department of public works constructing and operating a sewer system; beyond this, of course, industries are being regulated more and more from the standpoint of water and air pollution control. So, as you can see, we now have a system of three principal parties and interests: the regulatory group, the regulated group, and the public on whose behalf all this goes on. The two party system has been replaced by the three party system.

Systems Analysis Era

Looking ahead to 1970—although the line is not sharp we can already see it coming into focus—a new concept of environmental quality management appears inevitable and, in fact, is already coming into being.

Our ideas that every locality, every political jurisdiction, and every private enterprise consolidation of power and resource may operate under a three party system of regulation must give way to a broader concept. Our environmental burdens have reached a point where it is no longer possible to adhere to the concepts of pollution control. The assimilative capacity of the basic environmental resources is no longer the solution. Whether they are to be discharged into the air or into water or upon the land, we are approaching the time when waste products must be treated or otherwise improved to a point where they virtually meet the quality criteria set ultimately for the environment. This forces us into an entirely new concept, one commonly referred to now as the "systems analysis" approach.

The systems analysis approach is usually identified with a highly sophisticated methodology, relying heavily upon the use of mathematical models and simulation. This procedure is, however, marked by a few simple, basic concepts. For example, when one sets out to solve a problem under the systems approach he must describe a broad enough area to include all aspects of the problem. Every act that takes place in this area and within this system is circumscribed by the same perimeter. In like manner, all of the effects of these acts, all of the costs, all of the benefits, all of the penalties, and all of the rewards assigned to different people are within this same system. Also, under the systems approach, the objective is to optimize the end result in terms of benefits for the total population, not for just those with wastes to discharge, not for just those who want to use the water or the air or the land directly, but for the total population. This calls for a new set of standards and, in fact, a new vocabulary of environmental quality. Designing a system in this manner usually makes completely obsolete the concept of discharge of wastes in the classical sense. Instead, the process is apt to become a conservation operation —perhaps a direct recycling. It is almost certain to become a broad management function, usually within large topographic basins, embracing the entire air, water, and land resources. It discards the concept of discharging one's used waters into a transportation system that takes them to the ocean.

A new and profoundly important objective is reached at this point. There emerges here a realization of one of the greatest values of all in environmental quality control—to preserve what we call, sometimes half apologetically or with a lack of clear conviction—"esthetics." As was shown true for nuisance, our heritage of esthetics is also deep rooted. English statutes of the 17th Century, our own Bill of Rights, the Constitution of the United States as well as that of California says that men are possessed of certain inalienable rights, among which is the pursuit of happiness. This is the actual affirmative side of living.

If one tries to describe the economic values of esthetics and to compare them with the more familiar utilitarian values, some remarkable conclusions emerge. For example, I computed what it would take to shift in California from present disposal of liquid wastes by dilution to complete recycling, so that wastes are no longer wastes but become a useable resource. This would require the reclamation of all sewage and the mineral conversion of all agricultural and industrial wastes that are high in mineral content, with less than 5% of the total volume of used water leaving the basin and the other 95% remaining. This adds up to about a half billion dollars per year—5 billion dollars over a 10-year period—to make this transition. Usually this is expressed properly on an annual basis because we are talking about operating costs of conversion. This works out to just under eight cents per capita per day.

A similar analysis was made on air pollution, including a transformation of our present system of industrial use of the atmosphere as a regular repository for unwanted gaseous materials and a change over of the automobile to an exhaustless type vehicle. This also comes out about 5 billion dollars over a 10-year period. If we spread these costs we find they are not operating costs, but capital outlay costs. Again, we come out with almost the same figure. As a result, we end up with about 10 billion dollars over 10 years, or 18 cents per capital per day, to establish the water quality and the air quality of the state at desired levels.

In California we spend about one dollar per capita per day for food, and at least one-third of this is for the enjoyment of the food, not for its nutritional value. We spend a like amount, one dollar per capita per day, for housing, and at least one-third of this is spent not for sheer protection against the elements but for enjoyment of the place in which we live. We spend very close to a dollar per day for every adult in our society for transportation and at least one-third of this is, by our choice, for enjoyment, in contrast to using a utilitarian vehicle or mass transit. Here are just three areas in which we are spending a total of three dollars per day, one-third of which is for esthetics. This means that we are now spending a dollar per day per capita for the esthetic values identifiable with only a portion of our environment. Is it not immediately apparent then that 18 cents per capita per day for the total environmental setting in which these values take meaning is an absurdly small amount from standpoint of true human worth? Approached in this way esthetics becomes a pearl of great price, not a mere fringe benefit. It assumes its true stature in human values far beyond the so-called utilitarian system on which decision making has been based in the past.

When one uses the systems analysis approach one establishes the environmental quality that one intends to maintain because it is in response to these real values. From this, one then demands the technology required to accomplish the objective—*technology upon demand*. The Manhattan Project, established to produce the atomic bomb, did not come about by research as usual—this was technology upon demand, with a demand time-table. This is absolutely essential as we move into the area of environmental quality management under the systems approach.

Finally, this new era which we are embarking upon will not find the regulatory agency regulating the operating agency on behalf of the individual, or indeed regulating the individual himself. We now move into a system in which we realize that the power structure is almost equally balanced between government and private enterprise. This is because the financial resources, or the ability to spend money, are almost equally divided. We must, therefore, replace the one-over-one-over-one system with a joint venture. This must be willingly entered into so that the planning function for environmental quality and the restraints that must be applied are mutually respected.

The systems approach has been used with amazing success in the development of weaponry by the aerospace industry. The techniques are equally applicable to running the environmental closed capsule—California is an environmental capsule, similar in many respects to the space capsule, itself. The one thing that has not yet been produced by the aerospace industry is the know-how to bring this joint venture about—a joint venture of government and private enterprise, undertaken with the understanding and blessing of the electorate. This last frontier must be breached.

As has been stated, in the environmental sanitation era and in the pollution control era we have been preoccupied with wastes. As we move into the systems era there are no wastes—it becomes resource management. In this frame of reference let us now look at mosquito control in California as you and I have known it.

Our partnership began in 1946, just 20 years ago. You had a 20-year history before that but most of you came onto the scene at about the same time as our department did, with a realistic and productive partnership starting in 1946. I think we share an understanding of our common history and I believe you will recognize the description with which I would characterize the last 20 years of mosquito control in California.

Mosquito control has always dealt with a system. Because of the very nature of your work you are concerned with an ecosystem. Looking to the focal point of your system, the mosquitoes were there to some extent long before the human population moved into the area. A relatively stable biological system was in existence for a long period of time, although it has become increasingly unstable during the period of man's increasing dominance. It was impossible, however, to do realistic mosquito control work even in the early days in California without dealing with a dynamic environmental system and attempting to so modify and manage this system that the balance would be tipped in favor of mosquito suppression. It is significant here that fundamentally the approach to mosquito control in California has not been one of attacking the problem at the point of human contact by use of repellents, screening of buildings, or residual spraying of homes; here we have always said that we must deal with a comprehensive system, including again that basic ecosystem that produced the phenomenon in the first place.

The system of mosquito control is more complex than the system of water or the system of air because you have two primary biological entities or almost equal preoccupation to you—the mosquito and the human being. You want to make one regress and the other prosper. Most of you here got an early start with the systems approach and in doing so tackled one of the toughest systems possible. This makes the successes that you have had even the more remarkable.

The primary variable of concern to you, the controllable variable in your system, is really not wastes. Of course, wastes are an important consideration in your work. The accumulated water at the lower end of an irrigated pasture is a waste. Any careless disposition of unwanted water is a waste in this sense. The habits of householders and of cities in their handling of liquid wastes intensifies your problem. But the primary commodity that you are dealing with is not waste—it is a resource, and that resource is called water.

Your objectives have never been sharp and clear. I mentioned that in the environmental sanitation period the objective was sharp and clear; it was disease control and that was it. You started in with a sort of composite assumption of responsibility, some from the period of environmental sanitation, namely, disease control, some from the period of pollution control, namely, nuisance and property damage prevention. You are also in the area of esthetics but you are in it indirectly because mosquito control impinges upon esthetics by determining whether or not certain forms of recreation and enjoyment of the outdoors are available to the people. Your esthetic concern is to make an esthetic environment habitable to people. If the patio is not usable in the sundown hours, people have been deprived of that form of esthetics, whether it is the active forms of recreation or the more profound form of recreation. To many of us the most profound form of recreation is merely to be able to walk into an area, be it an agricultural area or a forested area, where true ecological harmony exists and where one can seek and find in this troubled age his real identity. This is the esthetic carried to the ultimate.

Mosquito Control at the Crossroads

Those of you in mosquito control have been at a distinct disadvantage in that you have never been sure what your responsibility is as a profession. Is it to make the full 102 million acres of California freely available and habitable to the people who wish and need to move freely through the area? You have been in a most confusing predicament because, for most of you, your professional lives have fallen entirely within this pollution control period. Other programs of environmental control during this period have been composed of a regulating team, a group of regulated operating agencies, and the public. You have been obliged to straddle the fence; you are a regulatory agency and you are an operating agency. With such a dichotomy there is a schizophrenic effect which is almost a conflict of interest. One cannot regulate himself. In a sense you are regulating individuals and, at the same time, as an operating agency you are serving individuals. Beyond this, what is your relation to the regulatory authority at the line level in the executive branch of state government? Exactly what is your relationship to the State Department of Public Health? This has never been clear. It is a mixture of relationships. There is nothing wrong with a mixture of relationships if they are visible, clearly understood and work efficiently.

Finally, you have been unable to do what one must do in the systems age—produce your technology with respect to time-table on a demand basis. This problem must be solved.

When one considers these obstacles, dilemmas, or burdens of confusion that cloud the official relationships in the field of mosquito control, it is amazing that the program has made such progress and that such good relations exist between your agencies and our group. This is a tribute to the human values and maturity of the individuals who are able to serve effectively in spite of a most tangled and confused system and general absence of clear ground rules.

It is always much easier to describe the problem as I have tried to do than to suggest a solution. In closing, however, I should just like to make three points, perhaps suggest three directions which our joint search for the solution must follow. By joint search I refer to mosquito abatement agencies, the State Department of Public Health, and the Legislature. We must first clarify the objectives of mosquito control in California by function and by geography, and give the right priority to these objectives—the objective of disease control, the objective of nuisance prevention, the objective of protection of property, and the objective of islators then have more time and a better opportunity to become well informed.

For example, the Natural Resources Committee, of which I am chairman, recently looked into the matter of "geothermal energy." We spent 2 days looking at geysers and molten brine that comes out of the earth. Two years ago this committee at Santa Barbara learned what a forest fire could cost. As a result, we have been very strong on fire prevention legislation. This is the kind of thing I urge you to bring before the fact-finding committees of the Legislature. Get hearings set up, bring your problems to these committees, and you'll find that you have a number of legislators who will be in great sympathy with your problems and try to help you.

I, for one, feel that I know a little more about your problem—having lived in Puerto Rico for a while, having travelled in Latin America, having read some of your literature recently and the fact that you asked me to be on your program. I certainly welcome the opportunity to work with you and to help you, because if we are going to develop the natural resources of California, as we anticipate we will, we must understand each other. We are developing great new bodies of water, which directly or indirectly will result in breeding places for mosquitoes; you have mosquitoes resistant to insecticides; when you use insecticides, you need to consider what they may do to the total environment; you certainly do have research needs; —all these items and others deserve the interest and attention of the Legislature.

I am confident you will meet with success in securing the consideration your vital service deserves by clearly showing to those influencing the direction of your program its relationship to other factors for sustaining a healthy and productive environment. Thank you.

IMPLICATIONS OF 1965 LEGISLATION ON LOCAL MOSQUITO CONTROL OPERATIONS

Gardner C. McFarland

Southeast Mosquito Abatement District

Control of mosquitoes and other vector activities in California is carried out within a framework of an existing body of state law and regulations. These laws and regulations are principally in the Health and Safety Code and the Government Code. Other laws and regulations that affect operations of mosquito and pest abatement districts are included in the Agricultural Code, the Penal Code, Fish and Game Code, Labor Code, and Vehicle Code, as well as the California Administrative Code.

It can be stated, that for many years mosquito and pest control law with its ramification of formation, powers, duties, annexations, consolidation, and dissolution was relatively stable. Although many amendments to the Health and Safety Code were adopted by the Legislature over the years, these amendments could in large part be considered minor clarifications and technical improvements. Some of the many minor changes included:

1. Elimination of the District Investigation Act requirements.
2. Authorization of minor boundary changes.
3. Establishment of terms and conditions by the State Board of Health for mosquito abatement agencies when State Subvention Funds were used.
4. Change of in-lieu expense amounts for trustees.
5. Codification of nuisance abatement powers and clarification of tax rates, power of borrowing money, liens, etc.
6. Maximum tax rates.
7. Authorization of annexation of noncontiguous territory under certain specified conditions.
8. Annexations of cities and portions of counties by actions of city councils and boards of supervisors as well as by petition.
9. Withdrawal of territory from mosquito abatement districts.

The additions and amendment were in large part sponsored by the California Mosquito Control Association since the members of the association were most closely connected with the mosquito and vector control field and knew its necessary needs from a legislative standpoint.

There was much legislation introduced in the 1965 legislative sessions that affected mosquito control agencies to one degree or another. Legislation that passed included:

Assembly Bill 186. This bill dealt with the formation of community service districts and authorized a filing date on new formations up to March 1, 1965 and is in Chapter 6.

Assembly Bill 407. Amends Section 3011 of the Fish and Game Code relating to pesticides in Chapter 74.

Assembly Bill 598. Involves labelling and use of pesticides in Chapter 882.

Senate Bill 169. Provides penalties for suit against governmental bodies which suits have no merit and is in Chapter 145.

Senate Bill 516. Requires beekeepers to notify the Agricultural Commissioner of movement and location of beehives within 5 days of such relocation and is in Chapter 199.

Senate Bill 877. Permits boards of supervisors of counties to call special elections for selection of governing board members of a district where a vacancy is not properly filled and is in Chapter 613.

Research Funds. Funds for operation of the mosquito research program of the Bureau of Vector Control were properly placed in the State Health Department support budget but were restricted by the requirement that they be subvented to the University of California. The mosquito research fund request by the University of California was omitted completely by the Legislature.

The most important legislation that passed was Assembly Bill 592, called the District Reorganization Act of 1965, sponsored very effectively by Assemblyman Knox. This bill materially changed the provisions of the Health and Safety Code relating to annexation, detachment, dissolution, and reorganization of mosquito and pest abatement districts. Many classes of special districts were also covered by the new law although certain special districts such as metropolitan water districts were excluded. As a matter of interest, the principal acts of formation of special districts were not affected by the District Reorganization Act and neither were the officers, powers, finances, taxation, and annexation of noncontiguous territory. Annexation procedures of noncontiguous territory, however, are covered in the Act.

Involvement of the California Mosquito Control Association in the deliberations of this District Reorganization Act was active, as was that of other government agencies, city, county, and other special districts. As a result of this legislative process, certain inequities in several sections of the bill were corrected. Of most importance, was the elimination of the provisions that required first class mail notice of detachments and annexations to all landowners of record as well as such notice to all resident voters of record. Elimination of these provisions will help save taxpayers the possible expenditures of thousands of dollars over the years.

Legislation affecting special districts, however, is not now in a state of stasis. No doubt, the next regular session of the Legislature will have a number of amendments providing for changes in the Government Code placed there by the District Reorganization Act. Perhaps much of this legislation will be of a technical nature to correct ambiguities and will provide necessary clarification. On the other hand, there may be additional legislation proposed that will have far reaching implications.

As you know, there is a body of thought that is concerned with the mandatory lumping together of many special districts under the umbrella of one master district such as community service districts, presently in operation in some counties. Perhaps legislation will be introduced in the next regular session which will attempt to accomplish this objective. All those concerned with the continuing accomplishments of mosquito and pest abatement districts should be ever alert to study each proposal made that will make changes in laws that affect our agencies.

For instance, of those bills in 1965 that failed of passage, several are in process of interim study and may be introduced in the next regular session.

Assembly Bill 613. Would liberalize certain rules for Workman's Compensation disability payments. Passage of such legislation may be desirable and would affect more than just mosquito control agencies yet must be balanced from the standpoint of its effect on the taxpayers and the needs of the State as a whole.

Assembly Bill 974. Involves more restrictive bid procedures of governmental agencies. Again, legislation of this type must be considered from the standpoint of its financial impact on the taxpayers.

Assembly Bill 1647. Would have allowed withdrawal of unincorporated territory from Mosquito Abatement Districts without any checks or balances. Checks and balances are now included in the District Reorganization Act, but could be negated by successful passage of such legislation.

Assembly Bill 3264. Would have given Special Districts representation on local formation commission boards. Legislation of this type has the purpose of making local agency formation commissions more representative yet the smaller districts would seldom be truly represented as a matter of practical fact.

Senate Bill 862. Would have restricted the free entry rights of mosquito control personnel into private property. Such legislation without proper safeguard could greatly damage the effectiveness of mosquito control.

Senate Bill 1205. Made certain algae research projects and control measures mandatory under certain conditions. Careful study of this type of legislation is most important for a position to be taken since haphazard functions required of our agencies could have disastrous financial implications on the taxpayer.

As can be seen from the foregoing observations, certain of this legislation may be desirable but much of it will have the opposite effect. What can be done about legislation is up to those directly affected. Certainly, the California Mosquito Control Association through its Legislative Committee, can study, make recommendations, and assist the Legislature by supporting good legislation and by opposing undesirable legislation during the legislative sessions.

More than this is needed, however, to be effective in support or opposition of introduced legislation. Our legislators in Sacramento are veritably deluged with legislation each session and find it impossible to consider each legislative bill in detail. The assemblymen, senators, and their aides are anxious to know the needs of their constituents, yet find it difficult to properly evalute these needs intelligently during the relatively short sessions. It therefore behooves all those concerned, trustees, employees, and other interested agencies and individuals to explain and document the programs and needs on a continuous basis year after year particularly between legislative sessions. How else can our legislators, appropriate state administrators, city councilmen, county supervisors, and organizations such as the League of California Cities, the Conference of Local Health Officers, and other concerned groups know the merit and necessity of our agencies and programs? If we inform these all-important leaders clearly, logically, and adequately, then they will be able to provide and protect our legislative needs intelligently and properly.

I repeat that our legislators are deluged with requests for action on particular matters at critical periods usually during legislative sessions and particularly at the hectic hours of the last days of a session. If they do not have the background and understanding of our justifiable needs, how can they be expected to serve us adequately? They will not be able to do so without this information and background so all in the fields of mosquito and vector control should make it their business to inform and educate. Our legislators and others concerned with legislation will then be able, from this broad base of knowledge, to consider the merits of our necessary and legitimate requirements. There will be no other result than better and more useful service to the people of California by our agencies.

SECOND SESSION

MONDAY, JANUARY 31, 1:30 P.M.

MOSQUITO PROPHYLAXIS

Oscar V. Lopp, *Presiding*

RECENT WATER MANAGEMENT RESEARCH

Robert J. Reginato and Lloyd E. Meyers

U. S. Water Conservation Laboratory

U. S. Department of Agriculture

Recent water management research conducted at the U. S. Water Conservation Laboratory relates both directly and indirectly to mosquito control programs. It is well known that faulty agricultural practices result in the inefficient use of agricultural water supplies and create mosquito problems in many areas. It is the responsibility of various research and action agencies to identify and correct these unsound practices. Generally, mosquito control programs and good water conservation practices complement one another.

Five research projects in progress at our laboratory are directly related to mosquito control problems. These are evapotranspiration, water measurement, seepage measurement, seepage control, and soil structure. Two other research projects relate indirectly to mosquito control programs; namely, evaporation reduction and water harvesting.

First let us examine those five investigations which have direct application to mosquito control.

Evapotranspiration research is aimed at increasing irrigation efficiency which will result in reduced surface waste water. Generally, more water than necessary is applied to crops, because exact crop needs are not well known. Our investigations in this area are to develop and verify methods that will enable the accurate determination of evaporation from crops and soils.

Since we live in a dynamic environment, we must be able to describe and measure those factors which affect evaporation for short periods of time. In the past, research workers have been handicapped by the necessity for working with daily and weekly averages of pan evaporation and various climatic factors used in estimating evaporation, even though it was known that these averages could be misleading. Electronically weighed lysimeters at our laboratory give accurate evapotranspiration measurements for time periods as short as 15 minutes (Van Bavel and Reginato 1962, Van Bavel and Myers 1962). At the same time, measurements are made of many climatic factors, such as net radiation, windspeed profiles, air temperature profiles, vapor pressure gradients, and heat flux through the soil (Fritschen and Van Bavel 1962, Fritschen and Van Bavel 1963). With such an array of instruments recording on 15-minute intervals, you can imagine the voluminous data that are rapidly collected. Fortunately, all these data are recorded on punched tape which is sent directly to a data processing company for automatic high-speed computation. The time saved by computer analysis as opposed to desk calculators is tremendous.

We have progressed to the point where some field applications are already in view. Presently we are developing and testing two separate methods for accurately and continuously measuring evapotranspiration in the field for time periods as short as 15 minutes (Fritschen 1965, Van Bavel 1965). The usefulness of these data is in the fact that by knowing how much water a crop has used and, from other investigations, the amount of water the soil can hold, the correct amount of water can be applied to fulfill crop needs. Excess water need not be applied, and standing waste water will be reduced.

This discussion leads to the next research project, water measurement. By knowing the water use of crops and the moisture-holding capacity of soils, the correct amount of water to apply must be measured on the field. In a larger scope, efficient management of all agricultural water supplies cannot be accomplished unless we are able to measure the flow of water in open channels and pipelines. Unfortunately, presently used measurement methods are not accurate. This is not surprising when it is considered that, with rare exceptions, the water measurement methods in use today are merely modifications of methods which were developed from 50 to more than 100 years ago. There is a great need for accurate water measuring methods suited to the needs of agricultural water management. We have completed a study of commercial pipe elbows used as centrifugal-flow meters (Replogle, Myers and Brust 1965 a). The idea of measuring flow through a pipe elbow by measuring the difference in pressure between the inside and the outside of the bend is not new. However, elbow flow meters have seen little use in the past because they were thought to be quite inaccurate unless individually calibrated in place. Our work has shown that this is not true, and this type of meter deserves much more attention. By measuring the physical dimensions of sand-mold, cast iron elbows, ranging from 3 to 12 inches in diameter, the discharge equation of the elbows can be determined with an accuracy of ± 3 percent. Flow through plastic pipe elbows, which are quite uniform because of the die-molding process used in their manufacture, can be predicted with less than 1 percent error. Elbows can be used to accurately measure flow in many pipeline systems, including discharge from pumped wells.

Another promising method of water measurement involves the use of fluorescent dyes as tracers (Replogle, Myers and Brust 1965). Basically, the method involves adding a known quantity of tracer material to a channel and measuring the concentration at some point downstream where complete mixing has occurred. The concentration after mixing is directly related to the quantitative flow in the channel. Again, this method is not new, but it has not seen much use because of the difficulty of obtaining precise measurement of tracer concentrations after mixing has occurred. Our work has solved the problem of adapting a precise laboratory fluorometer for field use. It is now possible to measure dye concentrations as low as 15 parts per billion in the field with an error of less than 1 percent. The next step which is currently under way is the investigation of the mixing problems which may occur in large channels. The method is presently feasible for accurately measuring flow in large pipelines and for calibrating measuring structures in canals and ditches.

All of these and other methods for accurately measuring water will greatly increase irrigation efficiency and reduce the amount of standing waste water.

A third research project relating directly to mosquito control is that of seepage measurement. Since seepage from canals and ponds may cause waterlogging of adjacent lands that will serve as breeding places for mosquitoes, it is necessary that we define and measure those factors which affect seepage. We have not, in the past, known the influence on canal seepage of such factors as depth to the water table, soil stratification, canal shape, and partial canal lining. The quantitative influence of these factors on canal seepage has recently been determined by an exhaustive study utilizing an electric analog. This same project has developed new and accurate methods for measuring seepage rates, and for measuring the hydraulic conductivity of soils in place above the water table. This latter method is quite useful in predicting the seepage that will occur in areas where proposed canals or storage structures are to be constructed. By locating areas where high seepage may occur prior to construction, preventative measures can be taken at the time of construction to reduce seepage, or alternate locations can be found.

Once seepage problems exist, a fourth research project, seepage control, enters the picture. There are three specific areas in which we are working to control seepage: crack sealers, waterborne sealants, and dispersants.

Irrigation canals and farm ditches lined with concrete crack, and through these cracks water is lost. Many methods and materials for repairing cracked linings are being used today. They range from applying expensive mastic sealers by hand to the individual cracks, to the removal and replacement of entire sections of cracked linings. All methods are costly. Through research at our laboratory, a new, more rapid and efficient method for repairing cracks in concrete-lined channels has been developed (Reginato and Myers 1965). The cracked area is cleaned with a high-pressure water jet and a crack sealer is sprayed on the wet concrete. Commercially available equipment is used for both of these procedures. Sealing the cracks with power spray equipment requires three men, one to clean the cracks with the water jet, one to spray the crack-sealing material, and one to drive the equipment truck. In recent demonstrations, about 800 ft. of cracks were sprayed with 10 gallons of sealer in an hour's time. This unique method of repairing cracked canal linings and other hydraulic structures offers a potential saving of money, labor, and water not heretofore possible.

There has been much interest in the past few years in developing materials that could be added to water, either in channels or ponds, that would react with the soil and reduce seepage losses (Myers 1960 a, 1963 a, 1965 a). This approach of adding sealants to the water is desirable because little labor and equipment is involved. These water-soluble or dispersible materials react with the soil to form a seal either at the soil surface or at some depth below the surface. There are a few commercially available waterborne sealants which have met with variable success in field applications. Our work in the laboratory and field has been with water-dispersible asphalt emulsions. Asphalt was chosen because of its low cost and availability. In the laboratory we have added emulsion to water ponded over soils packed in cylinders. The change in seepage rate with time indicated the effectiveness of the materials for reducing seepage. Emulsions in concentrations as low as 1000 parts per million gave 90 to 100 percent reduction in many cylinder tests. However, in the field, reduction varied from 55 to 75 percent. There is still a lot we must learn before we can use these materials effectively in the field. We do not know how long this type of treatment will last, but if the cost is low enough, a canal or reservoir might be treated once or twice a year if necessary. A perfect treatment for canals, ditches, and reservoirs probably can never be designed and built. We would like to have no seepage, no weeds growing through the material, no deterioration or damage, low cost, and so on. Concrete linings are the nearest approach to this objective, but when low cost is a major factor, we must settle for something less than perfection.

For many years, chemicals such as various sodium salts have been used to reduce seepage in ponds or reservoirs (Myers 1963 b, 1965 a). These chemicals have a dispersing action on the clay fraction of the soil. It is believed that by partially destroying the soil structure through controlled dispersion of the clay fraction, dispersed clay particles will reduce the pore area available for water flow but the soil strength will not be destroyed. Our laboratory work has shown that for soils containing at least 15 percent of clay of the montmorillonite type, sodium added to the soil will considerably reduce the seepage rate. However, because many of our western soils are well aggregated due to large amounts of calcium and magnesium, one problem we face is being able to effectively tie up these two elements as they are replaced by sodium on the soil. We have treated two stock tanks with sodium carbonate with good success. One pond that was treated with tetrasodium pyrophosphate had a low seepage loss for only a year and a half, and then the treatment began to fail. Apparently, the phosphate does not tie up the calcium and magnesium for as long as the carbonate. We must learn exactly what reactions take place when we add sodium salts to the soil for dispersion purposes.

All of this work on seepage control is aimed at reducing the waste of our agricultural water supplies. This in turn will eliminate many source areas where mosquitoes breed.

A fifth project that relates directly to problems of mosquito control is soil structure. You probably have observed that in many cases the rate at which water enters the soil in an irrigated field decreases as the season progresses. This is due in part to the breakdown of soil aggregates by the physical-chemical reactions of irrigation water on the soil. We are now conducting a fundamental study of the effects of various cations and anions on the breakdown of soil particles. Through this study, and others that will follow, we hope to learn exactly what causes soil structure to break down. Our ultimate goal is to develop practical means for managing the structure of the surface soil. Therefore, on one hand we may be able to maintain high infiltration rates on irrigated soils, and on the other hand reduce seepage in storage and conveyance structures.

Let us now examine two of our research projects which are indirectly related to mosquito control. The first has to do with evaporation reduction and the development of a new method for applying chemicals to water surfaces. Monomolecular, long-chain alkanol films for reducing evaporation from water surfaces have been little used, owing to the lack of satisfactory application systems. Existing systems are too costly and have not been satisfactory. These application problems have been well documented and we shall not discuss them.

Mr. Lloyd E. Myers, Director of our laboratory and who many of you know, recently found that long-chain alkanols can be applied to water surfaces at a continuous controlled rate by mixing them with water-soluble materials (Myers 1965). When the mixture is placed in water, the alkanol is released as the water-soluble material dissolves. The rate of release of the alkanol in water can be controlled (Bouwer 1961-2) by the type of water-soluble material (sugar or hydroxyethyl cellulose, for example), (Bouwer 1962 a) the concentration of the water-soluble material, and (Bouwer 1962 b) the amount of alkanol added. These mixtures can be applied to water surfaces from floating or sunken containers, and the containers can be placed from shore or aircraft. Although the method was developed to apply alkanols to water surfaces, it may be possible to apply insecticides in the same way.

A second project which has indirect application to mosquito control is "water harvesting" (Myers 1963 b). This can be defined as collection of water from an area specifically set aside and treated to increase precipitation runoff. It is the research on new materials and construction methods rather than the collection of runoff that is of specific interest.

We have developed procedures for stabilizing and waterproofing soil by spraying asphalt on the soil surface. Cutback asphalt is applied first to soak into the soil and make a reasonably strong pavement. Soil pores are not filled with asphalt because too much asphalt acts as a lubricant and reduces strength. The pavement is then sprayed with an asphalt emulsion which does not penetrate but seals the pavement surface. Plastic and artificial rubber films can be bonded to the soil to protect them against wind damage and vandalism (Myers 1965 b). Thin fiber glass matting or cloth can be bonded to the soil and sealed by spraying with asphalt emulsion. Other stabilizing and waterproofing materials are being developed and evaluated. All of these materials will be of interest to a mosquito control district engaged in drainage or irrigation construction. They can be useful for ditch linings, control structures, sealing pipe outlets, erosion control and for solving other similar construction problems.

All research at our laboratory is specifically directed toward improving the conservation and efficient use of diverted agricultural water supplies. Some of our research is related directly and and some indirectly to mosquito control programs. Through research on evapotranspiration and water measurement, irrigation efficiency will be increased, and standing waste water reduced. Seepage measurements can locate areas in canals and ponds where water is being lost and is waterlogging adjacent lands. Seepage control can reduce this water loss and eliminate mosquito breeding areas. Research on soil structure may help to solve the problem of diminishing infiltration rates and standing water in irrigated fields. Evaporation reduction methods may offer new means of applying insecticides to water surfaces. Mosquito control drainage structures can be built with new materials and methods developed by water harvesting research. It is readily apparent that research on water conservation will be beneficial to mosquito control programs.

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MOSQUITO PROBLEMS IN AGRICULTURE

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Mosquito problems in agriculture, as elsewhere, arise in areas where water is allowed to stand. As the irrigated acreage continues to increase, it becomes imperative that practices be implemented to eliminate this serious health hazard.

Certain soil, water, and crop factors can be used to evaluate the mosquito-producing potential of an irrigated area (Davis, 1961). Production potential would be high under the following conditions:

1. Slope of the field is less than 0.5 percent.
2. Water-intake rate is 0.1 inch/hr. or less.
3. Topography is rough, with deep and numerous undulations.
4. More irrigation water is applied than is needed to meet plant needs.
5. Shallow ground water restricts drainage.
6. Irrigation method leads to ponding.
7. Crop that is grown allows standing water; for example, hay or pasture.

Obviously, the solution to mosquito problems on irrigated land is elimination of breeding sites by proper management. This statement is a gross oversimplification, however. Davis (1959) describes some of the problems an irrigator faces in attempting to apply enough water and yet have no waste water for mosquito production. Factors the irrigator must consider include the water-holding capacity of the soil, the soil water content before irrigation, the intake rate, and the percolation rate. To further complicate the problem, soil-water-plant relationships need to be understood for each soil type.

Fortunately, many recommendations have been given to assist in coping with these problems. Bailey, Bohart and Booher (1954) outline correct procedures for land preparation, irrigation, and field ditches. The first major problem on which help may be needed is land leveling. Instructions can be obtained from the Soil Conservation Service or the Extension Service.

In a study in central California, Davis and Husbands (1955) found that mosquito production declined as irrigation efficiency increased. At 25% efficiency, mosquitoes were abundant; at 66% irrigation efficiency, mosquitoes were eliminated.

Most well-drained surface irrigation systems, either flooding or furrow type, that are operated properly, do not leave water to produce mosquitoes. Sprinkler systems (portable aluminum pipe) designed for the soil in which they are used, and operated as designed, do not foster mosquito production. The American Society of Agricultural Engineers (1965) gives specific instructions on the engineering aspects of irrigation. Also, Criddle et al. (1956) describe methods for designing and evaluating surface and sprinkler systems for low mosquito production.

The use of new materials in irrigation is being intensively investigated. Plastic pipe will probably be used extensively because it is inexpensive, easily handled and provides good water control Davis (1965) described an extensive citrus irrigation system using underground pipe, surface plastic hose, and sprinklers.

Interest in subsurface irrigation has increased greatly in the past few years. This system applies water below the surface of the soil into the root zone of the crop. The objectives of the sursurface irrigation studies are to apply water without runoff and excess evaporation losses and to obtain even distribution in the soil. Normal farming operations can be carried out on the soil surface while irrigation is being accomplished automatically and with less labor. This, of course, would product no mosquitoes, as no water is ponded on the soil surface.

Several state and federal agencies, as well as some private companies, are now doing research on subsurface irrigation. There are many problems to be solved before this system can be applied widely, but results so far are encouraging.

Results (Davis and Shumaker 1959, 1961a; Davis, Shumaker and Pepper 1962; Shumaker and Davis 1961), from a study in Montana, show that multiple benefits may be realized from good management practices. The study was made in a prolific mosquito-producing area where soils were as much as 85% clay with many potholes and uneven areas. Proper land preparation, adequate fertilization, and careful irrigation not only eliminated mosquitoes, but increased hay production from ½ ton/acre to 5 tons/acre.

In summary, general recommendations for controlling mosquitoes and increasing production are as follows:

1. Break up land, and level where necessary.
2. Plant crops such as alfalfa, corn, brome or other high-producing grasses, etc.
3. Install and properly operate irrigation systems that provide adequate water without ponding.
4. Use fertilizer at recommended rates. Legumes may need phosphate. Grasses and other nonlegumes need nitrogen and sometimes phosphate.

Most mosquito-irrigation problems connected with farm operations are preventable by using presently available information. New irrigation investigations and increased demand for water will further assist in preventing mosquito production in agriculture. Strong encouragement for water-control research and education by mosquito control agencies will steadily and surely improve mosquito-agricultural problems.

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PREVENTIVE CONTROL ASPECTS IN URBAN AREAS

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It might be more appropriate to speak on the problems of inducing preventive planning in urban areas. It is obvious that the growth rate of new polluted sources favoring the production of aquatic insect populations is exceeding the reduction of such nuisance potentials through preventive planning. For every preventive measure planned and executed in urban water management, we have a host of problem sources created through the age-old traditions of neglect, ignorance, and short-term economy.

Service agencies confronted with the control tasks have long been aware of the nuisance potentials and need for greater awareness of the biotic relationships inherent with poor planning and increased organic pollution of our waterways. Far too late for much of the needed prevention, the urban public has become aware of pollution as a nebulous term possibly affecting some of their personal interests or aesthetic senses. The hue and cry from recreational interests, fish and wildlife, conservationists, water and pollution control boards—even from the President anent the gray Potomac—is beginning to arouse the public support essential to the study, planning, legislation and eventual reduction in the rate of water pollution and its endless facets.

But how long will this be in rendering the material benefits that future generations might hope for? Unquestionably, preventive measures of adequate nature shall lag far behind the rate of human population increase and land development. When California's population has doubled in a couple of decades, will we be able to afford the essential planning and prevention for the future as well as paying for the corrective measures demanded by our current policy of "develop now, pay later"?

Compared to the previous dissertations giving excellent data and recommendations for preventive procedures in agriculture and irrigation water, I am sure that this presentation will short-change you in regard to statistical observations. Perhaps these introductory paragraphs have indicated that this offering pertains not only to gross factors influencing preventive control approaches, but also to associated nuisance vectors, such as midges, with which urban control agencies must necessarily be concerned.

Urban mosquito annoyance was once largely due to insect populations flying in from extensive adjacent marshes or natural sources, but the evolution of effective control work, as well as the urban expansion outward and over such areas, has pretty well eliminated this cause in most highly populated counties. Instead, control and the associated efforts toward source prevention are directed to tens of thousands of miscellaneous sources, large and small, of foul water and varied affected interests.

Preventive mosquito control could be considered from any number of different aspects and approaches including legislation, education, environmental management, maintenance, community planning, or even by the not-so-undesirable possibility of removing the people. But foregoing the pleasant conjectures upon the latter, I hope to stress the penultimate approach, which justifies the introduction.

What is the District's role in preventive planning? Since we have no member on the appropriate planning commission, and probably few mosquito abatement districts do, our evaluation often must await public release of initial plans on major developments. Of course, close contact and influence with members of such planning bodies is a great aid where this is feasible. One might say that being on intimate terms with instrumental officials, commissioners and governing bodies is one of the most effective approaches toward achieving preventive control, but this is more difficult in some areas than others, and it also may entail certain political complications.

Our primary tool is evaluative study of the biological potentials of such proposed water and drainage installations in regard to the production of nuisance insect populations. Previous studies, experience, and an increasing program of measurement, analysis, and source surveillance, have enabled us to present reviews of some such problem potentials to the appropriate engineering interests. Such reports are not designed to be a hindrance to developers, but rather to provide the needed awareness of such problem potentials to the individuals responsible for design, engineering approval and sanitation aspects of such plans.

Admittedly, our facilities and abilities are too limited to foresee and predict with precision or reliability the diversity of biotic relationships that may evolve into significance from a set of initial plans entailing water management. We do not aspire to formulate engineering designs or recommendations to yield a problem free environment. Yet the degree of our experience and knowledge does permit detection of the more obvious environmental factors usually leading to the creation of a nuisance.

Currently we are faced with the potential development of large areas of aquatic lakes along our Bay front. In an effort to provide awareness of the insect nuisance potential associated with the brackish water conditions created in such aquatic developments, this District prepared a release for the potential interests involved, and the basic causes of such excesses are essentially the same as are to be found on our local bayside; i.e.,

Increased organic nitrogen in water sources.

Dilution of the Bay periphery with waste and runoff waters in summer, thus limiting fresh sea water exchange and salt content in such lakes.

The natural evolution of newly created habitats or greatly modified environments to foster excessive populations of a minimal number of species in the absence of competitors, predators, and disease.

