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at the

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Edited by
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CALIFORNIA MOSQUITO CONTROL ASSOCIATION

OPENING SESSION

MONDAY, JANUARY 29, 1968, 9:00 A.M

HOW MOSQUITO CONTROL BENEFITS EVERYONE

Joseph A. Reich, chairman

Fresno County Board of Supervisors

The Fresno County Supervisors recently collaborated with the fifteen cities in this county to form a "League of Fresno County Government." Our League discusses the many mutual problems facing this county, demonstrating cooperation and teamwork, which subject is the theme of my remarks.

I found in my experiences in the Health Department that we were able to achieve many goals through working closely with local mosquito abatement district managers and representatives of the Bureau of Vector Control of the State Department of Public Health. In 1949 and subsequently, we met a number of times to develop plans to eliminate or minimize the many mosquito breeding sources in the metropolitan areas, especially the hundreds of exposed cesspools and private sewage systems. Through a methodical program, and with full support of the County Health Officer, the mosquito abatement district Board of Trustees, the District Attorney's office, and others, we systematically eliminated many mosquito sources.

The program extended to industrial waste disposal. We first proposed the development of an ordinance to control the obnoxious conditions which were prevalent in many of our industrial waste operations. We now have an excellent industrial waste program in Fresno County.

I have given so much emphasis to this theme of teamwork because in my experience in the Health Department I found many jurisdictions in which such relationship was totally lacking. Today I do not believe there is any justification for a lack of cooperation. One organization cannot isolate itself from another!

Our cooperative efforts were extended to the development of codes—we helped in the development of a uniform plumbing code in Fresno County. We noted the severity of the mosquito problem on the west side of Fresno County and assisted in the formation of the Fresno Westside Mosquito Abatement District and the Coalinga-Huron Mosquito Abatement District.

Now it is appropriate to talk about a future projection. We cannot stand still; there is constant change in government. Mosquito abatement districts must accept the challenge of expanding their operations. We have major rodent infestations in this state; we also have major fly problems. Control programs against them must be implemented, as well as programs against other vectors. This projection is inevitable. We are rapidly approaching a population of 20 million people in California. This constant increase creates additional problems. For example, the San Luis Project on the west side of the San Joaquin Valley will contribute to an increase in vector control problems. I was aware of this problem of rodents and flies ten years ago when I was Director of Sanitation but, like the vast majority of my friends, I was reluctant to accept any responsibility. Now I know that these problems must be given attention. I believe control efforts belong to mosquito abatement districts rather than relegating them to some other agency or creating new agencies. It will be incumbent upon these districts to consider the supplementation of their programs to include such additional vector control problems.

GROWTH AND DEVELOPMENT PROBLEMS FACING CALIFORNIA

Ernest N. Mobley

Assemblyman, 33rd District
California State Legislature

People everywhere are interested in the State of California. There are only six countries in the world that exceed California in gross national product, and one of these is the United States, itself. California's agriculture is unmatched anywhere in the world in terms of diversity, productivity and technical achievement. How did California receive the economic boost which brought it to its present position? The answer, simply, is growth. Growth is the underpinning of California's economy. California's physical attraction, its diversity of climate, terrain, etc. have combined with the work of man to make the state a place that seems to have everything. People are attracted here by these factors, plus the economy itself. California has the highest standard of living of any place in the world, including the United States.

Connected with California's growth and development are three major areas that present problems to the citizens of this state:

1. Increased population leads to an increased burden on government services. This, in turn, leads to increased taxes. The answer to this situation requires meaningful planning which will deal with the problems and not react to them.

Mosquito abatement districts represent a good example of governmental agencies which have had the foresight to plan and to deal with a serious problem. But foresight and planning are not enough. The matter of additional funds for these agencies brings up again the matter of taxes. Everyone is aware of the clamor on the part of the people for a reduction of taxes in all areas. But expanded services to meet the needs of the increased population will require additional taxes. One would think that the increased population would mean increased taxpayers, but this is not proportional. In fact, there is roughly a 15% built-in increase that is always necessary to meet increased costs of population.

2. Minority disadvantaged groups, escaping from unbelievable conditions of poverty and social servitude, increase our welfare burden and create special problems of education, employment and housing. The objective of welfare programs should be to help the individual to achieve a self-sustaining status. It was never meant to perpetuate a way of life. It is hoped that there can be a reduction in the cost of welfare. Then perhaps expanded services necessary in other areas can be funded.

3. The increased population is starting to affect the physical condition of California. There are crowded beaches and parks, new housing tracts which absorb the open spaces, and cause air and water pollution, etc. Provisions must be made for the ever-increasing population.

By dealing with these and other major problems, we can assure that California will continue to grow and remain the number one state in the Union and in the world.

RECENT DEVELOPMENTS IN VECTOR CONTROL AT THE NATIONAL COMMUNICABLE DISEASE CENTER

JOHN R. BAGBY, JR.

U.S. Department of Health, Education and Welfare Communicable Disease Center, Atlanta

When I was asked to discuss vector control at this meeting, I very quickly accepted the invitation. In large part, my rapid response was influenced by a real desire to revisit your beautiful State and to renew acquaintances of many years standing in vector control. Then I began to have second thoughts. If ever I have been put in a position of "carrying coals to New Castle" this is it. The reputation of this State in vector control is such that I now wonder what I can contribute. We at CDC have been knowledgeable of and impressed by the high quality of both research and services engaged in by the members of this Association for many, many years.