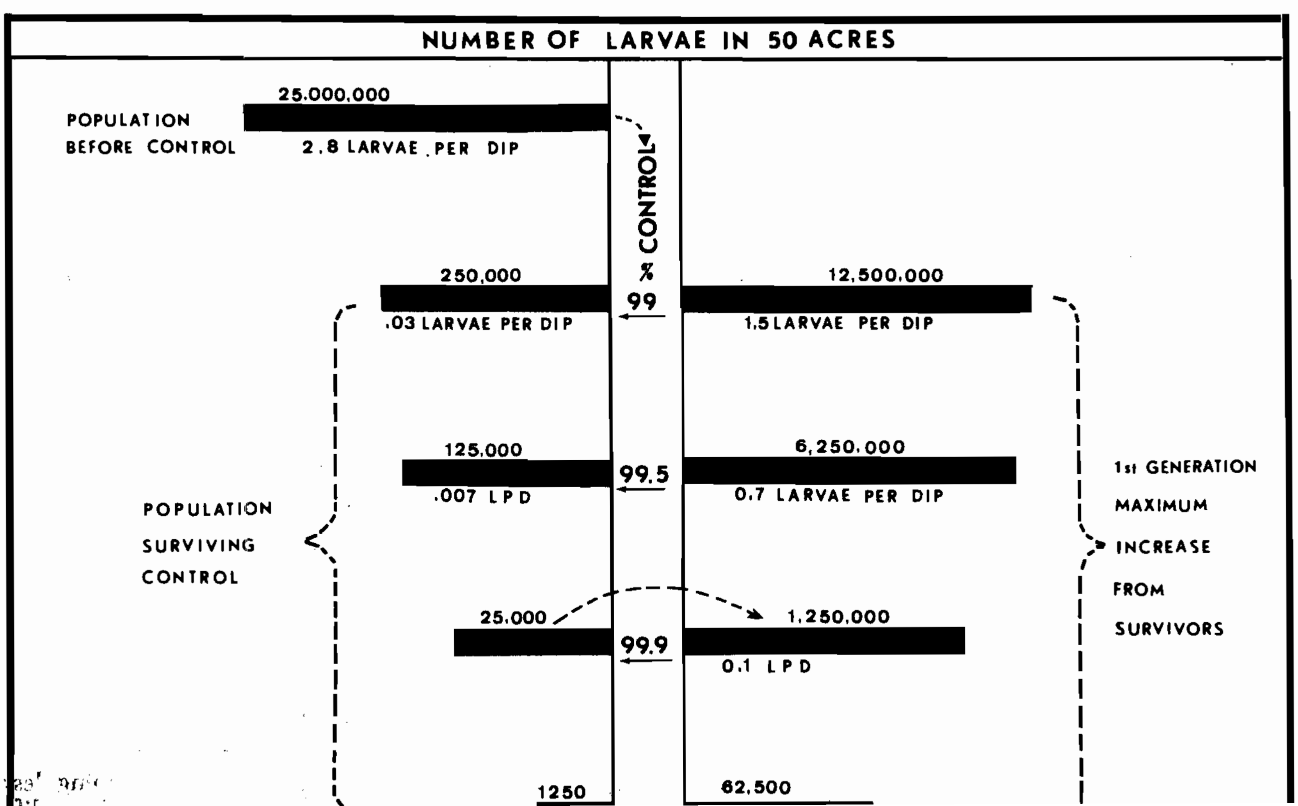
While the current level of organic content in our water outlets is already high and our seawater exchange patterns are highly inefficient in removing such waste waters, the future pattern of bay development

larvae per dip cannot be used with confidence in the field in most cases. Yet it is primarily at this low level or below that "resistance" develops and the percentage surviving becomes greater and greater.

The larval stage in the present chemical control program does not appear to be the point in the life cycle where we can apply management pressure and achieve population control. Apparently population control in the major species of mosquitoes that confront us in California is applied at some other point or points where possibly certain key factors *determine* extreme population fluctuations. The order in which mortality factors are applied also seem to be significant. A key factor *may* only operate efficiently when the number of insects is reduced by a previously applied suppressive mortality factor. For example, the reduction of larval populations by weather or chemical control may leave a small residual adult population which in turn can be greatly reduced by a previously overlooked mortality factor that operates upon a fixed low number of adults. It may be argued that this seldom occurs in mosquitoes, but we should not overlook its potential action or practical application. Eventually the strategy of control may depend upon "look ahead programming" (Watt 1963) in which the elements of control are adapted to the problem as it is modified by various combinations of biological and environmental factors. To achieve this program we must seek ways of determining and measuring the events that are involved in population dynamics.

If this analysis is valid it should be apparent that no major program of chemical, biological, or environmental control can function meaningfully or efficiently without competent entomological appraisal. It is especially important to keep in mind constantly the entire life cycle of the insect. This is sometimes neglected when we are concentrating on the tactics of our control program or because we have isolated certain elements of the program from the biological picture.

Let us take a look at the life cycle of a mosquito and its relationship to man as shown in Figure 2.



What do you see in this diagram that you haven't seen before? Nothing new, you think, but let me ask you a question: At how many points in this life cycle can you potentially apply regulation or suppression? You may estimate that population regulation or suppression can be applied to each stage in the life cycle. At first glance this appears to consist of the four successive stages of its development: egg, larva, pupa, and adult. But from the point of view of the ecologist the mosquito undergoes many dynamic changes during its developmental stages which make it susceptible to external and internal influence. With this in mind it is possible to select at least 13 points in the life cycle where regulation or suppressive action can be applied to interfere with the life processes or reduce the opportunity for disease transmission. Table 1 lists these potential regulating points and Table 2 illustrates some of the potential mechanisms that can be applied in different proportions to each of these points. By using this combination of mechanisms I have estimated that it is theoretically possible to apply over one hundred potential ways of regulating or suppressing mosquito populations. In California we are actively engaged in a control program that almost exclusively uses four methods — larvicides, adulticides, drainage, and predatory fish — with most of the em-

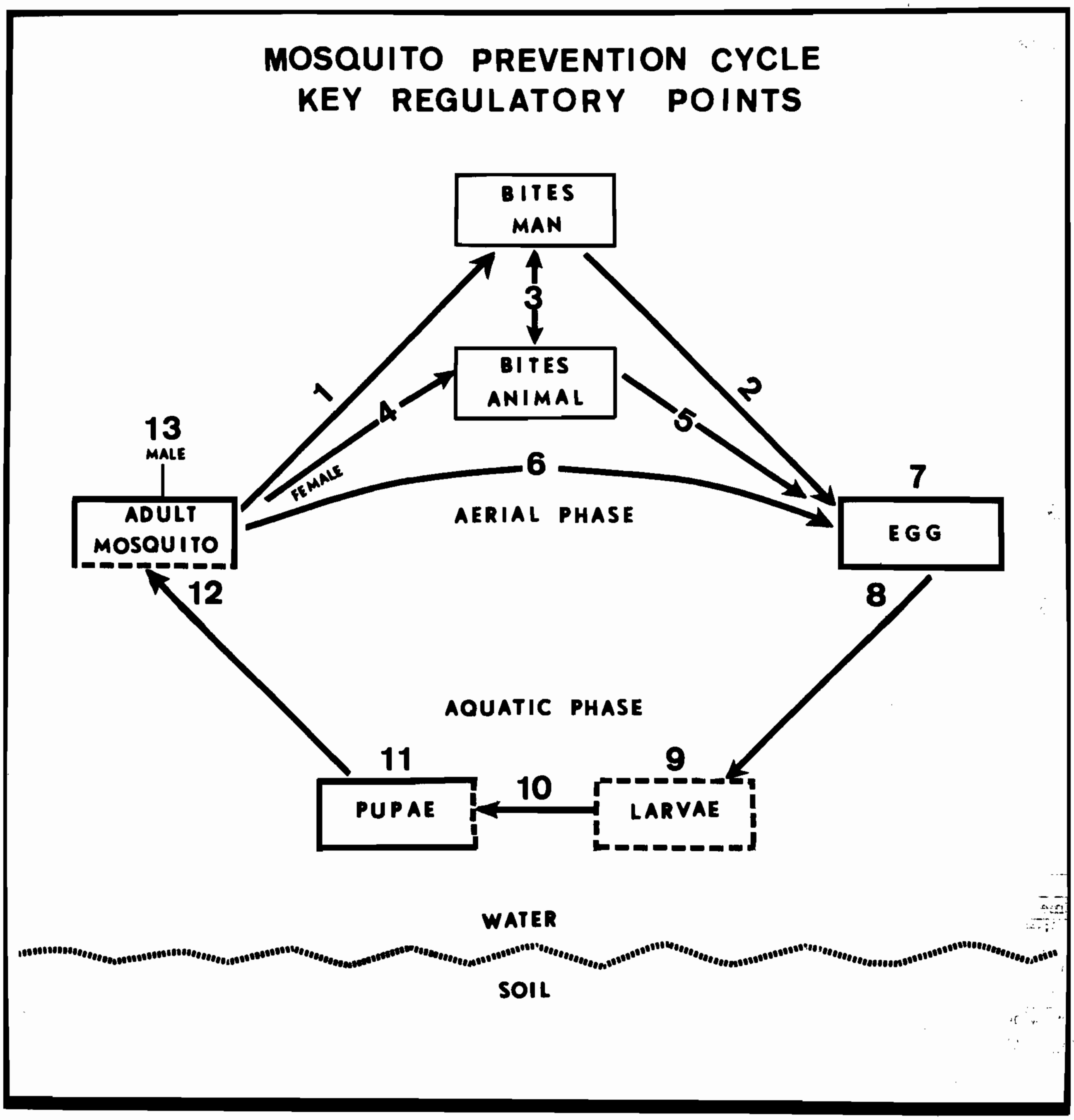


Figure 2. Mosquito prevention cycle key regulatory points.

phasis on larvicides. Considering these four methods further, they are applied at two points in the life cycle against adults and larvae, with most of the emphasis on the larval stage of development. It is realized that barriers, repellents, netting, clothing, and reduced exposure are indirect factors in this process but their application is seldom planned.

Table 1.

Points in the life cycle of the mosquito where the suppression or regulation of populations may be possible (based on Figure 2).

Regulating Points	Stage	Condition
1 & 4	Adult female	Blood seeking (appetential)
2 & 5	Adult female	Egg maturation
3	Adult female	Vector
6	Adult female	Autogenous
7	Adult female	Ovipositional
8	Egg	Embryonic development, conditioning, & hatching
9	Larval	Growth & metamorphosis
10	Pre-pupa	Metamorphosis & ecdysis
11	Pupal	Pre-adult
12	Adult emergence	Ecdysis
13	Adult male & female	Mating

In order to apply the principle of population regulation in mosquito control it will be necessary to determine if key factors can be found and how these can be developed as a part of practical control methods. Research on other insects has provided two methods that can be used. One method is to impose artificially a change in density in the field population at some point in its life cycle, and then observe its return toward the normal level. This may be done by treating isolated populations of mosquitoes experimentally with insecticides. Regulating process can be determined by treating several stages at the same time. The rate of recovery is a clue to a key factor. Another method is to provide data from survival rates based upon yearly census of successive mortalities through the life cycle in an isolated uncontrolled area. Both of these methods require considerable insight into the basic mechanisms that influence each stage in the life cycle. Considerable work on this has been accomplished but no attempt has thus far been made to examine this concept in the field and to seek ways of applying it in organized control programs.

Table 2.

Potential regulatory points in the life cycle of the mosquito with estimates of the influence of biological and environmental processes that may lead to the suppression or control of populations.

Regulatory Processes	Potential Regulatory Points (Based on Fig. 2) 1&4	2&5	3	6	7	8	9	10	11	12	13	Total Pts.
Biological												
Predator	S	S	S	S	U	U	S*	U	U	U	U	5
Pathogen	PR	PR	U	PR	PR	U	S	U	U	PR	U	6
Parasite	PR	PR	U	PR	PR	U	S	S	S	U	U	7
Genetic	PR	PR	PR	PR	PR	PR	S	U	PR	PR	PR	10
Behavioral	S	N	S	U	PR	N	U	N	N	N	PR	4
Physiological	U	PR	S	PR	PR	PR	U	S	S	PR	PR	9
Environmental												
Biocidal	S*	PR*	S	S*	U	U	S*	S	S	U	U	7
Photochemical	N	N	N	N	S	N	S	S	S	S	N	5
Antimetabolic	S	S	S	S	PR	PR	S	S	S	S	U	10
Repellent	S*	N	S*	N	PR	N	N	N	N	N	U	3
Hormonal mimics	PR	PR	U	PR	PR	PR	S	S	S	S	PR	10
Miotic poisons	PR	PR	S	S	U	U	S	S	S	U	U	7
Morphogenetic agent	S	S	S	S	PR	U	S	S	S	PR	PR	10
Chemosterilants	N	PR	N	PR	PR	PR	N	N	N	N	PR	5
Space (shelter)	N	N	S	U	N	N	PR	N	S	S	N	4
Time (sequence)	S	N	PR	N	S	S	S	S	S	S	N	8
Radiation	N	PR	N	N	N	PR	U	N	U	U	N	2
Weather	PR	PR	PR	S	S	PR	S	S	S	U	S	10
Edaphic	N	N	N	N	S	S	S*	N	S	N	N	4
Water	N	N	N	N	S	S	S*	N	S	N	N	4
Air (wind)	S	S	S	S	S	N	N	N	N	S	S	7
Motion (water)	N	N	N	N	PR	S	S	S	S	S	N	6
												143

Legend:
N = None or does not apply.
U = Unknown at this time.
S = Suppressive in most cases.
PR = Potential regulatory under certain conditions.
*-=Presently being used in control.

Some of the principles that I have proposed here can be applied to mosquito source reduction. In this context, a method of source reduction that acts only to suppress a population is less desirable than one that is designed to regulate a mosquito population. For example, the knowledge that environmental factors will influence the distribution of adults in fields and thereby influence the distribution of eggs can be used to design irrigation systems that will minimize (regulate) the survival or emergence of adults. A water control system that merely moves the larval population to one end of the field to increase the efficiency of chemical control will only act to aid the suppressive action of chemical control.

A population regulating action may occur in source reduction when the field surface or the water control system is designed to eliminate the successful completion of oviposition or direct the deposition of eggs into areas where they cannot produce a surviving larval population. This action will greatly reduce the mosquito production potential of a field over a period of successive generations. Carefully designed source reduction operations of this type when coupled with precision chemical control should eventually have a profound influence upon mosquito population regulation.

The thesis proposed here is apt to be met with some skepticism until it can clearly be demonstrated on an applied field basis. One fact cannot be denied however: full consideration *must* be given to the biology of any species under control. Future progress will require the use of this technical knowledge in an ecologically integrated program that is programmed to applied knowledge of population dynamics.

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PANEL: NEW TECHNIQUES IN MOSQUITO CONTROL

John R. Walker, *Presiding*

GENETIC CONTROL

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Genetic control is still a largely theoretical concept, but one that has clear promise of becoming a useful tool capable of reducing the numbers of pest population. Before I answer the question "What then is genetic control?" let me first review the framework in which it fits. The ideal control method is perhaps source reduction, for this removes the very need for control. Unfortunately, this is rarely compatible with man's needs. The first-line weapon of present control is and will probably remain chemical control. A characteristic of all chemical control is that dosage is proportional to area and not to numbers of target insects. Thus, at high pest densities, nothing can match the economy of insecticides. At very low pest levels, however, the cost per insect killed is very high. Human nature is such that it is hard to convince taxpayers or growers that control of small pest populations is good value for money. Leaving aside the "Rachel Carson" aspect, resistance is a major obstacle to the use of insecticides and the side kill of natural enemies often permits a rapid recovery of the pest.

Mosquito populations typically fluctuate between wet or warm season peaks and dry or cold season lows. Our bank balance also fluctuates but we do not assess our wealth on the first of the month nor do we ask for welfare on the last day. Hopefully, our expenses are no greater than income. Similarly, averaged over the years, the surviving progeny of each pair of mosquitoes is effectively just two, or we would long ago have lost all our blood to them. The excess of survival over death in the spring when conditions are ideal and natural enemies low, is offset exactly by the excess of death over survival later in the season when deteriorating growth conditions often augment an abundance of predators or parasites. Density dependent factors, by augmenting survival at low densities and promoting predation or dispersal at high densities tend to keep the year to year populations at an equilibrium. Only when we can lower this equilibrium are we really getting true control.

If we increase the death rate of a pest by some control method, and yet do not eradicate it, it is obvious that survival at some other time or place is increased. If taxes rise and we avoid bankruptcy yet remain honest, it is only by saving or earning more. We thus reach the absurd, but nevertheless wholly false, conclusion that some control methods promote pest survival. They do, however, reduce turnover—just as we can keep a tree small by regular pruning, even though pruning promotes faster growth.

If we could decimate an insect at its population peak, but leave untouched its natural enemies, the survivors would probably be rapidly exterminated by the sudden surplus of parasites and predators. Truly selective insecticides, analogous to the herbicides, have yet to be discovered. We tackle the problem from the other end in biological control, increasing the parasites or natural enemies. Even here, when the pest population is low, only sustained releases of parasites can push it below its low equilibrium range to extinction.

A good recipe for an army's defeat is mutiny in the ranks, or the infiltration of a fifth column. So it is with autocidal control where, typically, mass releases are made of individuals that are capable in some way of inactivating their wild counterparts. The release of sterile males is to date the best and fully documented example. You are all familiar with the success of the campaigns against the screw-worm fly and more recently the melon fly.

Chemical sterilizing agents act like any other insecticide when used in the field, since sterility is as good as death from the population standpoint. Like insecticides, chemosterilants are not very selective and many natural enemies will be killed. There is, however, the bonus effect of the chemosterilized males rendering infertile some of the females that themselves had escaped sterilization. I will let Dr. Mulla expound this topic.

Mass release of adults infected with a pathogen that is lethal to early stages has been suggested as a method of autocidal control but it is yet to be tried.

Now at last we return to the question, what then is genetic control? It concerns sex inasmuch as the transfer of hereditary material is intimately bound up with reproduction. Alterations of the genetic material of an animal, its chromosomes, or the genes that comprise them, if in the germ cells, can affect its progeny or its potential to have progeny. Dominant lethals can only exist in the germ cells since their presence in the body is by definition lethal. They cannot therefore be bred but must be induced by X-ray or gamma irradiation or radio-mimetic chemicals. Their presence in fact is responsible for the sterility of the "sterile males" used in autocidal control. Irradiation strong enough to sterilize is naturally unlikely to improve the vigor of an insect and may reduce it to a point where it cannot compete with wild males. This may explain the failure if two pilot releases of over 4½ million sterile males of *A. aegypti* and 3000 sterile males of *Anopheles quadrimaculatus* to achieve any control in Florida.

The mule illustrates well the general observation that hybrids between two closely related species are often not only sterile, but more hardy than either parent. This is true of many mosquito hybrids. If males of such sterile hybrids can be easily mass produced they would offer considerable advantages of radiation sterilized males, and might even behave like supermales with increased mating competitiveness through hybrid vigor. Because their sterility is determined at fertilization, hybrid eggs could be seeded into natural breeding places, thus avoiding some of the problems associated with mass rearing, handling and field release of adults that is necessary in the case of radiation-induced sterility. Mass rearing would be restricted to the parent species of the hybrids. The presence of sterile females in the control situation might add to the biting nuisance but should not affect the efficiency of control. Hybrid larvae which typically develop faster than either parent might exercise the bonus effect of competition with the wild larvae.

The release of fertile males into a population containing incompatible females will be discussed later by Dr. Barr. If the incompatibility is not reciprocal the terrible hazard exists of releasing a female of the introduced strain. This might simply result in the replacement of the original strain by the introduced one and nullify the whole control operation. Another possibility is the use of males of another species which competitively mate with the pest species to yield sterile hybrid offspring. The sterile-made hybrids produced would themselves have an extra control effect.

Perhaps genetic control in the proper sense should be restricted to cases where genetic factors, once introduced into the population, remain. Recessive lethal mutants are not uncommon, but their effect is necessarily less than that of dominant mutants, though compensated by their long-term action. A single released male, carrying a half or heterozygous dose of a recessive lethal, will transmit it to half its progeny. If the progeny mate among themselves an eighth of the second generation will be killed. With three independent recessive lethals a maximum of just over one-third of the second generation will be destroyed. Knipling has pointed out that any new hazard to survival, however small, will eventually drastically reduce a species if it is applied uniformly and constantly. By a limited lethal, I refer in particular to the case of lethals which act only in the female. The male offspring of a normal, carrier male would be viable. Ideal would be a dominant gene which for example might prevent the female leaving progeny; such mutants are known in *Drosophila*. The affected female might be sterile, or in the special case of mosquitoes, which mostly require a blood meal for egg production, might be unable to suck, or digest blood. Some such mutants are actually known in mosquitoes.

What I am terming latent lethals offer interesting possibilities. The ability to diapause, or hibernate, has been shown to be genetically determined in some species. Mutants preventing diapause may be expected in other pest species. Strains from a warm area where there is winter breeding might be genetically incapable of hibernating. Mass releases of such forms, starting immediately after winter, could swamp the local overwintering population to the extent that very few of the fall population would be able to survive the winter.

A single gene is known in *Aedes aegypti* which converts males to sterile females, but only at high temperatures. Similar effects are known in other mosquitoes. Mass releases of such forms during fall and spring could lead to a dramatic decline in fecundity during the following hot summer.

Sex ratio is usually a fairly constant feature of a natural population. A mechanism is known in *A. aegypti* which will distort the percentage of females from 50% to 10%, equivalent to 80% control. This works in large population cages but has not yet been tried in the field. This same mechanism, known as meiotic drive, may one day be used to force other deleterious factors into a population even against the pressure of natural selection.

Population replacement involves the refilling of a vacated niche by a nonpest species or strain. After successful control or near-eradication there is an ecological vacuum which the pest species may rapidly reinvade. Nonvector strains, nonman-biting strains of the original species may be used, or another harmless species of similar ecology. The most famous instance of this occurred naturally in Sardinia where, following eradication, the malaria vector *Anopheles labranchae* was replaced by the previously rare *A. hispaniola*. Mass releases of a competitive form might achieve at least partial replacement even without prior reduction of the pest species.

Population mixture is a term of my own coinage; geographically isolated races of the same species have often each evolved different blocks of coadapted genes on their chromosome through selection in their particular environments. Following race mixture, the benefits of the coadapted genes could be lost through recombination and the population would remain highly vulnerable until selection could, with time, build up a new gene combination. Such a measure would run the calculated risk that the pest might survive the operation and be strengthened by the influx of new genetic material to produce an even more virulent strain such as happened in a different context with the African bees introduced into Brazil. As a last resort, combined with other control methods this might prove useful.

To sum up, genetic control, like all methods of autocidal control, largely depends on mass release. Facilities for mass production and release of pest mosquitoes have already been devised, but must be developed to suit each particular operation.

The efficiency of all autocidal control methods increases as the size of the pest population decreases—the opposite situation from that of chemical control. Chemical control will therefore probably remain the choice method for the initial suppression of mass outbreaks. Subsequently, or at other times of low population levels, autocidal control offers perhaps the best solution for the future. Autocidal control together with biological control against immature stages would be a deadly combination. Some form of population replacement, mass release of nonpest or nonvector species that fills a similar ecological niche might well stabilize the ecosystem and retard the recrudescense of the original pest species.

Autocidal methods are sound in principle and when developed through responsible research, as in the case of the screw-worm and melon fly, have been proven immune but the pitfalls are numerous. Genetic control today is little more than a concept, a highly fertile ground of ideas, with more problems than answers. But out of such ground comes most scientific advance. Today, we cannot offer you the aid of genetic control; 8½ years ago man had not succeeded in orbiting anything around the earth. Now man even has photographs of Mars. Tomorrow we may manipulate a mosquito's genes.

CHEMOSTERILANTS

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Chemical sterilants are also called mitotic poisons, including a variety of compounds such as antimetabolites, alkylating agents, organotrin compounds, folic acid antagonists and other groups of compounds. These compounds produce reproduction suppression either in the males, females or both sexes. They are nucleophilic, producing biological effects through the production of biochemical lesions. They act on neoplasms, hinder gonadal development and thus are generally spermicidal or ovicidal. Lack of proper development of ova may result indirectly in the absence of mating. For example, female *Hippelates collusor* treated with an effective chemosterilant are not inseminated.

The overall effect of chemosterilants is similar to that of radiation. It is manifested through the introduction of dominant lethals as discussed by Dr. McLelland. The zygote (in cases where there is mating possible) eventually die. Dominant lethals have been known in genetics for a long time and are labelled as undesirable occurrences. Although the introduction of dominant lethals has been attributed to chemical sterilants, there possibly are many exceptions to this notion.

Chemosterilants are also considered to function as:

a—Mutagens
b—Carcinostats
c—Carcinogens—not generally true
d—Radiomimetic—producing effects similar to radiation.

This again is a generalization and there possibly are exceptions to be found.

The chemical sterilants are highly reactive, when introduced into biological systems. Some of these are also highly toxic from the standpoint of both acute and chronic manifestations. These properties impose severe limitations on the use of these chemicals in insect control and eradication programs. Their use requires a great deal of caution and regulation.

The most important question before us here today is as to how at best we can utilize genetic principles, chemosterilants and cytoplasmic incompatibility for mosquito control or eradication. The basic principles leading toward the successful exploitation of these techniques are essentially the same. These are complex phenomena and would need thorough investigation before they can be exploited for vector control or eradication. I agree with Dr. McLelland that we are a long way from utilizing either one of these techniques for the solution of our problems.

The potential use of these new techniques for mosquito control lies in the distant future. Many years of intensive laboratory and field research are needed before this potential can be realized. Pertinent information on the reproductive biology, ecology and behavior of many mosquito species has to be obtained.

This then brings us to the stage to outline the research needs in this field and to discuss some theoretical possibilities and assumptions for the control of reproduction in insect populations.

Principles of Sexual Sterilization.—

1—Sexual sterilization is more effective than conventional methods. This may hold true for some insects but would not be true for many others as we know the situation now.
2—Utilization of sexually sterile insects bring about rapid decline of insect populations. This however must be qualified.
3—More economical than the conventional use of of insecticides or other measures. There is no evidence to extend this principle to mosquitoes.
4—Inducing sexual sterility in natural populations by chemicals is more effective than the release of laboratory sterilized individuals.
5—The ratio of the sterile:fertile increases as the natural population declines in succeeding generations.

How can Chemical Sterilants bs used in Vector Control Programs.—

The potential use of chemosterilants can be directed and manipulated at two levels:

A—Control

B—Eradication

A—*Control*

1—Release of laboratory sterilized males. In order to accomplish this end the following problems should be solved:

a—Species must be reared economically. Not many mosquito species are being reared at the present time. The problem species such as *Aedes nigromaculis* will need intensive research before it can be reared successfully.

b—Sexes must be separated easily.

c—Sufficient numbers should be released to overwhelm the natural populations.

d—Repeated releases should be made each season. Frequently will depend on:
1—Reproductive potential
2—Length of life cycle
3—Number of generations

e—Organizational and technical adjustments in the operational phases. This will somewhat affect the mosquito abatement districts.

f—Released populations should be sexually and ecologically competitive with the natural populations.

g—Unlike insecticides (which are general purpose), the sterilants are specific in application. Therefore programs have to be initiated on one or a few species. The problem is as to how to continue with insecticidal treatment for remaining species.

2—Treatment and sterilization of natural field populations with a chemical sterilant. The following steps have to be developed before such applications can be made:

a—Development of safe and innocuous materials.

b—Development and availability of specific attractants. This is a new field which would require many years of research to advance this phase.

With all the ramifications involved, chemosterilants do not lend themselves readily for control programs of insect vectors. This, then, brings us to the second phase of the potential use of chemosterilants.

B—Eradication.—This term in defined in various ways. Some investigators feel that there is no such thing as eradication of many of our insect vectors. Whatever the case may be, eradication programs require the accomplishment of all the steps enumerated under "control" above. In addition, the following procedures and steps should be contemplated in eradication programs:

a—Releases made over large areas, involving various counties, states or countries.

b—Start at the periphery or center of geographical distribution of a species.

c—Administrative structure has to be organized accordingly.

d—Develop other means to reduce natural populations markedly prior to the initiation of an eradication program.

e—As the zone of eradication broadens, the problems of quarantine and surveillance will become more acute and expensive. Expenditures of surveillance and quarantine will continue to rise as long as the species exists somewhere in its zone of geographical distribution.

Conclusion.—In conclusion it can be said that chemosterilants as well as genetic and "cytoplasmic incompatibility" control techniques have some potential for mosquito control or eradication. Only long-range solutions should be sought through the use of these chemicals. Present knowledge available about these compounds in relation to mosquitoes is practically nil. Until this wealth of knowledge is broadened, one would not be in a position to predict the future potential role of these chemicals in mosquito control or eradication programs.

CYTOPLASMIC INCOMPATIBILITY AS A MEANS OF ERADICATION OF *CULEX PIPIENS* L.

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A number of years ago two British workers, J. F. Marshall and J. Staley (1937), established colonies of four strains of *C. pipiens;* three of these were from England and one was from France. When each of these strains was reciprocally hybridized with the others it was found that only seven of the twelve possible crosses produced viable offspring (Table 1); the other 5 crosses were apparently normal but the hybrid egg rafts did not hatch.

Table 1.
Fertility of crosses of strains of *Culex pipiens* (from Marshall and Staley, 1937)

	Male Parent			
Female parent	Paris	Hull	Westminster	Hayling
Paris strain		+	+	+
Hull strain	+		+	+
Westminster strain	—	—		+
Hayling strain	—	—	—	

Some years later a German worker, H. Laven (1951), assembled a number of strains of *C. pipiens* with which he confirmed Marshall and Staley's finding of sterile crosses. In such crosses he found that insemination was normal. The sterile rafts which were laid sometimes contained eggs which evidenced embryonic development and sometimes they did not. In some cases egg rafts showing no developing embryos were laid by inseminated females. In a later study (1953) Laven showed that the "mating type" or set of crossing relationships of any individual was identical with that of its mother. Since the mating type is inherited strictly through the mother it is thought to be a function of the cytoplasm of the egg rather than of the nucleus, which would carry paternal material as well. This explains the origin of the term "cytoplasmic incompatibility" although its mechanism is not yet understood.

An expert committee of the World Health Organization (WHO, 1964) has suggested that cytoplasmic incompatibility could be used to produce sterile males for eradication of *C. pipiens* by the sterile male technique (Knipling, 1955). It can be seen from Table 1, for example, that males of the Paris strain could be used in an attempt to eradicate the Hayling strain.

A number of strains of *C. pipiens* from various parts of the world have been assembled in our laboratory and crossed with various Californian strains in an attempt to find strains which could be used for eradicating this species from California by the sterile male technique (Table 2). Two of these strains, Scauri and Paris, kindly provided by Dr. H. Laven, proved to be incompatible with practically all Californian strains tested. The Paris strain was incompatible with all Californian strains except one from Jackson. The Scauri strain was incompatible with all Californian strains tested except one from Hanford. There were 10 Californian strains used in these tests; they were from localities from Orange County to Jackson; strains of autogenous and anautogenous *pipiens* and the subspecies *quinquefasciatus* were represented.

Each strain of *C. pipiens* tested showed a unique set of crossing relationships; the only exception to this was the pair of strains, Bakersfield and Porterville. In spite of this, however, the crossing relationships of Californian strains were similar enough to suggest that our results would hold for most of the state. It appears that males of the Scauri or Paris strains could be used to eradicate *C. pipiens* in almost any locality in the State.

The Scauri and Paris strains are also mutually incompatible. If an eradication attempt were being made with the Paris strain, and females of this strain were accidentally released, the Scauri strain could be used to eradicate both the indigenous strain and the Paris strain.

From our laboratory work thus far it appears that cytological incompatibility could indeed be used as a means of producing sterile males.

Laven (1951) showed that otherwise sterile egg rafts occasionally produced a larva or two, but these were difficult to rear. He later (1953) showed that these individuals were always female. Since he was unable to demonstrate by genetic methods that these females had any genetic material from their fathers, he concluded that they were parthenogenetic. If such parthenogenetic females occurred in an eradication program they would be of the same mating type as their mother and would be eradicable in the next release of males. We have tried on several occasions to increase the frequency of parthenogenesis by selection

Table 2.
Crossing relationships of several Californian and foreign strains of *Culex pipiens*.*

Female parent	Male parent																
	Di	St	Ma	Mt	Ja	Ba	Og	Po	Fr	Hf	Or	Ha	10	Sc	Pa	Au	Me
Dixon		A	A	A	A	A	A	A	A	A	A	A	B	C	C	A	C
Stockton	A		A	A	A	A	A	A	A	A	A	A	C	C	C	A	B
Malibu	A	A		A	A	A	A	A	A	A	A	A	C	C	C	A	C
Mt. View	A	A	A		A	A	A	A	A	A	A	A	A	C	C	A	B
Jackson	A	A	A	A		A	A	A	A	A	A	A	C	C	B	C	C
Bakersfield	A	A	A	A	A		A	A	A	A	A	A	C	C	C	A	A
Orange Co.	A	A	A	A	A	A		A	A	A	A	A	C	C	C	A	B
Porterville	A	A	A	A	A	A	A		A	A	A	A	A	C	C	B	A
Fresno	A	A	A	A	A	A	A	A		A	A	A	C	C	C	A	B
Hanford	A	A	A	A	A	A	A	A	A		A	A	B	B	C	A	A
Oregon**	A	A	A	A	A	A	A	A	A	A		A	C	B	B		A
Hamburg	C	A	C	A	C	A	A	A	A	B	A		A	C	C	A	A
10	A	A	B	A	A		A	B	A	A		C		C	C	C	C
Scauri	A	A	A	A	A	A	A	A	A	A	A	A	C		C	A	A
Paris	C	A	A	A	A	A	A	A	A	A	A	C	A	C		B	C
Australia	A	A	A	C	C	A	A	C	A	C	C	A	C	A	C		A
Melbourne	A	A	A	A	A	A	A	B	A	A	A	A	C	C	C	A	

*A=compatible; B=partially compatible; C=incompatible.
**Lost before tests were completed.

but with uniformly negative results thus far. If such induced parthenogenesis did respond to selection to an appreciable extent, this would constitute "resistance" to the incompatible male technique and would have results similar to those following insecticide resistance.

Granted that incompatibility can be used to produce sterile males, how likely is it that such males would be competitive with normal ones in the field? It seems likely that during colonization there is a strong selection for individuals with abnormal sexual behavior, for example individuals which will mate in very small spaces or under irregular light cycles. Males from laboratory colonies might therefore be expected to have a different kind of sexual behavior than do males in the field. Dame *et al.* (1964) believe that this was an important factor in their failure to eradicate natural populations of *Anopheles quadrimaculatus* by the sterile male technique.

Reference to Table 2 will show that although Paris males are incompatible with Hanford females, Hanford males are perfectly compatible with Paris females. Hybrids from this cross are genetically 50% Paris strain and 50% Hanford strain; male hybrids of this composition, however, are still of the Paris mating type and are incompatible with Hanford females. If such hybrid females are bred to Hanford males in each generation the proportion of genetic material from the Paris strain should be halved in each generation: F1, 50% Paris; F2, 25%; F3 12.5%; F4, 6.25%; F5, 3.125%, etc. In this way the genetic material of the incompatible strain can be gradually replaced with that of the strain to be controlled. In theory this will produce a strain which is genetically (and, presumbaly, behaviorally) identical with the strain to be controlled, but is still incompatible with it.

In practice males could be brought from the field, from Hanford, and crossed with females of the Paris strain. This operation can be carried out readily in a 1 $ft.^3$ cage. In the next generation more males can be brought in and crossed with the hybrid females. This operation can be carried out for several generations to produce a strain which is essentially the same as the wild Hanford strain but is incompatible with it in the reverse direction. Males from such a strain in theory should be fully competitive with wild males and could be used to eradicate the Hanford strain.

This kind of operation has been carried out by us once with equivocal results. Males of our Dixon (California) strain are incompatible with Hamburg (Germany) females. Only about one-half of the eggs of sterile rafts evidence development (Table 3). After 7 generations of backcrossing to Hamburg females the proportion of eggs showing embryonic development was no higher than it was initially. This suggests that the backcrossing did not improve mating of the incompatible males even though the strains should have become more similar genetically. It can be objected that the proportion of eggs showing embryonic development in an incompatible cross is not a fair measure of mating since Laven (1951) has shown that inseminated females may lay rafts in which none of the eggs evidence embryonic development. In the ninth generation of backcrossing the Hamburg and hybrid (Dixon) strains were crossed in both directions to see how well they rated. The results (Table 4) are expressed in terms of average number of infertile eggs per raft. (The actual numbers of egg rafts in the 4 crosses were 38, 57, 32, and 18). It will be noted that the hybrid males mated less well than did the Hamburg males. The results indicate that backcrossing did not in this case improve the mating ability of the incompatible strain.

Table 4.
Average number of infertile eggs in rafts laid in crosses of Hamburg strain and F_{10} backcross of Dixon to Hamburg.

Female parent	Male parent: Hamburg	Male parent: Hybrid (Dixon)
Hamburg	4.3%	38.5%*
Hybrid (Dixon)	11.2%	32.7%

*Incompatible cross

Finally, although incompatibility does seem to be a useful way of producing sterile males of *C. pipiens*, is it practical to use the sterile male technique for the

Table 3.
Analysis of egg rafts of Hamburg female - Dixon male crosses during several generations of back-crossing to Hamburg.

Female parent	Male Parent: Proportion Hamburg	Male Parent: Proportion Dixon	No. rafts	No. eggs	No. without embryos	No. with embryos	No. larvae	Proportion embryonated
Hamburg	.000	1.000	5	465	223	242	0	.520
"	.500	.500	15	894	301	592	1	.663
"	.750	.250	17	2162	806	1354	2	.627
"	.937	.063	5	255	107	148	0	.580
"	.969	.031	25	1526	556	969	1	.636
"	.987	.013	15	918	464	454	0	.494
			82	6220	2457	3759	4	.604

eradication of this species? Thus far there have been no encouraging results in the field with mosquitoes (Morlan *et al.* 1962 on *Aedes aegypti;* Weidhaas *et al.* 1962 on *Anopheles quadrimaculatus;* Krishnamurthy *et al.* 1962 on *Culex p. quinquefasciatus*). Knipling (1955) emphasized that the sterile male technique is best suited for pests that occur in small populations and for pests of which the males are highly mobile. The former is not likely to be true of any species of mosquito which is a candidate for eradication and the latter is probably true of very few species of mosquitoes.

The possibility of using this technique focuses attention on gaps in our knowledge of mosquitoes. How is mating competitiveness related to age of males Where does mating occur? How mobile are male mosquitoes? Although we have some knowledge about these points, we need much more. It seems obvious that *C. pipiens* breeding in relatively tightly closed septic tanks are likely to mate before leaving the enclosure of the tank. In such a case it would be most improbable that released males would have any effect on the population unless introduced directly into the tank. Where breeding is in fairly open places, such as sewage oxidation ponds, on the other hand, the sterile male technique would have a better chance for success.

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TRUSTEE INFORMATION SESSION

TUESDAY, FEBRUARY 1, 1966, 9:00 A.M.

EXPANDING PROGRAMS AND FISCAL RESPONSIBILITY

CARL W. MULLER, *Presiding*

ADDRESS

William L. Rusconi

President, California Mosquito Control Association

Mr. Chairman, Trustees of the California Mosquito Control Association and distinguished guests. It is a real satisfaction to me to see the large number of trustees who have turned out for this breakfast meeting. This is the largest group of trustees ever to attend one of our conferences. I am very proud of this.

During my tenure as President of the California Mosquito Association this past year, I have observed that we have been going through a period of some unrest, primarily concerning three issues of vital importance to all of us.

Perhaps the matter of highest priority has been, and continues to be, the need for research. We must obtain and assure continuing support for a research program that will meet both present needs, as well as the inevitably more complex problems of the future. After considerable discussion and debate, the Association has made its position unmistakably clear. This has been documented in a "Statement of Policy" and by appropriate resolutions supporting a collaborative research program by the State University and the State Department of Public Health. The job now is to make this position known to the Legislature in a convincing manner and to obtain their necessary support.

The second subject that we have been concerned about is the need to revise the Bylaws of the Association. The Bylaws Committee has worked diligently this past year. They have had meetings up and down the state with managers and trustees. As a result they are now prepared to submit a proposed revision. I know from what I have seen that much thought has gone into the proposal and that its intent is to improve the Association. The proposed revision as it now stands may need some refinements in wording and it probably does not anticipate all of the future needs of the Association. However, amendments can always be introduced for this purpose. I hope that at our business meeting we can reach an agreement on the proposed revision.

The third subject of primary concern during the past year has been the matter of the financial responsibilities of our Association. As managers, some of us have been accused of being too conservative. Maybe we have been overtrained by our trustees. The need exists, nevertheless, for us to examine much more realistically all of the financial needs of this Association and to develop a plan of responsible action. This is a problem in which you as trustees can be of great help to the Association.

In conclusion I would just like to say that during the past year I have met and worked with almost every manager in the state, and I have never been associated with a finer group of people in my life. This is intended as a compliment to you, the trustees, for your wisdom in selecting the administrators currently managing your respective districts. Thank you.

ADDRESS

Dale Hirt

Past District Governor Rotary International, Salinas

Amos Alonzo Stagg played tennis until he was 80. He ran every day until he was 96, and at 99 he still cut his lawn with a push-type lawn mower. Stagg had a world-wide reputation not so much as a builder of great running teams, although his teams did make fine records, but as a builder of team spirit. He knew how to inspire his athletes to peak performance and he was loved and respected by all.

We are all concerned with service to our community—helping the many groups and organizations that improve and enrich our lives. If we as responsible citizens did not accept the responsibility for volunteer work in our community, the control of many local organizations would pass by default to a government bureau in a central government.

Two hundred years ago the great historian Edward Given in his book, "The Decline and Fall of the Roman Empire," had this to say about the Greek civilization: "When the Athenians wanted not to give to Society but for Society to give to them—when the freedom they wanted most was freedom from responsibility—then Athens ceased to be free and was never free again." And, speaking about both the Greeks and Romans, he said: "In the end, more than they wanted freedom they wanted security—they wanted a comfortable life—and they lost it all: security, comfort and freedom."

I believe the greatest service we can perform in our community is to stand up and speak out for what is right and good. There has been too much silence on the part of those who should speak up. I challenge you to oppose evil because it is evil, to support that which is good simply because it is good.

We are concerned with service to our country—defend the principles of constitutional government and individual freedom, oppose excessive government expansion, controls and regulations. I would challenge you to be knowledgeable, to know what is being proposed in Congress, to know what is being decreed by executive order, and to know what motivates our public service. I would challenge you to be vigilant—don't be lulled into a sense of false security by platitudes and free spending.

We are concerned with service to the world in which we live. Probably the greatest service of all is to promote international good will and understanding among all the peoples of the world. The most important race is not the arms race or the space race but the human race, and, in spite of our national boundaries, people on this globe are neighbors—all of us have the same aspirations and hopes regardless of where our accident of birth or living might be. All of us have the same desire for peace and good living, and it is my hope and belief that, as the standard of living is raised in country after country around the world, and as travel between countries comes within the grasp of people in all walks of life, people will get to know each other and understand each other and our thoughts about each other, and our different customs. To know is to like—to know is to love.

I like the motto of the American Field Service: "Walk together, talk together, all ye people of the earth. Then and only then shall ye have peace." Dr. Albert Sweitzer once said: "I don't know what your destiny will be, but one thing I know—the only ones of you who will be really happy are those who will have sought and found how to serve." Who profits most from the service that you give? Is it your church, our young people, our country, your community, or the world? It's all of these, but most of all it's you. He profits most who serves best. You will find happiness in service that is unselfishly given. Yesterday is but a dream, tomorrow is only a vision, but today well lived makes yesterday a dream of happiness and every tomorrow a vision of hope.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION FUNCTION—PROGRAM AND ACTION

W. Donald Murray

Delta Mosquito Abatement District, Visalia

The CMCA was started in 1930, primarily through the efforts of Harold Gray, who at that time was the manager of the Alameda County MAD. For years Gray teamed with Wm. B. Herms, professor of Medical Entomology at the University of California, Berkeley. These two persons believed it desirable to have an association where all interested persons could get together to discuss mosquito control. At first the meetings were very informal. Talks were written or were recorded by shorthand, thus Proceedings have been maintained since the first Conference.

The first presidents of the CMCA included a Mr. Stober in 1930 who was manager of the districts which are now included in the San Mateo County MAD, and Harold Gray in 1932. The next two presidents were Professor Herms of the University and Professor Stanley Freeborn, also of the University. Thus, of the first four presidents, two were mosquito district managers and two were professors of the University of California.

Reviewing the secretaries, Harold Gray served as secretary for the first year, and afterwards he served as editor of the Proceedings continuously until about 1953 when he retired. It is interesting to note that after Mr. Gray's one-year term as secretary, Mr. Edward A. Reinke, of the State Public Health Department, served as secretary for seven years, followed by Mr. S. F. Dommes, also of the State Health Department, for two years, and by Richard F. Peters of the State Health Department for two more years.

After this we had a period with the office going from one person to another in three successive years, after which it stabilized when Mr. G. Edwin Washburn, at that time manager of the Turlock MAD, was elected to the office and served for seven years. When Washburn left California to go into foreign work, I was appointed to replace him and have now served for six years.

Today, CMCA is composed of mosquito abatement districts, together with several city and county health departments and other local agencies, making up the Corporate Membership. The most active participants of the Corporate Membership are the managers and the trustees. The managers are the professional staff developing the professional program both for their respective districts and for CMCA. The trustees both in their respective districts and in CMCA, are concerned with policy, political and fiscal matters. Thus there are similar or parallel functions in the respective districts and in CMCA.

Unfortunately for some years there were far fewer trustees coming to the Conferences than today. Those who came generally were content to sit back and listen to the talks, some of which were quite technical. Today the trustees have developed a much more vigorous interest in the Association, taking a more active part in political and fiscal matters, and developing and participating in sessions of, for and by the trustees.

Referring to my historical review, I mentioned that persons in the University and State Health Department once participated actively in the CMCA. Today our structure is such that it is difficult for such "outsiders" to work intimately with us. About 1946 a new factor was introduced into our program—subvention. Subvention brought in some conflicting concepts of politics—not Democratic or Republican politics, but money. We were eager for it. When this happened, there developed a desire on the part of many, especially some mosquito abatement district managers, to control and to protect. Therefore a new set of CMCA Bylaws was prepared, bylaws which made this a very restrictive organization, entirely different from the first fifteen years.

The CMCA thus became an organization composed only of the districts as first class citizens, everyone else being relegated to a lower class. The State Health Department could not participate directly in our program other than as they were invited or as they insisted that they had a vital interest in our program. And the University—what happened to them? For the first twenty years of our Association every Conference was held at the University, at Berkeley. But then we began to move around, we became independent, we didn't need the University so much. We got a little separated, and now we are paying for it. Some of our districts are in severe stress relative to insecticides to use.

There is no other answer except that we have a strong research arm. The research must come from those capable of giving it to us. We must be interested in the University and the State Health Department. These agencies in one way or another must be a part of our Association, because one of the original purposes of our Association is communication and development of program.

The CMCA has certain other members, as, for example, Associate Members. Associate Members are individuals who primarily want to receive communications from us. As Secretary I have tried to encourage this class, to stimulate the interest of people in this state and all over the country and world. Today there are more Associate Members than ever before. I received a letter just last week from Dr. E. S. Hathaway, professor emeritus of Tulane University at New Orleans. Dr. Hathaway is an Associate Member of CMCA. He wrote: "I certainly wish to continue my membership in your Association—am glad to enclose my check for 1966 dues. Anyone seriously interested in mosquito control certainly can get much more than his money's worth from the generous policy of the CMCA regarding the distribution of publications. During the past week I have been much impressed by this fact, because in a slight lull in an unusually overloaded schedule I've taken the opportunity to read some of your recent releases which heretofore I had not had the opportunity to read. I'm especially impressed by the actions taken by your board in grappling with problems which are very much like some of the knotty ones which concern our Associaton—the Louisiana Mosquito Control Association."

The CMCA is in a position to communicate with others—to help them and in turn to have them help us. This is our Association. We must do our level best to assure that everyone who belongs with us can participate with us as first class citizens.

STATEMENT OF RESEARCH POLICY

GORDON F. SMITH

East Side Mosquito Abatement District, Modesto

The policy of the CMCA regarding research was adopted by the Board of Directors at a meeting at San Rafael on August 27, 1965. It is as follows:

"1. Due to need, the C.M.C.A. supports adequate and balanced research on all possible techniques of value to mosquito control by whatever agency.

"2. Because of increasing difficulty in using insecticides due to resistance and increasing regulatory restrictions, research aimed at decreasing present dependence on insecticides should be especially encouraged.

"3. The C.M.C.A. feels that both the State Health Department and the University of California have an essential and proper place in research designed to create new and more effective mosquito control techniques and to translate these techniques from the purely research phase to final field use.

"4. The Association recognizes that recent action by the Legislature assumes the University of California is the primary research arm of the State; however, it is the consensus of the C.M.C.A. that the State Health Department has a strong responsibility for obtaining or performing needed research on mosquito control techniques, since the State Health Department function is in an advisory capacity to mosquito control agencies."

(Aside) There were some very severe restrictions put on the State Health Department by the Senate at last year's legislative session which forbade them to do any departmentally staffed research. We feel that this is unrealistic.

"5. The Association endorses and makes a part of its policy the 'Joint Report of the State Department of Public Health and the University of California on Mosquito Research,' signed by the Director of the Department of Public Health and the President of the University of California.

"6. A Joint Committee of the State Department of Public Health and the University of California on Arthropods of Health Importance, formed in 1963 through the Director of the State Department of Public Health and the President of the University of California, is functioning to review continuously the research programs of the State Health Department and the University of California, to decide the propriety of the research within each agency and to prevent duplication of effort. It is the consensus of the C.M.C.A. that this committee is carrying out this function in an exemplary manner and that it is the proper body to make these necessary decisions. The C.M.C.A. will support the findings and recommendations made by this committee."

Now I would like to refer to the joint report by Dr. Merrill and President Kerr. Briefly, it was made at the request of the Senate because of their concern that there was duplication. They stated that they found no duplication. They further stated:

"Expanded and intensified research is needed to fill many broad gaps in our knowledge of mosquitoes and their control. The combined resources for mosquito control research of the University of California and the Department of Public Health are much too small to deal adequately with these problems at the present time. Limitations of manpower, facilities and time have prevented both the University and the Department of Public Health from pursuing at appropriate levels the avenues of needed research. It is unrealistic and undesirable for either the University or the Department to assume sole responsibility for all research in this field; the solution of the many problems will require the support and collaboration of both agencies. It is agreed therefore that the best way of handling the overlapping interest and responsibility is a coordinated research effort by the University of California and the Department of Public Health. Adequate financial support will be needed to carry out fully the responsibilities of both the University of California and the Department of Public Health in this plan.

To facilitate such a program and to expand current collaborative efforts, the following plan has been effected.

1) The University of California will continue to accept the major responsibility for basic research carrying its findings to the applied level wherever necessary.

2) The State Department of Public Health will continue to conduct research necessary to carry out its regulatory, advisory, surveillance and control responsibilities when basic or applied research of other agencies is inadequate or will not meet critical time schedules.

3) A joint committee of the University of California and State Department of Public Health has been established to coordinate their research efforts. This joint committee will develop collaborative projects where necessary, direct the attention of researchers and administrators to areas of research need or overlap, and in other ways coordinate and facilitate the research program. Therefore, the research programs of the two agencies will be independent, they will be closely integrated, and appropriate research will be conducted in a collaborative manner."

This is the policy as adopted by the Association for the guidance of the Association and its members.

ADDRESS

DONALD L. GRUNSKY, *Senator*

Santa Cruz and San Benito Counties

I'm always gratified to speak before a group such as yourselves — dedicated public servants without any object other than to serve at great personal sacrifice. It is a deep appreciation that I have for what you do. You are also one of the rare groups that we legislators appear before where the greater the success, and the better the job that you do, the less evidence there is around of the objects of your efforts.

My subject matter to you today is on the very important theme of expanding programs and fiscal responsibility. We are really concerned with two basic problems: one, the problem of your developing programs and research projects to provide for continuing effective control of present and future misquito populations at the best possible cost-result ratio; and two, and perhaps the larger problem, that of the justification of the special purpose districts as a valid and useful segment of the local government structure. This is in no way being critical of your districts, but is a desire to analyze a current consideration throughout the country at the federal, state and local levels.

The growth of our statewide mosquito control program appears to be best illustrated by examining the growth of the numbers of agencies, the total area encompassed by them, and the expenditures during the 20-year period since the end of World War II. At the end of World War II there were only 30 mosquito control agencies, which included an area of 5,000 square miles and reported expenditures of $500,000 annually. At the present time we have 60 agencies encompassing 35,000 square miles and expenditures of $7,000,000.

For the foreseeable future we can reasonably anticipate a constant growth in expenditures by the local mosquito control agencies. Factors contributing to this growth are the increased development of water resources, an accompanying increase in populations, and insect resistance to presently known chemicals.

In the past, the role of state government in the field of mosquito control has been related largely to carrying out research on new techniques and approaches. The 1965 general session of the Legislature directed the State Department of Public Health to discontinue its existing departmental staffed mosquito control research program and to use their state funds to contract with the University of California for any necessary mosquito research. Though Mr. Peters of the Bureau of Vector Control of the Department of Public Health might have a different idea, I believe this was a big step forward in what we think of as fiscal responsibility in obtaining the greatest benefit per tax dollar spent on mosquito control. The various campuses of the University do have, admittedly, the available staff, the equipment and the facilities to meet more effectively our research needs within the limits of currently available funds.

Since the state's participation is only in the field of research, the greatest responsibility for obtaining the greatest benefit for each tax dollar spent depends on decisions made at the local level by your agencies. One has only to look at the agenda of your conference program to see that your Association is actively pursuing new ideas in technology to cut the burden on the local taxpayer.

Coming to the very timely important matter of the special purpose districts, your districts are not the target, but are simply an example of the special purpose district. They are very close to you by reason of your participation in the program. There is a question of the justification of the special purpose district, so we must ask: "What gave rise to these independent creatures outside the normal structure of local government?"

Special purpose districts have been a part of the American governmental structure for a long time. The toll road, the Canal Corporation of the 1800's are examples of the early use of the special districts, established to perform functions which the government was obliged to undertake. Similarly, special districts were formed to provide benefits to limited groups of property owners for maintaining local roads or providing protection against the ravages of fire or flood.

As late as the beginning of the 20th Century these historic uses apparently created little or no conceptual or practical problems. In the first instance they were created by action of an appropriate unit of general government. The special benefit district generally provided an extremely limited service, benefiting a very small group of people and rarely affecting programs of the general local government.

Back about 1897 the City of Spokane, Washington, sold a bond issue for the extension of its water system, and pledged the revenue received from the furnishing of water for payment of the bond. This revenue bond operation by a unit of general government provided a financial technique which was to play a major role in development of a large number of special districts, particularly public authorities as we know them today.

While in the United States almost one half of the units of government enumerated as special districts by the Bureau of Census enjoy the power to tax property, the opportunity to issue revenue bonds secured by service charges provided a significant stimulant to the use of special districts. However, the device that started way back with the Spokane example lay largely dormant until about 1930. The depression, with the resulting erosion of the property tax base of local government and the impetus for construction of local public facilities provided by various federal programs stimulated the growth of special districts. The State Legislature, authorizing creation of special districts in order to avoid debt limits, best permitting state and local participation in various federal public works programs, was actively promoted by the federal government.

The scarcity of equipment and materials for capital construction purposes during World War II proved a dampening effect on the growth of special districts, but the removal of these limitations in the period of 1945-46 and the needs of the nation's rapidly expanding population provided the impetus for a phenomenal growth of the number of these special districts following the war.

Special purpose districts as governmental entities require prior enabling legislation or other statutory authority before they can be created or can undertake the performance of any function. California codes are replete with enabling statutes authorizing a seemingly limitless variety of special districts—airport districts, fire protection districts, water districts, cemetery districts, irrigation districts, etc. The fundamental principle underlying all of the statutes has been that when general purpose government — specifically cities and counties — cannot provide a necessary service to an area it is appropriate for a specialized agency to do the job. Today 175 general and special enabling statutes have provided the means to create over 3500 special districts. The 3500 districts are found throughout the state, but primarily concentrated in growing urban counties with large areas of unincorporated territory.

Collectively special districts represent big government in terms of the land they serve, the services they render and the money which they collect and spend. In 1962-63, special districts collected more than 479 millions of dollars in service charges in taxes. Expenditures during the same period exceeded 522 million. The total long term special district debt outstanding at the end of the 1963 fiscal year approached $2 billion.

During the past decade these levels of revenues and expenditures have shown significant annual increases, principally in response to the demands of growth. Because of the rapidly rising revenues and expenditures of the special districts and because of their rapid proliferation, the federal government and many states including California have recently made studies aimed at evaluating the performance of special districts as governmental agencies.

While these studies have been critical of some aspects of district government and have resulted in new state laws designed to overcome some of these deficiencies, they indicate that most special districts are serving the public well. For example, one federal study, by the advisory commission on intergovernmental relations, reported in May, 1964, that in general the public appears to be satisfied with services received from special districts and that by and large the districts have resolved the problems which spawned them. This federal report, however, went on to say that the establishment or continuation of special districts creates intergovernmental problems and is frequently an uneconomical means of providing services. Further, the use of special districts has tended to distort the political process through which competing demands for the local revenue dollar are evaluated and balanced.

This report, which was disseminated throughout the country, indicates that the multiplicity of special districts often prevents the citizen from knowing exactly what is going on in his community. Frequently, no unit of general government within a state or a locality is fully aware of the various aspects of special district activity. The programs of many districts appear to be completely independent from and uncoordinated with similar programs of general government. This federal report also states that in many if not in most instances special districts increased the cost of governmental services. Services often are performed uneconomically, and there is a duplication of administration burdens. The cost of borrowing for capital construction due to heavy use of revenue bond financing has been at an excessively high cost. The report concluded that it was apparent that many special districts had outlived their usefulness. While this report does not discuss mosquito abatement districts, nevertheless they are a part of the problem and therefore this discussion is relevant. The report concludes that many statutes permitting the creation of districts decades ago are of questionable value today, and that steps should be taken to permit general government to absorb the functions of special districts in many instances.

The report also urged: 1) steps be taken by all levels of government to assure effective control over existing special districts; 2) concerted efforts be made to encourage the consolidation of existing special districts where appropriate—we thave already seen the unification of school districts; 3) that reasonable restrictions assure that in the future special districts be created consistent with the criteria previously described. The report made clear that its recommendations did not reject—out of hand—the use of special districts and the various governmental structures. Quoting from the report: "While many people urge their demise, special districts often fill a gap in the structure of local government in this country. In many instances this gap is temporary and in others it may be permanent. However, when the gap is temporary the solution should also be temporary and not permanent. Statutes should provide for an easy means for the dissolution or consolidation of districts when there is no longer any need for the services provided or when a unit of general government is willing and able to provide the service."

All this is important because, in order to preserve those districts which have a continuing important permanent problem and need, in order for them to survive and be accepted, you have to eliminate the inefficient ones which are not needed. After studying the federal report, the California Legislature, acting through the Assembly Committee on Municipal and County Government, conducted its own hearings and made its own report during the 1963-65 interim period. This study brought about the enactment of "The District Reorganization Act of 1965."

This new act is extremely complicated, and affects over 600 sections of the various codes of the State of California. The act was designed to provide a uniform procedure for the initiation, conduct and completion of proceedings for annexations, detachments, dissolutions and consolidations of districts; reorganizations and formations of districts, mergers of certain districts with cities, establishment of certain districts as subsidiary districts of cities, and review by local agency formation commissions. In addition, the powers and duties of the local agency formation commission were expanded at the 1965 legislative session. This commission was created to discourage urban sprawl and to encourage the orderly formation and development of local governmental agencies based upon local conditions and circumstances.

For the past two years the commission has had the job of reviewing proposals for the incorporation of cities, the formation of special districts, and the annexation of territory to cities. The 1965 amendments add to the commission's responsibility: special district annexations, detachments, dissolutions, consolidations, and mergers with cities, and allows the commission itself to initiate studies on the makeup and structure of local agencies. The changes in the commission's responsibility were brought about as a result of the assembly committee recommendations that in order to provide local citizens and local governmental agencies with appropriate and accurate information about governmental organizations within each county and the implications of any proposed changes in that organization, it is necessary to encourage the local agency formation commissions to gather data and to make studies in regard to the various governmental organizations within the county and to recommend changes in governmental organization as a result of its studies, provided that such changes would encourage orderly community growth and would achieve tax savings.

I think that the 1963 and the 1965 laws were a step forward in eliminating many of the criticisms of special purpose districts. However, I note that in one county at least there is agitation for drastic reduction of the number of special purpose districts—perhaps even the total elimination of them. The SAN JOSE MERCURY recently pointed out that the 1965 Santa Clara County grand jury was building a case for wholesale governmental reorganization and consolidation. The newspaper, in an editorial published on December 29, 1965, recommended taking the "ultimate reorganization step" to reorganize the entire complex of local government in Santa Clara County into a "City and County of Santa Clara," just as there is now a City and County of San Francisco. The purpose of this reorganization would be so that the assorted tasks now performed by special purpose districts could be assigned to appropriate city and county departments, and their performance subject to review and control by the voters of the entire county.

I do not in any way predict or recommend the widespread elimination of special districts, because I truly feel that the problems that gave birth to these districts still exist, particularly in your work in mosquito abatement. Yet I think that the future months and years will bring forth more and more discussion as to whether special districts, including, of course, mosquito abatement districts, are in themselves proper and correct and in agreement with the subject of today's theme of fiscal responsibility. I anticipate that many groups such as the Santa Clara County grand jury will be studying our local governmental structure, that the local agency formation commissions will be looking at the setup of local government and will perhaps recommend some consolidation of districts with overlapping functions in order to reduce administrative and operating costs.

You, ladies and gentlemen, are dedicated public servants as well as taxpayers. You have a wide range of knowledge in your local areas in all fields as well as that of mosquito abatement. You can study this matter and come up with recommendations as to how you can do your job most economically under the present administrative setup. On the other hand, after your studies you may find that your functions can be combined with another special district or with a general county government and be run more efficiently. I am not prepared to say; I think you are qualified to study and to recommend this.

When you have answered these questions, then it is your responsibility to initiate a strong public information program to educate the voters in your respective districts as to how to obtain the best results from each tax dollar spent on mosquito control. And, if your self-analysis is correct, if your public information program convinces the voting public that you are right, your guidance can save the taxpayers in your district many valuable tax dollars. Certainly your participation in the study of all special districts, not just your own, to provide a needed service at the lowest possible rate, and to provide an attendant public information program, should be one of the planks in your program of fiscal responsibility.

ADDRESS

JOHN G. VENEMAN

Assemblyman, Thirtieth District

Stanislaus County, California

I feel that every time a group of people such as yourselves get together, it is inevitable that you will be making decisions which will plot the future course of your Association and probably the future course of the particular problem in which you are interested. I am fully aware that your primary interest is the elimination of mosquitoes, for they pose a threat not only to humans but to livestock; they pose as an annoyance to the public and as a hindrance to the full enjoyment of the recreational facilities that we have in California.

Your primary problems with these particular interests, as an Association, are first of all the shortage of funds both for control and for research, which is a key problem with which you are confronted today; second the ability of the mosquito to survive and become impervious to the conventional methods of control;

and third the normal apathy of the citizenry which becomes aroused only when a particular problem reaches acute proportions and when a solution costs the most. Senator Grunsky made this point—you are doing too good a job and you can't get the citizenry aroused.

You are to be commended for the reason you exist as an Association, and it is regrettable that more support for your efforts has not been forthcoming. The fact that it has not is related to this state's phenominal growth since World War II. Cities have sprung into existence overnight, state parks are overcrowded, freeways are next to useless at peak hours. Crime, welfare, education, air and water pollution, housing—each of these is, or presents, ongoing problems, the solutions of which are vital to the future of California.

Each of these problems can make legitimate claims to resolution and to necessary funds. Each one insists upon its right to a share of the time, attention and the resources necessary to prevent its development into completely unmanageable proportions. But funds are also needed to support services designed not just to solve problems outright but to mitigate the effects. State government has had to struggle to keep up, combatting the competition within itself, with the interests we have just outlined, and at the same time combatting interests from without. These are from the people who are rightly concerned lest the government grow so big and powerful that it become big brotherly. The critical and little-understood need for more attention to mosquito abatement has thus been suffering from competition with hundreds of other needed programs, some more and some less pressing. It is a fierce struggle for the time and attention and favor of those who control the purse strings of California's treasury.

It is principally a matter of allocation of scarce resources, and your proper concern is the allocation of more of these scarce resources to the research of mosquito abatement. The resources, however, are indeed scarce, and I should like to point out that during the last seven years our population has increased by 27% in California, while the rate of state revenue has increased by 87.3% and the rate of expenditures has increased by 102.2%. Social welfare costs, needless to say, have soared, with the spending in this area up 133% in the last seven years. Crime costs in California now cost the citizens of this state one billion dollars a year, and the crime rate is still going up. The largest single portion of the state budget is allocated to education. In the last 10 years California has increased its expenditures per pupil ADA by 80%. The state supports the many branches of the University of California as well as the state college system, and from this part of the budget would come funds for basic, long-term research into the genetic resiliency of the mosquito. On the other hand, the people at the local level support the state's public education system through the use of the property tax, and even in this area the competition is keen, for the mosquito abatement districts also get their support from the local property tax.

Next Monday we legislators will return to session for the purpose of adopting a budget for the state of California for 1966-67. There already are indications that this budget will amount to some 4.5 billion dollars. The first budget in which I participated in 1962 was for 2.75 billion dollars, so we have gone up in this very brief period by nearly 1.75 billion dollars. The big problem we are faced with is not how to spend the money, but how to get it. For this coming budget it is predicted that the expenditures will be about 240 to 300 million dollars short of having adequate revenues to cover them. All of us realize that this is not the popular year to raise taxes or to obtain new revenues, with every member of the Legislature coming up for election, and every constitutional officer up for election. So this is probably one year where there will be more surveillance of the budget and the purse strings than ever before in history.

In citing some of the figures I have alluded to, I am merely recounting what you already know, that too much needs to be done, and there are too many places to put the tax dollar, and the decision as to who gets the money, how much and for how long, is a most difficult one. It is a decision, however, which depends on facts, information and testimony on one hand, and public support and even public demand on the other. It is my impression that there is far too little public awareness of the seriousness of the mosquito control problem.

It is a popular misconception that DDT and other insecticides will continue to keep mosquito swarms at a minimum. I speak a little from personal experience, inasmuch as my occupation is that of a peach grower. I am certainly aware of the effect of insecticides over a long period on the peach twig borer, which we used to be able to control with a couple of sprayings of lead arsenate, then with DDT, and now with parathion. It is a rather uncommon thing for the public to understand that environmental and genetic changes are the combining forces which present your problem.

According to the Dept. of Water Resources, 8½ million acres are presently under irrigation, and each year at least 50,000 acres more will be added. The amount of water in the Central Valley Project will double in the next 25 to 30 years. Flood control and multipurpose projects being constructed by the Army Corps of Engineers will be added to the 4 million additional acre feet of water provided each year by the State Water Project. All of these taken together will vastly increase the amount of surface water available to the mosquito for breeding.

Even if the conventional sprays would remain effective, it is obvious that the cost of control in so favorable an environment may become astronomical. But the proliferation of the breeding grounds is only part of the problem faced by the mosquito control people, and it is certainly ill-understood by the taxpayer. The genetic agility of the mosquito renders conventional insecticides increasingly ineffective, and it is in this area that research must make its greatest contribution.

Another complicating factor is public support of the continued existence of a mosquito abatement district when it has operated effectively, has done a good job, and has temporarily eliminated the mosquito problem. But a public already hard pressed for new taxes, with more and more places to put the tax dollar, may question the need for the continued existence of a local agency once the reason for its formation seemingly has been eliminated. It seems clear to me that public awareness of the imperative need for research is an essential factor in the furtherance of this Association's primary interest.

Something else is clear—while we are all agreed as to the necessity of research to solve the genetic riddles and to prevent future epidemics of malaria and other diseases, we must realize that short term, year by year funding is not the way to operate a research program holding such far-reaching consequences. The public insists on getting the best possible use of its tax dollar, and it is imperative that the research programs be carried on over a period of years so that worthwhile results will be seen.

In summary, we can say that yours will probably be an uphill grind in this effort for additional funds, due primarily to two factors: the expanding number of interests competing for limited state resources, and the apathy of a rapidly expanding population. Another factor which may be a hindrance is the possible effect of reapportionment, as the rural agricultural areas are more thinly represented in the Legislature. The problems of the urban communities, where mosquito control may not be as serious a problem, may receive more attention and possibly more of the resources of the state. I can only conclude by suggesting that I am fully aware of the profound problem that you are confronted with, and offer to you my support as one member of the State Legislature as we proceed in your objective in the future.

ADDRESS

GORDON H. WINTON, JR.

Assemblyman, Thirty-first District

Merced County

I would like to talk to you today in a little different tenor than either Senator Grunsky or Assemblyman Veneman, and on a different idea, although it is again on finances.

As we legislators meet in Sacramento, particularly when we consider the budget, we see many organizations representing public entities, with regular and paid staffs and lobbyists who appear before us. They appear before us to represent the thinking of the public entities they represent, and to protect that thinking, or at least to give us the benefit of their knowledge and experience. In the 10 years that I have been in the Assembly, we have had problems almost every year on the budget concerning mosquito abatement districts. I have appeared before legislative committees on which I do not serve, with mosquito abatement districts and members from my district to explain to legislative committees why particular items were necessary—why we should continue them. I have also appeared before committees on other legislation which would have, I think, harmed mosquito abatement districts in their work.

As I have said, organizations that represent public entities have full-time paid staffs which represent them. The mosquito abatement districts with CMCA have no such staff. Their representation must be done on a voluntary basis, and it seems to me that this can be harmful to your organization.

When I first became acquainted with mosquito abatement districts we had state subventions. I remember Merced County Mosquito Abatement District had $40,000 per year from the state to assist it. We had other advantages which have been slowly chipped away in the budget. I can think of the continuing fight that you have in Lake County to continue gnat research as one of the areas of operation for mosquito abatement districts. It seems that in almost every session there is an attempt to remove the funds for gnat research from the budget. We also have other problems with research funds.

It is most difficult for an organization where the entire structure is voluntary to marshal its forces and really present a united front to the Legislature in furtherance of its aims. I think it is usually difficult for an organization which operates entirely through a voluntary staff to function quickly and efficiently.

In November 1964—November 3, to be exact, the day after general election—I flew down to Oklahoma City to represent the Merced County Mosquito Abatement District. The Federal Aviation Administration had developed proposed regulations regarding the use of insecticides from air. The regulations, of course, could not have touched spray by ground vehicles, but they would have regulated mosquito abatement districts as well as other aerial applicators (commercial). In our opinion, after reading the proposed regulations of the FAA, it would have put mosquito abatement districts out of business insofar as aerial spray is concerned. I flew down with members of the Board to appear before the FAA hearing at their headquarters in Oklahoma City. We were the only mosquito abatement district anywhere in the U.S. that appeared, and we were the only agency interested in public health that appeared. We were thankful that the California State Department of Agriculture had a representative there. He was representing people interested in health problems, but he was there to point out the regulations that we had in California that regulated both aerial and ground sprays so that the regulations were equitable between the two methods of control. However, I think it was largely due to our appearance that when the FAA regulations came out they, in effect, exempted public health organizations—mosquito abatement districts—from the regulations enacted which apply to commercial applicators.

One of the things that bothered us briefly was the giving of notice to everybody in the area before we spray—a notice which would have been impossible for us to give—because, as you know, when you discover a pasture which has just been irrigated and there is a possibility of its breeding mosquitoes, you can't wait three days. By that time the adults have emerged and are flying around. Other regulations such as this, which had been proposed, would have eliminated any practical use of aerial spray by mosquito control districts.

I don't know how many other districts knew about that hearing. We picked it up by chance in a commercial spray applicator's magazine. It seems to me that, for information such as this, there should be some central staff—minimal—but at least a staff to disseminate information throughout the state to the interested people in this organization. It is of vital importance to all the people involved in mosquito control work in California that this organization try to come up with a budget that would afford them the finances with which to set up a minimum staff that would work full time to coordinate the efforts in legislative representation, and coordinate the efforts in dissemination of information. This staff also might well coordinate efforts in research.

This is going to cost—no question about it. But look at the League of California Cities, and the fund which the Cities put into that organization to support their state-wide office. Look at the California Supervisors Association, and you can go right down the list of the many other public entities that do maintain such liaison offices. In my opinion, it would be well worth while for this organization to explore seriously the means by which this could be accomplished. I think it would be to the public's benefit because very often the public—since it is not plagued by mosquitoes as it was some 30 years ago—tends to forget the necessity and the need for mosquito control.

It seems to me that through a state-wide organization such as this, you could protect the public interest by seeing that the use of funds and the dissemination of information are carried out on an efficient and effective basis which would be to the benefit of all the public that is going to be affected by mosquitoes and the problems they cause if an effective program of mosquito control is not carried on.

THE PAST, PRESENT AND FUTURE OF MOSQUITO RESEARCH IN THE UNIVERSITY OF CALIFORNIA

Maurice L. Peterson

University of California, Berkeley

Division of Agricultural Science

The best summary of past research by the University on mosquito control was reported to your Association by former Chancellor Stanley B. Freeborn almost exactly 15 years ago. I will review his report briefly.

The first work on mosquitoes was begun about 1903 by Prof. C. W. Woodworth, an entomologist, who became interested in salt marsh mosquito problems at San Rafael. The following year H. J. Quayle, an assistant in entomology, was detailed by Prof. Woodworth to work with the Burlingame Improvement Club to devise a plan for the control of mosquitoes on the San Francisco peninsula, from South San Francisco to San Mateo. In the following year he developed a program of draining, leveeing and oiling, and in 1906 he published experiment station bulletin 178 on mosquito control.

Prof. William B. Herms came to the Division of Entomology in 1908. Freeborn reported that his enthusiasm and his drive for accomplishment were transmitted to his colleagues and his students over a period of 40 years. Freeborn no doubt spoke with some authority as he was one of Prof. Herm's junior colleagues at that time. Throughout the years and up through World War II, much of the effort was directed toward malaria control and research on equine encephalitis. Both these programs were very successful.

Freeborn in 1926 published on the taxonomy and ecology of California mosquitoes. Time permits little more than the mention of the names of Usinger, Douglas, Bohart, Bailey, Reeves, Furman, as among those who over the years have made substantial contributions towards solving mosquito control problems.

At the present time there are about 25 active experiment station projects which in one way or another relate to mosquito problems. Projects dealing with insect resistance to chemicals, taxonomy, morphology and ecology are related to mosquitoes and their control, although some are aimed at agricultural insect pests in general. Some projects are primarily or solely concerned with mosquitoes: Dr. Bailey at Davis, for example, is working on the ecology of the mosquitoes of rice fields, concerning which he is reporting elsewhere in this Conference.

Other projects include Dr. Judson's work on the physiology of hatching of mosquito eggs, Dr. McClelland's studies on mosquito genetics, Prof. Akesson's work on application methods for chemical control, Dr. Mulla's and Dr. Metcalf's studies on better insecticides, Dr. Bay's research on biological control, and Dr. Anderson's and Dr. Weinmann's studies on the relationship and significance of mosquitoes and other insects attacking deer and other wild life. Most of these scientists are reporting elsewhere at this Conference.

I suppose the question might very well be asked: "Why, after some 60 years of doing research on mosquitoes, haven't the problems been solved?" I think there are a variety of answers to the question.

First, I should say that many, many problems have been answered, just as we have answered many problems in medical and in engineering research. But we still have many medical problems and engineering problems to solve. Also, as in these fields, the nature of the problems changes, with changes in public expectations, demands, and human populations. Malaria, for example, was once a very great problem in California, but now is extremely rare. People today are unwilling to accept the discomfiture of mosquitoes which in the past they considered to be unavoidable. Also, more people are moving into the valleys and suburban areas where mosquitoes may be more prevalent. Increasing uses of water for rice production and other types of irrigated agriculture, recreation and industry have favored the environment for mosquito production. Chemicals which once provided good control are no longer effective because of built up insect resistance. Further, the continued pollution of the environment with repeated and heavier applications of chemicals is increasingly unacceptable. Also, as I have reviewed the 1965 report of the California State Water Project, with its 13 billion dollar price tag, I have concluded that planning for the peripheral problems such as mosquito control, which this gigantic project will create, has fallen far short of the need.

In 1962 the State Senate Finance Committee directed the University of California and the State Dept. of

Public Health to study the feasibility of the University assuming the research responsibility for mosquito control. A joint report which resulted from this directive attempted to clarify the respective roles of these two public-supported state agencies. There was appointed a joint committee of the University and the State Dept. of Public Health to coordinate this research, and it has been working very effectively.

From that time, 1962 to the present, this joint committee has been active, has met regularly, has reviewed the entire research activity of both agencies, and continues to meet regularly. The projects in existence, and the project proposals by the University, have been modified in response to suggestions by the Public Health representatives.

Two years ago, in response to repeated requests by trustees and officials of mosquito abatement districts that the University enlarge the program of research on mosquito control, I organized a study group to make a detailed and thorough analysis of our research efforts and additional needs to cope with this growing problem. The group did a very thorough job – in fact it has remained as an active planning group up to the present time. The latest summary of its plans have been made available to the mosquito abatement districts, to the University budget officials, and to the State Department of Finance. This summary, copies of which are available, is backed up by a series of detailed projects all of which have been reviewed and endorsed by the joint committee referred to earlier.

The expanded research program was scheduled to get into operation over a three year period. Final annual cost is estimated at $300,000 for the University Division of Agricultural Sciences, and about $60,000 for the school of Public Health. The University approved my initial budget request for $100,000 a year ago, but it was not included in the Governor's budget. This year I repeated the initial request and added step 2, making a total budget request of $200,000.

I would be less than completely candid with you if I did not say that we are hesitant to commit such a large proportion of our increased budgetary needs of the Division of Agricultural Sciences to the control of mosquitoes. Our primary obligation is to commercial agriculture, and I recognize the limitations of the state treasury. Other important agricultural projects have been held in abeyance or delayed in our budget request to make a place for this research. Also, I must call attention to the plain fact that this is not, strictly speaking, an agricultural problem, although I admit that agriculture has contributed substantially to its creation. Also, in the interest of being completely candid, I must tell you that if the increased budgetary needs for mosquito research are not included this year, I do not believe it will be possible for me to convince the University President and the Board of Regents that I should submit them again in the third year.

I would like to turn my attention now to the actual plans and proposals we have made toward solution of the mosquito problem. I would predict that the results of this planned research would be expected to reduce substantially the tax bill of approximately 7 million dollars spent for mosquito control for the present districts. I have no way of predicting what the impact of the California Water Plan and other programs will have on mosquito control problems in new areas which will come under irrigation, or the influx of many new people. I can only assume that new problems in new areas will arise.

There are six major lines of interlocking effort proposed in our research and extension program. They are as follows:

1. Mosquito control in water impounded areas.
2. The development of safer and more useful chemicals and application techniques.
3. Fundamentals of behavior and biology that may lead to control.
4. Biological control.
5. Mosquito control and wildlife.
6. Extension education in mosquito suppression.

I will comment briefly on our plans in these areas and will indicate some of the new projects to be undertaken if we are permitted to expand our programs.

Many water impoundments which in earlier years were a source of mosquitoes have been drained. Most of those remaining are lakes, reservoirs, duck ponds, water fowl management areas, log ponds, rice fields, etc. which cannot be drained. For such areas, the solution must be sought through biological and ecological factors which could lead to control. Management of water levels, the types of vegetation, and biological control are some of the possibilities.

Dr. Bailey has proposed to concentrate on the control of species of mosquitoes prevalent in rice fields, looking into such factors as the maximum lethal temperatures for the adults in summer and winter, as well as the maximum and minimum water temperatures for the larvae. He will also study light requirements, plant associations and flight patterns. All of this is aimed at finding the weak link in the biological chain which might be further weakened through management so that reproductive capacity is reduced.

On these same lines Dr. Mulla at Riverside proposes a broad approach to the use of chemical and physical factors which will retard, kill or sterilize the insect during one or more stages in the life cycle. He has already made progress with the use of film-forming chemicals related to detergents which apparently kill mosquitoes by physical rather than chemical method. If this works, he believes that mosquitoes will be unable to develop resistance as they have to other chemicals. He will present more information on this elsewhere in the Conference program.

Dr. Hall, in biological control at Riverside, proposes extensive explorations into the use of entomogenous microorganisms. To put that in terms I understand, this is simply to find some mosquito diseases which will either kill the mosquitoes or make them sick enough so that they are unable to reproduce. Subsequently, it is simply a matter of finding a way to culture the disease organisms and start the epidemics at the appropriate time. Dr. Bay, also at Riverside, will be looking into the natural enemies of mosquitoes, other than diseases, and finding ways of increasing their effectiveness. Apparently little is known about the variety of aquatic and other animals which may feed upon or compete with mosquitoes. He will be telling you about the annual fishes elsewhere in the Conference program. Dr. Huffaker in biological control at Berkeley envisions similar possibilities of exploiting species parasitic or predatory on mosquitoes, and manipulating the environment in a way which is conducive to their efficiency.

Dr. McClelland at Davis also proposes a biological approach but from an entirely different direction — genetics. Some knowledge of heredity might not only give us clues to the rapid natural selection of mosquitoes resistant to insecticides, but might also indicate the possibility of using lethal or harmful genes released in the population as a control system. He cautions us about overoptimism in this area, however.

Some work is being done now in all of these areas, but the scope is limited to the time and funds that are currently available. Certainly one of the hard facts of life that we face is that we must always deal with priorities of time and priorities of funds. I suppose it is possible to reach a point of diminishing returns on the investment in research, but we have never had an opportunity to test this theory. In this field of mosquito control research we are far below an efficient level of research investment.

Now I would like to discuss extension education as a means of mosquito control. I believe we all recognize that research alone answers no problems whatsoever. It is only when this information is put into usable form and made available to those most concerned that research discoveries can be made useful.