Perhaps my situation today is not too precarious since I shall confine my remarks to recent vector control activities of the National Communicable Disease Center, and largely to administrative details of those activities.

As you know, the Public Health Service has been undergoing the labor pains of rebirth brought on by an extensive reorganization plan that had its beginnings about eighteen months ago. Major portions of the Public Health Service have been realigned into new bureaus and activities. During all of this activity, the National Communicable Disease Center has been affected far less than some other parts of the Service, but has experienced changes in the form of additions of program activities to the Center.

Actually the addition of major programs began before the current reorganization of the Service. For example, two programs in the vector control area were added to CDC in 1966 before the reorganization became effective on January 1, 1967. In March 1966 responsibility for the bilateral malaria eradication programs assisted by the United States in seventeen countries was transferred from the Agency for International Development to the Public Health Service and subsequently established as a program of CDC. In August 1966 the Office of Pesticides, which had been headquartered in Washington as an operation of the old Bureau of State Services (EH), was transferred to the Center and it too was given program status in CDC.

Then the reorganization of the Public Health Service became effective on January 1, 1967, and, as part of that reorganization, the Division of Foreign Quarantine of the Bureau of Medical Services was added to CDC to become the Foreign Quarantine Program. This latter program, as you know, is concerned with protection of the United States against the importation of disease and is largely concerned with the possibilities of humans as carriers, but it does have responsibility for control of the importation of vectors of disease as well.

In July 1967, it became obvious to us that it would be administratively desirable to consolidate all of the responsibility for domestic vector control activities into one program of the Center. This was done by transfer of the Vector Control Training Section and of responsibility for vector control associated with water resources development into the Program of the *Aedes aegypti* Eradication directed by Dr. James V. Smith. His responsibilities now include the provision of consultation and training services in vector control, and the provision of the vector control services associated with epidemic aid, along with continuing responsibility for the eradication of the *Aedes aegypti* mosquito from the southeastern United States, Puerto Rico, Virgin Islands, and Hawaii.

The most recent acquisition to the Center in the vector control field occurred on December 8, 1967, when the decision was made to establish CDC as the Center responsible for administration of the recently enacted legislation concerning the control of domestic rats in urban centers.

Several of you have indicated an interest in this legislation so I shall provide what details there are concerning it at the present time. The legislation provides federal funds to assist in relieving problems associated with domestic rats in urban areas. This came about by the authorization of an increase in federal funds that might be appropriated for grants under Public Law 89-749, the Comprehensive Health Planning and Public Health Service Amendments Act of 1966. The so-called "Partnership for Health Amendments of 1967", Public Law 90-174, does not specifically mention rats, but it is understood that rat control is one of the public health problems that state and local agencies may wish to consider in preparing applications for grants under Section 314E of PL 89-749.

A number of cities, particularly those with major rat problems in blighted or ghetto areas, will apply for and receive grant fund for rat control in Fiscal Years 1968 and 1969. In my opinion, competition for funds under Section 314E will be great.

Grant applications for rat control, just as for all other health activities under Section 314E, are submitted to the Regional Health Director in the appropriate Regional Office of DHEW, and when approved will be funded by the Office of Comprehensive Health Planning, PHS, DHEW, Washington, D.C.

Guidelines to assist applicants in the preparation of the supporting documents for grant funding are being prepared and will be issued soon. I can tell you some of the things that I feel sure will be incorporated into the guidelines when they are issued. It is almost certain that proposals for 314E funding for rodent control will be granted highest priority when those proposals are directed toward the problem of rats in urban areas, with strong emphasis on control in the ghetto areas of cities. They will quite likely be given greatest consideration when they are associated with other federally assisted programs including model cities, neighborhood service centers, neighborhood health services programs, and youth opportunity planning programs.

Grant proposals should be designed to provide multiple agency funding whenever possible. For example, local support for garbage collection and disposal and federal funds from other agencies when available for code enforcement activities, demolition of structures, etc.

The legislative history of the Partnership for Health Amendments is such that the intent of the legislation is quite clear in the desire that disadvantaged persons be utilized in the program to the greatest extent possible.

Although the situation varies from community to community, a well designed rat control program will most likely include certain basic elements. It will not be necessary that all of the essential elements of a well-balanced, adequate community rat control program be funded from comprehensive health planning grants. In addition, any community will quite likely have sound, well financed activities covering some of the essential elements of a total community-wide effort. Comprehensive health planning funds should not be requested for such on-going activities except to expand them if necessary. The funds should be used to establish control activities not currently funded by communities.

Even though certain elements of a good rat control program are already being adequately funded within a community, statements to that effect should be made in the grant application to insure those who review the applications that the proposal is truly a comprehensive endeavor.