There are two cardinal principles that we have followed in our extension education program in California — these have proven themselves to us over the years. The first is that extension education should be directed almost entirely in those fields in which fresh new usable information is being created. Old information is about as attractive as stale fish. New information, on the other hand, is stimulating and provocative.

The second principle that we have followed is that the job of extension goes well beyond the strictly teaching function to that of problem solving as well. In many cases this means that new discoveries of a basic or fundamental nature are further developed and made useful by adapting them to local situations. Director Alcorn of the Agricultural Extension Service has repeatedly stated that a high proportion of the questions which are brought to the local extension offices are those for which there are no readily available answers. The public recognizes this, but they expect that we will find answers. The problems might be solved locally; they might require a combination of local and campus effort for their solution. One way or another, we will attempt and usually are successful in finding answers.

In the case of mosquitoes, the scope of the extension program will be commensurate with the research program. The program in extension will be conducted in coordination with research personnel in the experiment station, with the extension services in the fields of animal husbandry, agronomy, economics, entomol-
their effectiveness. Apparently little is known about the variety of aquatic and other animals which may
ogy, irrigation, drainage, parasitology, range, weed control, and wildlife. Work emphasis at present is on source reduction, and stresses management of water on irrigated pastures, rice fields, cotton, and in fact all the irrigated agriculture which provides breeding places for mosquitoes.

I have established a committee in agricultural extension which, among its responsibilities, will work cooperatively with the Bureau of Vector Control, the State Department of Fish and Game, the California Mosquito Control Association, and the State Department of Agriculture, to help guide the program emphasis and direction of work effort. The agricultural extension program will not replace or interfere with programs of mosquito abatement districts or the Bureau of Vector Control, except as its success in certain areas might require program adjustments. Rather, it is our intention that the agricultural extension program will complement existing programs by working towards a modification of crop production practices.

Time does not permit going into details of the extion program. However, I'll only mention that we will attempt to demonstrate to farmers the value of mosquito control and that certain modifications in production practices will both improve production and control mosquitoes. We intend to use training conferences, both for our own people and others, publications, visual aids, demonstration tours and any or all possible productive methods of making California a healthier and more pleasant state in which to live. As a single example of an interagency effort I cite the joint publication by Agricultural Extension, the Delta Mosquito Abatement District, and the Southern California Edison Company. One of the real joys of University work is that we are free to work with anyone and everyone who can further the aims of making this a better state, and we always do this.

One remaining point which I wish to clarify is that if the funds for the research effort are approved, they will be kept as an identifiable budget item, with annual allocations to the most critical research areas and projects. The projects will be those which have been reviewed and recommended to me by the Joint University - State Department of Public Health Research Committee. If, for example, funds allocated to a critical problem in one area or department have met their objectives, they will be withdrawn and assigned to new problem areas in other places. In this way, the often quoted criticism that the University's priorities are different from those of—or from the needs expressed by — the Bureau of Vector Control will have been greatly tempered through the process of joint critical review.

We look forward to working closely with you in the years ahead in the solution of the critical problems of mosquito control. I fully expect there will be great strides made within a few years which will radically change and improve our effectiveness in mosquito control.

MOSQUITO CONTROL RESEARCH BY THE BUREAU OF VECTOR CONTROL— PAST, PRESENT AND FUTURE

Richard F. Peters

Bureau of Vector Control, State Department of Public Health, Berkeley

My challenge today appears to be that of establishing program responsibility consistent with fiscal responsibility. The State Department of Public Health has for many years been active in providing mosquito control consultation and technical guidance in support of California mosquito control and is keenly concerned with the destiny of the program faced by all of you. Research is only a part, but a very vital part of this program.

As Senator Grunsky has mentioned, the California mosquito control program has experienced a meteoric rise in the past two decades in terms of agencies, area covered and dollars expended. Why have these increases occurred? Because of abundant water, the life blood of California, being used and abused by our communities, industries, farmers, conservationists, and recreationists, and eventually abandoned to become sources of mosquitoes. Diversified water use is a characteristic of our rapidly developing state. Our mosquito control program must be correspondingly dynamic.

Every day it is estimated that 1,500 new people enter California, and that approximately 600 births occur in excess of the deaths. This is translatable into an additional 200-gallon water need per new person per day, imposed upon the like daily requirement for the state's almost 19 million population. The prospect is that between 40 and 50 million people will occupy this state early in the 21st century. This domestic water use, however, is insignificant compared with the total water needs of agriculture and industry. When the future outlook for water usage and the resultant mosquito potential are contemplated, it becomes urgently evident that a mosquito preventive program must be prominent in our plans. I am sure that those of you who represent local operational public health agencies recognize the fiscal and program obligation to prevent this ominous mosquito problem from developing. If it is allowed to happen, control will be very difficult to accomplish.

Going back into history and the role of the Department of Public Health in mosquito control, our predecessors participated in the first meeting of your association in 1930. Mr. E. A. Reinke, former Chief, Bureau of Sanitary Engineering, served as Secretary-Treasurer of this Association for many years during the early days of the Association. Thus, the Department has been active in seeking new and more effective ways of suppressing mosquitoes--accentuating the preventive approach—for over 35 years. Recently, I completed a quarter of a century of mosquito control service within the State Department of Public Health. Looking back on the California mosquito problems to which I was introduced in 1940, my recollections are that they were then blissfully simple. Our control technology included four basic tools: diesel oil, the shovel (whether mechanical or hand), *Gambusia affinis*, and weed control —primarily by physical means. If these sublime conditions had continued, the need for research today in this field would be inconsequential.

Upon my return to California after World War II, however, a changing scene with something new called "population pressure" was already upon us. A state subsidy program to local mosquito control agencies was in the blueprint stage. This was designed to reduce the threat of introduced mosquito-borne diseases through an increased state-wide mosquito suppression effort.

It is worthy of mention that today *P. falciparum* malaria in some parts of the world cannot be effectively treated owing to drug resistance. *Anopheles freeborni*, our principal malaria vector, is now probably twice as abundant as when malaria was a major disease problem in California. I just checked this with Dr. Stanley Bailey to see that I wasn't guilty of an exaggeration. From the vector standpoint, the malaria potential is probably many times greater than it was 50 years ago, and it could become even greater, particularly if we become more deeply involved in Asia or if we are obliged to increase the quota on rice production in California.

In 1952 California had an encephalitis epidemic which none of us who were here to experience it will ever forget. Viewed in terms of the most apparent causative factors, precipitation and snow pack were approximately 200% of normal that year and an abundant *Culex tarsalis* population had been able to survive a rather mild winter. The potential for this happening again is just as great in the event these and other required conditions occur again. Dr. William C. Reeves of the University of California School of Public Health, who is prominently identified in California mosquito research, has been a most significant force in exploring the natural history and ecology of the viral encephalitides. His research project began in 1943 and all the intricate aspects of this disease complex have proven most difficult to decipher as a basis for obtaining effective control. At this stage we are obliged to deal with this problem by extensive and carefully timed use of insecticides. Even here, we have been confronted with a perpetual dilemma—what insecticides? In this regard, I am delighted to learn of Dr. Mulla's revelation and the possibility that another group of insecticides may carry us a little longer. If these materials possess characteristics which preclude mosquito resistance, it will be the first such instance in a long, discouraging period of insecticide use.

Returning to the matter of research, in 1950 with the first evidences of failure of DDT and the other chlorinated hydrocarbon insecticides, your Association requested that a proportion of the state subsidy be applied to organized research on the ecology and control of mosquitoes. Approximately $25,000 was earmarked for this purpose and the Turlock Mosquito Abatement District became the setting for the first cooperative California mosquito control research activity. After a couple of years at Turlock, in order to serve the state-wide interest more effectively, the California Mosquito Control Association asked the Bureau of Vector Control to accept the responsibility for mosquito control research. This we agreed to do, locating a field station in Fresno, contrived out of war assets structures and considerable hard work. Over the years since that time, this program has, to the limited extent of available funds, made sound progress in researching the ecology and related facets of California mosquitoes as the basis for developing alternate control technologies. In the mid-1950's there occurred what may be viewed in retrospect as a period of complacency about mosquitoes. Almost immediately after the manifestation of resistance to chlorinated hydrocarbon insecticides, organophosphorus materials—malathion, parathion, and subsequently fenthion—came to the rescue. But once again, we are reeling under the impact of resistance, this time to the organophosphates. If a new insecticidal approach can be developed in time to carry us a little longer, this will be a stroke of good fortune. However, this is not fulfilling our responsibility for organizing an environment most suited to human living, which was the message Mr. Stead sought to make indelible yesterday. The problem we face today and in the immediate future is that of determining how we can successfully emerge from this pollution of our atmosphere, our land, and our water. This challenge confronts every one of the agencies in this Association, as well as a great many other organizations sharing these responsibilities throughout this state.

Over the years there has been some uncertainty expressed concerning the Department's role in mosquito control research. As early as 1955, in order to put these concerns to rest, our Director asked for both administrative and technical reviews of the Bureau of Vector Control. A review team was organized. The Management Analysis Division of the Department of Finance sent its representative, a Mr. Dale Hanner, and the U.S. Public Health Service sent an engineer, Mr. John Henderson, a former professor of sanitary engineering at Columbia University, and a biologist, Dr. Melvin Goodwin, director of the Phoenix laboratory of the USPHS Communicable Disease Center. These people made a very careful and thorough assessment of our program and rendered a report commending the Bureau for having vision in dealing with the water problems of the state through the development of a highly productive, prevention-oriented mosquito control research program.

The Legislature in the mid-1950's imposed a condition that at least $25,000 of the funds available for subvention be utilized by our Department for mosquito control research. This amount was increased to $43,000 in 1959, and in 1961, when the California Mosquito Control Association determined that the remaining state subvention funds could be better employed in research, a request was made that such action be taken. The net effect was the elimination of operational funds from the state budget with the remaining subvention divided into $101,000 for mosquito surveillance, and $90,000 for mosquito control research. Subsequent developments in 1963 saw the $101,000 deleted and in 1965 the Department was instructed by the Legislature, at the end of the conference session, to discontinue all mosquito control research activity and to contract with the University of California for any necessary research. We have complied with this directive.

In 1962 the Senate Finance Committee instructed the Department and the University to establish a joint committee for the purpose of mosquito control research coordination. This charge has been carried out in a highly effective manner. In pursuing this Committee assignment the University's research representatives—Dr. Reeves, Dr. Bohart, Dr. Ray Smith and Dr. Carman—have met nine times in all since then with our Assistant Director, Dr. Pulley, Dr. Clark of our Division of Research, Mr. Frank Stead, Chief of the Division of Environmental Sanitation, and myself. This committee has fulfilled a responsible program and fiscal service, not only to the Legislature but to the California Mosquito Control Association and the two principals in this discussion—the University of California and the Department of Public Health.

I would follow this by stating that I am a strong advocate of a complementary University of California and State Department of Public Health research effort, which I believe is needed to achieve our respective objectives. I strongly endorse a University of California research program and I believe equally in the research program conducted by the Department, which your Association has followed closely in recent years. The Bureau of Vector Control, since the issuance of the 1965 legislative dictum, has been obliged to operate under very difficult circumstances. The responsiveness of the School of Public Health of the University of California in contracting the research funds (with support of the Joint Committee) and the continuation of the program in the pattern conducted by the Department have been most reassuring. However, the matter is presently in limbo. I am sure the University of California appreciates this present situation as does the Department. The task before us is a tremendous one, difficult of accomplishment even if all the funds proposed by your Association are made available. The Department supports, if it is determined fiscally possible, the entire budget request made by the University of California for supplemental funds. We also believe that a clear definition of mosquito control research responsibility by the Department has been enunciated by the President of the University of California and the Director of the State Department of Public Health. With the guidance of the Joint Committee this policy statement assures that the best interests of the state will be served on a meaningful and well-defined partnership basis. It should also be pointed out that the Department is charged with responsibility for the extension of technological information to the 50 local mosquito abatement districts plus all of the local health departments in California. Our predicament is that without a research role we would be working in a vacuum. I believe the underlying concept of the University Agricultural Experiment Station and the Agricultural Extension Service is to be mutually reinforcing. The School of Public Health has never been endowed with state funds for mosquito control research, yet mosquito control is a public health problem. The encephalitis research program of the School of Public Health is largely funded by outside grants and we have heard ominous mention here today that the present level of grants may not continue in the future.

To illustrate how complex this matter is, I have been asked why each of the agencies responsible for water development, distribution and use cannot accept individual responsibility for preventing and controlling mosquitoes. In answer, consider just one genus of mosquito, *Aedes*, and see how impractical this suggestion is. Starting with the coastal *Aedes dorsalis,* a salt marsh mosquito, theoretically the diverse conservation interests ought to be able to suppress this particular mosquito which can fly 20 miles or more if uncontrolled. Regrettably, these interests are still discussing among themselves what conditions are most advantageous for the preservation of waterfowl and fish, irrespective of mosquito suppression. A little further inland we encounter *Aedes sierrensis,* the tree hole mosquito, a very important suburban pest which also extends to the 9,000-foot elevation in the mountains. Could the forest service deal with this problem? Next, consider the river-bottom lands in California. Is it feasible to expect the water projects and reclamation agencies to handle all the bottom-land problems from which *Aedes vexans,* also with an extensive flight range, originates? Then to agriculture and *Aedes nigromaculis,* the scourge in the inland valleys, which if uncontrolled could make the entire Central Valley uninhabitable, not to mention its severe impact upon livestock. Should agricultural agencies pursue this problem into our cities? Next, return to the mountains and consider the more than a dozen *Aedes* species that originate in the snow melt. Could various recreational agencies or the U.S. Forest Service handle these problems? As you can readily see, these are problems that cross almost every boundary of interest in California. One agency must have the responsibility for coordinating this program to assure that the total effort is conducted for the best interest of the entire state. The Department of Public Health, having no vested interest except the well-being of people, is uniquely equipped to serve this function in support of local mosquito abatement agencies.

So what is in store for the future? The Bureau of Vector Control developed a research proposal which in my judgment dovetails with the proposals prepared by the University's Division of Agriculture Sciences and School of Public Health. Our research proposal seeks maximum collaboration and cooperation toward resolving the otherwise unmet needs in this field. This proposal would emphasize our role in the areas of mosquito surveillance (the development of improved monitoring systems both for immature and adult mosquitoes); mosquito source reduction (through case history studies to obtain correlatable data from source reduction projects); and field testing and demonstrating any promising control technology developed by the University of California, the USDA, the USPHS, the World Health Organization and other research agencies. The great misfortune at the moment is the dictum from the Legislature under which we are now apparently obliged to operate—" . . . the Department of Public Health shall discontinue all mosquito control research activity." The Department feels that it is equipped for an applied research role in mosquito control, working under purview of the Joint Committee to undertake either collaboratively or independently certain specific, high priority work that may extend beyond the range of resources or interests of the University. A research increase of $200,000, or even $300,000, for the University will provide only a moderate amount of additional effort when viewed in the face of the task to be performed. It is evident that the Department must be identified in research relating to the vector-borne diseases that I have mentioned — encephalitis and malaria — since it is charged with responsibility for conducting investigations into the cause of diseases. Thus, it is evident that conflicting interpretations may exist in fulfilling these legislative assignments.

In closing, I can only reassure you that the Department of Public Health is prepared to perform with dedication what the Legislature assigns us to do. I believe, however, that you can all understand something of our present predicament. Taken literally, we are directed to discontinue any original staff work, or applied research, on mosquitoes—the most important group of vectors for which we have responsibility. Being acutely aware of the fine, sustained support that your organization has given our research program over the years, I am impelled to make this candid and forthright statement. It is our hope along with that already expressed by the CMCA, that logic will prevail in this matter and that we will be given a renewed charter to conduct the most effective possible program in the interest of mosquito control in California.

ADDRESS

HARRIS E. HOGAN

Principal Legislative Analyst

California Legislature

The Legislative Analyst's Office has had a direct concern with the state's participation in mosquito control programs since 1947 when the Legislature enacted Chapter 5.5 of the Health and Safety Code, and provided a $400,000 subvention to support local programs. Annually since that time the budget has contained support of several kinds of mosquito control programs, and we have annually considered the problems associated with the provision of such state support. When we have deemed it appropriate we have made specific recommendations to the Legislature with regard to this matter. They have not followed our advice in every instance; however, in recent years and most specifically as regards the level of support and the assignment of responsibility for producing research results, they have tended to recognize the validity of the positions we have taken.

It has seemed self-evident to us at all times that research was a necessary component of any effective mosquito and gnat control program. Soundly conceived and directed basic research coupled with the practical application of research results in the field by the experienced staffs of the local districts would certainly appear to be the best attack which can be mounted upon our common enemy, the mosquito. The necessity for research, as part of that attack was amply demonstrated when it became evident that the enemy was capable of developing countermeasures, and of becoming immune to the insecticides which have been our principal weapons system since this war began. And incidentally, these insecticides are themselves the products of research.

Our difficulty with research in this area has been with the fact that it has been so organized as to be separated from the mainstream of state supported research activity within the state. We have consistently recommended that research in this field be carried out within the extensive research capability of the University. We have made this recommendation in the interests of maximizing the effect of the research, and have not entertained any thought of minimizing the need for research or of handicapping or inhibiting the ability of you people in the front lines in your fight to control this pest.

At the same time, our responsibility to the legislature and to the taqpayer requires us to be conscious at all times of the relative needs of the numerous problem areas of state government. It is necessary to think in terms of cost-benefit ratios and to evaluate alternatives to existing courses of action.

In this context we have supported our recommendations that mosquito control research be centered in the University research complex, on the basis that, first, the likelihood of increased benefits from the same research effort could be enhanced by accessing directly the broad scope of basic research in all areas, which characterizes the University of California. Secondly, the University is capable of responding directly to the needs of local entities, and has demonstrated this capability in its agricultural research relationship to the State Department of Agriculture and to the agricultural industry of the state for over 30 years. Thirdly, the role of the University itself as an educational institution, is enhanced by incorporating this area of research into its teaching and research programs. Fourthly, the State Department of Public Health is not organized primarily to conduct research, and the dual role of research activity and concern with day to day operating problems in the field of public health can result in neither activity being as efficient as it might otherwise be.

In the current year the Legislature has directed that the University conduct the preexisting research activities in the mosquito control field. This has been accomplished by directing the Department of Public Health to contract with the University for those research activities which it formerly carried out directly. From the point if view of continuation of responsive research activities related to your problems, I do not believe that there is any evidence that your operations have suffered any detriment by this change.

As you are all aware, there is a proposal by the University to enlarge the sphere of its research activity in this field. This proposal was developed by the University in direct response to your expressions of need for more research and in cooperation with the responsible officials of your organization. I understand that this proposal has been receiving consideration in recent weeks in the regular course of the development of the budget for 1966-67. The Governor will present that budget to the Legislature for consideration at the session starting next week. Our role will be as usual to advise the Legislature concerning the details of the various parts of the budget, and I can assure you that your research proposal will not be overlooked if it is contained in the budget. I can and do assure you that in all matters affecting your interests we will make every effort to be consistent with the principles I have outlined, and to the best of our ability support your continuing efforts on behalf of the health and comfort of the people of California.

ADDRESS

LOWELL R. GANO

Assistant Chief Budget Analyst

California State Department of Finance

Six days from today the Legislature will meet in Sacramento to consider the budget proposal of the Governor. We have been working since early last fall in trying to bring together in some cohesive manner the various program presentations which the administrative and operating agencies wish to submit for consideration by the Legislature.

The budget proposal in its full context represents a plan to achieve certain goals that the Administration believes are desirable. It is a system of planned expenditures. I know all of you gentlemen, as trustees of your respective organizations, probably have had considerable experience with budgets that are required for your own operations, so I feel it needless to belabor this point.

The legislative session, to consider the budget as submitted, provides the people, through their elected representatives, a public forum to review programs represented by the planned expenditures that I referred to before. The legislators thus take an important role, together with the administration, in determining what the program structure of state government will be. In all honesty, the program determinations in the final analysis are actually the responsibility of the legislative arm. The administration merely acts in the capacity of recommending for legislative consideration the direction that the state's structure will take.

I was asked early in this month—or perhaps it was in the latter part of December—to just briefly go over some of the manners in which the state budget is put together—what are some of the budget concepts that we are concerned with. This is a difficult topic to present to a group such as yours without sounding like I am presenting a course in elementary public administration. The concepts that I had intended to outline in rather an unspectacular fashion I believe have been covered in many respects by Mr. Veneman's comments in relation to the ability of the Legislature and the administration to cope with rather unending demands upon the public dollar when the resources to meet the demand of themselves were limited. The budget, as I mentioned before, is a comprehensive plan of operation. It must of necessity cover a specified period of time; it must be expressed in financial terms, and it must be based on clearly defined policy objectives that are responsive to changing attitudes, both social and political.

The budget document, and you who have seen it will realize it is quite a large tome, represents a comprehensive revenue and resource plan of the administration for consideration by the Legislature. The budget, as it is finally enacted, through both the budget document and its implementation source, the budget statute, represents the legal base for the expenditure of the funds outlined in the budget. The document represents a framework of fiscal accountability, the budget provides a means of systematic re-examination of the internal operations of government from the standpoint of both efficiency and economy, and through the budget bill there is put to the administration a basis for the delegation by the Legislature of certain operating as well as financial authority and responsibility.

Some of the budget objectives that we must outline are that the document as it stands represents a means of executive control and coordination. It provides a means by which the administration can comply with legislative intent and attain a proper balance among programs. Starting with these foregoing concepts, there follows a long development period in which the budget is put together by the administration. From my point of view as a staff representative of the executive branch of the government, budget development is not a static thing. Administratively, we are concerned with the 1965-66 fiscal year. That is, in my day-to-day work I am now concerned with the day-to-day operations of the budget that was passed by the Legislature this past June. But we continuously are looking, backward for historical reference to see how the budget programs have actually accomplished their purpose, and we are looking forward 5-10 years to develop a logic which might suggest a plan of action for the administration. Such a plan of action becomes the budget for ultimate communication to the legislative branch.

The decisions that must be made in bringing together the budget document which will go before the Legislature next Monday or, by Constitution, within the first three days of the budget session, represent decisions concerning both resources and expenditures. I am sure that Mr. Veneman has already alluded to the gap which would appear to be existing between the resources available to fulfill all the budgetary needs of the state, and the many, many program proposals that we have had. The executive arm of government must make a determination of needs which they believe are appropriate for recommendation to the legislative branch. In many cases they must prepare alternative plans that will further policy objective. They must allocate the state's resources among competing programs, and it is at this point that we probably reach the greatest impact upon your own particular areas of interest. As you well know, and it has been pointed out, there are many conflicting demands for funds.

The execution of the budget document then involves decisions both by executive branch and by the legislative branch. It provides a means by which the government can then cope with many, many emergencies. I will try and pass over some of my prepared remarks in the interest of time.

The allusion has already been made to the responsibilities people such as Mr. Peters have in trying to effectuate a program within the structures placed by the legislative branch of government. He also undoubtedly has many instances where we as staff people on the budget staff have caused him some concern. I haven't had a chance to compare notes with him just now.

Sometimes a budget representative feels that he is some sort of an ogre when he goes out into an operating agency, because he represents "those people in Sacramento" who didn't let them do what they wanted to do. We become in a sense a sort of whipping boy for these programs. The questions which we attempt to resolve, however, are questions we raise to provide us with a better understanding of the program direction that the departments wish to accomplish. We must try to interrelate the program direction with the needs—at least our understanding of the needs—of state government. In this way we can present a cohesive statement to our administrative leaders, and they in turn can pass on those selected programs that they feel the Legislature should consider.

Of concern to this Association is how all of this relates to mosquito control and research, as I pointed out initially. In one concept the budget represents a plan to achieve certain goals—administrative objectives—through a system of planned expenditures. The definition of goals will come from a number of sources. It represents a synthesis—a public expression of needs—an expression by associations such as yours, and it will come from departmental program expertise such as presented by Dr. Peterson and Mr. Peters. The budget staff will function as an interpreter of programs. Our philosophy on mosquito control, which I was asked to comment upon—on mosquito control and research—was considerably persuaded by the quality and demonstrated validity of the information which is presented in support of a proposal. Obviously, however, if we consider our total responsibility, we must relate our concepts of the place of mosquito research to the place of several hundreds, or perhaps thousands, of other proposals. The problem, as you well know, is limited resources and unlimited demands.

So I seem to be coming back to this same theme. This discussion has sidestepped the question which was put to me several weeks ago, but I really don't know that I can give a direct answer. The question was—what is the philosophy of the Department of Finance in regard to mosquito control and research? As a staff specialist, I have a high regard for the value of research in determining a logic upon which a course of administrative action may be determined. I have no reason to doubt that the departmental philosophy is different collectively than my philosophy individually. As I mentioned before, the Legislature will convene on Monday, February 7. The discussion of the status of research in the forthcoming budget is not my normal role until this budget has been presented to the Legislature by the Administration. I know you understand that it is my boss's prerogative to make his presentation of the budget, but I would like to take this opportunity to indicate to you that the discussions that have been held here already this morning are of value to me because this gives me a chance to better understand what problems you look to as being of overriding concern, and I can then gain a perspective that I could not possibly gain sitting in Sacramento.

We are still putting the final touches on the budget, and our staff has been working long hours to meet the constitutional deadline. We do want to take time, however, to understand your problems, for not only now but also for subsequent years.

FOURTH SESSION

(CONCURRENT)

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

TECHNICAL SESSION

RICHARD F. PETERS, *Moderator*

RESEARCH IN PROGRESS IN UTAH IN 1965 ON MOSQUITOES AND MOSQUITO CONTROL

DON M. REES

University of Utah, Salt Lake

Research in Utah on mosquitoes and mosquito control has been influenced and greatly assisted by the research work in this field conducted in California and elsewhere in the world where such work is in progress. This is made possible by meetings such as this which delegations from Utah have been attending since near the beginning of the Califirnia Mosquito Control Association and through the published proceedings of the programs presented in these meetings.

It is obvious that some of the information obtained concerning mosquitoes and mosquito control in California and in other parts of the world is not equally applicable in Utah. We, therefore, have found it not only necessary but economically essential to encourage research in this field in order to adapt known information to local conditions. In so doing, the search for additional information in this field has been stimulated and developed in Utah.

In addition to the routine mosquito control activities conducted in the ten organized mosquito abatement districts in Utah there is some research work being conducted, especially in the larger districts, as part of the control activities. This type of work is an essential part of effective mosquito control operations. In addition there were at least twenty specific problems considered in Utah in 1965 by various investigators in the universities, mosquito abatement districts, and by other federal and local agencies interested in this program.

The following are the names of some of the principal investigators of mosquitoes during 1965 and the problems considered:

Collett, Glen C. and Dean M. Andersen

Host preference of mosquitoes in the Salt Lake Valley as determined by precipitin test. With W. C. Reeves, Ph.D., and C. H. Tempelis, Ph.D., University of California.

Gaufin, Arden R., Ph.D., and students

Residual effects of mosquito larviciding on the aquatic habitat.

Gebhardt, Louis P., M.D., and students

Possible overwintering reservoirs and experimental epidemiology of Western Equine Encephalitis virus.

Graham, Jay E. and Glen C. Collett

Measurements of mosquito larval populations and population dynamics. A statistical study supported by an NIH grant.

Surveillance of Western Equine Encephalitis virus in Utah.

Monitoring, in Utah, mosquito resistance to organo-phosphorus larvicides. Sponsored by Utah Mosquito Abatement Association and assisted by D. J. Womeldorf, California Bureau of Vector Control.

Nielsen, Lewis T., Ph.D., and Don M. Rees, Ph.D., and students

Taxonomic, distributional and ecological studies of the mosquitoes of the Rocky Mountain region.

Nielsen, Lewis T., Ph.D., and students

Mountain *Aedes* and their control.

Tree hole mosquitoes in Utah.

Taxonomy of mosquito pupae.

The *Culex* complex in Utah.

Rees, Don M., Ph.D., Robert K. Vickery, Ph.D., and students

Comparative study of karyotypes and pattern of DNA synthesis in chromosomes of mosquitoes. The pattern of meiosis in *Aedes dorsalis* (Meigen).

Rees, Don M., Ph.D., and students

Mosquito larval succession and the effects of larvicides on the larval environment.

Life history and control of *Culex erythrothorax* in Utah.

Selective oviposition response of *Aedes dorsalis* and *Aedes nigromaculis* to soil salinities.

Parasites of mosquito larvae in Utah and adjacent states.

Predators of mosquito larvae in the marshes bordering the Great Salt Lake.

Development of techniques for multipurpose management of reusable water before it enters the Great Salt Lake.

This is a cooperative program supported in part by an NIH grant. The objective is to develop water management facilities and practices that will be of greatest mutual benefit to agriculture, wildlife, recreation, and mosquito control.

All research projects on mosquitoes in Utah are cooperative programs. The principal investigators in these research projects are encouraged to obtain the assistance of others who are able to contribute to the solution of the problems involved. As a result, a very cooperative relationship has been established among those engaged in this work which is reflected in the productivity of the research program and the application of these findings to more effective mosquito control operations in the mosquito abatement districts.

Salt Lake City and Salt Lake County mosquito abatement districts, as an example, have maintained for many years a close relationship with the University of Utah whereby the managers of these districts with consultants from the universities and other agencies have jointly investigated mosquito control problems within these districts.

As a result of this arrangement a number of graduate students at the University of Utah have obtained employment each year with these districts. This has provided field training and frequently Master's and Ph.D. theses problems for the students and essential seasonal employees for the abatement districts. The results have been mutually beneficial.

We plan to continue in Utah with this cooperative research work on mosquitoes and mosquito control and request your continued cooperative support to this program.

ECOLOGICAL STUDIES OF CALIFORNIA ANOPHELINES–A PRELIMINARY REPORT

Stanley F. Bailey and David C. Baerg

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A comparative study of the ecology of California anophelines offers some of the most interesting and challenging of mosquito problems in need of solution. Freeborn, Aitken, Markos, Loomis and Sherman have made many significant field observations on this important group of insects. Nevertheless, a large amount of research yet needs to be undertaken for a better understanding of the factors that limit the distribution, fluctuations and dispersal of the four species involved, namely *Anopheles franciscanus* McCracken, *freeborni* Aitken, *occidentalis* Dyar and Knab and *punctipennis* Say. In 1963 we began a study, both in the field and laboratory, to determine the relative importance of these ecological factors. With the exception of the dispersal and flight range study of *freeborni*, we have attempted to conduct laboratory experiments that would complement the field study. Our work has been carried on in northern California, particularly within a transect of the state from about Emigrant Gap (5,340 ft. elevation) in the Sierra Nevada Mountains to the Pacific Ocean in Marin County. For ecological purposes we have divided this area into four zones: (1) Coastal, (2) Interior Coastal, (3) Sacramento Valley and (4) Western slope of the Sierras. This report presents a general summary of the work to date, with certain highlights. Detailed papers on specific segments of the work, together with experimental data, will be published elsewhere.

Laboratory procedures for determining the effect of temperature on both the adults and immature stages necessitated maintaining colonies. In developing certain new techniques with inexpensive equipment to insure a reliable supply of the various stages, we have profited by the suggestions of Boyd (1930), Hardman (1947), and Barr (1952). The initial field survey was made to locate representative sites in which three or, hopefully, all four species occurred. Biological "stations" then were selected which we could study on a year-round basis recording the temperature, pH, water depth, elevation, and other factors along with the seasonal succession and abundance of the species. The collected larvae were reared to adults in the laboratory for positive identification. These collections, extending through two seasons, are summarized in Table 1.

Only one species, *Anopheles freeborni*, has a pronounced migratory habit; this mosquito disperses extensively in the fall, and to a lesser extent in the spring. Release-recapture experiments with marked *freeborni* adults have been a separate study.

Abundance and Seasonal Succession of Species

The sequence of the appearance of the species of *Anopheles* varies with the locality and elevation.

Coastal Region – We have collected *occidentalis* either as adults or larvae every month except December. This species appears to breed all year (Aitken, 1939, 1945), reaching its greatest density in late summer or early fall. The population of *punctipennis* is at a peak in the spring, becomes somewhat depressed in the summer and then is increased slightly in the fall. The most widespread species throughout summer is *franciscanus*. The malaria vector, *freeborni*, is very rare along the Coast; it never is found in numbers west of the Sacramento Valley proper. During 1964 and 1965, we collected anopheline larvae at 34 locations in the coastal area. The reared adults were 948 *occidentalis*, 424 *punctipennis*, 258 *franciscanus*, and 15 *freeborni*.

Interior Coastal Range – In the warmer valleys *franciscanus* is by far the most widespread and dominant species, while *occidentalis* is absent. *Anopheles freeborni* is found in small numbers in isolated locales but remains at a low level, which probably makes successful swarming and mating difficult. *Anopheles punctipennis* is found all year (to date no larvae have been collected by us in January and February) and reaches high densities only very locally. However, as one approaches the Sacramento Valley, i.e., northwestern Yolo and southwestern Colusa Counties, breeding sites become more scattered and its relative abundance is greatly reduced. Fall and winter adult station counts in 1963-64, from 335 to 1,725 ft. in western Colusa County totaled (females) 2,121 *freeborni*, 447 *franciscanus*, and one *punctipennis*. Above 1,000 ft. *freeborni* decreased noticeably. In the Capay Valley of Yolo County, 200-480 ft. elevation, from August, 1964, to March, 1965, weekly collections of adults (both sexes) totaled 6,185 *freeborni*, 377 *franciscanus* and 57 *punctipennis*. These figures are misleading in that they do not show the actual amount of breeding in the area—only that *freeborni* migrates into these areas adjacent to the Sacramento Valley in large numbers in the fall, passes the winter in such locations, and further extends itself somewhat in the spring "emergence flight" seeking blood. Freeborn (1932) well stated this phenomenon in that "This flight inundates . . . areas well out of the natural range of the species where breeding is attempted but is ecologically impossible."

Sacramento Valley—Any series of collections can be preselected, perhaps unconsciously, by an experienced culicidologist and "prejudiced" in favor of a particular species known to occur in an area. Even with this possibility in mind, it is very difficult to make biased anopheline larval collections in the intensively farmed Sacramento Valley. Rice fields and "tail-off" water in ditches from irrigated sugar beet, tomato, bean, and alfalfa fields are the preferred and major sources for the breeding of *freeborni*, which is *the* predominant anopheline. Larval collections from early June through October are almost always *freeborni*. This environment, no longer a natural one, is not comparable to the hills and mountains which have not been altered as extensively by man. Along the margins of the valley and where some gravelly stream beds contain water throughout the summer, *franciscanus* often breeds in pure culture. Also, in small unpolluted pockets shaded by willows, oaks, overhanging or grassy banks, or by bridges on these tributary streams, particularly those emptying into the valley from the east, *punctipennis* can be found in small numbers.

In the summer, CO_2 traps have been used extensively by us in flight range studies of *Culex tarsalis* Coq. in and about rice fields in the lower Sacramento Valley. During 1960-63, in 37 experiments these traps caught 475,408 *tarsalis*, 18,502 *Anopheles freeborni* (including one female), 3 *franciscanus* and no *punctipennis* (Bailey, Eliason and Hoffmann, 1965). Female adults of *freeborni* are not as readily attracted to CO_2 (unless warmed) as are *tarsalis*, so these comparative trap counts are not truly indicative of the relative abundance of this anopheline. We have no comparative data on the other two species. Large numbers of *freeborni* of both sexes, however, can be collected in artificial resting units (i.e., red boxes) placed in the rice fields, while in farm buildings nearby very few are to be seen. We feel that during midsummer adults are reluctant to disperse from the cooler, more moist immediate breeding area. Thus the usual sampling methods, such as resting station counts under bridges and in man-made shelters, show the so-called "summer depression" noted by Freeborn (1932). Larval sampling in rice checks, on the other hand (Markos, 1951, and Markos and Sherman, 1957), indicate that *freeborni* was equally or slightly more abundant than *tarsalis* although its seasonal peak occurred about a month later.

Sierra Nevada Mountains — At lower elevations (about 200-600 ft.) on the western slope of the Sierras *freeborni* is the species most often found. It is located chiefly in farm ponds, reservoirs, and sunlit, grassy ditches. Freeborn and Bohart (1951) state that it is not collected above the digger pine belt. Frequently in shallow ponds or small pockets of water at the margins of streams covered with algae *franciscanus* will be numerous very locally. In the cooler water and more shaded thickets and canyons *punctipennis* is the commonest species. Herms (1921) wrote that this latter species "shows a distinct inclination to hug the Sierra foothills with sporadic foci." In eight adult stations from 268 to 2,640 ft. elevation, collected in the fall and winter of 1963-64 in Yuba and Nevada Counties (females only), 1,811 *freeborni*, 86 *punctipennis* and no *franciscanus* were taken. A farm pond and adjacent drain ditch in Nevada County at 1,400 ft. elevation on State Highway 49 at Wolf Creek were sampled for larvae all year. Here *punctipennis* was the dominant species, reaching a seasonal peak in the cooler water of the ditch in July; *franciscanus* was second in abundance with a maximum in September in the pond. The third species, *freeborni* (*occidentalis* is absent), maintained its population at a low level in both ditch and pond, never having a definite seasonal peak. The total numbers of larvae taken (32 collections) and reared to adults in the laboratory in 1965 from this location were (both sexes) 1,403 *punctipennis*, 518 *franciscanus*, and 299 *freeborni*. Proportionately, the adults of all species taken at and near the breeding site were surprisingly few.

At higher elevations *Anopheles* are scarce, probably the result of so few suitable breeding niches in addition to cold water, severe winters, and a frequent flushing action of the streams due to the steep gradient. In the larger mountain meadows with grassy pond-like areas, such as shown by earlier limited adult collection records in Modoc, Lassen, Plumas, Shasta, and Sierra Counties, *freeborni* appears to barely hold its own (Herms, 1921, and Freeborn, 1926). On the east side of the Sierras, Eugene Sherman (unpublished notes)

Table 1. Summary of *Anopheles* larval collections in northern California. 1964-65

Species	No. sites each species occurred	No. collections	Seasonal range of collections by date	Water temp. range°F.	pH range
franciscanus	49	90	Mar. 22-Nov. 19	54-98	7.3-10.2
freeborni	34	71	Mar. 30-Nov. 19	55-96	7.3-10.2
occidentalis	19	26	Jan. 28-Nov. 11	57-91	8.0-10.1
punctipennis	57	133	Mar. 16-Dec. 3	46-97	7.3- 9.6
No. sites checked					
93		320	Jan. 28-Dec. 3	46-98	7.3-10.2

collected *freeborni* (three females) in Tahoe Valley in buildings on October 17, 1961. Chapman (1961) found *freeborni* and *franciscanus* in very small numbers in old mine shafts in and near Virginia City, Nevada. No information is yet available on the specific larval breeding sites, with water temperature, pH, or plant associations in these areas. It would appear, however, that the water temperature is an important factor as Freeborn (1926) noted that *freeborni* (adults) invaded the warm valleys of the Sierra having an easterly exposure to the Nevada plateau.

Adult Resting Sites

The types of resting sites in which adult anophelines are found vary both in structure and location. There is also some difference in the relative exposure of the site which they select in the summer vs. winter. According to the field records we have obtained so far, *franciscanus* is the most tolerant of high temperatures; this species has been collected commonly under bridges in the summer at which time the afternoon temperature at the resting surface was in the 90's. Specifically, the highest temperature we have recorded for resting *franciscanus* in nature is 97°F. In contrast, the highest natural resting surface reading we have for *freeborni* (both sexes) and *punctipennis* is 89°F. No data is yet available on *occidentalis* under summer conditions. When confined in resting boxes outdoors with water available, all male *freeborni* died in two hours at 100°F. and 100% mortality of day-old females occurred in two hours of exposure to rising temperatures from 103-110°.

During the spring it is difficult to find any *Anopheles* adults in the fall and winter resting places. By early summer the numbers have increased sufficiently to enable the collector to find *franciscanus* readily under open bridges and in culverts near breeding areas. This species does not prefer buildings. At this time only an occasional individual of either sex of *freeborni* can be seen in these and similar locations. We have been bitten by *punctipennis* in full sunlight and shade at the breeding location during the summer but observed that the adults did not go into open buildings, sheds, and under bridges until the cooler weather in the fall, particularly after the first rain. Loomis and Sherman (1959) have shown that both light traps and box units attracted very small numbers of *freeborni* until September when the box shelter became far superior. We found, like Soroker (1953), that *freeborni* would readily enter boxes placed on rice checks and remain there all day if shaded even though the temperature rose to 90°F. Soroker noted a daily summer peak of numbers in such units around 2 p.m. We have found that if the temperature and humidity become unfavorable in a resting site this species will continue to relocate, sometimes only a matter of inches, until a more favorable micro-environment is found (see also Gjullin, Mulhern, and Husbands, 1963). During October, however, when *freeborni* begins its major dispersal its habits change somewhat. We have observed large numbers of males in farm buildings as far as two miles from the nearest breeding source.