The essential program elements should include (1) a community-wide plan to identify rat infested areas and contributing factors, and to establish priorities of need for control; (2) procedures for the involvement of residents and property owners in the planning and programming of the community activity; (3) a proposal for community education to assist in gaining resident cooperation in rodent extermination activities; (4) a description of an effective administrative organization for conduct of the rat control activity and assurance of interagency coordination by all interested agencies; (5) the employment and training of disadvantaged residents of rat infested areas to insure that maximum opportunities are provided these people in all phases of the program; (6) demolition and clearance of deteriorated or dilapidated buildings; (7) statements indicating the quality and extent of municipal services including the collection and disposal of garbage and trash maintenance of alleys and other public ways and the removal of refuse cleaned up from vacant lots; (8) a plan for code enforcement; (9) plans for supplementing permanent control measures with poisoning, fumigation, and trapping where appropriate; and (10) the establishment of a suitable evaluation program based on the measurement of improvements of both health factors and the physical environment.

CDC will continue to provide training courses, develop training literature, and provide rat control consultation to communities and states when requested on rat control methods to the greatest extent with existing funds. I hope I have given you a feeling of the scope of our work on recent vector control activities of the National Communicable Disease Center, and the Center's responsibility in administering the recently enacted legislation concerning the control of domestic rats in urban centers.

MOSQUITO AND RELATED VECTOR CONTROL RESEARCH DEVELOPMENTS IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Claude H. Schmidt

Agriculture Research Service, U.S.D.A., Beltsville, Maryland

I would like to thank Mr. Peters for his invitation to your annual meeting. This is quite an occasion for me since it is the first time I have had the pleasure of meeting with the California Mosquito Control Association and is also my first visit to Fresno.

As you are undoubtedly aware, most research on mosquito control in our Branch of the Entomology Research Division is done at our Gainesville, Florida or Lake Charles, Louisiana laboratories. The emphasis at Gainesville is on chemical aspects—screening in the laboratory, field evaluations of larvicides and adulticides, investigation of methods of application, and some research having to do with chemosterilants and sterile males. At the Lake Charles laboratory, which is located on the campus of McNeese State College, the main emphasis is on mosquito biology, ecology, identification, host-pathogen relationships, and determination of the abundance of pathogens and parasites and their potential for mosquito control. Also, some work with pathogens is carried out at Gainesville. The work with mosquitoes that was being done at Corvallis, Oregon has been phased out, and much of that work will be continued here at our expanded facility at the Old Air Terminal in Fresno.

It is impossible in the short time available to cover adequately all phases of our mosquito research; for those wishing additional information, see the excellent review by McDuffie and Weidhaas (1967).

Screening for Insecticides

At our Gainesville, Florida laboratory we screen hundreds of chemicals each year for effectiveness against mosquitoes. I am going to discuss some of our results, but first I want to emphasize that these are research results and that many of these materials are not yet cleared for use, and that this report should not be construed as endorsement by the USDA.

Laboratory tests have recently been made with two experimental compounds, Shell SD-15134 and Montecatini L-561 (ethyl mercapto-phenylacete S-ester with O, O-dimethyl phosphorodithioate), both organic phosphates. Both were 100% effective as larvicides at 0.01 ppm, and thus were within the range of effectiveness of DDT. Also, comparative tests with Abate® (0,0-dimethyl phosphorothioate 0,0-diester with 4,4'-thiodiphenol) and Dursban® (0,0-diethyl 0-3,5,6-trichloro-2-pyridyl phosphorothioate) showed them to be two of the most efficient larvicides ever developed, at least against the black salt marsh mosquito, *Aedes taeniorhychus* (Wiedemann) and they are two to three times better than parathion and considerably more effective than fenthion, malathion, naled, or DDT.

Abate has shown some curious characteristics. Although most insecticides quickly break down when they are placed in conjunction with concrete (which is alkaline), Abate was highly effective for 6 weeks in preventing mosquitoes from breeding in concrete water jars in Thailand (Lofgren et al. 1967). Additional tests in Thailand by Glancey et al. (1968), indicated that in emulsion formulation, Abate killed all larvae of *Aedes aegypti* (L.) added to water in concrete jars treated with 1 ppm for 34 weeks; the same control was obtained whether the water level remained constant or fluctuated. Good control was even obtained for 20 weeks at 0.05 ppm. Also, 1 percent granular formulations on calcined attapulgite gave the same control at 1 ppm as the emulsifiable concentrate, and concrete pellets impregnated with Abate were effective for almost 12 weeks. Dursban was effective for a much shorter period than Abate, even at 10 times the concentration; a maximum of 5.3 weeks of effectiveness was demonstrated at 1 ppm. However, in field tests Dursban was also an effective larviciding agent, for example the residual activity of Abate was 13 days at 0.06 lb./acre and 18 days (one third longer), with Dursban at roughly half the amount, 0.035 lb/acre.