In the fall all four species, in varying degrees, move into man-made shelters which frequently offer locally the best protection. The species that reaches the greatest numbers in these sites, except in the coastal area and above 1,000 ft., is *freeborni*, followed by *punctipennis* in the foothills. An occasional specimen of *franciscanus* is found inside buildings at this time even though it does not prefer to bite man. In late summer and fall this latter species in particular becomes quite numerous temporarily under bridges over streams where breeding has taken place. However, by November it (*franciscanus*) largely disappears and only scattered individuals are seen in such places. On the west side of the Sacramento Valley it remains fairly common during the cold months but on the east side it completely disappears from the commonly collected adult wintering sites. The coastal species, *occidentalis*, is seen in small numbers nearly all year under bridges. In the most favorable breeding areas, and some seasons only, a hundred or more adults can be collected from various shelters near the larval habitat.

The most outstanding adult collection made by us was the finding of the four species together in a small, open tool shed in Napa County on October 28, 1965.

Therefore, it can be seen that more information is needed, particularly on summer resting habits of all species, and more specifically, the winter habits of *franciscanus*.

Tolerance of Adult *Anopheles* to High Temperatures

We have conducted laboratory experiments to determine the resistance of laboratory-reared speciments to 110°F. Results indicate that the males of the four species are considerably less tolerant of this high temperature than their respective females. Most females tested recovered from an exposure period of two minutes longer duration than the males were able to withstand (an average of six minutes for females vs. four minutes for males).

There are interspecific difference in survival as well. Concerning the males, *franciscanus* is the most tolerant, requiring longer than seven minutes for complete kill, whereas an interval of six minutes is sufficient in the remaining species. Comparative differences in endurance of empty females to 110°F. in the laboratory is not great but is probably critical in nature. Of females tested *franciscanus* and *punctipennis* (> nine minutes) outlast the survival of *freeborni* (> eight minutes). The range in tolerance of *occidentalis* females has not been determined. The blooded condition (in *freeborni*) does not noticeably affect the susceptibility to this high temperature.

Factors Affecting Immature Stages

Effect of water temperature on immature stages.—Field collection records made by us of the water temperature of breeding sites indicate that larvae of all four species can withstand relatively high ranges (i.e., 91-98°F.). We have not found larvae in the field at water temperatures below 46°. In the laboratory some general information has been accumulated on the rate of growth as follows:

At a water temperature averaging 72°F. the larval stage, in days, is as follows: *franciscanus* 13-20; *freeborni*, 15-45; *occidentalis*, 14-24; *punctipennis* 11-19. In contrast, *Culex tarsalis* larvae reached maturity under the same conditions in 11-13 days. The much more rapid rate of growth of the latter species may account, in part, for this species developing faster and reaching a seasonal peak a month before *A. freeborni* in rice fields (Markos 1951; Markos and Sherman 1957). The mean water surface temperature in rice fields was recorded by Stone (1953) as 68 to 74°F. in various fields from August 11 through September 22, 1952. Earlier in the season the rice water is colder, while frequently in July it is much warmer than 70° (Robert Washino, unpub. notes). If temperature were a major limiting factor and the fields were invaded at the same time in May by these two vector species, *tarsalis* would have about twice as many broods as *freeborni* during the growing season. The *Culex* species undergoes a diapause early while *freeborni* continues to reproduce in September and October, after the rice fields are drained. These late broods (from ditches chiefly) undoubtedly account for large numbers of local over-wintering *freeborni* adults.

Laboratory experiments with a water bath maintained at a constant temperature of 42°C. (107.6°F.) have shown so far that *occidentalis* is much less tolerant than *freeborni* or *punctipennis* (see Table 2). Our results are similar to those reported by Barr (1952) at 42°C. for *freeborni*.

Table 2 — Mortality of laboratory-reared immature stages of *Anopheles* at 42°C. (107.6°F.).

Exposure times in minutes causing 100 per cent mortality						
	Eggs	Larval instars				Pupae
		1st	2nd	3rd	4th	
freeborni	5+	9+	7+	6	5	7
occidentalis	—	5+	4	3	2	—
punctipennis	—	11+	7+	6	5	7

Low temperatures, however, appear to be much more important than high temperatures in limiting the activity and growth of the immature stages in this part of the state. *Anopheles punctipennis* is the only species found to date at a temperature below 55° and *occidentalis* has not been collected at a water temperature higher than 91°F. (Table 1).

Hydrogen ion concentration of water—The range in pH of positive larval collections made in northern California from Emigrant Gap to the ocean in Marin County has been from 7.3 to 10.2. No larvae were found at 6.6 which was the most acidic pond sampled. Although *punctipennis* normally inhabits stream-fed pools in forested areas, no larvae were found in water having a reading lower than 7.3. On the other hand, *occidentalis,* a coastal inhabitant, was collected in water ranging from 8.0 to 10.0. All four species have been raised successfully for many months in Davis tap water having a pH of 8.0. It appears that the California *Anopheles* species are tolerant of a moderately wide range of alkaline water.

Water depth and movement—It is generally considered that anopheline larvae are inhabitants of quiet water. The portions of streams and ponds that nearly always have the calmest water are at the margins. Also, it is here that the water is usually the most shallow resulting in the more dense growth of emergent plants which in turn give protection from predators. Our observations have shown that relative water depth, i.e., 2 in. or 3 ft., is not important if surface protection is offered by algal mats, floatage, or dense clumps of erect, emergent plants. *Anopheles franciscanus* larvae are found on and within algal mats even though the water may be actually flowing beneath. Among floatage, immediately adjacent to partially submerged logs, and in mats of water cress in flowing streams we have found *punctipennis.* Unlike *franciscanus,* the former species may be found in water with no algae. The other two species, *freeborni* and *occidentalis,* are very rare in water having any movement. Very careful and prolonged dipping, however, has shown that isolated larvae of anophelines can survive in the surface film among small plants growing on the banks of swiftly flowing irrigation canals.

Shade and Plant Association—Plants and their debris create a micro-environment in which it is possible for mosquitoes to survive where conditions are otherwise unfavorable. The two most important influences that plants seem to have on mosquito breeding are protection from predators (a subject which we have not investigated) and the creation of shade, which we feel has been over-emphasized. Aitken (1945), Markos (1950), Freeborn (1949) and others have discussed shade in relation to the larval bionomics. We should point out, however, that all four species can be successfully reared in the laboratory under constant light, which appears to indicate that when other factors are favorable shade is not a limiting factor.

In the field, shade is very difficult to measure and evaluate. At different times of day the amount of shade varies at a given point, and as the season progresses (in a rice field, for example) the plants grow rapidly and conditions change from none to nearly full shade in a few weeks. In this respect it should be noted that *freeborni* attains a larval peak in the rice fields in August (Markos 1950) after the rice reaches its maximum density. By the end of the summer *franciscanus* reaches a seasonal peak, at which time the algal mats in the direct sun are of maximum size in shallow ponds and stream beds.

During early spring breeding starts before the willows, oaks, alder and other native trees have leafed out and before many annuals have developed. In the fall nearly all egg-laying has ceased before or by the time the leaves are shed. It would seem therefore that the seasonal cycles are more closely tied to factors other than seasonal plant succession and shade.

Flight Study of *Anopheles freeborni*

As mentioned above, *freeborni* only has dispersal flights of any moment. Freeborn (1932, 1949) considered the fall migrant brood to be a different "phase" of the species. He referred to this phase as a "prehibernation" form that migrates for many miles invading areas that have harbored no mosquitoes throughout the summer. He believed that areas 10-12 miles from the breeding sources were reached during the fall dispersal. Rosenstiel (1947) separated the fall population into a local congregative phase and a dispersion phase which "was most striking within 10 miles of the breeding area." While no marked specimens were released and recaptured by this latter worker, he believed the dispersion in the Sacramento Valley extended for at least 26 miles.

During the past three seasons we have conducted release-recapture experiments in the fall with field-collected marked *freeborni* in Colusa, Yolo, and Placer counties. The marking materials and general techniques of dusting the mosquitoes were the same as previously employed in the *Culex tarsalis* study (Bailey et al. 1965). All specimens, those obtained for marking as well as those in the resting stations, were aspirated.

The first experiment was conducted in 1963-64 near the rice area west of Williams, Colusa County. The canyon utilized was oriented east to west for about 2.25 miles and opened into rolling hills extending in a north-south direction. Only seven collecting sites, all under bridges, were employed over a distance of ten miles in an S-curve on State Highway 20 south and west to the Lake County line. As a result, no recaptures could be made radially from the release points.

Two lots of marked mosquitoes were released; 4,000 on October 14 at 335 ft. elevation and 1,500 on November 26 at 1,016 ft. elevation. During the first month two marked females were recaptured 0.9 mi. and four 1.75 mi. at 640 ft. elevation west of the October release point. The second release was made during cold weather after the fall flight had been completed. During the remainder of the winter, up to March 19, 28 marked females were recaptured at the release site only. A large number of marked individuals could be seen visually resting under the bridges serving as the release sites for 33 days. The last marked specimen was collected 82 days after release at the November site. Not including many dusted individuals seen resting at the release sites by means of a flashlight, a total of 55 marked females were positively identified in the laboratory using an ultraviolet light or microscope to determine the presence of fluorescent or metallic dust. A total of 2,221 specimens were collected at the seven stations from October 17 to March 19.

From this experiment we learned that the fall dispersal from the rice fields into the adjacent, hilly, wooded areas did take place, but could not be followed in such east-west oriented canyons because of lack of accessibility. Also, sufficient good resting and collecting sites were unavailable to give an adequate sample of the population. In addition, the prevailing winds in the fall are very strong from the north, and much less severe from the south. These winds carry the mosquitoes away from the east-west highway which included all the bridges employed as collecting stations.

In the fall of 1964 release experiments, therefore, were made in the Capay Valley of Yolo County, a north-south oriented narrow valley of about 14 mi. in length. Collections were made weekly from an average of 14 sites which included culverts, bridges, and farm buildings. Three release sites under bridges were utilized, one at each end of the valley and one about in the center. Two releases were made at each site between September 22 and October 20 (which totaled 4,800 mosquitoes). Between October 10 and November 24, four recaptures were made; three at the release sites and one at 5.75 mi. to the south. One additional recapture was made 17.5 mi. southeast of its release point four months later (February 18) during the spring dispersal. Recaptures from the southernmost release site, where the valley becomes reoriented to the east, were only at the release point. Collections of the overwintering adults (4,969 total) were concluded on March 18.

This valley is very hot and dry in the summer and almost entirely devoted to almond growing. Cache Creek flows along the eastern portion. *Anopheles* breeding in this area is minimal and restricted to isolated "pockets" where *punctipennis* is found, and to many algal mats suporting *franciscanus* in shallow portions of the stream's gravelly margin. Larvae of *freeborni* are extremely scarce and adults were not seen in the collecting sites until August 25, with the exception of one specimen colected in July. During September, there was the usual fall influx of large numbers; *freeborni* made up 93 to 100 per cent of all adults taken. The only explanation possible for this very great increase is immigration from the Sacramento Valley rice fields to the east and north. It should be noted that all recaptures were to the south only of the release points, which indicates that, aided by the north winds, this is the principal path of fall dispersal in this area.

In 1965-66, a more extensive release-recapture experiment was carried out in the rice-growing area four miles west of Lincoln, Placer County, which is without a mosquito abatement district. Six releases of wild, dusted *Anopheles freeborni* (totaling 30,500), one each week from September 14 to October 19, were made at the same location. Within a radius of approximately five miles around the release point 29 key collection stations were established at various distances. Weekly collections of adults were made in the 14 most productive sites. During a period of 28 weeks, September 16, 1965 to March 29, 1966 (this experiment was in progress at the time the report was given to the Conference on February 1), 49 stations in the county were collected, 14 of which were sampled not less than ten times. In all, 365 collections were made totaling 40,587 *freeborni*, seven of which (2 males, 5 females) were marked. Large numbers of males taken in September and October (1,903 or 11 per cent of the catch) indicated that the initial movement into fall resting sites to a great extent was local. No males were observed or collected after November 23. The maximum average number of adults per station (262) was reached on November 30.

In the fall strong winds, slightly west of north, frequently sweep the region. It is the general belief that these winds blow large numbers of *freeborni* into the communities to the south of the breeding area. We considered this prevailing north wind only in establishing upwind, downwind and crosswind quadrants in analyzing the collection data. Recoveries were made in each quadrant, but four of the seven marked specimens were found in the downwind quadrant. The last recovery was on January 18 or three months after the last release. The maximum distances of recovery of the marked mosquitoes were one female 3.25 mi. northeast of the release point and one male 1.5 mi. west.

The rural area in which the experiment was conducted has literally hundreds of winter resting niches. The limitation of weekly collections by the authors to only 15 to 20 sites enabled us to recover but a small percentage of the very large hibernating wild population. Each specimen had to be sought out and collected by hand (in comparison with the CO_2 baiting method employed for *Culex tarsalis*). However, the long period of five months during which the over-wintering adults normally live and move about greatly increases the odds in favor of recapture.

The recovery of two males (September 23 and October 21) from the estimated 450 released indicates that this sex, like the females, disperses during the early fall even though none survive. A blue colored powder was employed in the first two releases (14,500), red for the second two (9,000) and a gold color in the last two (7,000). The first recovery, a male on September 23, was blue, the second a female on October 14 was red, and the remaining five, captured October 21 to January 18, were marked with gold powder which was used on October 12 and 19. We believe this trend indicates either that in the warmer weather of September there is a high mortality or that the mosquitoes left the area more quickly.

Conclusions

The north wind appears to be a significant force in the fall "pre-hibernation" flight. This factor was very noticeable in the 1964 experiment.

The males migrate also, although a much shorter distance than females.

A general mass movement takes place from the breeding areas in late September and early October. Large numbers invade the low foothills and valleys adjacent to the rice districts.

In favored sites very great numbers congregate, from which a dispersal continues throughout October.

Limited movement of *freeborni* takes place all winter. In the majority of collection sites in the past two seasons, all adults were removed each week and yet the following week these sites again were occupied.

In the fall and winter of 1963 and 1964 we were assisted in the flight study of *A. freeborni* by D. A. Eliason and B. L. Hoffman. The laboratory mortality tests of the immature stages at 110°F. and the resting site mortality observations of *freeborni* were conducted by A. G. Gentile.

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POTENTIAL INVERTEBRATE PREDATOR-PREY RELATIONSHIPS IN A RICE FIELD HABITAT[1]

Y. Hokama and R. K. Washino

Abstract

Studies were carried out in a rice field in Colusa County to obtain data on the seasonal distribution of aquatic insects which may serve as mosquito predators. The insect population was sampled at weekly intervals from June 7 through September 20, 1965, by means of six aquatic light traps, six clear aquatic traps, and dipping at fixed sites. Most of the insects sampled reached their maximum abundance early in the summer; thereafter they disappeared or occurred in markedly reduced numbers. Two aquatic Hemiptera (*Belostoma flumineum* and *Corisella*), however, attained a second peak of abundance later in the summer, thereby enhancing their utility as predators of mosquitoes which are ordinarily prevalent at that time.

From the same field, many of the common aquatic insects were taken alive and their predation on mosquitoes was observed in aquaria arranged with soil and plants selected to simulate the field environment. A crude index of predator efficiency was calculated on the basis of number and proportion of mosquito larvae killed. The insects were also observed in various combinations to determine the compatibility of one species with another. Because *Belostoma flumineum* ranked consistently high in both series of laboratory observations and had a seasonal activity pattern similar to that of mosquitoes found in rice fields, it is being investigated further as a mosquito predator.

[1]University of California-State Department of Public Health Mosquito Project, Davis.

POPULATION FLUCTUATIONS OF THREADFIN SHAD, CLEAR LAKE GNAT LARVAE, AND PLANKTON IN A LAKE COUNTY FARM POND 1961-1965

S. F. Cook, Jr. and R. L. Moore

Lake County Mosquito Abatement District

As an initial phase to the Clear Lake gnat biological control program, the Lake County Mosquito Abatement District introduced the threadfin shad, *Dorosoma petenense* (Gunther), into a Lake County, California, farm pond in May, 1961. This introduction was designed to determine the potential of this fish species in suppressing population levels of Clear Lake gnat larvae, *Chaoborus astictopus* Dyar and Shannon. Although results of this introduction from the standpoint of gnat reduction are still inconclusive, enough data have been gathered from this continuing study to permit some tentative conclusions.

The threadfin shad was introduced into California waters in 1954 from a stock obtained from Tennessee by the California Department of Fish and Game. The species was introduced to provide open water forage for game species in warmwater impoundments. (Kimsey, Hagy, and McCammon 1957). The initial planting was in Lake Havasu of the Colorado River system; it has subsequently been widely introduced throughout the state although it has yet to be officially introduced into Clear Lake.

Interest in the threadfin shad as a potential gnat suppressant developed soon after its introduction into California. Many of its behavioral and biological characteristics, desirable from a fisheries standpoint, were also desirable from the standpoint of gnat control (Cook 1965). It remained to be determined, however, if prey/predator or competitive relationships existed between the two.

The pond chosen for this introduction is owned by Mr. Don Lampson and is located south of Lakeport, about 2 miles inland from Clear Lake. In order to placate concern expressed by the Department of Fish and Game that the species should not be permitted to escape into the watershed prior to an evaluation of its possible effects upon the existing Clear Lake fishery, the pond was chosen primarily from the standpoint of security. Until the winter of 1964-1965, the pond had not been known to overflow as it is located in a level pasture away from any runoff ditches.

The pond was originally used for irrigation but has been used for nothing but horse drinking water since the inception of this study. It measures 88 x 210 feet with a 2:1 slope. Maximum depth at capacity is about 20 feet, although this is seldom reached. Since the water level is dependent upon the ground water table, the pond fluctuates widely in size and depth during the year.

From the standpoint of gnat populations, Lampsons Pond was not the most desirable for purposes of this study; larval numbers in the pond prior to the introduction of the fish were relatively low compared to other ponds in the area. This was perhaps due to the fact that it had been sprayed with a heavy dose of Richfield larvicide the previous summer (1960), and is relatively isolated from other gnat sources. Nevertheless, it was felt that any gross results over a period of sufficient time could be related to what is known of the development of gnat populations in similar environments throughout the area. Attempts to divide the pond with a polyethylene barrier for the purpose of establishing a control pond, proved futile.

Other fish species have been present in Lampson's Pond since the introduction of the shad. These have included brown bullheads, green sunfish, and hitch. At no time, however, have they attained densities comparable to those of the shad. Their influence on this study has been regarded as negligible.

Also of interest from this introduction was the effect the shad might have on the plankton populations, since this fish species is regarded as primarily a planktonic feeder. Clear Lake gnat larvae also feed exclusively on the small organisms comprising the zooplankton. In view of the competitive potential between the gnat larvae and the fish for food, data were also acquired on plankton levels.

Methods and Procedures

Bottom samples for late instar gnat larvae were taken with an Ekman dredge. Larvae brought up from the bottom in the mud were seived free of the mud and counted. Early instar larvae are planktonic and were sampled along with the plankton by use of a standard plankton towing net, 125 meshes to the inch. The plankton samples were taken vertically from the bottom to the surface and collected in 30 ml vials. The samples were then centrifuged at a consistent rate and the quantity of plankton expressed in terms of cc/tow. Gnat larvae taken in the plankton samples do not centrifuge down and were counted separately.

The most difficult parameter to assess quantitatively during this study has been the shad populations. Seining in a pond of this size with such seasonal variation in size and depth will naturally be highly biased unless it is possible to sample a fairly large portion of the pond from top to bottom in order to obtain a quantitative assessment of fish densities. Unfortunately such a seine was not available for use in this case except during periods of low water in the late summer and fall. Two seines were used to sample the fish; one measured 120 x 6 feet and the other 40 x 8 feet. Both had a mesh size of ¼ inch. Neither of these will reach the bottom during most of the year.

Although accurate measurements of shad numbers have not been obtained, the sampling has provided a basis for determining relative numbers from one period to the next, and, most important, has provided an indication of annual trends in population density fluctuations. Results expressed in Fig. 1A reflect these general trends, rather than absolute numbers.

Frequency of sampling has varied from year to year and has been influenced by various uncontrollable circumstances. Generally, an attempt has been made to sample the pond 4 times a year, although this has varied from 3 to 7.

Results

Results of this study from June, 1961 through December, 1965, are summarized in Fig. 1. Perhaps the most significant results were obtained during 1965

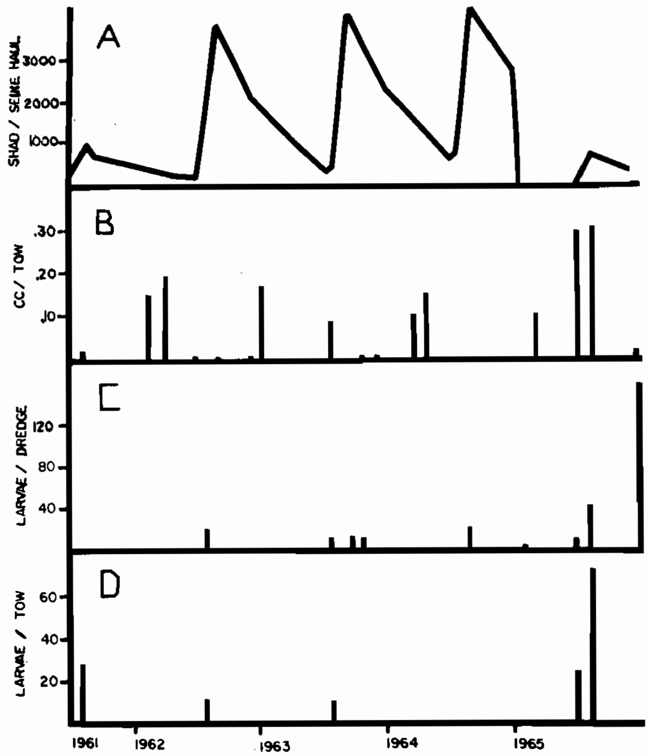

Figure 1A. Population fluctuation trends of (A) threadfin shad; (B) zooplankton; (C) benthic late instar chaoborid midge larvae; and (D) planktonic early instar chaoborid midge larvae. Threadfin shad experimental pond, Lake County, California, 1961-1965.

when the shad population was considerably reduced during the floods of the winter of 1964-1965. It was during this period that Lampson's Pond became lost in a sea of water that covered much of the whole area. As the water receded, many dead shad were found in the surrounding pastures and in nearby residents' yards. Several seinings taken during the spring months of 1965 failed to reveal a single shad. It was believed at that time that they had all moved out with the high water. A small residual population remained, however, and although the numbers increased during the summer of 1965, they nowhere approached the numbers of the previous years (Fig. 1A).

Zooplankton levels are indicated in Fig. 1B. The predominant organisms comprising the zooplankton were various cladocerans, copepods, and rotifers. Population levels of these small organisms typically vary in numbers quite erratically from one environment to another and from one period to the next. Compared to population levels of zooplankters in most environments similar to Lampson's Pond, the quantity taken per vertical tow is quite low. Similar sampling in other ponds in the area indicates "typical" levels to be in the order of 5 times as high as encountered in the study pond.

Of primary concern in this study was the relationship between the shad and chaoborid populations. Fig. 1C depicts the late instar benthic population levels of gnat larvae, while Fig. 1D indicates planktonic early instar population fluctuations. The relatively low densities of these organisms in the pond since the inception of this study, along with the ensuing population increase during the summer of 1965 when the shad numbers were low, is apparent from the figure.

Gnat numbers also vary from pond to pond in this area. Generally, however, the numbers are far greater than those encountered in Lampson's Pond during the 3 years of high shad densities; some ponds in the area produce over 1000 larvae per dredge. No pond sampled regularly during this study has shown such consistently low gnat numbers as the study pond.

Phytoplankton levels in the pond from the onset have been so low as to be unmeasurable by the methods employed. While traces of *Volvox*, *Spirogyra*, and bluegreens have been observed, algae blooms, which occur with regularity in most similar environments, have not been observed.

Conclusions

It would be presumptuous at this time to ascribe a positive correlation between the population fluctuations of threadfin shad, chaoborid gnat larvae, and plankton, in Lampson's Pond. Nevertheless, results and observations to date indicate that a cause and effect relationship may exist. Generally, during the 3 years of high shad densities, biological activity in the study pond was very low compared to the biological activity in similar environments in this area. There were times during the late summer when samples extracted from the pond indicated a virtual absence of plankton organisms and gnat larvae. Stomach analyses of the shad during these periods revealed primarily detritus or perhaps organic bottom mud in their guts. Stomach contents at other times, and from other environments where shad are present, indicated a predominance of entomostraca. Chaoborid larvae have also been found in stomachs, and laboratory observations indicate that the threadfin shad will readily feed on gnat larvae.

If future study indicates that the threadfin shad is in fact responsible for the suppression of gnat larvae in Lampson's Pond, be it by direct predation or reduction in the gnat food resource, care must be exercised in projecting the results to other environments. Nevertheless, results to date are encouraging. Perhaps some measure of biological control of the Clear Lake gnat can be achieved by the use of fish.

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SNIPE FLIES *(Symphoromyia)* ATTACKING MAN AND OTHER ANIMALS IN CALIFORNIA[1]

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The Rhagionidae is a cosmopolitan family of flies which, according to Oldroyd (1964, p. 109), ". . .

stands(s) at the base of the stem of evolution of all Brachycera . . ." Hematophagous members of the family have been reported from Australia, Europe, North America and South America. Although Philippi reported *Dasyomma obscurus* Philippi biting in Chile in 1865, *Symphoromyia* was the first genus in the family to be widely recognized as hematophagous (Osten Sacken, 1877; Aldrich, 1915; Riley and Johannsen, 1915). There is an unconfirmed report by Heim and Leprevost (1892 of *Rhagio scolopacea* L. and *R. strigosa* Meig. biting man. Paramonov (1962) stated that the genus *Spania* (=*Spaniopsis* in part) contains hematophagous members, as do *Atrichops* and *Suragina* according to Desportes (1942) and Knab (1912), respectively. Malloch (1932) has suggested that the genus *Austroleptis* is probably hematophagous, on the basis of its close relationship to *Spaniopsis*.

In 1867, Frauenfeld erected the genus *Symphoromyia*, based on one European species, *Atherix malaena* Meigen. Ten years later Osten Sacken (1877) reported collecting representatives of what he suspected to be six species of this genus in northern California, and commented on the hematophagous habit of certain female *Symphoromyia*. During the next 17 years Williston (1886), Bigot (1887) and Coquillet (1894) contributed descriptions of 15 new species of *Symphoromyia* from North America. In 1915, Aldrich revised the systematics of the North American *Symphoromyia*, adding eight new species to the 14 previously-described species that he recognized as valid. Recently, Dr. James G. Chillcott of the Canada Department of Agriculture has undertaken revision of the genus. He is presently studying many of the specimens collected by us during 1964 and 1965 while studying the species associated with deer at the University of California Hopland Field Station.

Symphoromyia is holarctic and generally montane in distribution. Lindner (1925, p. 39), referring to the palaearctic fauna, stated that the species are generally rare and that there are six species, five of which are found only in Europe. Hence, despite the mountainous terrain of the Old World, the genus *Symphoromyia* is not abundant there in number or in species.

The Nearactic region, however, is quite rich in species. Several of the New World species are sometimes very abundant locally (Aldrich, 1915; Frohne and Williams, 1951; Shemanchuk and Weintraub, 1961; Sommerman, 1962). Aldrich (1915) reported 22 North American species, all of which occur west of the Rocky Mountains but only three of which range eastward. He credited California with 15 species. Wirth (1954) amended the California total to 17. Preliminary findings by Chillcott indicate that all of the above numbers for the West are conservative (personal communication, 1964). Combined records from Aldrich (1915) and Wirth (1954) indicate that California has six species limited to the Coastal Range, six species limited to the Sierra Nevada and five species shared by both ranges.

Symphoromyia atripes Bigot was first reported as a bloodsucker by Aldrich (1915) based on his observations in Washington. In 1928 Essig reported *S. atripes* (and *S. pachyceras*) biting man in El Dorado County, California. Aldrich observed this species biting both man and horses. Frohne and Williams (1951) reported that dogs are also attacked by *S. atripes*.

During late June 1965 Messrs. John R. Poorbaugh and Woodbridge A. Foster, Division of Parasitology, University of California, Berkeley, were attacked by large numbers of *Symphoromyia* while collecting insects in El Dorado County, California (1965, personal communication). Dr. Chillcott identified a part of their catch as *S. atripes*, and placed the remainder in the *S. johnsoni-inurbana* complex. On 27 June 1966, W. A. Foster also collected members of this complex feeding on him in Los Angeles County. Figs. 1-3 illustrate a member of the *S. johnsoni-inurbana* complex in the act of biting. There is no previously published record of biting by members of the *S. johnsoni-inurbana* complex.

Symphoromyia kincaidi Aldrich, a species well documented as a man biter (Aldrich 1915, Frohne 1957 and 1959, Frohne and Williams 1951), has been found in California; however, there are no local biting records.

Despite the abundance of *S. limata* Coquillet in certain areas of southern California this species has never been reported to bite man. The large numbers of *S. limata* in the California Insect Survey collection (Department of Entomology and Parasitology, University of California, Berkeley) coupled with the absence of biting records might suggest that biting occurs only under special conditions, or not at all. Yet in conversations with colleagues in the Department of Entomology and Parasitology during the summer of 1965 two instances of *S. limata* taking blood were disclosed. In both cases series of specimens were associated with the reports. Although chance could account for the chronological proximity of these two records we suggest that failure to so label specimens taken when biting is the reason that this species has not been recognized previously as a biter of man. The notes accompanying the specimens are reproduced below:

Loc: 5 mi. SE Julian, San Diego Co.
June 11, 1965
Elev. 4500±

Very persistent in attacking exposed areas of the body, particularly the head and neck. Difficult to discourage by swatting, returning to the body immediately. The large size of the flies made it easy to feel them light, so that most were prevented from biting. The bites were painful, resembling the sensation produced by a needle being poked into the skin. Although I received several bites, none of the attacking flies probably succeeded in feeding on me, and I received no noticeable lumps or itching. The flies were most numerous near a stand of *Ceanothus* shrubs about 6-10 feet tall. This area was partially shaded by taller trees. In the full sun 50-100 yards away, the flies were much less abundant.

J. Doyen

Loc: Upper San Juan Campground
San Juan Canyon
Santa Ana Mts. El. 2000
Riverside Co., Calif.
12-VI-65—Biting
Collected by J. Burger

> *Symphoromyia* was biting from approximately noon until 3 p.m. when I left the area. I walked along a small creek and was generally in a shaded area surrounded by brushy vegetation and tall trees. The flies landed mainly on my arms and wrists. A few circled my head, but as I was wearing a hat, I was not bitten there. Also, a few landed on the upper part of my legs but did not try to bite through my pants. The flies which landed on my arms appeared very restless and were quite easily disturbed; however, once they had pierced the skin and begun to feed, they were relatively easy to capture. I had no noticeable reaction from the bites which I received, although the initial piercing was quite painful, about comparable to *Chrysops* or a small *Tabanus*.

Symphoromyia pachyceras Williston has long been known to attack man (Aldrich 1915, Riley and Johannsen 1915). Our study of five species in the *S. pachyceras* complex suggests that these flies are strongly host specific for deer or closely related animals, and that only a small portion of a population could take blood meals from man.

The Bureau of Vector Control collection in Berkeley contains specimens taken while biting man in Alpine, El Dorado, and Contra Costa Counties (Keh 1965, personal communication). Specimens of the *S. pachyceras* complex collected while biting man in Santa Clara County were received from the museum collection of the County Health Department (Blair, personal communication). Furthermore, one of the authors (JRA) had a specimen of *S. pachyceras* s.s. engorge to repletion on his arm in Mendocino County.

Symphoromyia sackeni Aldrich has been reported as a biter twice. The first record was by Wirth (1954) who described a bite that he suffered in Santa Clara County. More recently Oldroyd (1964) mentioned a personal communication from Professor G. C. Varley regarding his being attacked by *S. sackeni* in California.

Our studies of the *Symphoromyia* species attacking deer showed that like *S. pachyceras, S. sackeni* has a very strong preference for deer. Nevertheless, through search of museum collections, personal experience and conversation, we have found ten additional, authenticated cases of *S. sackeni* biting man. Six of these cases are from our group working at the University of California Field Station at Hopland in Mendocino County. Two cases (one each from Santa Clara County and San Luis Obispo County) resulted in specimens being sent to the Bureau of Vector Control, California State Department of Public Health.

Personal communications (with specimens) from both Mr. John G. Shanafelt, Jr., of the Orange County Mosquito Abatement District and Dr. Charles L. Hogue of the Los Angeles County Museum have described attacks by *S. sackeni* in the southwestern corners of San Bernardino County.

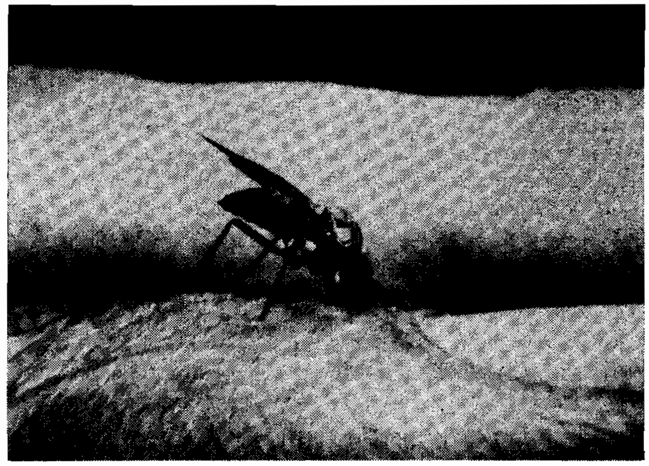

Fig. 1. A specimen of the *S. johnsoni-inurbana* complex beginning its initial probe. The elevated position of the abdomen is typical of the initial feeding position assumed by all species studied by us at Hopland, Calif.

Fig.2. A specimen of the *S. johnsoni-inurbana* complex about ¼ engorged.

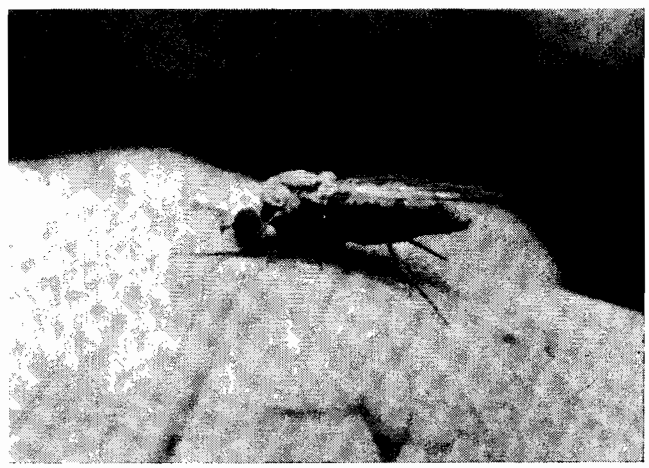

Fig. 3. Same specimen as in Fig. 2, now nearly ¾ engorged[4].

Wirth (1954) wrote that *S. fulvipes* Bigot and *S. flavipalpis* Adams will eventually prove to be synonyms. He also stated that Aldrich (1915) listed *S. flavipalpis* as a biter. If one accepts the proposed synonomy and also that *S. fulvipes* is separate from *S. hirta* Johnson (contrary to Aldrich's decision) then seven species (*s. lat.*) of *Symphoromyia* indigenous to California are currently known to take blood from man (i.e., *S. atripes, S. fulvipes,* at least one member of the *S. johnsoni-inurbana* complex, *S. kincaidi, S. limata,*

S. *pachyceras* s.s. and S. *sackeni*). The S. *pachyceras* complex, however, undoubtedly contains several species which bite man.

The seasonal occurrence of *Symphoromyia* adults can be expected to vary greatly. In areas with mild winter temperatures attacks might be anticipated in late March, whereas adults may not be found until June or July in areas with severe winters or late springs. A seasonal succession within the S. *pachyceras* complex became apparent with intensive investigation (Hoy 1966). Each univoltine species was represented by adults for only seven to ten weeks. Adult S. *sackeni* are present for a similar period in Mendocino County.

When mentioned in entomology textbooks authors have implied that adult Rhagionidae are primarily predatory on other insects. However, in contrast to the vague and limited information regarding their predilection for predation, hematophagy by adults is widespread and well documented for several genera of this family.

In many areas of the western United States and Canada *Symphoromyia* spp. are locally very abundant during certain years, causing annoyance to man, livestock, and game animals. The potential medical and veterinary importance of these flies, however, is not well determined. Mills (1943) suggested that rhagionids might serve as vectors of "such diseases as tularemia" and Shemanchuk and Weintraub (1961), noted the repeated probing of individual flies taking a single meal, which suggests that this behavior increases the probability of the flies acting as mechanical vectors. To be convinced that these flies can be extremely abundant and annoying, one has only to note the landing rates of 25-30 flies per minute reported by Frohne (1959), or Mills' (1943) report of as many as 50 flies on the back of one fisherman. The increasing importance of the foothills and mountains as recreation areas (especially in California) undoubtedly will make these flies more noticed in future years.

Acknowledgments

We express our thanks to all persons who so willingly provided us with either specimens or descriptions of attacks, or both. We are particularly grateful to Messrs. W. A. Foster and J. H. Poorbaugh, Division of Parasitology, University of California, Berkeley, for making their photographs available to us. The combined cooperation of the above persons made possible this expansion of knowledge on the feeding habits of certain *Symphoromyia*.

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Footnotes

[1]This work was supported, in part, by U.S. Public Health Service Research Grant AI-04918-01-02 from the National Institute of Allergy and Infectious Diseases.

[2]Part of the material in this paper was included in a thesis submitted by the senior author to the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[3]Present address: USDA-ARS-ENT, 5545 E. Shields, Vector Control Field Station, Fresno, California 93727.

[4]All photographs were taken by W. A. Foster and J. H. Poorbaugh, Division of Parasitology, University of California, Berkeley.

NEWER COLLECTING METHODS FOR VECTORS OF ARBOVIRUSES

R. L. Nelson

Encephalitis Field Station, University of California

The purpose of this presentation is to describe some of the insect collecting methods being used in studies of arboviruses in Kern County.

During the past few years evidence has accumulated that there are a considerable number of viruses in California that may be transmitted by blood-feeding arthropods. Dr. W. C. Reeves, in a talk to this group in 1964 (Reeves 1964), briefly discussed 12 of these viruses, excluding those of Western Equine and St. Louis encephalitis. In addition, there are a growing number of unidentified viruses in California that may be arthropod-borne. Studies of the possible vectors of these newer viruses thus far have concentrated on mosquitoes and *Culicoides* gnats. This has entailed the use of trapping methods designed to collect large numbers of flies in good condition for virus or blood-meal-identification tests. While these methods are not completely new, they have not received wide-spread use and hopefully will be of interest to the present audience.

CO_2 bait trap—The first of the traps is the carbon dioxide (CO_2) bait trap. Traps baited with CO_2, or dry ice have been used to collect mosquitoes for more than 10 years at the Encephalitis Field Station in Bakersfield. The original traps (Bellamy and Reeves 1952) were made by soldering cone-shaped screen baffles into the ends of large cans. However, since 16-mesh screen was used, the traps would not retain any very small flies that might enter them. Also, it was not known until recently that some biting flies other than mosquitoes are attracted to CO_2. To test the possibility that CO_2 traps would collect *Culicoides* and other small biting flies, the inner surfaces of the screen baffles of some of the original mosquito traps were lined with fine 60-mesh screen that would retain small insects. These modified traps and their operation are described in a recent note in the Journal of Medical Entomology (Nelson 1965). The traps are set out overnight and are placed directly on the ground. Each is baited with a 4-pound block of dry ice. Originally, the ice was wrapped in a paper or plastic bag and placed inside the trap. However, moisture sometimes would condense inside a trap, due to the cooling of the ice, and some specimens stuck to the moist surfaces. This problem was eliminated by placing the bait outside the trap in a closed plastic box connected with the trap by rubber tubing through which CO_2 flowed into the trap.