The screening for adulticides is a continuing program at our Gainesville laboratory. This program consists of three stages, (1) wind tunnel tests to select promising materials, (2) preliminary field evaluations with caged mosquitoes exposed to either thermal or nonthermal aerosols, and (3) aerial spraying or fogging of natural populations of mosquitoes. In the past two years, a great deal of work has been done at our Gainesville laboratory on ground aerosols, primarily because of the increased interest by the military in nonthermal aerosols. In 1966, Mount et al. demonstrated that nonthermal and thermal aerosols were equal in effectiveness. Also, Mount and Lofren (1967a) used a truck-mounted nonthermal aerosol generator, Curtis Model 55,000, calibrated to deliver 40 gal/hr in a series of tests with caged mosquitoes. Of the materials tested against three species of mosquitoes—*A. taeniorhynchus, Culex pipiens quinquefasciatus* Say, and *Anopheles quadrimaculatus* Say—fenthion, Bayer 41831 (0, 0-dimethyl phosphorothioate 0-ester with 3-chloro-4-hydroxybenzonitrile), and Bay 39007 (o-isopropoxyphenyl methylcarbamate) were the most effective materials tested (they were 2½ times more potent than malathion, which was used as a standard), naled and Dursban were 1½ to 2 times more effective than malathion, and Shell SD 8211 (2-chloro-1-(2, 5-dichlorophenyl)-vinyl dimethyl phosphate) was about equal to malathion. These results were based on the average LC_{90}'s. Moreover, the effectiveness of aerial fogging with Bay 39007 for control of adult *Aedes sollicitans* (Walker) and *A. taeniorhynchus* was also studied by Mount et al. (1967) because the salt marsh mosquitoes along the east coast of Florida were becoming resistant to malathion, the principal material in use. At a concentration of 10%, Bay 39007 gave 97% reduction in 6 hours after treatment as compared to only 41% for malathion when applied to 10-25 acres of citrus groves.

Application of Ultra Low Volume Insecticides

In our Branch, we believe that the term ultra low volume (ULV) should be restricted to the use of technical materials applied directly, since we commonly use only a few ounces or less per acre.

Mount and Lofren (1967b) compared ULV and conventional aerial sprays against *A. taeniorhynchus* and *A. sollicitans* in citrus groves. Of the insecticides tested, naled was the only material that gave essentially the same control with both methods of application; malathion gave poor control, undoubtedly because of the resistance that I mentioned previously.

A most interesting innovation reported by Mount et al. (1968) was the application of ULV aerosols with ground equipment for mosquito control. As they mentioned, such application would have several advantages: "(1) it would eliminate or reduce to a minimum the need for carriers, solvents, and additives, (2) it would reduce the amount of spray solutions or mixtures that have to be carried and applied, (3) it would eliminate mixing and diluting insecticides, and (4) it would permit a reduction in the size of equipment". In that study, the Curtis Model 55,000 nonthermal aerosol generator was modified by installing a 3-nozzle head and substituting a CO_2 pressurized system for the insecticide pumping system. With this arrangement, a range of particle sizes of malathion from 6 to 22.4 microns could be produced by varying the rate of flow of the air discharge, and greater kill per given dose was obtained with particles in the range of 6 to 12 microns. Also, in a field test with naled against *A. taeniorhynchus*, the ULV nonthermal aerosol generator was more effective than the fogger; for example, applications of 0.036 lb/acre produced 95% control with the ULV aerosol generator in a half hour versus only 74% with the fogger.

Sterilization

Smittle et al. (1968), compared the effects of gamma irradiation and chemosterilization of *C. p. quinquefasciatus*. When one-day-old pupae were exposed to 7-12 kr gamma irradiation, the resulting adults were not completely sterilized (untreated females mated to treated males were only 92-97% sterile). However, 2- to 3-day-old males dusted with pyrophylite treated with apholate were 97% sterile. Also, the chemosterilized males were equally competitive with normal males; those sterilized with gamma irradiation were as much as 38% less competitive. It is important to know whether a treatment reduces the mating competitiveness of the males; this is a situation that we cannot afford if sterile males are to be used for control.

Resistance

A few years ago when we were first beginning research on chemosterilants, Dr. Carroll N. Smith of our Gainesville laboratory, raised the question as to whether insects would develop resistance to chemosterilants. Although some researchers felt they would not, the fact is that insects do develop resistance to insecticides and there is no reason why they should not develop resistance to chemosterilants. As a result, we began applying selection pressure to mosquitoes with chemosterilants. Patterson et al. (1967), found that our colony of *A. aegypti* that had developed resistance to apholate through laboratory selection was now more than 20 times more tolerant of apholate than the regular colony of *A. aegypti*. However, this resistant strain shows little if any cross-resistance to tepa though it has a 3- to 4-fold cross resistance to metepa. Interestingly enough, the resistance to apholate is less in adults than in larvae; only a 6- to 7-fold increase was found in adults when the apholate was offered in sugar solution.

The resistance to insecticides is still very much with us and growing, as A. W. A. Brown pointed out in his presidential address at the ESA meeting in New York last November. However, though the insects may be gaining ground, so are we, because we are learning more and more about the mechanisms that are involved. For example, by using genetic markers, Plapp and Hoyer (1968) demonstrated that resistance to DDT and pyrethrins in *C. tarsalis* were genetically linked.

Our investigations of repellents and attractants is continuing. The work being done to develop chemical space repellents is of special interest. In a preliminary study, Gouck et al. (1967), reporting on 242 compounds tested in the laboratory, found 5 that prevented mosquitoes from coming through quarter-inch treated netting. Additional tests by McGovern et al. (1967) indicated that 4 carbanilates, 2 benzamides, and 1 acetamide gave more than 100 days of protection. The acetamide was the most effective space repellent found to date and provided 266 days of protection. Field tests are now being conducted with the more promising materials in cooperation with Walter Reed Army Research Institute and the SEATO Medical Research Laboratories, and field tests were also made in Thailand. Also, bed nets treated with deet and M-1960 (the standard army clothing repellent: N-butylacetanilide, benzyl benzoate and 2-butyl-2-ethyl-1, 3-propanediol) gave complete protection from *C. quinquefasciatus* and *A. aegypti* for more than 15 weeks. Oddly enough, deet, the best insect repellent yet found, is produced in nature by the pink bollworm, *Pectinophora gossypiella* (Saunders), a pest of cotton, and is used by the female moth in conjunction with another unknown material to attract her mate (Jones and Jacobson, 1968).