Results from operation of these traps have been gratifying, as a single trap sometimes collects several thousand *Culicoides* on a single night. To date, most of the specimens taken have been of the *Culicoides variipennis* complex (Wirth and Jones 1957). Of interest is the fact that the traps sometimes collect small numbers of *Leptoconops, Stomoxys,* black flies (Simuliidae), and ticks (Ixodidae).

Portable light trap—The next type of trap is the battery-operated portable light trap. This trap was developed by graduate students at the University of Wisconsin, and was introduced to us by Dr. J. R. Anderson of the Division of Parasitology, University of California at Berkeley. It consists basically of two connecting units—a top unit bearing a small motor and fan, and a bottom unit consisting of a plexiglass cylinder. There is a small cone-shaped opening in the bottom of the cylinder beneath which a small light bulb is attached. The motor, which operates the fan, and the light bulb are powered by two 1½-volt, dry-cell batteries. Small flies attracted to the light are drawn into the cylinder by a gentle suction created by the fan. A removable disc of 60-mesh marquisette glued to a plexiglass rim fits snugly into the top of the cylinder below the fan. This prevents specimens from being sucked out of the top of the cylinder. The two units of the trap are separated and the disc is removed from the cylinder to permit removal of insects collected.

The obvious advantages of this trap are that it can be easily transported and used in areas where electrical outlets are unavailable. In addition, because of the gentle suction of the fan, small, soft-bodied flies are collected in good condition while large, strong-flying insects are largely excluded. This trap has been very useful for collecting *Culicoides* and occasionally collects small numbers of *Phlebotomus* flies. While the trap also collects mosquitoes, the numbers taken generally are much smaller than the numbers taken in standard mosquito light traps.

Truck trap—The final trap to be described is the truck trap. This trap is shaped like a four-cornered funnel and is mounted atop a pickup truck. It is modelled after a trap developed at the Florida Entomological Research Center at Vero Beach. The opening at the front of the trap is 2 feet high and 7 feet wide, and the trap is 10 feet long. The walls of the trap are of fiber-glass screen attached to a wooden frame which tapers to a round opening 3 inches in diameter. Inserted at the end of the trap is a small sheet-metal funnel carefully molded to provide a smooth transition from the interior of the trap to the round opening at the tip. The trap can be easily removed or transferred to another pickup if desired.

At the beginning of each period of operation, the open end of a fine-mesh cloth collecting bag is fitted

Table 1. Truck trap collections of *Culicoides variipennis, Culex tarsalis,* and *Culex erythrothorax*. Poso Creek study area, evening of August 9, 1965.

Pacific Standard Time	*Culicoides variipennis*		*Culex tarsalis*		*Culex erythrothorax*	
	Males	Females	Males	Females	Males	Females
6:30-6:40	1	0	0	0	0	0
6:40-6:50	21	0	0	0	0	0
6:50-7:00	131	18	0	0	0	0
7:00-7:10	148	51	0	0	0	0
7:10-7:20	67	41	557	124	0	9
7:20-7:30	50	54	273	157	43	139
7:30-7:40	44	47	347	109	138	125
7:40-7:50	23	30	196	64	21	84

over the tip of the trap and held in place with a heavy rubber band. In our studies, a selected 2-mile course is repeatedly covered in the course of a night. The truck is driven approximately 15 miles-per-hour, and collecting bags are exchanged at the end of each 2-mile run. When a bag filled with insects is removed, the open end is promptly tied shut. The bag is then labelled and stored in an ice chest until specimens are to be identified. This effectively inactivates the insects and keeps them from damaging one another.

A valuable aspect of this trap is that it effectively samples blood-engorged specimens for blood-meal-identification tests. The trap is not dependent upon any kind of attraction and is believed to fairly sample flying populations in a given area. In addition to mosquitoes and *Culicoides*, the trap has collected *Leptoconops, Stomoxys*, black flies, and horn flies (Muscidae).

The trap is providing interesting data on the flight activities of biting flies. Table 1 gives an example. It shows the number of male and female *Culicoides variipennis, Culex tarsalis*, and *Culex erythrothorax* collected in an early-evening series of runs made on August 9, 1965, in the Poso Creek area north of Bakersfield. In this case, one 2-mile run was made every 10 minutes for 8 consecutive 10-minute periods. Of interest is the relatively early appearance of *C. variipennis*, the preponderance of males males in the early runs, and the sudden appearance of *C. tarsalis*. It will be noted that no *C. tarsalis* were collected during the 10-minute period from 7:00 to 7:10, 557 males and 124 females were taken during the following 10-minute period.

All of these trapping methods have been effective in providing large numbers of *Culicoides* for virus tests. More than 25,000 *C. variipennis* were collected and prepared for virus tests in 1964, and the tests resulted in 17 virus isolations. Although these have not been positively identified, they are believed to include at least two distinct agents. Two isolations of a new virus named Buttonwillow virus (Reeves *et al.*, unpublished data) previously had been made from a relatively small number of *C. variipennis* collected in the summer of 1963. More than 35,000 additional *C. variipennis* were collected for virus tests in 1965; however, tests of these have not been completed.

It may be that some of these newer viruses will be found to cause diseases of humans or domestic animals. If this happens, *Culicoides* and other biting flies, and ways of trapping them, will be of increased interest to mosquito abatement agencies. However, at this time, the three collecting methods described may be of greatest interest as methods for sampling mosquito populations.

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ELECTRON CAPTURE GAS CHROMATOGRAPHY AS A TOOL IN MOSQUITO CONTROL

JAY E. GRAHAM[1] AND GLEN C. COLLETT[2]

In 1965 the Salt Lake City and the South Salt Lake County Mosquito Abatement Districts began a cooperative study with the University of Utah to determine in detail the effects of mosquito larviciding on other organisms. As a part of this study analyses of water and soil of mosquito larval habitats were made by electron capture gas chromatography to determine residues of insecticides that might be present. Other areas not known to have produced mosquito larvae or to have been treated by mosquito abatement districts were also analyzed. The procedures used for collecting and analyzing samples have been outlined by Warnick and Gaufin (1965), and Warnick, Gaufin and Gaufin (1966). This paper is a report of the benefits to mosquito control operations derived from the research program to date but includes only incidental information regarding the progress of the research.

There are a number of things that mosquito abatement districts want to know regarding the concentration of insecticides in water of mosquito larval habitats. Some of these are: (1) The concentration of insecticides in water after application for mosquito control; (2) the duration of the insecticide in the water; and (3) what other insecticides might be present from sources other than mosquito control operations.

We have selected two examples from the data collected that best illustrate direct advantages to control operations derived from this research program. The first, Table I, is an application of Baytex applied as an emulsifiable concentrate at a rate planned to disperse 0.1 lb. of Baytex per acre. The second, Table II, is an application of parathion sand-core granules with a sling-type spreader under normal operating procedures. Granules are applied at a concentration planned to give approximately 0.1 lb. of parathion per acre. Actual results in the field indicate considerable variation in concentrations applied to various mosquito sources. In most situations this amount is adequate for control but in some instances control failures have been noted.

Several things are apparent from Table I that apply to control operations. First the highest concentration is reached immediately after application and steadily deteriorates. The area was sprayed at 9:10 a.m., August 7. The time elapsed from the high concentration on 9:12 a.m., August 7, to the first sample on August 8 was 26 hours and 23 minutes. During that time 75% of the insecticide had disappeared from the water. Although the concentration on August 8 was still sufficient to kill mosquito larvae, it was approaching the lower level of effectiveness. If the initial concentration had been less, the effective concentration would presumably last less than 24 hours. We do not know why the rate of disappearance of insecticide from the water decreased after the first day.

DDT had not been applied to this source for mosquito control for several years, yet measurable quantities could be found in the water and significant quantities were found in the soil and flora. This was typical of most standing water areas in Salt Lake County including those which had never been treated by mos-

[1]South Salt Lake County Mosquito Abatement District
[2]Salt Lake City Mosquito Abatement District

quito abatement districts. This information is of great value to control agencies when discussing residue problems with dairymen, wildlife interests and others since it clearly indicates that mosquito abatement cannot be considered wholly responsible for insecticide residues in mosquito sources and in many cases contributes nothing to them.

Table II, in which the insecticide was applied as a 1% parathion sand-core granule, shows a different type of pattern. The highest concentration of parathion was reached 24 hours after application and then began to decrease. In this example, even though the rate of application should have given a much higher concentration, the amount of parathion in the water reached only a minimum effective level. Water flow caused by seepage in and out of the pool was apparently removing the toxicant almost as fast as it was being released from the granule. These concentrations of parathion indicated that in some cases the reason for some control failure was inadequate pesticide in the water. This resulted in a decision to use 2% parathion sand-core granules even though earlier calculations, before analyses, had indicated that 1% granules would result in overtreatment rather than undertreatment. Note also, that DDT concentrations are comparable to Table I even though DDT had never been applied here for mosquito control and, because of the location, it is doubtful that DDT has been directly applied by anyone for any purpose. Other data collected but not reported here indicate that the concentration of parathion after application of 1% sand-core granules is normally about 30 to 40 ppb 24 hours after application.

Summary

The Salt Lake City and South Salt Lake County Mosquito Abatement Districts in cooperation with the University of Utah began a research program in 1965 to determine the effects of mosquito larviciding on other organisms. Analyses of water in mosquito sources were made by electron capture gas chromatography for residues of pesticides. Some of the information obtained was of value to control operations in: (1) determining proper rates of application; (2) determining the duration of pesticide applied in different formulations; (3) finding causes for control failures; and (4) providing information for public relations programs relating to pesticide residues in the environment.

Acknowledgments: We wish to acknowledge with sincere thanks, the efforts of Mr. Richard Gaufin in collecting samples, the work of Dr. Stephen Warnick in operating the gas chromatograph, and the advice and encouragement of Dr. Ardin Gaufin.

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Table 2: Pesticide concentrations in area 21-36.

		Water ppb				Soil ppm		
Date	Time	Par	DDE	opDDT	ppDDT	Par	DDE	opDDT
Aug. 24	9:25	1.0	3.0	2.0	2.0	0.04	5.70	0.49
Aug. 24	11:45	4.0	4.0	1.4	1.6			
Aug. 24	18:00	5.0	4.0	3.1	1.3			
Aug. 25	9:30	6.9	1.5	3.1	0.5	0.22	7.20	0.54
Aug. 25	18:30	6.3	2.0	2.6	1.0			
Aug. 26	9:45	5.7	3.7	1.6	2.8	0.25	6.00	0.50
Aug. 26	18:10	3.8	2.9	1.1	3.2			
Aug. 27	17:05	2.7	3.5	2.4	1.7	0.32	5.80	0.43
Aug. 31	11:15	1.3	4.0	3.0	2.0	0.33	5.50	0.26

Table 1: Pesticide concentrations in area S-3.

		Water ppb				Soil ppm				Flora ppm		
Date	Time	Baytex	DDE	opDDT	ppDDT	Baytex	DDE	opDDT	ppDDT	Baytex	DDE	opDDT
Aug. 7	8:30		3.0	2.0	1.1		1.25	0.83	0.04		1.40	1.94
Aug. 7	9:12	53.5	6.0	2.6	3.0					2.33	1.20	1.28
Aug. 7	9:30	50.0	6.0	1.4	1.0	0.06	3.65	1.34	0.03			
Aug. 7	9:45	45.0	2.5	1.7	1.4					1.00	1.60	1.49
Aug. 7	10:15	40.0	3.0	1.1	1.4	0.05	4.50	3.86	0.95			
Aug. 7	11:15	39.2	6.0	2.6	2.6							
Aug. 7	12:30	38.4	3.5	3.1	2.1	0.03	4.47	3.00	0.65	1.33	2.00	1.28
Aug. 7	16:30	33.4	4.0	3.7	2.1	0.03	3.50	2.60	0.58	1.67	2.00	1.74
Aug. 7	20:20	28.3	1.5	2.6	2.0							
Aug. 8	11:35	13.3	7.5	1.7	2.0							
Aug. 8	16:30	9.2	1.5	1.6	0.6	0.03	6.80	4.06	2.25	1.33	1.60	1.94
Aug. 9	16:40	8:3	5.0	2.6	1.2							
Aug. 15	10:15	6.7	2.5	1.1	2.1	0.02	4.00	2.27	1.34	3.00	1.80	1.83
Sept. 5	12:10		10.0	7.0	1.3	0.08	3.00	7.43	2.90			
Oct. 10	13:25		4.0	2.4	4.0	0.12	9.50	5.49	2.43	1.00	1.75	1.59

THE INTRODUCTION OF HELICOPTERS INTO CALIFORNIA MOSQUITO CONTROL

W. E. Burgoyne[1], N. B. Akesson,[1] T. D. Mulhern[2]

When, shortly after World War II, liquid insecticides were widely introduced to aircraft use, their advantages inspired more and more such applications until by 1949 more than half the crops treated by air in the United States were sprayed with liquid pesticides. Today most aerial spray applications are made at rates from one to nine gallons total volume per acre. In 1962 Plant Pest Control and Entomology Divisions, A.R.S., U.S. Department of Agriculture, found that certain insecticides applied at one pint total volume per acre controlled grasshoppers as well as the customary one gallon total volume per acre rate. Spectacular results from the initial applications with low volume concentrate, no diluting oil or water added, have led to extensive tests over the United States against a variety of insects. In 1965 there have been reported experiments using low volume concentrate sprays against boll weevil by E. C. Burgess (1965), against grasshoppers by F. E. Skoog (1965), and for cereal leaf beetle control by M. C. Wilson (1965), and this is only a minute representation of the total interest in ULV spray techniques throughout the country today.

In California where public agencies treat nearly one and one-half million acres each year for mosquito control at a rate of one gallon per acre of emulsifiable water mixed spray, abatement districts and the Bureau of Vector Control have been highly conscious of the low volume rates that can be used for effective control. Mulhern (1965) reported on experiments using undiluted technical malathion for control of mosquito larvae as early as October, 1963. Results were so encouraging that experiments with this technique continue among the twenty-three abatement districts in California using aircraft for mosquito larviciding.

The Department of Agricultural Engineering at the University of California, Davis, has for many years cooperated with the California Bureau of Vector Control on problems relating to application methods for dispersing insecticides by ground and air equipment. When contractual funds became available from the U.S. Department of Agriculture for investigating ultra low volume techniques in mosquito control, the University, along with the State Department of Public Health, was pleased to accept responsibility for research in this area. The following, in brief, were the goals of the study:

1) To test the effectiveness of one or more insecticides that are adaptable to ULV application techniques.
2) To evaluate the performance of several helicopters and fixed-wing aircraft applying chemicals in concentrate form.
3) To evaluate the data obtained and submit conclusions on the effectiveness of mosquito control by the dispersal of highly concentrated insecticides by airsprays.

The contract was signed in September, 1965, and work began shortly after on the first of our objectives

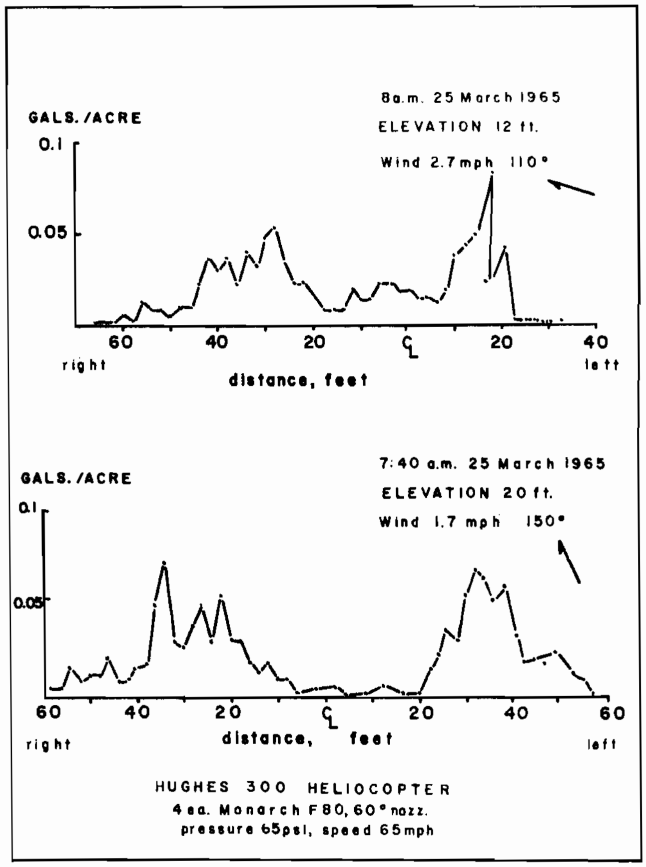

Figure 1. Ultra Low Volume Spray. A Comparison of Spray Runs made at Different Elevations and Wind. Conditions Otherwise the same.

which was to obtain base-line data on ULV techniques using malathion and following the recommendations of the manufacturer as closely as possible. The Tulare Mosquito Abatement District, which has mosquitoes showing considerable malathion resistance, and the Merced District, with almost no malathion resistance, were selected for duplicate tests. The use of the abatement district's most common aircraft, the Piper Pawnee 235, was our first plan; but when the Hughes Tool Company offered the use of one of their helicopters and a pilot we were pleased to accept.

Equipment

The helicopter was one of the new Hughes Ag 300 types equipped with a twenty-six foot boom and two sixty-gallon Agavenco spray tanks. The pump was power-take-off driven. Nozzles used were six Spraying Systems Co. 8001 flat fans (the Delavan Manufacturing Company FS 80-degree nozzle is an equivalent product). The Department of Agricultural Engineering at Davis had made, in March, 1965, a number of tests on a similar aircraft (Figure 1) and we decided on the following boom and nozzle arrangement: a twenty-six foot boom with six nozzles (8001's) located at eight inches, nine feet, and eleven feet three inches from both ends of the boom, the nozzles to be pointed directly down. The volume of 10.2 fluid ounces per

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[2]State Department of Public Health, Bureau of Vector Control

acre we obtained at a pressure of 42 psi, an airspeed of 60 mph, and an altitude of 10-12 feet, and a swath of 72 feet.

Method

Three fields were selected in the Merced and Tulare districts approximating 325 by 750 feet. The area to be sprayed was measured to the foot and pretreatment larvae counts made. Technical malathion was applied under conditions of minimum wind, while the application times were measured by stopwatch. Post-treatment larvae counts were made three hours and 24 hours after spraying. A spreader, Golden Bear (Tulare) and X-100 (Merced) was added to the mix, one ounce per gallon. Five gallons of chemical were sufficient to fill the spray system.

Results

Figure 1 compares two swath patterns obtained from a Hughes helicopter in March, 1965, the aircraft calibrated to deliver 0.5 pint per acre with four Monarch F80, 60-degree cone nozzles. The curves were obtained by plotting the deposits of fluorescent dye from glass plates placed at two-foot intervals across the path of flight. The patterns were not impressive and we later changed to the 8001 flat fan nozzles mentioned above. Of significance, however, is the accentuation of rotor-tip "pile-up" when the aircraft is flown above 15 feet. Of interest, too, and certain to be a problem when ULV sprays are used on small areas, is the sharp cut-off on one side of the pattern caused by a relatively low wind velocity of 2.7 miles per hour.

The use of flat fan nozzles is not the entire answer to obtaining a satisfactory pattern, as is illustrated by Figure 2, a ULV swath of a Bell "Ag-4" helicopter tested under the same conditions as the Hughes. Even with a wind of less than one mile per hour a sharp cut-off of the curve is visible (west end) along with a gradual taper on the east end indicating considerable drift.

Concern that ULV applications may increase the drift hazard caused Akesson and Yates to include a

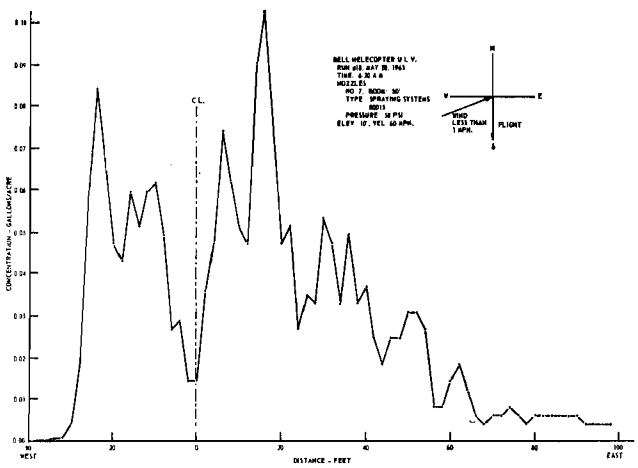

Figure 2. Ultra Low Volume Spray. (0.5 pints per acre, Technical) Helicopter Spray Patterns made under Conditions of very Low Wind.

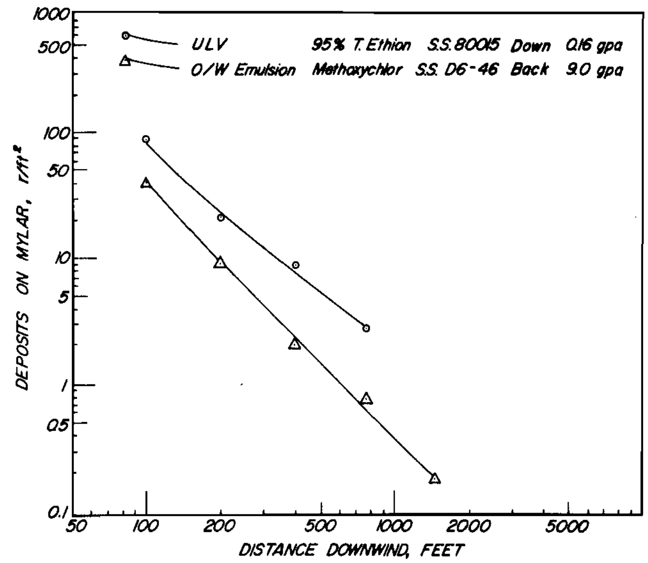

Figure 3. Ultra Low Volume Spray. A Comparison of the Drift from Pesticide Applications made with ULV, at 0.16 gpa (Technical) and at 9 Gallons per Acre in an emulsifiable formulation.

comparison of ULV and normal application rates (8 gallons per acre) in their July, 1965, drift runs. Plotted on log-log graph paper, Figure 3, our results indicate that ethion applied at one pint per acre shows drift residue at least four times more at all downwind stations than methoxychlor applied at a rate of 8 gallons per acre. The applications were adjusted for dosage, distance, and wind and the pesticides were recovered from mylar sheets placed downwind to a distance of 2,640 feet, then measured by gas chromatograph at the Richmond, California, laboratories of the Niagara Chemical Company. This experiment will be repeated in 1966 and, although not conclusive, the University advises the utmost care when using ULV in areas of mixed crops, and where bees may be present.

Table 1 summarizes the results of spraying by helicopter technical malathion over irrigated pasture against the larvae of *Aedes nigromaculis* and *Culex tarsalis*. There exists in the Tulare District, sprayed on September 17, 1965, considerable resistance and we obtained a rough correlation between our kill and resistance studies made by Gillies and Walsh (personal communication) in the same area. This will be further investigated in 1966.

When the Tulare work was duplicated in the Merced Mosquito Abatement District where no resistance to malathion has been reported, 100% larvae kill was observed on all test plots within 24 hours.

There remain only small areas in California where malathion is effective against mosquito larvae. As time goes on, other insecticides will be approved for mosquito control using the low volume techniques. Table 2 reports on some pilot studies made in September 1965 with the Hughes helicopter applying Baytex against larvae in Tulare, and a mixture of chemical 52160 (10%) and malathion (90%) against both larvae and adults in Merced. Excellent control was obtained in each area.

Discussion

With the ULV technique, considerations of payload and gross weight become secondary to limitation of aircraft and pilot endurance. While remembering that the ULV technique is equally adaptable to fixed-wing planes, the rotorcraft operator is able to use his equipment's unique capacity for spraying small areas, observing and landing in areas unapproachable by ground vehicles, and in a variety of off-season applications that are limited only by the ingenuity of the district staff; this, without the cost penalty of frequent trips for reloading made necessary by higher application rates.

In 1966 a helicopter will be used by one California mosquito abatement district. It is hoped that this will demonstrate that ULV spray techniques and the rotorcraft can combine to make helicopter operations economical for other abatement districts.

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We wish to express our appreciation to the managers and staff of the Tulare and Merced Mosquito Abatement Districts, the Niagara Chemical Company, and the Hughes Tool Company Helicopter Division without whose aid this work could not have been done.

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Table 1. Ultra low volume spray. Larvae kills on malathion sprayed test plots, Merced/Tulare, Sept. 1965. Flight path 90 degrees to the wind.

	run	chemical	wind velocity	larvae counts	kill
Tulare 9/17/65	1	Mal, tech	2.04 mph	*Aedes* 3, 4 instar ½ per dip	98.2% 24 hours
	2	Mal, tech	2.04 mph	*Aedes* 3, 4 instar 10/dip	88.0% 24 hours
	3	Mal, tech	1.40 mph	*Aedes* 2nd instar 10/dip	34% 28 hours
Merced 9/22/65	1	Mal, tech	0.68 mph	*Aedes, Culex* instar 1-4 adults over 5/dip	100% 20 hours
	2	Mal, tech	2.50 mph	ditto above	100% 20 hours
	3	Mal, tech	3.10 mph	ditto above	100% 20 hours

All runs over irrigated pasture
Technical malathion: 10.2 oz./acre (Tulare), 10.3 oz./acre (Merced)

Table 2. Ultra low volume spray. Test results of ULV applications on mosquito larvae and adults using chemicals other than malathion. Flight path 90 degrees to wind.

	run	chemical	wind	larvae count	kill
Tulare 9/17/65	4	Baytex 0.8 gal.	*	*Aedes* 1, 2, 3 instar 10/dip adults	100% 72 hours
	5	Baytex 100 oz.	*	*Aedes* 1, 2, 3 instar 5/dip adults	100% 72 hours
	6	Baytex 40 oz.	*	*Aedes* 1, 2, 3 instar 15/dip adults	98% 72 hours
Merced 9/22/65	4	Malathion tech. plus 52160	4.0 mph	*Aedes, Culex* larvae over 20/dip adults**	100% larvae 20 hours

**Adult count after Merced run 4: *Wind over 5 mph

	pretreatment	90 min.	20 hrs.
	27	33	0
Adult	13	12	1
Count	6	6	1
	8	6	1

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RESEARCH ON MOSQUITO RESISTANCE TO INSECTICIDES AT THE UNIVERSITY OF CALIFORNIA, RIVERSIDE[1]

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It would be inappropriate for me to take time to explain to this gathering the importance and implications of mosquito resistance to insecticides. Suffice it to say that California mosquitoes have the dubious distinction of being the most "progressive" in the world, insofar as their ability to develop resistance to organophosphorus insecticides is concerned (Brown, Lewallen and Gillies 1963). It is natural, therefore, that this problem should occupy a considerable share of our attention at the University of California at Riverside.

Our work revolves around several facets of the resistance problem. On the applied side, an extensive program of screening new compounds in the laboratory has been conducted since 1960 under the auspices of the World Health Organization. Reference to this program was made by Dr. R. L. Metcalf (1965) in last year's proceedings. The field evaluation of insecticides was covered at the same session by Dr. M. S. Mulla (1965). With respect to more fundamental aspects of resistance, the following questions are of continuing interest to us:

1. The nature of the processes and influences involved in the development, stability, and regression of resistance. It is well known that resistance to certain compounds, such as dieldrin, develops rapidly and usually persists for a considerable number of generations. With other compounds, such as certain organophosphates and carbamates, resistance develops more slowly and often regresses relatively rapidly in the absence of continued selection. Therefore, some insight into these processes enables one not only to understand the "behavior" of resistance in the field, but also to form sound judgments concerning the advisability of introducing a given compound in particular areas.

2. The elucidation of the biochemical mechanisms involved in resistance to insecticides is of considerable importance in the development of new compounds against which these mechanisms are not effective, and also in the development of synergists which, by blocking the insect's defenses, enhance the toxicity of the insecticide.

3. The identification of the genetic factors controlling resistance, i.e., the number of genes involved, their degree of dominance, linkage, and epistatic effects, are questions which aid in the interpretation of field observations and in making rational predictions on the expected course of events.

4. Last but not least, the knowledge that many field populations of mosquitoes are at present resistant to one or more insecticides dictates further evaluation of promising new compounds against strains possessing these various types of resistance.

It follows from this series of questions that the development of strains of mosquitoes resistant to the various "old" types of compounds, such as DDT and dieldrin, as well as to representative members of the more recent groups, such as the organophosphates and carbamates, is an essential aspect of our research. We have chosen to work with two species of mosquitoes: 1. *Culex pipiens quinquefasciatus* because of its importance as a "nuisance" mosquito, a vector of encephalitis, a vector of filariasis and other diseases in many parts of the world. 2. *Anopheles albimanus* from Central America, a representative of the malaria vector species. Essential details concerning the strains of these species, which are maintained in our laboratory, are given in Tables 1 and 2. Time does not permit me to discuss the characteristic properties of all these strains. Therefore, I shall limit myself to recent results of our carbamate selection and its effects on carbamate, DDT, and dieldrin susceptibility. We have been particularly interested in carbamates, in recent years, as potential insecticides for mosquito control because of the high toxicity of some of these compounds to adult mosquitoes, their relatively low mammalian toxicity, and their long persistence on treated surfaces. Details of the early stages of this work have already been published (Georghiou 1963, 1965, Georghiou and Metcalf 1961, 1963).

What appeared to be most intriguing about carbamate selection was the failure of *Culex (II)*[2] and *Anopheles (XII)* to develop significant resistance to AC-5727 (*m*-isopropylphenyl methylcarbamate) despite prolonged and rigorous selection (Georghiou 1963). Also puzzling was the loss of dieldrin resistance in *Anopheles (XII)* during carbamate selection, while the unselected parental strain *(XI)* lost practically none of its dieldrin resistance(Georghiou and Metcalf 1963). Failure to develop carbamate resistance in *Culex (II)* could easily be attributed to lack of the proper genes in the genetic pool of the parental strain *(I)*, possibly as a result of prolonged inbreeding since its colonization in 1950. But the *Anopheles* parental strain *(XI)* was of fairly recent origin (1958); it already possessed resistance to dieldrin, and to a smaller extent to DDT, yet it also failed to develop carbamate resistance. Thus, continued investigation seemed to be indicated.

In order to test further the potentiality of mosquitoes for development of resistance to carbamates, we obtained a new population of *Culex* from the Coachella Valley, Calif., *(IV)* and a population of *Anopheles* from Haiti *(XVI)* (Georghiou and Gidden 1965). Since the earlier-used carbamate (AC-5727) had in the meantime been shown to be of rather high mammalian toxicity (LD_{50} oral, rats, 16-60 mg/kg), the new strains were selected with the closely related compound Bay-

[1]This investigation was supported in part by U.S. Public Health Service grant GM11880-03 from the National Institute of General Medical Sciences, and by a grant from the World Health Organization.

[2]Roman numerals in parenthesis refer to strain designations in Tables 1 and 2.

gon® (*o*-isopropoxyphenyl methylcarbamate) (LD_{50} oral, rats, 175-200 mg/kg). Most of our information comes from the *Culex* strain (*V*) of which some 35 generations have been completed under selective pressure. Due to the longer life cycle of *Anopheles*, its selection (*XVII*) has not advanced sufficiently to allow conclusions to be drawn (Georghiou and Gidden 1965).

The response of *Culex* (*V*) to selection was positive but very gradual, so that within 35 generations a 25-fold increase in the level of resistance to Baygon was achieved in fourth-instar larvae (LC_{50} 5.79 p.p.m.). Interestingly enough, resistance in adults of this generation, as determined by exposure to treated filter paper for one hour, was only 2-fold greater than initially. The mechanism of resistance in this strain (*V*) appeared to be, at least in part, physiological, since the larvae were shown capable of metabolizing the carbamate more efficiently than was the case in the parental population (*IV*). The resistance mechanism was effective also against carbamates closely related to Baygon: a 20-fold and 26.7-fold resistance was present

TABLE 1. Strains of *Culex pipiens quinquefasciatus* maintained at the University of California, Riverside.

Designation		Origin	Selective agent	Generations under selection	Resistance levels[1]
I	Laboratory	San Joaquin Valley, Calif., 1950	none	continuous rearing	susceptible
II	8084	Strain *I*	AC-5727[2]	50	AC-5727 (2x)
III	Malathion[3]	Strain *I*	Malathion	38	Malathion (2.5x)
IV	Indio	Coachella Valley, Calif., 1963	none	continuous rearing	DDT (4x); Dieldrin (2x)
V	Baygon	Strain *IV*	Baygon[4]	35	Baygon (25x)
VI	Sumithion	Strain *IV*	Sumithion[5]	18	Sumithion (4x)
VII	DDT	Strain *IV*	DDT	11	DDT (>25x)
VIII	Dieldrin[6]	Strain *IV*	Dieldrin	15	Dieldrin (9x)
IX	*y;ru*	California[7]	none	continuous rearing	----
X	*red eye*	----[8]	none	continuous rearing	----

[1] In parenthesis, degree of resistance in larvae at LC_{50} level, in comparison with strain I.
[2] *m*-isopropylphenyl methylcarbamate.
[3] Discontinued, 1963.
[4] *o*-isopropoxphenyl methylcarbamate.
[5] *0-0*-dimethyl *0*-3-methyl-4-nitrophenyl phosphorothioate.
[6] Discontinued, 1965.
[7] Obtained through the courtesy of Dr. A. R. Barr, Calif. Dept. Public Health, Fresno.
[8] Obtained through the courtesy of Dr. H. Laven, Mainz, Germany.

TABLE 2. Strains of *Anopheles albimanus* maintained at the University of California, Riverside.

Designation		Origin	Selective agent	Generations under selection	Resistance levels[1]
XI	Panama	Panama[2]	none	continuous rearing	Dieldrin DDT
XII	8084	Strain *XI*	AC-5727[3]	56	AC-5727 (2.8x)
XIII	120	Strain *XI*	sib selection for susceptibility	continuous rearing	----
XIV	DDT	Strain *XI*	DDT	25	DDT (18x)
XV	Dieldrin	Strain *XI*	Dieldrin	4[4]	Dieldrin (>100)
XVI	Haiti	Haiti	none	continuous rearing	Dieldrin (>100)
XVII	Baygon	Strain *XVI*	Baygon[5]	10	Baygon (2x)
XVIII	Sumithion	Strain *XVI*	Sumithion[6]	10	Sumithion (1.5x)
XIX	Stripe[7]	Strain *XVI*	none	----	----

[1] In parenthesis, degree of resistance in larvae at LC_{50} level, in comparison with susceptible strains.
[2] Obtained through the courtesy of H. Simkhover, Shell Chemical Co., Modesto, Calif.
[3] *m*-isopropylphenyl methylcarbamate
[4] Now under continuous rearing.
[5] *o*-isopropoxyphenyl methylcarbamate.
[6] *0,0*-dimethyl *0*-3-methyl-4-nitrophenyl phosphorothioate.
[7] Mutant strain.

toward *o*-isopropylphenyl methylcarbamate and 2,3-dihydro-2,2-dimethyl benzofuranyl-7-methylcarbamate, respectively. In contrast, resistance was extremely low toward less closely related compounds, i.e., 2.1-fold toward 2(methylcarbamoyloximino)-1, 3-dithiolane, and 2.2-fold toward Temik® [2-methyl-2-(methylthio)-propionaldehyde *O*-(methylcarbamoyl)oxime]. A certain degree of specificity was also evident toward the *ortho*-substituted phenyl methylcarbamates. For instance, resistance to *o*-isopropylphenyl methylcarbamate was 20-fold, but only 8.8-fold toward *m*-isopropylphenyl methylcarbamate. Similarly, it was 8.6-fold toward *o*-propargyloxyphenyl methylcarbamate but only 3.4-fold toward *m*-propargyloxyphenyl methylcarbamate. Such specificity of resistance is encouraging inasmuch as the development of resistance to one carbamate does not appear to embrace all members of this group. This situation is in contrast to the dieldrin-resistance which extends to most other cyclodiene insecticides.

The Baygon-selected strain of *Culex* (*V*) also exhibited varying degrees of cross-resistance to organophosphorus compounds, i.e., 1.8-fold to Sumithion® (*O,O*-dimethyl *O*-3-methyl-4-nitrophenyl phosphorothioate), 8.3-fold to malathion and 15.1-fold to fenthion. Resistance to DDT, which was present in the parental population (*IV*), was enhanced by carbamate selection pressure, but susceptibility to dieldrin remained unchanged. The latter fact may be due to absence of dieldrin resistance genes in the parental population (*IV*) since dieldrin selection pressure on a substrain (*VIII*) of this population for 15 generations caused only a steepening of the dosage-mortality regression line.

Of interest to us, also, was the question of whether the presence of DDT or dieldrin resistance would influence the degree of susceptibility of the population to carbamates. This problem was approached by subjecting *Culex* and *Anopheles* populations to selection by DDT or dieldrin and determining the effects of this selection on carbamate susceptibility .DDT resistance was developed fairly rapidly in both *Culex* (*VII*) and *Anopheles* (*XIV*), as was dieldrin resistance in *Anopheles* (*XV*). In none of these strains was there any significant increase in tolerance to Baygon or AC-5727. The dosage-mortality regression lines for these carbamates became steeper than they were initially, but did not extend beyond the upper limits of tolerance of the parental strains. It appears from these results that selection by DDT or dieldrin does not result in enhanced tolerance to carbamates, even in a population possessing the potentiality for carbamate resistance (as demonstrated by strain *V*). The linkage relationships of genes contributing to carbamate, DDT, or dieldrin resistance are now being investigated by appropriate crosses.

The relatively high level of resistance to Baygon achieved in *Culex* (*V*) may be rather disquieting. On the basis of past experience it was to be expected that given adequate time and a broad genetic background some resistance would appear. However, the important question is how soon resistance appears, to what level, and what the mechanisms of such resistance are. From this standpoint, I feel that the slow rate of development of resistance to Baygon, the specificity of such resistance, and its low degree of expressivity in the adult mosquito may prove to be rather encouraging features in the utility of this or other related materials for mosquito control.

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SOLUTION TO THE PHOSPHATE RESISTANCE PROBLEM

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The development of acquired resistance to insecticides has been a major concern of this group through the past several years. As DDT and other synthetic insecticides appeared on the horizon, hopes for a continuous success of mosquito control programs were held by most of us. However, due to the continuous development of resistance in *Aedes nigromaculis* to a succession of these materials, our hopes were partly or completely shattered. The situation as it stands today is such that the average life expectancy of a new phosphate insecticide at best is not more than four years (Fig. 1). Now that many districts are switching to fenthion, it is only conjectural as to how long this material will last against the notorious *Aedes nigromaculis*. The same could be true of Abate® and Dursban® if and when these are employed for mosquito control.

Although a number of promising newer phosphate insecticides are being registered for use against mosquitoes, it is not easy any more to come up with such relatively safe and highly effective materials at the proper time. Costs of development are soaring high, and therefore the ultimate cost of mosquito control is correspondingly increasing. Newer techniques and procedures must be developed to prolong the use of such ideal mosquito larvicides such as Abate®, fenthion and Dursban®. Obsolescence of any one of these materials due to the development of resistance in a few years would automatically result in increased cost of mosquito abatement.

I remember very well that in my earlier days of association with this group, symposia and panels dealing with the problem of resistance were organized. Even a few years prior to that, the late Mr. Harold F. Gray keynoted an address to you entitled "Which Way Now?" (CMCA proceedings, 1950, p. 3). This was the time when resistance in *Aedes nigromaculis* larvae to DDT was reported from Tulare County (Bohart and Murray 1950) and Kern County (Smith 1949). By 1952 more reports of resistance to DDT and dieldrin were documented (Gjullin and Peters 1952). Subsequently, in 1957, a panel of this association entitled "Mosquito Control Insecticides—Where Do We Go From Here?" was chaired by A. F. Geib (CMCA Proc., 1957, p. 85). By this time, quite a few of our mosquito abatement districts in California had resorted to the use of malathion and parathion. Resistance to the former material had been confirmed. In the 1958 meeting of this association a panel entitled "Where Are We Going in Mosquito Control? Chemical, Physical and Biological Control—What and How?" was chaired by W. E. Reeves (CMCA Proc., 1958, p. 40). By this time resistance to parathion and other organophosphate insecticides had become widespread (Lewallen and Brawley 1958, Lewallen and Nicholson 1959). Further detailed studies on the course of resistance in *Aedes nigromaculis* to organophosphates were accomplished (Brown, Lewallen and Gilles 1963; Mulla, Metcalf and Kats 1964). In the 1964 meeting, a panel entitled "What Now in Chemical Mosquito Control" was organized by T. G. Raley (CMCA Proc., 1964, p. 57).