Hazard et al. (1967) found that bacteria isolated from hay infusions produced chemicals that stimulated gravid female *C. p. quinquefasciatus* and *A. aegypti* to oviposit. Gjullin, et al. (1967) noted the presence of male pheromones in three species of mosquitoes, *C. p. pipiens, C. p. quinquefasciatus,* and *C. tarsalis* Coquillett. The search is continuing for the substance or substances that attract mosquitoes to humans. Schreck and James (1968) noticed that a broth culture of *Bacillus cereus* derived from smears taken from a human arm attracted female *A. aegypti.*

Biological Control

At our Lake Charles laboratory, research is continuing on the biology and control of mosquitoes in relation to land and water management practices in the coastal marshes and rice growing areas. An excellent summary is given in the recent paper by Chapman et al. (1968). Most of the emphasis thus far has been on the mosquito viruses, fungi, nematodes, and protozoa found in wild mosquitoes, especially their distribution, abundance, life cycles, and host ranges. Petersen et al. (1967) reported that large populations of *A. sollicitans* were parasitized by a mermithid nematode. This nematode prevents development of the egg and usually kills the host at emergence and they concluded that the nematode is a biological control agent worthy of further study. Although many questions remain to be answered before biological control agents can be used on a large scale, these agents appear to have a great potential.

Concluding Remarks

I would like to depart from my topic to make a plea that we workers in mosquito control do not let ourselves be drawn into major controversies about such control. Too many people are ready to choose sides, and unfortunately, once a man has chosen his side, his mind is closed. He has nothing more to offer and nothing more to learn. I would like to quote from a recent speech made by Assistant Secretary George Mehren before the Entomological Society of America last November in New York.

"Three broad classes of dogma seem firmly to be held. One group seems basically to hold that insects must be left completely undisturbed; that the immediate ecology in which they exist must not be subject to what usually is called tampering; that at any cost to any other value there must be no alteration in any element of the general environment, now or ever; and that it is the moral duty of man to preserve forever the status quo of nature, perhaps preferably as it would be were there no men in it, and no works of man either.

"Another broadly specified group seems to hold that man must do battle only with bugs that are destructive to values cherished by that group. Yet, at the same time, he must exert only the minimal pressure necessary to serve those values. There are people in this group who seem to hold that stringent measures are acceptable against alien pests that have moved far beyond their native environment—whatever that may be. Long-established insects are called native, and some people say they must be left alone.

"At another extreme is a third group who insist upon what they call a practical approach. People, they will say, are more important than bugs. Accordingly, they will tolerate or even advocate substantial collateral effect of pest control if given economic or other values be served thereby.

"One cannot question the right or the probity of any human being—including entomologists—to held any of these varied views. But dogmatically to embrace any one of them as beyond discussion or compromise is to foreclose rational making of decisions which must be made."

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MOSQUITO CONTROL DEVELOPMENTS IN UTAH AND VICINITY

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At the thirty-fourth annual conference of this Association held in Monterey in 1966, Glenn C. Collett and Jay E. Graham (1965) presented a paper on "Mosquito Control Activities in Utah" and I discussed "Research in Progress in Utah in 1965 on Mosquitoes and Mosquito Control" (Rees, 1965). Many of the programs mentioned in these papers are still in progress and others have been introduced since that time. I will attempt today to bring you up to date on mosquito control developments in Utah and vicinity.

At my request, the following summary on the status of mosquito control in the six states adjacent to Utah, with the accompanying statements on each state, was prepared by Louis J. Ogden, Chief, Vector Control Services Unit, NCDC, PHS, Fort Collins, Colorado.

Arizona

The one regularly operating program that we know of in Pinal County is under the jurisdiction of the Health Department, which carries out county-wide abatement operations on essentially a full-time basis. The County Health Department is responsible for defining the mosquito problem and evaluating insecticides and their control work.

New Mexico

The three regularly operated programs in New Mexico, at Las Cruces, Roswell, and Albuquerque, are under the jurisdiction of the local health departments. The State Health Department does contribute some funds, primarily in the form of surplus equipment and materials that they are able to buy at reduced prices. Being a Health Department responsibility, I feel quite sure that some funds are utilized that come to the Health Department from federal sources; these would not be earmarked particularly for mosquito control, but rather for normal environmental sanitation activities. In addition to the three local programs, the State Health Department has a vector control staff of three individuals, who are responsible for providing technical assistance on mosquito as well as other vector problems throughout the State.

Colorado

In addition to the three mosquito abatement districts and four regularly operated mosquito programs, there are six other communities in the State that carry out some mosquito abatement measures, primarily chemical in nature. The Alamosa and Delta Districts will be funded for the first time in 1968. The Durango District has been funded since 1961. The State Health Department has a vector control specialist who is responsible for providing consultative services and technical services on mosquito and other vector problems throughout the State. This individual has been especially active on mosquito control work since his employment.

Wyoming

There is a great deal of interest in Wyoming on mosquito control, particularly in the State Department of Agriculture, and several communities are working towards establishing programs. The regularly operated program at Cheyenne, Wyoming, is under the jurisdiction of the City Health Department. The others are municipally sponsored programs that are being initiated necessarily on a rather small scale. At least they have begun to define their problems and plan an organized control program.

Idaho

The Idaho Department of Health has a vector control specialist, Mr. Robert Olson, who is responsible for providing technical information and guidance on the organization of mosquito and other vector control programs throughout the State. He is particularly concerned with mosquitoes and has been stimulating organized abatement efforts in problem areas. As in all states, Idaho has some rather severe problem areas that contain relatively few people, a condition that makes organized mosquito abatement difficult.

Nevada

In a discussion with Mr. Wally White this morning, he advised me that there is only one mosquito abatement district, Lyon County, presently in Nevada and that this district is relatively inactive. Regularly operated programs, though, do exist in Sparks, Las Vegas, Hidden Valley, Hawthorne, and the Battlement Creek area, Lander County, and Winnemucca. The Las Vegas program is county-wide. Two organizations, the Department of Agriculture and the District Health Department, are involved in this program. The Agriculture Department does the actual control work and the Health Department assists in evaluating control efforts. The Public Works Department in Sparks is responsible for mosquito control efforts in that area. In addition, a significant amount of progress has been made in eliminating mosquito-producing areas through coordination of efforts of the Drainage District, Bureau of Reclamation, and other agencies. Mr. White has been largely responsible for getting this drainage work accomplished as a part of normal water management procedures. He is also stressing source reduction through drainage and other means in the Hidden Valley area and in the Fallon area. Actually, a Water Resources Committee has been established in the Fallon area to deal with vector problems. Again, Mr. White makes it his personal responsibility to incorporate mosquito control into the activities of such a group.

Incidentally, I might mention, too, that Montana has five mosquito abatement districts organized under its enabling legislation, and there is an organized program at Great Falls.

From the above report prepared by Mr. Ogden, it is evident the mosquito control programs are developing in the intermountain states. Judging from this report, the future prospects for further developments in mosquito control activities in these states have never appeared to be more promising than they are at present.

In Utah, at present, there are ten mosquito abatement districts organized as prescribed by state law. There is also a mosquito control program conducted in Utah County by the County Health Department, and in the City of Logan a program was conducted by the Logan City Health Department. In addition, there are several small communities in Utah that have, during certain seasons, conducted some mosquito control operations.

The success of these various programs is as variable as the types of organization under which they operate and the control methods used. In the five organized mosquito abatement districts that employ trained, full-time managers, the control programs consist of the application of a combination of control methods and, in general, mosquito control is very effective in these districts. In Davis County a district manager is employed full time during most of the mosquito season and fairly successful results are obtained. The remaining four districts are small in size and operating budget and the work in these districts is largely directed by local, untrained personnel. The effectiveness of the mosquito control programs in these four districts is erratic and variable from year to year.

The mosquito control operations conducted by county or city health departments or other local governmental units have not been very successful in Utah. In Utah County the amount allocated by the county commissioners to the County Health Department for mosquito control varies considerably from year to year and has never been adequate to do a satisfactory job of mosquito control on a county-wide basis. Mosquito control operations financed by the City of Logan, in Cache County, were started a few years ago under the supervision of the City Department of Health. During the past two years, funds have not been allocated by the city for mosquito control work. Logan City purchased some good equipment for this purpose which has been in storage for the past two years.

In the smaller communities where mosquito control has been attempted usually only adulticides have been applied by aircraft. This has been done by commercial operators employed by the community for this purpose. Generally, little planning has gone into the operation and little success has been achieved. Fortunately, after one or two experiences, this method of mosquito control has been discontinued in most of these small communities. Unfortunately, the loss of tax money on such a program cannot be recovered and the community in most instances can ill afford the loss.

Judging from these experiences in Utah those more closely associated with mosquito control programs have come to the conclusion that Utah has provided in a state law excellent implementation for the organization and operation of effective mosquito abatement programs and that attempts to provide this service through other local governmental agencies should be strongly discouraged. It has also been demonstrated in Utah that attempts to organize a mosquito abatement district according to state law that covers a taxing area of low property valuation should also be discouraged. The reason is because the maximum funds made available for mosquito control by statutory law in such districts are inadequate for effective operation.

There are a number of research and related programs in progress in Utah that were mentioned in the 1966 papers that may not be directly related to mosquito control, but indirectly all of these investigations are an essential part in the development of effective mosquito control programs. The following are some of the studies reported at that time that are continuing at present, namely, studies on the: taxonomy, distribution, life histories and habits of mosquitoes in general; larval population dynamics; host preference; determination of kinds and amounts of residual insecticides in larval habitats; monitoring of resistance of mosquitoes to insecticides; overwintering reservoirs of WEE virus; surveillance by sentinel chicken flocks of the seasonal incidence of WEE virus; and the effectiveness of larval predators as a mosquito control measure.