The answers and solutions to these hair-raising questions and problems are not simple. There has to be a change in our concepts of mosquito control technology; and various approaches in light of new information have to be practiced. A solution to the ever increasing problem of resistance to the insecticides currently used or developed requires a new search to find compounds or techniques which will be resistance-proof. During the past year and a half, we have been engaged in exploring these new approaches for possible use in mosquito control programs. In order to alleviate the resistance problem, we have spearheaded our research program in three directions. These three approaches definitely offer outstanding possibilities in coping with the resistance problem. These are:

Petroleum Oils—Here oils, fractions and formulations must be found which will be 10 to 20 or more times as effective as currently used diesel oil. Development of resistance to oils in insects is unheard of, even though they have been used for decades. The prognosis is good in this direction and this research program due to lack of time will not be detailed any further. But further research could definitely produce promising results in this field.

Application Techniques—The present techniques of application are highly conducive to the development of resistance. Curative measures consisting of applications made after older larvae and pupae are detected lead to partial control. Since the first instar larvae are generally more susceptible than the older instar larvae to organophosphate insecticides, prehatch treatments or chemical irrigation techniques would be more effective than post-hatch treatment. A great deal of research is of course needed to assess the efficacy of these techniques.

Newer Compounds, Different From Insecticides—During the past year in our research program aimed at finding compounds having different modes of action we hit upon some interesting groups of compounds which appear to increase our capabilities in coping with the resistance problem. These compounds belong to a group called aliphatic amines, fatty amines or fatty nitrogen chemicals. They are physicochemically different from the organochlorine, organophosphate and carbamate insecticides. Their modes of action against mosquito larvae and pupae are similar to that of petroleum oils, thus providing us with an effective measure against resistant as well as susceptible populations. In general, they are more effective than the currently available petroleum oils. These compounds in our preliminary research program seem highly promising and the remainder of this discussion will deal with the information obtained thus far.

The aliphatic amines are a diverse group of chemicals and potentially could yield hundreds or thousands of compounds. They are used as intermediates, surfactants, precursors to household and industrial detergents, anticorrosive agents, fungicides, algicides and bactericides. Their toxicity to warmblooded animals is quite low and information on their effect on fish and other aquatic wildlife is not adequate.

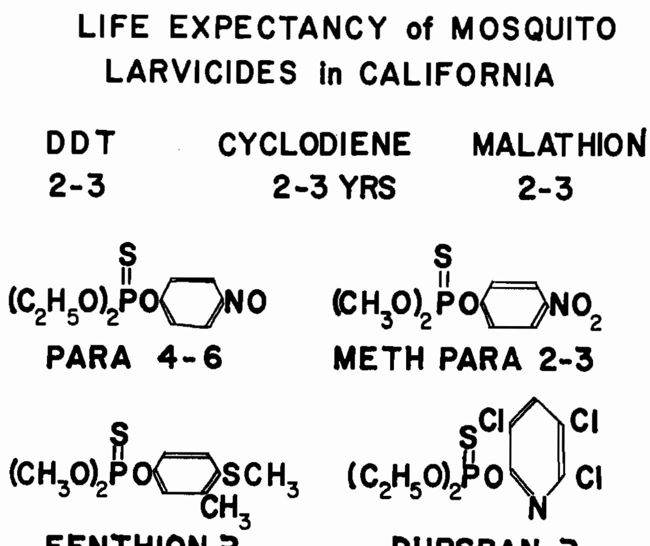

Figure 1. Organochlorine and organophosphate insecticides employed or which will be employed in California Mosquito Control Programs. The average life expectancy of materials used up to 1966, is about 3-4 years.

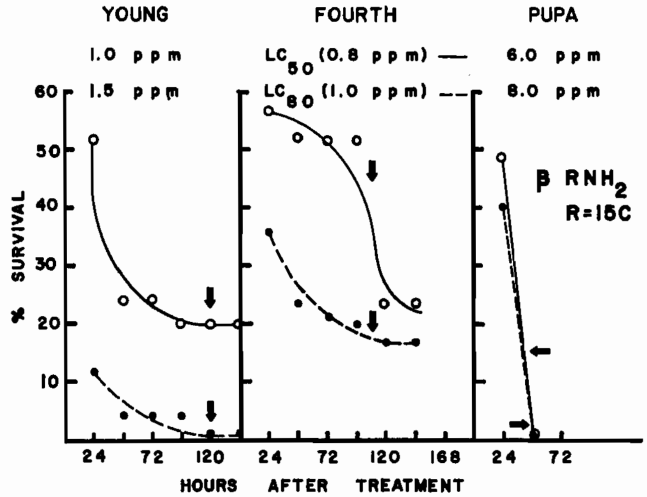

Figure 2. Influence of an aliphatic amine on survival of emerging adult mosquitoes, when young and 4th stage larvae and pupae of *C. quinquefasciatus* were treated. Arrow indicates start of adult emergence and subsequent decline in survival is due to adult die-off. Adults from young larvae treated are not affected.

These compounds are straight chain amines, with 7-20 carbon atoms in the aliphatic chain. Most of the compounds are generally weak cationic surfactants, they are attacked by microörganisms and thus are biodegradable. Substitution of branched chain in place of the straight chain groups yields less biodegradable compounds. Most of these amines have electrostatic attraction to many kinds of natural and synthetic surfaces, displacing water, thus forming hydrophobic films.

In the *beta* mono-amines, the activity increased as the carbon chain increased from 7 to 15. Maximum activity against both larvae and pupae was shown by the 15 carbon chains. In the *beta* diamine series, maximum activity was shown when the side chain contained 15 carbon atoms. These compounds as well as some quaternary salts yielded excellent kill of pupae and larvae or produced debilitating effects in adults emerging from treated population. Ethoxylated products of the *beta* diamines showed considerable activity but were not as effective as some of the quaternary, mono-amine and diamine compounds.

Activity Against Pupae—The discovery that the fatty nitrogen chemicals can kill pupae at larvicidal rates is quite significant. No synthetic chemical has been known to manifest this type of activity. For example, in the case of parathion, Abate and fenthion, over 1,000 times the larvicidal concentration is needed to kill the pupae. In other words, larvicidal treatments of synthetic insecticides currently used would not touch the pupae. This is even true for many of the petroleum oils. It is on this account that some adult emergence may take place in a treated field, because a few pupae present at the time of a larvicidal treatment were not affected. Availability of a larvicidal-pupicidal material increases the accuracy of timing of application as well as the time interval in which a given population of immature mosquitoes should be controlled.

Are Fatty Amines Resistance-Proof?—This question cannot be answered with certainty. The mode of action of these compounds in gross appearance resembles that of petroleum oils. Since no resistance has been reported in mosquitoes to petroleum oils, even though they have been used for many decades, it is logical to deduce that the fatty amines would not be as prone to resistance development as are the chlorinated hydrocarbon and organophosphate insecticides. It is more likely that the aliphatic amines kill by physical action; blocking the trachae, trachioles or destroying the inner lining of these. It is also possible that these compounds might change the membrane characteristics of anal gills through which water balance and ion exchange takes place. Dehydration of mosquito larvae, even though in water, through the electrostatic forces might also be responsible for the kill. These modes of action all seem to be physical in nature. It is altogether possible that mosquitoes may not be able to develop resistance to compounds having this type of mode of action. If this hypothesis would hold true, then indeed the future of mosquito control programs seem to be bright. And, only further research could prove or disprove this hypothesis.

Interference With Morphogenesis—During the course of initial laboratory screening, it was observed that surviving 4th instar larvae in some of the sublethal treatments with fatty amines, pupated normally, but the emerging adults were incapable of flight. Soon after emergence these adults floated on the water surface. This die-off of emerging adults is quite noticeable with some of the compounds. Treated pupae are more affected in this manner than are the larvae (Fig. 2). In the figure, the arrow indicates the start of emergence, and further decline in survival of the population is attributed to adult die off. Such a phenomenon does not occur with the survivors from parathion, Abate and fenthion treated larvae (Fig. 3).

Formulations—The success or failure of the fatty nitrogen chemicals will greatly hinge on proper formulation techniques. It has been found in preliminary laboratory studies that a proper solvent system must be found for an effective formulation. For example

TABLE 1—Effectiveness of 10% *beta* R NH_2 (R=15) in Toxisol B against 4th stage larvae.[a]

Material PPM	Solvent PPM	Surfactant AK 16-97 (%)	Mortality %
1	9	0	5
2	18	0	15
1	9	0.5	11
2	18	0.5	16
1	9	2.0	15
2	18	2.0	17
1	9	5.0	23
2	18	5.0	24
0	0	0	0

[a]The test was run in pans, and results read 20 hrs. after treatment. In all treatments film formed, but disappeared within 5 minutes.

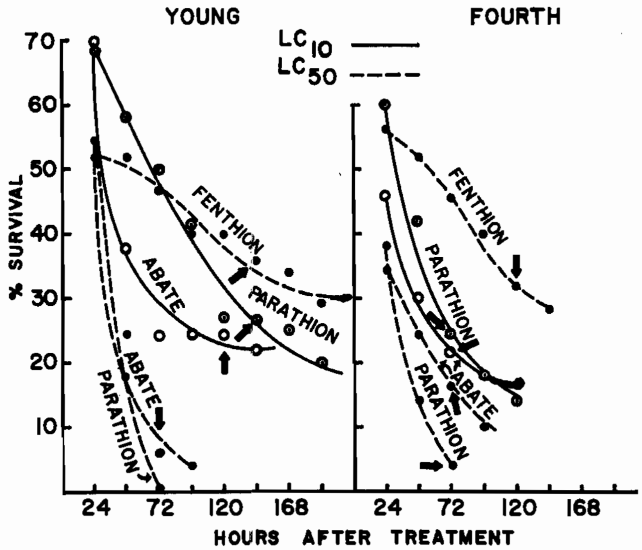

Figure 3. Continuous exposure of mosquito larvae (*C. quinquefasciatus*) to Abate, fenthion and parathion and their survival. Arrows indicate start of adult emergence. Decline of survival is not due to emerging adult die-off.

Toxisol B, an aromatic solvent was found to be inferior (Table 1). Other solvents of the same series proved highly effective (Table 2,3). Therefore solvent of dilution as carrier would greatly influence the biological activity of the fatty amines. Some surfactants as a matter of fact completely nullified the biological activity of these compounds. The surfactants AK-16-97 and AG-1256 are some of the better ones. Surfactant concentrations produced minor changes in the activity (See Table 2), increasing the surfactant, yielded increased biological activity. However, it was found that concentration of a good surfactant should not exceed 2%; one per cent being generally adequate (See Tables 1, 2).

TABLE 2—Biological activity of 10% *beta* R NH_2 (R=15) solution in Toxisol TB against 4th stage larvae.[a]

Surfactant Emcol AK 16-97 %	Material (PPM)	Solvent (PPM)	Mortality[b] %
0.5	1	8	82
0.5	2	16	93
2.0	1	8	86
2.0	2	16	97
5.0	1	8	89
5.0	2	16	98
0.5	0	20	0
2.0	0	20	0
5.0	0	20	3
0	0	0	0

[a]Test was conducted in pans. In all cases five droplets formed ½ hr. after treatment. Mortality occurred fast.
[b]Avereage 24 hrs.

Conclusions

The fatty amines or fatty nitrogen chemicals seem to have a good potential for use against insecticide-resistant as well as susceptible mosquitoes. Due to the peculiar mode of action of these chemicals which is not clearly understood at this time, it is possible and very likely that mosquitoes would not readily become tolerant to these materials.

In order to explore the full potential of these simple chemicals, detailed and longterm laboratory and field studies have to be accomplished. New formulations and application techniques have to be developed. Without such an adequate and comprehensive research program our ability to cope with the ever increasing problem of pest and vector mosquitoes will diminish materially. The approaches suggested here seem promising and it is through a fair understanding of these that practical solutions in the near future can be achieved.

TABLE 3—Biological activity of *beta* R NH_2 (R=15) solution in Toxisol FLC/4th stage larvae.[a]

Material % Solution	Material PPM	Solvent (ppm)	Surfactant AG-1256 (%)	Mortality[b] (%)
10	0.5	4.5	0	85
	1.0	9.0	0	91
	2.0	18.0	0	97
	0.5	4.5	1	84
20	1.0	4.0	1	84
	2.0	8.0	1	96
0	0	5	0	2
0	0	10	0	12
0	0	5	1	0
0	0	10	1	29
0	0	0	0	0

[a]In pans. In all treatments there was a film initially. However an hour later, the film broke into fine droplets. Where no surfactant was used with the amine solution, large droplets formed, 24 hours after treatment. Mortality occurred fast in the Amine treatments.
[b]Average 24-hour mortality.

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MOSQUITO LARVICIDE SUSCEPTIBILITY SURVEILLANCE – 1965

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A program to monitor developing organophosphorus insecticide resistance in California mosquito larvae was begun in 1963 as a survey for both resistance and susceptibility in treated populations (Gillies 1964). The program continued on a limited basis during 1964 (Gillies and Womeldorf 1965) and received increased attention in 1965, with the cooperation of many California mosquito control agencies.

TEST PROCEDURES

Field-collected larvae (occasionally eggs) were reared and treated at the third or fourth instar. Twenty larvae were placed in each of a series of waxed paper cups containing 100 ml distilled or aged tap water, then exposed to a range of concentrations of technical insecticide dissolved in acetone. Differential amounts of the acetone-insecticide solution were used to a maximum of 1 ml per 100 ml of water. Dosages were duplicated, when possible, at each treatment concentration. At the end of 24 hours, the average total dead and moribund larvae at each dosage were recorded. The percentages were plotted versus concntration on logarithm-probability paper, and a line was fitted to the points by eye to obtain rough estimates of the LC_{50} and LC_{90} subsequently, most of the data were processed on an IBM 7094 using a Probit Analysis program to obtain the best fitting lines and maximum likelihood estimates of the LC_{50} values with 95% confidence intervals. Tests were considered invalid if more than 10% pupation occurred within the 24-hour period.

FAILURE THRESHOLDS

The approach of the program has been to collect and test larvae of as many species as possible whether or not a problem has been encountered in control. Information received from the mosquito abatement agency as to any difficulty in achieving satisfactory kills is compared with the laboratory data. When several agencies have reported control problems, and many tests have been performed on problem populations, a threshold is established. Test results obtained from other populations are then compared with the threshold to confirm or deny high larval tolerance in the event of an observed operational failure, or to warn against approaching problems due to incipient resistance.

Thresholds listed by Brown et al. (1963) for *Aedes nigromaculis* against parathion and methyl parathion were 0.005 and 0.004 ppm, respectively, at the mean lethal concentration (LC_{50}). Gillies (1954) speculated that the methyl parathion threshold might be as low as 0.003 ppm in the species. Observations made since that time in an increased number of mosquito abatement agencies show that the differences are probably due to variations between agencies in the manner in which they detect operational failures rather than due to differences between insecticides or species. For instance, a mosquito control agency with a routine and exhaustive post-treatment inspection system, encompassing every source to which insecticides are applied, is apt to discover a failure sooner than is an agency with less manpower to do the job and therefore required to rely upon spot checks or citizens' complaints to discern incomplete kills.

The principal basis of a threshold is the amount of insecticide routinely applied in a situation. The three chemicals, parathion, methyl parathion, and fenthion, are applied at the rate of 0.1 pound per acre by most California mosquito control agencies, and all exhibit the same failure threshold. Tentative thresholds have been established for parathion, methyl parathion, and fenthion against the *Aedes* and *Culex* species receiving large-scale and intensive control, usually by means of aerial or power ground insecticide application equipment.

The LC_{50} at which most agencies experience some degree of control difficulty is about 0.005 ppm, although some mosquito abatement districts detect problems when the LC_{50} is as low as 0.003 ppm, and others do not recognize a failure until the LC_{50} is about 0.01 ppm. If any other insecticide were to be applied at the dosage rate of 0.1 pound per acre, it is probable that most agencies would experience operational problems at an LC_{50} of about 0.005 ppm, and that all agencies would recognize field failures at an LC_{50} of 0.01 ppm.

Less information is available regarding malathion, but a conservative figure of 0.1 ppm at the LC_{50} is indicated as the failure threshold. Malathion is usually used at the dosage rate of 0.5 pound per acre, but is most often applied with hand equipment with consequent tendencies toward overdosing.

The reason that a population may exhibit a tolerance level exceeding the failure threshold is operationally unimportant. In some species and against some insecticides, it is due to physiological resistance. Other causes include ecological conditions, vigor tolerance, and the normal differences between populations of the same species. Regardless of the cause, the effect is the same: the mosquito larvae cannot be controlled by usual operational doses of the chemical.

CURRENT STATUS

Table 1 lists, by year of first laboratory confirmation, findings to date of high organophosphorus tolerance in five mosquito species. Literature references to documented instances of organophosphorus resistance are included for completeness. The sole criterion applied in choosing other material to be listed in Table 1 was that the population LC_{50} exceeded 0.005 ppm parathion, methyl parathion, or fenthion, or 0.1 ppm malathion.

Most high larval tolerance in *Aedes* sp. is probably due to developed resistance. Organophosphorus resistance in *A. nigromaculis* has been well documented, although vigor tolerance has been suggested as a cause of some instances of low susceptibility as reflected by test results (Mulla et al. 1964).

Information was gathered in 1965 that malathion resistance, known in *Culex tarsalis* (Gjullin and Isaak 1957), also exists in *C. peus* and *C. pipiens* ssp. Cases of *Culex* sp. exhibiting high tolerance to parathion, methyl parathion, and fenthion are probably due to factors other than induced resistance.

Table 1. Year of first laboratory-demonstrated high organophosphorus tolerance in larvae of five California mosquito species and LC_{50} levels with 95% confidence limits.

CONTROL AGENCY	MALATHION			PARATHION			METHYL PARATHION			FENTHION		
	Year	LC_{50}	95% Limits	Year	LC_{50}	95% Limits	Year	LC_{50}	95% Limits	Year	LC_{50}	95% Limits
Aedes nigromaculis												
Kern MAD	1963	0.10	0.092-0.11	1962	0.04[a]	0.031-0.051	1963	0.0091	0.0074-0.012	1962	0.01[a]	0.0082-0.013
Delano MAD				1963	0.013	0.01-0.016						
Tulare MAD	1963	0.12	0.097-0.14	1962	0.026	0.021-0.031	1963	0.015	0.011-0.02	1963	0.0053	0.0048-0.0059
Kings MAD	1963	0.14	0.1-0.18	1958[b]			1962	0.0056		1964	0.009	
Delta MAD	1963	0.15	0.12-0.20	1960	0.014	0.011-0.017	1962	0.0086	0.0084-0.0089			
Consolidated MAD	1964	0.15	0.082-0.29[h]	1964	0.0059	0.0052-0.0066						
Fresno West Side MAD				1965	0.016	0.013-0.02						
Fresno MAD	1960	0.15	0.10-0.2									
Turlock MAD				1962	0.0058							
East Side MAD				1963	0.006	0.0033-0.021[h]						
N. San Joaquin Co. MAD	1963	0.20	0.14-0.31									
Sutter-Yuba MAD				1963	0.016	0.013-0.021	1965	0.014	0.012-0.017			
Butte Co. MAD				1964	0.053	0.034-0.1[h]	1964	0.0053	0.0044-0.0065			
Los Molinos MAD	1965	0.12	0.066-0.57[h]									
Tehama Co. MAD				1965	0.0069	0.006-0.0083						
Pine Grove MAD	1964	0.13	0.077-0.36[h]									
Aedes melanimon												
Tulare MAD				1961	0.018[c]							
Solano MAD				1965	0.0062	0.0051-0.0082						
Sutter-Yuba MAD				1964	0.026	0.02-0.037						
Butte Co. MAD				1965	0.017	0.014-0.022						
Culex pipiens Subspp.												
Kern MAD	1956	0.14[d]	0.066-0.44[h]	1956	0.0062[d]	0.0055-0.007						
Consolidated MAD	1965	0.11	0.095-0.12							1965	0.0075	0.0069-0.0082
Fresno MAD	1963	0.13[c]	0.12-0.15	1963	0.0063	0.0057-0.007						
Turlock MAD										1963	0.0054	0.0051-0.0057
East Side MAD	1964	0.11	0.086-0.14							1965	0.0059	0.005-0.008
Culex tarsalis												
West Side MAD	1965	0.11	0.082-0.14									
Consolidated MAD	1965	0.21	0.12-0.47									
Fresno MAD	1956	0.73[e]										
Merced MAD	1965	0.21	0.11-0.95									
Solano Co. MAD	1965	0.11	0.066-0.17									
Culex peus												
Orange Co. MAD	1965	0.11	0.1-0.13							1965	0.006	0.0053-0.0068
Turlock MAD										1963	0.0055	0.0042-0.0089[h]
East Side MAD	1965	0.12	0.11-0.14				1965	0.0066	0.0059-0.0074	1965	0.0067	0.006-0.0074
San Joaquin MAD										1965	0.013	0.012-0.15
Butte Co. MAD										1965	0.0083	0.0075-0.0092
Tehama Co. MAD										1965	0.0066	0.0056-0.0089
Corning MAD										1965	0.0058	0.0052-0.0064

[a] L. Isaak data [b] Lewallen and Brawley 1958 [c] Gillies 1964 [d] C. M. Gjullin data [e] Gjullin and Isaak 1957 [h] Heterogeneous data

Although most populations listed produced operational problems, a few exhibited high tolerance without a known history of the particular insecticide being used or without a failure being noted by the control agency. In general, tolerance exists in each major species against some of the organophosphorus compounds commonly used for larval control. Whether or not developed resistance is the cause, the presence of high tolerance may be expected to continue to create operational difficulties as long as organophosphorus insecticides are used.

Acknowledgments

Personnel of participating mosquito control agencies are thanked for assisting in collecting and processing larvae. Dr. Kathleen E. White, California State Department of Public Health, Bureau of Vector Control, performed the statistical analyses.

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FOURTH SESSION

(Concurrent)

TRUSTEE BUSINESS MEETING

TUESDAY, FEBRUARY 1, 1:35 P.M.

CARL W. MULLER, *Presiding*

Note: A complete recording of the minutes is on file in the office of the Secretary of the Association. The following is a summary of actions taken.

The CMCA Trustee Business Session was called to order by Carl W. Muller, Chairman of the Trustee Advisory Committee, at 1:35 p.m.

Mr. Muller introduced the Parliamentarian, Lee G. Brown, Trustee, Kings MAD, and the Credentials Chairman, Marion C. Bew, President, Board of Trustees, Sutter-Yuba MAD.

Gordon F. Smith, Chairman, of the CMCA Research Committee, presented a review of the activities by the Committee and its members during the past year. As a result of the activities of the CMCA Research Committee, the State Dept. of Public Health, and the University of California, the following funds have been requested for 1966-67:

1. The State Department of Public Health budget includes funds for continuation of the existing program, with all funds to be contracted—approximately $150,000.00.

2. The University of California Division of Agriculture is requesting $200,000.00 with plans for an additional $100,000.00 to be requested in next year's budget.

3. The University of California School of Public Health is requesting $60,428.00.

Fred DeBenedetti presented the following resolution:

Resolution: That the CMCA supports actively, and without qualification, the budget requests of the State Department of Public Health and the University of California for mosquito control and disease transmission research, as submitted to the Director of Finance. The CMCA further supports the concept that the University of California should have primary responsibility for, and should carry on the necessary basic research in these fields, and that the State Department of Public Health should have authority and necessary funding to carry out surveillance, extension to the governmental agencies and field supportive investigations consistent with the duties of that Department.

Fred DeBenedetti: I move the adoption of this Resolution.

J. W. Bristow: I second this motion.

On call for vote, the resolution was adopted unanimously.

Howard R. Greenfield, Chairman of the CMCA Bylaws, presented the activities of this Committee during the past year.

A. H. Sagehorn moved that the Trustees recommend at the general business session Wednesday that the proposed amendments be adopted. This motion was seconded by Abel Machado and unanimously carried.

James W. Bristow, Trustee of the Southeast MAD, reviewed the CMCA, its expanding program and its fiscal responsibilities. He concluded with the following motion:

I move that a committee of the Trustee Advisory Group be appointed for the next year to study the subject of fiscal responsibility of this organization in the fields of its publication and a paid staff. The motion was seconded by Lee G. Brown and, after discussion, carried unanimously.

Following a caucus by Region in order to select, ratify and approve a Regional Trustee and alternate to the Trustee Advisory Committee, the following representatives were chosen:

COASTAL REGION:

Trustee Representative: A. H. Sagehorn, San Mateo Co. MAD; Alternate: Robert Bowen, No. Salinas Valley MAD.

SACRAMENTO VALLEY REGION:

Trustee Representative: Marion C. Bew, Sutter-Yuba MAD; Alternate: Harold Olson, Colusa MAD.

NORTHERN SAN JOAQUIN VALLEY REGION:

Trustee Representative: Fred DeBenedetti, San Joaquin MAD; Alternate: Harold Joliff, East Side MAD.

SOUTHERN SAN JOAQUIN VALLEY REGION:

Trustee Representative: Roy H. Howard, Fresno Westside MAD; Alternate: J. W. Chezick, Madera County MAD.

SOUTHERN CALIFORNIA REGION:

Trustee Representative: Jay B. Price, Southeast MAD.

J. W. Bristow presented information on activities of the Southeast MAD in making public relations and informational contacts with local, state and national governmental representatives.

Carl W. Muller: I appoint Marion C. Bew, A. H. Sagehorn and Fred DeBenedetti to report this trustee session to the CMCA business meeting on Wednesday.

The fine program at this Conference, and the interest of the trustees, indicates a new era for CMCA and I am sure its future is in excellent hands in the group here today. It has been a pleasure to me to have worked with all of you, collectively and individually.

FIFTH SESSION

WEDNESDAY, FEBRUARY 2, 8:30 A.M.

REGIONAL PRESENTATIONS FROM CALIFORNIA AND OTHER STATES

LESTER R. BRUMBAUGH, *Presiding*

SACRAMENTO VALLEY REGION

MELVIN L. OLDHAM

Regional Representative

The use of an airplane in mosquito control operations is "old hat" to most of the mosquito abatement districts in California, but to some of the smaller districts in the Sacramento Valley Region this marks a good step forward. Until 1965 there were no aircraft available to our districts in the north end of the Sacramento Valley without extreme ferrying problems. Our budgets and scope of operations did not justify purchase of a plane nor could we entice the one or two operators in the area to give up the lucrative fire fighting contracts with the forestry service. However, last spring one of the fire fighters switched to general ag spraying and became available to us with a Call Air 150 and a Pawnee 235.

This, of course, proved to be a godsend to our operation by permitting more efficient treatment of our problem areas as well as treatment of some areas seldom or never before treated. In Shasta District, Joe Willis was able to treat dredger pits and river island ponds that were almost inaccessible by land. In Corning and Tehama County Districts the operators were able to spend more time inspecting and locating new sources.

Since our problem consists of numerous small sources and our mapping system is not adequate to pinpoint these for aircraft operation, we were faced with trying to beat the plane from one location to another. We finally ended up "copiloting" from a small jump seat behind the pilot in the Call Air. This proved very effective and we were able to show the pilot exactly what we wanted to treat as well as spot new sources and generally inspect the district. The main drawback to this, however, was the lack of an anti-airsick pill that would last more than an hour while I was riding backwards in a cramped, stuffy jump seat.

Parathion granules were used and, of course, proved very effective since we are not yet faced with serious resistance problems in this area. One application of volclay 5% granules consistently gave control for two irrigations on a pasture in Tehama County. This is a one-hundred-acre pasture, taking 7 to 10 days per irrigation. The granules were applied in one application when about 1/3 *had been* irrigated, 1/3 was *being* irrigated, and 1/3 was dry. Treatment by hand or jeep required several return trips and inspections but with the airplane it took a preinspection, a postinspection and about 45 minutes of flying.

The majority of our sources range in size from 2,000 to 3,000 square feet to 3 or 4 acres and, unfortunately, treatment does not always work so well as it did on this larger pasture.

This season the pilot is installing two-way radios and with improved mapping we will be able to eliminate some of the copiloting. We hope eventually to reach the efficiency of some of the more experienced districts.

A few other highlights of the year:

Ken Whitesell successfully pregranuled several sections of his duck club for the second year in a row.

John Brawley moved from his Big Barn in Biggs to a brand new facility in Oroville.

COASTAL REGION

DEAN H. ECKE

Regional Representative

Solano County MAD is investigating some gnat control problems with the use of carp. One test was to determine the tolerance of carp to salt water. Other tests were run to determine how well carp did in the low oxygen content of oxidation ponds. The District uses an Eckman dredge to take bottom samples to determine the number of gnat larvae. The carp were maintained in a holding tank, with an aerator.

Alameda County MAD is concerned with adapting equipment to the conditions they find in the urban areas. For one thing, a '57 International pickup has a wheel adaptation to handle 12x16 1/2″ tires. Another vehicle has under the hood an electric clutch. This clutch when engaged drives a 1/2″ bronze gear pump which is used on the catch basin vehicle. Many of the waterways in the urban areas have been concreted. The District drives along these waterways, but contends with bottles and junk thrown by litterbugs. A guard to protect the tires has proven very effective. The District also has an adaptation on its mist blower-duster unit with which it can force dust into the catch basin system. This is very effective for treating water that is beyond the reach of conventional spray equipment.

Marin County MAD's major problem is the salt marsh area. There still are many thousands of acres of salt marsh which have not been developed. The District even gets some of the Sonoma salt marsh problems in the northern part of the Bay. These marshes produce large numbers of the salt marsh mosquitoes, and they require a great deal of surveillance. With ample inspection and the use of aircraft the District can get fairly good control. Some marshes have been reclaimed for agriculture, but this doesn't completely eliminate the problems, because there are ditches which must be inspected and treated as necessary. Aircraft may be used, or power-operated ground equipment. There are many tide gates which the District must check regularly. These gates work fine if they are watched, but occasionally a stick will get stuck in one and permit quite a bit of flooding behind the gate. In Santa Clara County one time we had a duck club whose members had a very ingenious way to prop the gates open so one could hardly tell it. We were wondering where all the water was coming from, so finally we had to get down in the water and look inside. They had shoved a block of wood back into the gate so as to prop it open. This gave them reverse flooding for their duck areas. The Marin County MAD has sloughs which silt up from the Bay and must be dredged. Some of the marshes are being reclaimed for housing developments.

The San Mateo County MAD is doing quite a bit of work with yellow jackets, aquatic gnats and *Leptoconops* biting gnats. *Vespula vulgaris* was a severe pest in 1965—this is the one that tries to swipe your chicken when you have a barbecue. *Vulgaris* is a ground nesting species. Another related wasp, *Vespula arenaria*, builds paper nests above the ground, sometimes under eaves of houses. The District has been trying to work out baiting and control systems. So far nothing has been effective in controlling the aerial wasp. The bait has been very useful against the ground yellow jackets, however. The District does contract work in some of the park areas to control the yellow jackets. Much of the District's work on *Leptoconops* gnats has been written elsewhere. Much good work has been done, and much still remains to be done.

Santa Clara County Health Department, in addition to its regular mosquito and fly control program, has become quite concerned with some of the aquatic insect problems that are being created from the newly developed percolation ponds. Santa Clara County is trying to recharge its water table by means of these ponds. This is one of the first distributions of the California Water Plan. A big underground aqueduct brings water from the Livermore area. The first delivery occurred this past spring. These percolation ponds used to be temporary, using run-off water from the local hills, and drying up sometimes by midsummer. Now they probably will be flooded almost the year-round because this water will be available year-round. The Health Department realized the need to start an ecological study of some of these ponds just as they were being developed. There hasn't been much of this type of work done in California. It is known that ponds develop wider and different varieties of insects as they grow older. It is hoped that standard collections can be made from these ponds for about two years to determine what may be "normal," then the ponds will be manipulated by water level management, etc., to determine if production of pestiferous insects can be minimized.

Northern Salinas Valley MAD has a very good formula for going into source reduction problems. The board has agreed that if the District can do a source reduction project which within five years' time would be cheaper than continual treatment within the same five-year period, the project will be OK'd. The District has also gone in with some of the flood control people and are contracting some of the projects.

We were talking about the California Water Plan the other day, and the problems that might be an outgrowth of it. We have already run into one which isn't mosquitoes, but it shows how these biological problems can be transported. In the Livermore area an interim canal system is being used for about three or four years until the main canal is constructed. The Asiatic Clam was introduced in this area some years ago, invaded the Delta Mendota Canal, and has now invaded this Livermore Canal. The clams cause a terrific maintenance problem in the ditch because they accelerate the silting. They are going to drift, and they are going to invade the entire water system fed from this source. They also get into water works and pumping plants, and they lodge in water valves, etc.

SOUTHERN REGION

JACK H. KIMBALL

Regional Representative

In the Southern California Region we have emphasized interagency planning and cooperation, especially in the area of aquatic insects in sewage reclamation and water spreading operations. During the past three or four years new sewage reclamation plants have gone in to serve new communities. This is a change from the past when a community might be developed, then sewers would be constructed and finally the sewage treatment plant. In several of the new developments the first thing that goes in is the sewage plant, and that is finished and ready to go while the houses are being built. And now sewage reclamation aims at using this water primarily for irrigation. They may start with golf courses, then develop green belts, then use it for farming operations which are still in the area. Finally, the sewage effluent is used for underground replacement of water.

The other operation of interest that has been going on in Orange County for some ten years is the spreading of metropolitan water into the underground. We are bringing in fresh water into what would otherwise be a desert area, so we now have water in the summertime when previously the river beds were dry. We have had to develop interagency cooperation between the Orange County Water District and the Orange County MAD in working out water spreading operations that would accomplish their purpose yet minimize mosquito production. At first the water was run directly into the Santa Ana River with little advance preparation. Some areas produced a *Leptoconops* problem. In other areas, heavy production of *Anopheles* occurred. By removing the weeds and keeping the algae out, thus permitting the water to flow instead of standing stagnant, we have eliminated the mosquitoes. By calling to the attention of the Water District what appeared to us to be poor management, that agency proceeded to clear the banks and rotate their ponds and also aided the water to circulate. This alleviated the mosquito problems near the many new home sites nearby. Unfortunately, the mosquito fish which were present and taking care of the mosquitoes were not very effective on the gnat larvae, so our chironomid population is still up. The Water District wants no insecticides put on this operation, so we are in an enviable position in that we can recommend turning the water off, permitting the basins to dry up to control the gnat populations. We make a quick sample of the bottom of the ponds at weekly intervals to determine whether the water should be turned off and the ponds permitted to dry.

In the river we may get simuliid larvae at the end of the culverts where the water rushes through as it goes downstream. Fortunately up until this year no one ever complained of biting, but a new Autonetic plant in Orange County which has about 10,000 employees started calling in a couple of months ago about some little flies biting the girls when they went out for their lunch, or in the early evening before they went home.

In one deep pond, when the water was removed for cleaning we found many pockmarks made by carp. We have never seen many chironomids around this area. The pockmarks have been seen down to a depth of 25 feet on the sides. We do not know if the chironomid larvae go any deeper, but we haven't seen any.

We get mayflies and dragonflies from some of these ponds; they move into the adjacent home developments and stimulate calls to the Health Department. When the Water District dries the ponds, they remove bottom silt before reflooding. Sometimes in the early stages of reflooding we get a slight buildup of mosquitoes before the fish take over.

When the chironomid counts reach 500 per sq. foot with a week's time before emergence, we contact the Water District and then it is up to them to cut the water off and dry it up if a nuisance is to be prevented. In the development of cooperative services, when a new sewage plant is under consideration we give the agency all the data we can on what their problems will be so they can design the facility correctly from our standpoint. Then we train their operators on the prevention of mosquitoes and gnats. Next we give them surveillance and we teach them how to correct any nuisances themselves. When they have a failure they can't avoid, we supply emergency service.

In the Southeast MAD written contracts are prepared between the District and the Flood Control or other agencies.

SOUTHERN SAN JOAQUIN REGION

David E. Reed, *Manager*

Fresno Westside Mosquito Abatement District

During the past two or three years some very exciting although somewhat nerveracking things have been happening in the Southern San Joaquin Valley Region. The most spectacular thing has been the development of resistance, both to ethyl and methyl parathion, and in several districts to fenthion. Resistance to ethyl and methyl parathion was found in Tulare, Kings, Delta, and in certain areas of Consolidated and Fresno Westside MADs. Kings and Tulare counties had resistance to fenthion.

The vacation is about over in the Coalinga Huron MAD, with San Luis water delivery in a couple of years bringing in vast quantities of new water. Consolidated MAD is in a state of reorganization, having purchased a new airplane. One of the things that concerned both Fresno and Kern counties was an increase of western encephalitis in horses. There weren't very many human cases, however.

Delta MAD once again has become a one insecticide district, primarily fenthion. It uses this material on all species — *Aedes nigromaculis, Culex tarsalis, Culex quinquefasciatus,* and others. Another district that will be influenced by the first waters from the San Luis Canal is the Fresno Westside MAD. This district has also developed some parathion resistance in *Aedes nigromaculis.* We are interested in a regional study, including a number of our districts, of the resistance problem, to help solve the question of why we pick up resistance in certain areas but not in others.

Kings, Tulare, Delta and Fresno Westside MADs all are proud owners of two aircraft. In Kings and Fresno Westside MADs a spray application rate by plane of one half gallon per acre was pretty standard in 1965. Madera MAD has had an appreciable change of problem through the years—cotton used to be a severe source area, but this has shifted to field corn. The district has been using granular insecticides to get down to the water in the corn.

In summary, *Culex tarsalis* was generally more prevalent in all districts in 1965, particularly in Madera, Fresno Westside, Fresno and Consolidated MADs. *Culex quinquefasciatus* was especially severe in Consolidated, Tulare and Kings MADs. A slight increase of this species occurred in the Delta MAD but it did not become particularly troublesome. *Aedes nigromaculis* continues to be intense in all districts where pastures are found.

MOSQUITO CONTROL ACTIVITIES IN LOUISIANA

Glenn M. Stokes, *Director*

Department of Mosquito Control, Metairie, Louisiana

We have an extensive and a severe mosquito problem in Louisiana. Salt marshes constitute a major part of our problem, a source for *Aedes sollicitans. Culex salinarius* is also one of our more important species, and each year it assumes more importance in the south, not only in Louisiana but also in Texas, Mississippi and Florida.

We use a 20,000-gallon diesel storage tank and we have a 10,000-gallon insecticide mixing tank. We have trucks which carry a 280-gallon insecticide tank, and a Tifa fogger unit on the back. We also have a smaller Leco 40 fogging unit on a trailer. We also use CJ6 Jeeps in our larviciding program. These Jeeps are just like the CJ5 except they are 18 inches longer in the middle. We use a boat when surveying water hyacinth for *Mansonia perturbans.* We use a Piper Pawnee spraying malathion for *Aedes sollicitans* adults, obtaining about 97% control.

There are now four mosquito control programs in Louisiana, and all approach mosquito control with balance in mind. We do inspection surveys, adulticiding, larviciding; we emphasize source reduction, and we have a public relations program.

We are using Vapona strips as the killing agent in our light trap collecting jars.

It seems to be popular these days for mosquito control districts to be responsible for more than just mosquitoes—thus biting gnats, snipe flies, even hornets are popular in California. Spiders are popular in Louisiana. The brown recluse spider has a very bad bite that may result in surface gangrene of the body tissues. Sometimes this lasts up to six months. The death rate is very low, however.

I would welcome all of you to come visit us in Louisiana.

MOSQUITO CONTROL ACTIVITIES IN UTAH—1965

Glen C. Collett[1] and Jay E. Graham[2]

Mosquito control in Utah has steadily advanced since the organization of the first district in 1924. At the present time mosquito control extends from Logan City at the north end of the state, along the Wasatch Front to, and including, Utah County. Well over 80% of the citizens of the state live within boundaries of mosquito control districts.

Continued progress of mosquito control in Utah in 1965 was evident with the organization of a district in Carbon County, located in the eastern central part of the state; in addition, limited mosquito control work was done in the Uinta Basin through the efforts of the service organizations in that area.

Unfortunately, the mosquito control program in Utah County, organized as part of the City-County Health Department and in its third year of operation, has been plagued with problems which have included instability in budget and administration. As organized at the present time, this district is not functioning as well as other districts in the state which are organized as special districts.