The Utah Fish and Wildlife—Mosquito Control Coordinating Committee is functioning in Utah. The studies of water management practices on the marshes for multipurpose

Table 1—INFORMATION ON STATUS OF MOSQUITO CONTROL—INTERMOUNTAIN AREA

	ARIZONA	NEW MEXICO	COLORADO	WYOMING	IDAHO	NEVADA
1. State enabling legislation for mosquito abatement	No	No	Yes	No	Yes	Yes
2. Number and name of organized districts	0	0	3 Alamosa Delta Durango	0	3 Bear River Bonner's Ferry Gem County (not funded)	1 Lyon County
3. Number and name of regularly operated mosquito control programs	1 Pinal County	3 Las Cruces Roswell Albuquerque	4 Gunnison Pueblo Colorado Springs Las Animas	4 Basin Greybull Lovell Cheyenne	2 Boise Emmett	6 Sparks Las Vegas (Co. -wide) Hawthorn Hidden Valley Battlement Creek (Lander County) Winnemucca
4. Source of support	County funds	County and State funds	City and/or County funds	Municipal funds	County and municipal funds	Municipal and/or County funds

None of these states has a state mosquito control association.

Utah Mosquito Abatement Association was organized in March, 1948.

beneficial use of the water and the reduction of mosquitoes and other noxious insects produced on the marshes are continuing.

A cooperative drainage program financed by county, city and mosquito abatement districts is continuing in some counties.

I shall now attempt to present some of the developments in Utah that have taken place in continuing programs and new programs that have been introduced since 1966.

During the past two years the Utah Mosquito Abatement Association has changed the time for holding the annual meetings of the association from the spring to the early fall of the year. This, in the opinion of the officers of the association, seems to be a more satisfactory time of the year for most members and guests that attend the meetings.

Weber County Mosquito Abatement District during the past two seasons has attempted as a control measure the mass rearing and stocking of *Gambusia* fish. Lew Fronk, district manager, reports the results to date are inconclusive.

In 1967 a water commissioner was appointed to regulate among the users the reusable water in the lower Jordan River drainage system. The salary of the commissioner, travel and other expenses involved are to be shared by the gun clubs and others using this water. The Salt Lake City Mosquito Abatement District was instrumental in having this commissioner appointed and shares in these expenses, not as a water user but because of its great concern in obtaining better water management practices on these marsh lands as it relates to mosquito control. The program will continue in 1968 and we hope it will continue as long as this service is necessary.

During 1967 Salt Lake City Mosquito Abatement District provided employment for eight members of the Neighborhood Youth Corps. They were used in cleaning small drains where cleaning is not feasible by other means. Costs to the district were very small and the returns were helpful to mosquito control operations.

Utah State Health Department is engaged in the Community Pesticide Study in Utah in an attempt to determine the amount and source of different pesticides in the environment and in man. This project is funded by the Public Health Service. The University of Utah, mosquito control districts and other agencies are assisting in this investigation.

A study has also been started in Utah to determine the effects of some applied mosquito control measures such as water management and the use of insecticides on aquatic organisms other than mosquitoes.

Finally, I call to your attention the conclusions obtained as the result of a four year investigation on water management on the southeastern shore of the Great Salt Lake.[1] This investigation was conducted at stations located on large units of inundated marsh land. The results were presented in mimeographed reports and summarized in a paper published by Rees and Andersen in Mosquito News (1966).

To further test the validity of conclusions presented as a result of this study, an investigation is now in progress using five small units in which the water can be controlled and several larger units where the shore lines have been modified to provide variable water depth and vegetative cover.[2] If results from current investigations confirm our previous conclusions, this information should have a tremendous influence on water management programs on the marshes bordering the Great Salt Lake as it relates to mosquito control and wildlife management. It should also be applicable in other areas where the terrain and other marsh land conditions are similar to those in these study areas in Utah.

[1] This study was financed in part by funds provided in Research Grant WP-00027 Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, Research and training Grants Branch, Division of Water Supply and Pollution Control.

[2] This program was supported in part by Research Grant CC-00171, Department of Health, Education and Welfare, Public Health Service, National Communicable Disease Center.

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MOSQUITO AND OTHER VECTOR PROBLEMS OF THE PACIFIC NORTHWEST

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The three vectors of prime importance to public health in the Pacific Northwest at the present time are the mosquito, the tick, and the rodent with its ectoparasites. The mosquito, however, receives the major attention, being a biting nuisance in more populous areas as well as an important public health vector.

Not too many years past, the major purpose for the creation of mosquito control programs in the region was contingent upon the public health importance of the particular species of mosquito, the anopheline because of the potential of malaria, which did exist at one time in the Willamette Valley, and the *Culex tarsalis,* associated with the transmission of western equine encephalitis, which is now endemic in the region.

Today we are beginning to look at the mosquito problem from another side. With tourism and outdoor recreation ranking as the third largest industry in the Pacific Northwest, the control of the mosquito as a biting nuisance has become an important economic factor. Many new campgrounds and recreation areas created in previously classified wilderness areas, with new easy access by the general public, are experiencing a drought of visitors as a result of excessive populations of mountain *Aedes* mosquitoes. This, with the increasing urban population, has brought about a change in rationalizing the needs of the region for more extensive control measures.

In Oregon, particularly, this has resulted in unprecedented revisions in the Forest Service manual (under title 2300 — "Recreation Management" November 1967 R-6 Supplement No. 9) which sets up criteria defining a nuisance mosquito population, and allowing the local Forest Service districts to contract with existing local agencies, or private pest control operators, for mosquito control in the affected areas.