A statement was made by Dr. Don M. Rees, a member of the Board of Trustees of the Salt Lake City Mosquito Abatement District, 17 years ago at the 17th annual meeting of the C.M.C.A. that much of the success of mosquito control in Utah has been made possible through the advice and encouragement of your association and attendance by representatives from Utah to these meetings has produced far more profitable returns than any similar amount of money expended in any other phase of our abatement program. This statement holds true today, possibly more so, because of the increased technical aspects of mosquito control and the need for keeping abreast of advances being made in this field.

The 18th annual meeting of the Utah Mosquito Abatement Association was held at the Brigham Young University in Provo, Utah, March 26 and 27, 1965. We wish to extend our thanks to those of you from California who attended this meeting and meetings in the past and who have contributed so much to the success of our association with your attendance and participation.

Plans are being formulated to hold the next annual meeting in the fall of 1966. This meeting will be cosponsored by the Utah Association and the Utah Mosquito Control-Fish and Wildlife Management Coordinating Committee. Program plans are being formulated to make this a meeting which will attract many of you in California.

During 1965 there was an abundance of water in the counties along the Wasatch Front which borders the eastern shores of the Great Salt Lake. Precipitation in the Salt Lake Valley was above normal each month from April through September with a total rainfall of 11.70 inches. This compares with the established normal for this period of 6.12 inches.

As a result of the above normal precipitation, larval survey and light trap records indicated an increase in *Aedes dorsalis, Culiseta inornata* and *Culex pipiens,* while *Culex tarsalis* population remained about normal. An unusual change took place in the *Culex erythrothorax* population. This mosquito, a vicious biter, is abundant and a severe nuisance on the marshes of the Great Salt Lake in the late fall of the year, but it never occurred in numbers that are very numerous outside of its marsh habitat. During the past season this mosquito was abundant early in the season and apparently moved several miles into the northwest section of Salt Lake City and constituted a minor nuisance for a considerable length of time. Climatic and water conditions were apparently favorable for the upsurge in this species.

It is evident that progress is being made with increased appreciation for water management and the resulting improvement in mosquito control operations and waterfowl habitat on the marshes in this area. Emphasis on improved water management practices on the marshes has continued in Utah and has been stimulated with the study which is being carried out by the University of Utah under the direction of Dr. Don M. Rees with several collaborating agencies on "Multi-purpose Management of Reusable Water Before It Enters the Great Salt Lake."

Other research studies being conducted in Utah the past year directed at mosquitoes and mosquito control have been insecticide susceptibility surveillance, encephalitis surveillance, residue studies, larval and adult population studies, and host preference studies. These were discussed by Dr. Rees in an earlier session of this conference.

[1]Manager, Salt Lake City Mosquito Abatement District, Salt Lake City, Utah.

[2]Manager, South Salt Lake County Mosquito Abatement District, Midvale, Utah.

WEDNESDAY, FEBRUARY 2, 11:00 A.M.

ANNUAL BUSINESS MEETING

Presiding: WILLIAM L. RUSCONI, *President*

President Rusconi: The business meeting of the California Mosquito Control Association will come to order. There are 29 corporate members present, two absent. We will now hear the report of the Secretary-Treasurer.

Secretary W. D. Murray: The annual audit was conducted by J. Michael Finch, C.P.A., of Fresno and Exeter:

January 11, 1966

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

Gentlemen:

We have examined the balance sheet of the California Mosquito Control Association, Inc., as of December 31, 1965, and the related statement of Revenue and Surplus for the year then ended. The foregoing statements were prepared from records kept on the cash basis. Except as noted in the following paragraph, our examination was performed in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other procedures as we considered necessary in the circumstances.

Our examination did not include confirmation or verification of members' dues or other revenues since the Association does not accrue uncollected amounts.

Comments

Cash in Bank:

Commercial $2,737.05—Amount was reconciled with the bank statements as of December 31, 1965, and confirmed directly with the depository.

Savings $4,292.38—Amount was verified by examination of the savings pass book as of December 31, 1965, and confirmed directly with the depository.

Insurance:

The following was in force as of December 31, 1965, according to the Secretary-Treasurer. The policy was examined by us.

Coverage	*Insurer*
Secretary-Treasurer	Fidelity Casualty

Policy Number	*Term*	*Amount*
03 - 71 - 60	2/10/63 - 2/10/66	$10,000

In our opinion, subject to the preceding qualification, the accompanying Balance Sheet and Statement of Revenue and Surplus present fairly the financial position of the California Mosquito Control Association, Inc., at December 31, 1965, and the results of the cash basis operations for the year then ended in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

We wish to thank Mr. Donald Murray, Secretary-Treasurer of the Association, for his assistance and cooperation during our examination.

Respectfully submitted,
SIGNED Finch & Janzen
FINCH & JANZEN
Certified Public Accountants

California Mosquito Control Association, Inc.

BALANCE SHEET

December 31, 1965

EXHIBIT A

ASSETS	
Petty Cash	$ 31.19
Cash in Security First National Bank, Visalia:	
Commercial Account	2,737.05
Savings Account	4,292.38
Fixed Assets (Note 1)	173.01
Total Assets	$7,233.63

LIABILITIES AND SURPLUS	
Sales Tax Payable	$ 3.72
Deferred Revenues (1966 Surplus) (Note 2)	115.00
Surplus invested in Fixed Assets	173.01
Available Surplus: (Exhibit B)	
For Administration	3,205.65
For conference activities	3,736.25
Total Liabilities and Surplus	$7,233.63

Note 1: The "fixed assets" consist of a tape recorder purchased in 1961. The cost of a filing cabinet purchased several years ago is not known to the present Secretary.

Note 2: Pertains to money collected during December 1965, which is properly classified against 1966 revenues.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

STATEMENT OF REVENUE AND SURPLUS
For the Year Ended December 31, 1965

EXHIBIT B

	Budget Estimate	Derived From: General Activities	Derived From: Conference Activities	over (under) Budget
Balance Available, January 1, 1965		$1,591.50	$2,216.25	
Add Revenues:				
Corporate Member Contracts	$ 4,000.00	$4,278.00		$ 278.00
Associate Member Dues	48.00	250.00		202.00
Sale of Publications	250.00	217.85		(32.15)
Miscellaneous (Note 1)	100.00	298.27	$ 160.81	359.08
32nd Conference Registrations	800.00		1,020.00	220.00
32nd Conference, Exhibits	950.00		1,240.00	290.00
32nd Conference, General	1,300.00		1,829.67	529.67
32nd Conference, Proceedings	250.00	5.00		(245.00)
Total Revenues	$7,698.00	$5,049.12	$4,250.48	$1,601.60
Deduct Expenditures: (Exhibit C)	$10,483.00	$3,434.97	$2,730.48	$4,317.55
Balance Available, December 31, 1965		$3,205.65	$3,736.25	

Note 1: $292.38 of the miscellaneous revenues was interest on the $4,000.00 in savings. Since about 55% of the savings represents conference funds, that per cent of the interest is allocated to conference revenue.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

STATEMENT OF EXPENDITURES WITH BUDGET COMPARISON
For the Year Ended December 31, 1965

EXHIBIT C

	Budget As Amended	Actual Expenditures	(over) under Expended
Administration:			
Advertising	$ 108.00	$ 108.00	
Communications	500.00	435.40	$ 64.60
Office of Secretary	1,200.00	1,200.00	
Office Supplies	175.00	188.26	(13.26)
Committee Expenses	2,000.00	964.58	1,035.42
Auditor	100.00	100.00	
Travel Expenses	500.00	399.60	100.40
Contingencies	100.00	39.13	60.87
Total Administration—Exhibit B	$4,683.00	$3,434.97	$1,248.03
Conference:			
General Expenses	$2,500.00	$2,569.48	$ (69.48)
Proceedings	3,000.00	—0—	3,000.00
Steno Service	300.00	161.00	139.00
Total Conference—Exhibit B	$5,800.00	$2,730.48	$3,069.52

Several comments by the auditor are in a separate letter.

"(1) Expenditures over budgeted amounts—The Board should be aware of and authorize expenditures that exceed the amount budgeted. This should be done in advance of the payment whenever practical.

"(2) Signatures on checks—At the present time the Association requires two signatures on all checks. We agree that this practice is sound policy when strictly enforced. It protects the individuals and the Association from any one person misappropriating funds. We believe that a single signature would be more practical under the existing circumstances. The Association members authorized for signature do not live close enough to each other or associate with each other often enough to make the double signature readily available."

REPORT OF THE BUDGET COMMITTEE

William L. Rusconi, *Chairman*

On December 3, 1965, we held a Budget Committee meeting when for the first time two trustees were represented. We developed a budget which was adopted by the Board of Directors on December 4, under which we will operate this coming year. It was mailed to all members with the minutes of the December 4 Board meeting.

REPORT OF THE EDUCATION AND PUBLICITY COMMITTEE

Norman Hauret, *Chairman*

During the year, the pamphlet "Mosquitoes About the Home" has been revised, and a printing of 2,000 has been ordered. Additional work will be done on the next printing so it will be even more up to date.

An entomology course is being held at various locations throughout the state. A resource unit on mosquitoes and how to control them was prepared in the rough. This will be given a field try by the University of California at Berkeley, and if it seems to work out we will go to print on that.

REPORT OF THE ENTOMOLOGY COMMITTEE

James Mallars, *Chairman*

The annual entomology seminar was held at the University of California, Berkeley, with John R. Walker presiding. Approximately 80 persons attended. A refresher course on public health arthropods was sponsored jointly by this committee and the Bureau of Vector Control. A key has been compiled for the field guide to predacious fish of mosquita larvae in California. The format of the guide is being developed. The Mosquito Larval Habitat Project has been assigned to a new subcommittee, and arrangements have been made for the next annual entomology seminar to be held at San Jose in April.

REPORT OF THE FISH AND WILDLIFE COMMITTEE

Oscar V. Lopp, *Chairman*

The Fish and Wildlife Committee sponsored a project designed to determine the state-wide distribution of *Gambusia* and other small fishes believed to be predacious on mosquitoes. Samples sent in by the districts and other agencies included 13 different species, with *Gambusia* predominating.

It is expected that the incoming committee will continue this survey during the spring or summer of 1966 to determine if warmer weather conditions might contribute to the collecting of additional species of minnows believed to be useful in controlling mosquitoes. Collections made at varying elevations in the foothills and mountains, not sampled in the present survey, might reveal interesting information regarding the possible presence and effectiveness of minnows in any future mosquito control program conducted at higher elevations.

REPORT OF THE TRUSTEE ADVISORY COMMITTEE

Fred DeBenedetti

By a unanimous vote, the Trustee Session approved the following resolution:

RESOLUTION:
Be It Resolved That the CMCA supports actively, and without qualification, the budget requests of the State Department of Public Health and the University of California for mosquito control and disease transmission research, as submitted to the Director of Finance. The CMCA further supports the concept that the University of California should have primary responsibility for, and should carry on the necessary basic research in these fields, and that the State Department of Public Health should have authority and necessary funding to carry out surveillance, extension to the governmental agencies and field supportive investigations consistent with the duties of that Department.

(A motion for adoption of this resolution was made by Fred DeBenedetti, seconded by C. W. Muller and carried unanimously.)

A. H. Sagehorn: Relative to the proposed amendments of the Bylaws, it was the unanimous action of the trustees that Item III ,as amended, be adopted. I so move.

(The motion was seconded by J. W. Bristow and unanimously carried. Item III contains a provision for a Trustee Advisory Committee to be incorporated within the Bylaws of the Association.)

Marion C. Bew: I move the adoption of the following: "That a committee composed of members of the Trustee Advisory Group be appointed for the next year to study the problems and the subject of the financial responsibility of C.M.C.A. in the field of its publication and paid staff, and report its findings to the next trustee conference."

(The motion was seconded by J. W. Bristow and carried.)

REPORT OF THE NOMINATING COMMITTEE

J. D. Willis, *Chairman*

The full report of this committee was given at the December 4 Board meeting. The nominees presented were:

President:	Oscar V. Lopp
President-elect:	Stephen M. Silveira
Vice President:	James W. Bristow

(There were no nominations from the floor. L. E. Brumbaugh moved that the Secretary be instructed to cast a unanimous ballot for the nominees. The motion was seconded by Dean H. Ecke, and carried.)

Regional representatives were selected as follows:

Coastal:	Dean H. Ecke
	R. E. Bowen, *Alternate*
Sacramento Valley:	Eugene Kauffman
No. San Joaquin Valley:	Gordon F. Smith
So. San Joaquin Valley:	Roy H. Howard
Southern California	W. S. Brown
	Jack H. Kimball, *Alternate*

REPORT OF THE RESOLUTIONS COMMITTEE

JOHN H. BRAWLEY, *Chairman*
with FRED DEBENEDETTI, *Member*

I move the adoption of the following resolutions:

1. *Be It Resolved* by the California Mosquito Control Association, Incorporated, assembled at its 34th Annual Conference held at Monterey, California, February 2, 1966, that we the members do hereby express our thanks to the Visitors and Convention Bureau, Monterey Chamber of Commerce, for their services.

2. *Resolved* that we the members express our thanks to the No. Salinas Valley MAD for their services as host to this Association.

3. *Resolved* that we the members hereby express our thanks to Howard Greenfield, Chairman of the Local Arrangements Committee, and to the other members of this Committee, for their contribution to the success of this Conference..

4. *Resolved* that we the members hereby express our appreciation to the management and staff of the Casa Munras Garden Hotel for the very fine services and assistance they have rendered.

5. *Resolved* that the California Mosquito Control Association hereby expresses its thanks to the Sustaining Members and Commercial Exhibitors, with special acknowledgment of sponsorship of the coffee break by American Cyanamid Co., of the ladies tour of historical sights of Monterey by International Harvester, of the 17-Mile Drive bus tour and luncheon for the ladies by Ford Motor Co., of the Fiesta Hour by Kaiser Jeep Sales Corp., of the Spanish favors and entertainment by Moyer Chemical Company, and of the prizes contributed by the Monterey Artichoke Growers Association.

6. *Resolved* that we the members hereby express our sincere appreciation to the officers and committeemen of this Association for their fine work during the year.

7. *Resolved* that the California Mosquito Control Association wishes to express its appreciation to Carl W. Muller, Chairman of the Trustee Advisory Committee, for his untiring and highly successful efforts to stimulate and encourage trustee attendance and participation at the Annual Conference, and for his very fine work in helping trustees develop a better appreciation and understanding of the problems confronting this Association, and the need for the continued interest and support by the trustees.

8. *Resolved* that we the members request that the President and Secretary take the necessary steps to communicate the actions taken by this assembly to the appropriate parties.

(The motion to pass these resolutions was seconded by C. D. Grant and unanimously carried.)

C. W. Muller: I want to pay particular recognition to the Program Committee, to William Rusconi, Howard Greenfield and Steve Silveira. I also want to recognize the State Chamber of Commerce, which provided the trustees with an insert in the trustees' folder; the staff of Turlock MAD, which added to the insert; the folder itself and the material in the folder done by the No. Salinas Valley MAD staff; and the great effort which was made by everybody associated with the arrangements for this convention.

Robert H. Peters: It is customary at this Annual Meeting to make a motion approving all the actions of the Board of Directors and of the Association throughout the year. I so move in order to assure continuation of this policy.

(This motion was seconded by Jack H. Kimball and unanimously carried.)

REPORT OF THE SOURCE REDUCTION COMMITTEE

FRED COMPIANO, *Chairman*

This committee is reviewing ways and means of improving methods on source reduction information. A bibliography on the following subjects is in progress: irrigated pastures, dairy waste and return flow systems, irrigation, industrial wastes and sewage, land leveling and land preparation, and flood control. A seminar is being planned for 1966 with the University of California at Davis. It is recommended that the Board of Directors consider the appointment of additional members to this committee.

REPORT OF THE WAYS AND MEANS COMMITTEE

L. R. BRUMBAUGH, *Chairman*

During 1965 this committee considered the following items:

1. Section 2302, California Health and Safety Code. This section directs the Board of Supervisors of any County to determine the rate of tax for mosquito abatement districts by deducting 15% from anticipated delinquency of assessed valuation of taxable property. The committee considered lowering this 15% to 10%, but decided to make further investigation before making a recommendation.

2. State assistance to mosquito abatement districts. Consideration should be given to the development of a program of State financial assistance to mosquito abatement districts, due to the change in tax structure in California.

3. Mosquito control operational manual. It is recommended that the State Health Department prepare an operational manual on insecticide and weedicide materials used in mosquito control, and that such publication be distributed annually to mosquito control agencies.

4. Mosquito control employee certification. Further study should be made of this problem.

5. Request for State Health Department to employ two civil engineers. It is the recommendation of this committee that the State Health Department employ at least two engineers to work in the source reduction field of mosquito control, and that such positions be provided for in the forthcoming State budget. (This recommendation was unanimously endorsed by the Board of Directors at San Rafael, August 27, 1965.)

C.M.C.A. RESEARCH COMMITTEE

GORDON F. SMITH, *Chairman*

The C.M.C.A. Research Committee met formally twice during 1965.

The first meeting was at the University of California at Berkeley, July 14, 1965, to discuss the University plans for research proposals to be submitted to the 1966 Legislature and means for supporting them.

The second meeting was held at San Rafael August 26, for the purpose of defining C.M.C.A. policy on research and presenting a written policy statement to the Board of Directors for adoption. This policy was adopted and sent to all districts with the minutes of the Board of Directors meeting of August 27.

The Chairman attended meetings of the joint State Health Department-University of California Committee on Research.

The chairman also maintained liaison with the University of California and the State Health Department while Legislature was in session and made a number of trips to Sacramento in support of the funds requested to implement their research proposals.

The 1965 legislative session was a confused and hectic one, insofar as mosquito research funds were concerned, and in the final analysis highly unsatisfactory.

The funds to support the research proposals of the University of California were lost from the Governor's budget at the last minute, and an effort to have them returned in committee failed.

The funds in support of the State Health Department research were finally allowed but with a proviso by the Senate Finance Committee that they be contracted to the University of California only and that the State Health Department discontinue departmental staffed research. This was also a last minute action.

The existing State Health Department research program was maintained virtually intact through the cooperation of the State Health Department and the University of California. The University was able to hire nearly all of the personnel involved and the program was placed under the direction of Dr. William Reeves in the School of Public Health.

During the summer and early fall, planning was toward the resubmission of the University Programs and that of the State Health Department. It was hoped that the State Health Department would resubmit their requests without restriction on staffed research; however, this was not found to be advisable by the Director's office.

Dr. Reeves resubmitted his proposal without change.

The Division of Agricultural Sciences decided to resubmit their proposal requesting $200,000.00, the first two portions of last year's proposal.

Dr. Peterson was assured that the Association would support this proposal and secure an augmentation bill should the request not be included in the Governor's budget.

During the 1965 Annual C.M.C.A. Conference, it was decided to seek a meeting between the California Mosquito Control Association, State Health Department, University of California, the offices of the Legislative Analyst, and the Director of Finance. This was not found possible during the Legislative Session.

At the Board of Directors meeting on August 27, it was decided to seek such a meeting the last of September or the first of October. It was agreed that the State Health Department and University of California would be able to participate.

This meeting was arranged for September 30, 1965. At the last minute, it was the decision of the State Health Department that, due to reasons of protocol and policy, they would not be represented.

Present at this meeting were: Carl W. Muller, Chairman, C.M.C.A. Trustee Advisory Committee; S. M. Silveira, Vice President, C.M.C.A.; W. Donald Murray, Ph.D., Secretary-Treasurer, C.M.C.A.; Gordon Smith, Chairman, C.M.C.A. Research Committee; Maurice L. Peterson, Ph.D., Dean, Division of Agricultural Sciences, University of California; John E. Swift, Ph.D., Extension Specialist in Entomology, University of California; Jack Sheehan, Assistant to Director of Finance; Roy Bell, Assistant to Director of Finance; Larry Hogan, Assistant Legislative Analyst; Don Christen, Assistant Administrative Analyst.

The C.M.C.A. representatives presented a review of research to date, the critical need for research, and the Association policy.

Dr. Peterson discussed the universities' place in mosquito research, their cooperative position with the State Health Department and their proposed program.

Since the State Health Department was not present, their position received little direct attention other than th statement of C.M.C.A. policy.

The meeting lasted approximately an hour and a half and it was felt by those attending that it was beneficial. Discussion was freely entered into on both sides and the need for expanded research seemed to be well accepted by the representatives of the Legislative Analyst and the Director of Finance.

The situation at present is:

1. The State Health Department budget includes funds for continuation of the existing program with all funds to be contracted (approximately $150,000.00).

2. University of California, Division of Agricultural Sciences, request for $200,000.00 with an additional $100,000.00 next year is in the University of California budget.

3. University of California, School of Public Health, request for $60,428.00 is in the University of California budget.

4. Contacts have been made in support of all these funds as a package needed for adequate mosquito control research.

5. Should the University requests be excluded from the Governor's budget, provisions have been made to have a bill entered supplementing the University budget in the necessary amount.

6. Association policy calls for support of all funds requested and the removal of the restriction on staffed research placed upon the State Health Department at the last legislative session.

PANEL: EXPANDING AIRCRAFT USAGE FOR MOSQUITO CONTROL

THOMAS D. MULHERN, *Moderator*

Mr. Mulhern: While attempting to choose words to satisfactorily introduce this subject and the thoughtful, scientific members of the panel which have been assembled to present it, and who will attempt to direct your thoughts to the attractive and still largely unrealized potential service which may be had by the further utilization of both fixed-wing and rotary aircraft, I came across certain prophetic words of wisdom which were offered 30 years ago to an audience similar to this one by Frank W. Miller, then an analytical technical consultant to mosquito control agencies in New Jersey.

He said then, and it is equally true today, "the possibilities of the airplane as a useful instrument for mosquito control work are very attractive and worthy of serious consideration. . . . One of the most important phases of an anti-mosquito campaign is that of survey and inspection. In this direction the aeroplane offers speedy, practical and economical service."

He supported this view by data from some trial inspection flights which he had made in one of the crude aircraft of that period, and exhibited samples of aerial photographs which he had made to record the results. He calculated that an inspector in an aircraft could in a given period of time observe the standing water conditions on an area 355 times as great as he could cover in the same time on the ground!

All of us have used aerial inspection to a limited extent, with aerial photography even less, so I am confident that some of our panel members will inform us of the great advances which have been made in the equipment and techniques of aerial survey and inspection, and will direct our attention to ways in which the potential for employing the "birds eye view" may help us to sharpen our intelligence programs.

Mr. Miller also briefly referred to trials conducted during the same year of the aircraft as a dispenser of larvicidal dust, granular materials, and liquid sprays. The latter was the most effective, and had reduced the cost as compared to hand spraying by about 50%. How crude those early pioneering attempts were may be judged by the fact that the calculated cost of the airspray operations was about $6.50 per acre! Nevertheless, Mr. Miller's concluding statement was "I firmly believe that the aeroplane can tremendously increase the efficiency of our mosquito control work."

Mosquito abatement agencies in California attained an efficiency in the application of liquid larvicides by aircraft far beyond any which Mr. Miller could have envisioned, with a per-acre cost less than one tenth of that of those first early tests – but our panel of speakers will present equally exciting prospects for potential future advances. They will, hopefully, give us an insight into the ways by which we may fit into our programs the marvelous newer and better aircraft, electronic communications, aerial reconnaissance, low-volume dispersal of liquid and dry insecticide formulations, and perhaps most important of all, the cooperation of all who can contribute to such advances.

The first speaker will be Mr. Oscar V. Lopp, Manager of the Merced County Mosquito Abatement District, which agency after preliminary trials, and a thorough review of the factors relating to efficient utilization of rotary-winged aircraft, has the distinction of procuring the first helicopter to be owned by a mosquito control agency in California

EXPEDITED SURVEILLANCE BY HELICOPTER

OSCAR V. LOPP

Merced County Mosquito Abatement District

The Merced County Mosquito Abatement District has just purchased a Bell Model G5 helicopter. There were three major reasons for deciding to do so at this time. First, there is the population expansion, which means housing expansion. People no longer build just from the fringe of the city outward–they go out into the suburbs and the rural areas where the mosquities are produced. There are areas left between buildings which must be sprayed to achieve mosquito control.

Second, the district has used aircraft as the principal spray machine in the control program for many years. Relatively little field work is done by ground operators. The ground men function as inspectors, developing records which are used by the pilots to guide the airspray program. In this new situation, the breeding areas between houses and buildings must be inspected and treated, which cannot safely be done with fixed-wing aircraft.

Third, the Federal Aviation Authority regulations are becoming more strict, prohibiting the use of fixed-wing aircraft close to residential areas.

After reviewing these problems, comparative costs were estimated. To increase the use of automotive equipment, buying more vehicles and necessary equipment and hiring more operators would increase costs very greatly. A first reaction was that the cost of a helicopter for this type of work would be prohibitive. However, when the other possible uses in addition to spray treatment were considered, the added values appeared to justify the extra cost. If a helicopter is used for spray work alone the costs may be fairly high. Even then, they may not be prohibitive, because there is safety factor with the helicopter that justifies extra cost. But there is a great advantage for surveillance; for field inspection, which can be performed in an economical way.

The helicopter, complete with spray equipment, was priced at approximately $40,000.00. The total estimated operating cost is $45.00 per hour. By operating on an efficient plan, the cost of applying spray may be only 18 to 20¢ per acre. The cost with fixed-wing aircraft was 26¢ per acre in 1965.

The helicopter flies at 6-10 ft. elevation, and at 60 miles per hour, which is the most effective speed. The effective swath is 120 ft. when using a 50-foot boom. This means a potential of 240 acres per flight hour. When the $45.00 per hour calculated cost is divided by 240, the product is 18¾¢ per acre. Thus, if you consider the initial cost and don't develop the cost per acre, you will not have the total picture.

The estimated operating cost of the helicopter is developed as follows:

	Per hour
Gas and oil	$ 7.00
Maintenance, parts and labor	8.00
Reserve for engine overhaul	3.50
Contingency reserve	1.50
Direct operating costs ... Sub total	20.00
Pilot's salary	10.00
Insurance	5.00
Depreciation	10.00
Total	$45.00

Many districts now have fixed-wing aircraft and pilots to fly them. The Merced District plans to send three pilots to the Bell Helicopter flight school at Fort Worth, Texas. Fixed-wing aircraft pilots can acquire helicopter capability in approximately 30 hours of training at $30.00 a flight hour. Private helicopter schools elsewhere may run up to $100.00 per flight hour of training. The A. & E. mechanic will go to the same school and receive a two-week training course for $300.00. Thus, the District has three pilots and a mechanic who can fly and maintain the helicopter and the fixed-wing planes.

Helicopters are being used more in mosquito control because improvements have been made which allow them to compte with other aircraft. The helicopter has some definite advantages over ground operations and over fixed-wing aircraft, particularly in surveillance operations.

Accuracy of flight characterizes its operation. There is infinitely variable, controllable operating speed, from the maximum of 105 miles per hour to zero, and the helicopter can stop and hover over any selected point. The craft can be landed wherever there is a level space of an acre or so. It lands vertically and takes iff vertically, so it can be operated from a very small base. No runway is required. A forward speed of up to 100 miles per hour is practicable when flying cross-country, or the pilot may fly slowly to look over an area being surveved. One can alter course at any time, stop, and look down at an area, or even stop and inspect on the ground. There is outstanding visibility, as compared to inspection from the ground, where one can see only what is in the immediate vicinity.

Trucks get stuck in the mud — helicopters don't. Trucks leave ruts which may produce more mosquitoes than the original source. With the helicopter there are no gates to open, no keys to lose. Travel to places that would be inaccessible on the ground is simplified. Surveillance work can be done with the helicopter when the wind is too high to spray. There is no lost time for the helicoptor.

With no lost time, the fixed costs are lower. Surveillance can be more thorough, hence a better control is practicable. Much ground work, which is time-consuming and costly, is eliminated. There is then time to make both pre-treatment and post-treatment inspections. Frequently the same pilot can do surveillance and a limited amount of larviciding or adulticiding where immediate treatment is needed.

There is another advantage: this intensive surveillance permits the director of the program to know what he should treat, and it also helps him to know what he should not treat. People who have used the helicopter for surveillance report that the acreage to be treated decreases enormously, for with less effective surveillance, much acreage may have been sprayed which did not need treatment.

Summary

To be economically feasible, the helicopter must be used in an area big enough to utilize its great covering power, in order to keep the unit costs down. It is used to best advantage where intensive, precision control is required, in other words, where people live. It meets the stricter FAA safety regulations for aircraft in residential areas.

On a trial inspection, Mr. Mulhern took along a tape recorder, and I took a dipper. In a flight of about 40 minutes, we surveyed 20 square miles for standing water. The helicopter would come down, I would get out and dip, and a running story was recorded on tape. At the end of 40 minutes, we had a good, complete report of the water situation over 20 square miles.

COMMENTS ON LOW-VOLUME SPRAYING

Norman B. Akesson and William Burgoyne

University of California, Davis

(Extemporaneous presentation by Mr. Burgoyne)

Low-volume sprays are receiving considerable attention. Small droplets are extremely important to the low-volume concept. At an application rate as low as perhaps 8-10 fluid oz. per acre, very small droplets must be used to obtain uniform coverage.

In California, we are very much concerned about drift of insecticides onto nontarget crops. The Agricultural Engineering Department of the University of California, Davis, has been working on this problem for five years. Our tests are flown across the upwind end of a single strip of alfalfa. There are recovery stations at 165 ft., 330 ft., 660 ft., and on to one mile to recover any actual drift of the chemicals. Recovery of the chemicals from the plants is possible but difficult. It has been more satisfactory to recover the chemicals from Mylar squares, which are placed in the alfalfa at the desired distances from the flight before applying the insecticide.

A conventional commercial application of liquid spray using D46 nozzles on a Stearman aircraft and an application rate of 7 or 8 gallons per acre was compared with a dust application. Residue samples were taken 500 feet downwind from the point of application. The liquid spray yielded a residue of only 0.1 ppm, while the dust residue recovered amounted to 10.0 ppm, 100 times the recovered residue of liquid spray.

A comparison was made of a conventional 7-gallon-per-acre application with the low-volume application of 8-10 liquid ounces per acre. At 1000 feet downwind there was an increase in recoverable drift of the low-volume application over the conventional spray of five to ten times. In the low-volume technique, small droplets are used for better coverage, but this means more drift. Therefore, care must be taken to avoid drift where the LV system is used.

I should like to comment about the "Minispin" nozzle. Each unit costs around $50.00. We have compared the droplet spectrum produced with that of the 80005 flat fan nozzle. At low-volume rates, there is little difference in the range of droplet sizes produced. In other words, the statement that the Minispin will give mostly drops of only a particular size is not supported by our studies. The tests were made with the Minispin operating at 8,000 rpm in a wind tunnel. The Minispin is not effective in its present form on helicopters; at 60 or so miles per hour there is insufficient forward speed to produce the fine droplets that are required for low-volume spray. There is under development a Minispin with an individual electric motor drive. This would increase the cost.

ROBERT A. PHILLIPS, *President*

California Agricultural Aircraft Association

I have been in agricultural aviation 22 years. There was a period in the early days when we spent more time looking back than ahead when we treated. With dust we had a difficult time getting the material to feed evenly, so we'd look back to observe the feeding, then look ahead to see if there were any power lines in front of us, then look back again really quick. There might have been from 20 to 150 lbs. per acre applied! We have come a long way since then in our business, as have you.

In the final analysis, application is the nucleus of the airspray business as well as of yours. Research and technical development in aircraft and dispersal equipment will upgrade our respective businesses. There are many correlated problems on which we need cooperation for mutual benefit.

During the past three or four years many segments of government have had something to say on public health and the public image with relation to insecticides. Governmental agencies have enacted new and sometimes difficult-to-comply-with legislation against pesticides and their users; with certainly more to come!

As an industry, we must have the cooperation of all concerned in pursuing the safety of the general public through the proper use of pesticides. In the near future we anticipate an acute shortage of pilots and mechanics.

As a small business, we had legislative problems last year. We were concerned because of the rise in the cost of doing business. The cost of aviation gas, for example, may reach prohibitive proportions. There are several factions thinking about adding to the aviation gas tax, and of prohibiting any aviation gas tax refund. We are deeply concerned about this because there are 3½ million gallons of aviation gas used by agricultural aviation. The main contention on the aviation gas refund matter is the improvement of county airports, but agricultural airspray operators rarely use county airports anywhere in California. We use fields, farmers' strips and our own private runways.

We also have in common with mosquito control agencies much legislation regarding pesticides. We are greatly concerned with low-volume control, as I know you are too. Currently, there are only two insecticides on the market that we can use. Our main concern is that when some aerial applicators in other areas heard about low-volume spray, immediately they began using parathion at 4 or 5 oz. per acre. They report that they are killing the insects, but we would like the State and Federal governmental agencies to evaluate the effectiveness and safety of this usage.

We, too, are spraying near houses, cattle and people, and we are going to be working more closely with them during the population explosion.

FAA Regulation Part 137 affects us. We tried to get enough cooperation among the applicators to get this item rejected, but were unsuccessful. It is now law and we must live with it. We hope it won't be too detrimental; however, there is a strong feeling that it is a federal agency infringing on State's rights. Part 137 is no more comprehensive nor strict than the California State Regulations, and we help write most of these by providing consultation; nevertheless, it is quite difficult to live with some of these regulations.

PRESIDENTIAL MESSAGE

Oscar V. Lopp, *President*

California Mosquito Control Association

The general needs and characteristics of the Association have been discussed at great length in the past and most of them are still with us today. Sometimes it seems that as time passes, many of them are even compounded. To be sure, it is proper and necessary that we continue to study and attempt to find solutions to all of those problems which we have faced during the past years: research, bylaws, trustee participation, membership classes, voting privileges, and the many others. Today, however, I would like to concentrate our thinking mainly on two vital subjects: the critical need for adequate mosquito control research both basic and applied, and changing dynamics of attitudes.

The question may be asked: "Why do we so desperately need more research efforts invested at this time?" The answer lies in the fact that our mosquito control problems, many of them produced by changing situations over which we have no control, are increasing on all fronts at a pace we are unable to match. One such situation concerns water, which is being distributed in increasingly enormous amounts through the development of water projects over much of the State. At the same time, drainage of waters of all kinds is lagging and plans for taking care of additional drainage are recognized as insufficient, if they exist at all. We in mosquito control are extremely interested in both the acquisition and the disposition of this increasing amount of water, for the simple reason that all mosquitoes have one common characteristic: they all need water in which to hatch and pass the larval and pupal stages of their life cycles.

The enormous expansion of the State's population, expected to increase from 19 million to 25 million in another decade, is an additional important factor which correspondingly accelerates and multiplies our requirements for providing an adequate level of mosquito abatement. Greater numbers of people generally mean changes, including restrictions in control techniques; increased possibility of introduction and transmission of mosquito-borne diseases; multiplication of the day-to-day problems involving people, mosquito production and mosquito control, and many other influencing factors.

Adding to the difficulties of achieving control is the fact that in recent years a considerable number of our important species of mosquitoes have developed increasing resistance to the insecticides available for our use, limiting what little choice we formerly had, and frequently entailing adverse price differentials. Restrictions of many kinds have been placed upon our operations by federal, state and local organizations too numerous to mention here. These limitations emphasize a wide range of important subjects and activities including drift of insecticides, residues on crops, persistence of chemicals in the environment, and side effects on wildlife and other non-target organisms. In addition to the research required on the above items to obtain answers and solutions which will assist us in achieving acceptable mosquito control objectives, we need additional research in the wide fields of biological control, chemosterilants, attractants, etc., as well as on improved source reduction procedures to enable us to practice more effective measures and place less dependence on chemicals. Today the need for effective mosquito control is probably greater than ever before, largely as a result of the increased threat of introduction of serious mosquito-borne diseases carried by military personnel returning from many foreign countries. For the past two decades malaria has practically disappeared from the United States, and arthropod-borne encephalitis has risen in importance during this time, as evidenced by the severe human epidemics in Texas, Florida, New Jersey and in 1952 in California. Although encephalitis is still a disease of major significance in most parts of the country, malaria has suddenly become of grave concern to this nation because of three significant contributing factors:

1. The development of malarial organisms resistant to previously effective drugs.
2. Returning Vietnam military personnel harboring a resistant strain of malarial organism (*Plasmodium falciparum*).
3. Presence of anopheline mosquitoes here capable of transmitting malaria to previously uninfected persons.

In this regard, it should be pointed out that the last major outbreak of malaria in the United States occurred here in California in 1952 (total of 32 cases) as a result of local infection acquired from mosquitoes which had fed upon a Korean returnee suffering from a relapse of malaria.

The seriousness of this important falciparum malaria is indicated in a U. S. Public Health Service Malaria Surveillance Special Report 66-1 dated January 17, 1966, which states that in the United States "... Through January 15, 1966, a total of 106 case reports of malaria occurring in 1965 had been received by Malaria Surveillance. All cases were imported with the exception of 2 civilian cases, ... Fifty-one cases occurred in military personnel and 36 of these cases originated in South Vietnam ..." The same report also states "Four cases of falciparum malaria occurring in personnel recently discharged from the military service were reported to Malaria Surveillance by State Health Departments. These are the first of such cases to be reported to the Communicable Disease Center. All were discharged and developed malaria during the month of December 1965. None had malaria in Vietnam. ... Two of the four cases terminated fatally." In discussing an outline for current treatment of falciparum malaria, the report further states "... This outline is presented here because of the increasing possibility that resistant malaria will be encountered in domestic medical practice as a result of the increasing numbers of servicement returning from South Vietnam ..."

It would be difficult to overestimate the medical significance of the information contained in the report here quoted, particularly since we have present today in this country approximately as many as we have ever had of the anopheline mosquitoes capable of carrying malaria. This is one of the chief reasons why we who are engaged in mosquito abatement work in California looked with dismay upon the action of the last legislature when it deprived the State Health Department of its prerogative to engage in mosquito control research, by authorizing State Health Department funds of approximately $126,000.00, and then stipulating that if any mosquito control research is necessary, it would be contracted with the University of California.

Throughout the years since their organization the California mosquito abatement agencies in general have leaned heavily on the research assistance given to them by the State Health Department, and have every hope that the legislature at the next session will reconsider their recent action and will return to the State Health Department its full prerogative to use its funds to carry out its own mosquito control research. I should also add that the great majority of mosquito abatement agencies regret that the legislature over the past several years has completely eliminated the State Subvention funds which the districts once received. Beginning in 1946, $400,000 allocated to the State Health Department was earmarked for subvention to local mosquito abatement agencies, and this amount continued until 1961, when it was reduced to $191,000. By the close of FY 1963-64 State funds for assisting local mosquito abatement agencies had been completely eliminated. Most of the districts are now furnishing valuable surveillance data to the State at actual expense to the local districts.

Recognizing the immediate need for greatly expanded mosquito control research, the University of California Division of Agricultural Sciences, the University of California School of Public Health and the California State Department of Public Health have worked closely with the California Mosquito Control Association, and have developed a reasonably adequate and well coordinated research program. Consequently, the following funds are being requested in the 1966-67 budget of each agency:

University of California Division of Agricultural Sciences	$200,000
University of California School of Public Health	60,428
California State Department of Public Health	150,000
	$410,428

In consideration of the critical and urgent necessity for continually improving the effectiveness of mosquito control techniques to provide adequate protection for the people of this State against mosquito-borne diseases, the California Mosquito Control Association has gone on record by a resolution endorsing in its entirety the above proposed mosquito control research program of the State Health Department and the University of California. Representatives of our Association, particularly the Research Committee, have consulted frequently with appropriate representatives of the above agencies, and we are of the opinion that the research programs proposed by them represent the minimum effort which will be required to produce the essential results needed immediately. Furthermore, we feel that all three of the above designated organizations, working in a coordinated program of both basic and applied research, can best serve the needs of the organized mosquito abatement agencies in California.

In the year ahead, as in years past, there will continue to be problems of varying degrees of importance confronting the Association. In facing up to them it is my opinion that we should show that we have learned a good lesson from the past: we should discontinue reliance upon a defensive philosphy of action wherein the interests of the Association are concerned. Too frequently in the past we have remained inactive until someone or some organization evidenced an intention which we felt would affect us adversely, and then we would object — we would go on the defensive. I think we have learned that an organization's progress is seldom accomplished by a defensive program; instead, we should adopt a positive attitude of thinking, we should formulate and support a dynamic program that will clearly define our needs so that others concerned may better understand how they can best assist us.

In closing, I want to express to you my appreciation of your confidence in conferring on me the responsibility of serving as your President in the coming year. I look forward with pleasure to this opportunity of working with you toward the full realization of the objectives of our Association. I now declare the Thirty-fourth Annual Conference of the California Mosquito Control Association adjourned.