To date, control measures put into effect in areas of this nature are primarily adult control by low temperature fogging with malathion and diesel oil only. Though lethane added to the malathion-oil mixture in a fog would give superior adult control, we have been limited to malathion alone in order to protect other aquatic insects which are important as the primary food of game fish in the lakes and streams of these areas. Larval control in some of the high lake areas has been attempted by application of granular material on the snow, theorizing that when the snow melts the granular material will become an effective control agent in the snow pools. Effectiveness of this method has been questionable, with too many variables interfering with the desired concentration of insecticide in the resulting pools.

During 1967 the majority of the region experienced a year of heavy mosquito population. This was attributed to the heavy snow pack in the mountains, subsequent run off and extensive inundation of the flood plains of the major rivers for extended periods of time. This resulted in more monies being spent on mosquito control than in any previous year. Even with many districts spending over their budget, a poor control season was experienced in many areas. Almost all species were more numerous than in previous seasons. *Aedes vexans, Aedes nigromaculis,* and *Culex tarsalis* predominated the picture. At present it appears that *Aedes nigromaculis* is taking over in many areas previously free of them and is fast becoming the predominating species. This species has thus created an economic loss in irrigated pasture areas due to livestock annoyance and necessitated extended control beyond otherwise usual urban requirements.

Materials used and the application of them have changed with advancements in technology. DDT has all but disappeared in routine application because of resistance and imposed legal limitations in agricultural and dairy areas. Replacement has been, in most instances, with malathion, Baytex and Abate. In some areas low volume application by mini spin nozzles was used extensively with excellent results.

In many of the log ponds as well as other shallow mosquito breeding areas, the mosquito fish (*Gambusia affinis*) has been successfully introduced. This has given adequate control in those waters which these fish can tolerate. Some of the ponds, however, are so grossly loaded with wood sugar and other organic pollutants that the resulting BOD eliminates even this hardy, acclimated species of fish. This species has now been accepted by the Oregon State Game Commission for this use, but as yet the states of Washington and Idaho will not allow importation and planting. It is hoped that this can be accomplished in the near future.

One problem of particular concern has been in the southeast Washington area recently placed under irrigation and producing alfalfa seed commercially. The problem is to create an adequate method of control for the mosquitoes produced, without damaging the population of alkali bees which are essential for pollenization of the alfalfa.

An innovation in control of breeding areas along a shallow, slow-flowing stream was tried with relative success in Lane County, Oregon during the summer of 1967. In cooperation with the Corps of Army Engineers, the flow of water from Hills Creek Reservoir was increased once each week for several hours. This increased flow was sufficient to raise the stream level and "wash out" breeding areas along the banks and in gravel bars on the flowing stream. During this program, which continued for about two months during the height of the breeding season, there was more than a noticeable drop in complaints and biting counts. The same procedure will be followed this year in an attempt to reproduce the same results.

Ticks and the diseases transmitted by them continue to be a problem throughout the Northwest. At the present time no control methods have proven effective in reducing the natural population of these vectors. Immunization appears at present to be the only preventive measure available and this only for Rocky Mountain spotted fever.

A state-wide survey to determine Ixodid and Argasid tick species distribution population densities and the incidence of infectious organisms in the ticks was instituted in Oregon in 1967. This survey will be continued and expanded in 1968 and 1969. Tularemia, Colorado tick fever, Rocky Mountain spotted fever and an agent of tick paralysis were isolated from tick pools collected in 1967.

Inasmuch as sylvatic plague is endemic in the rodent population in the Northwest, both rodents and their ectoparasites are of serious concern. Low level surveillance programs are carried out in and about recreational areas on a continuing basis. Intensified field work is performed only when a large scale mortality of rodents is apparent. During the year of 1967 no plague positive animals were found in Oregon.

Rabies has been of increasing concern in the region over the past several years. It appears at the present time to exist endemically in the bat population and is a constant threat to the domestic animal population. In March of 1967, a rabid dog was found on Hayden Island near Portland, resulting in mass immunization of domestic pets and quarantine of the area. Ten individuals underwent rabies vaccine treatment, eight of whom were bitten by the rabid dog, plus the veterinarian and his helper who were dangerously exposed during examination of the animal. It was brought to light during the epidemiological investigation that the dog was native to Mexico and had been brought illegally into the United States without proper vaccination for rabies. One death from rabies occured in Oregon in 1967, a boy bitten by a dog while in Egypt, prior to returning to the States.

As everywhere, the largest and yet unsolved problem is adequate budgeting. This, in itself, has proven to be a real handicap, especially in obtaining adequate salaries to retain qualified personnel in the Northwest.

It is indeed gratifying for us in the Northwest to look back and see the progress made in vector control in the past fifteen years in the establishment of the programs that now exist, but, we still realize there remains a great challenge to all of us to develop the existing programs which, by existing standards, are still in their infancy.

AFTERNOON SESSION

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

JAMES W. BRISTOW, *President-elect, Presiding*

PANEL: VERY LOW VOLUME SPRAYING FOR MOSQUITO CONTROL

Thomas D. Mulhern, *Moderator*

California State Department of Public Health Bureau of Vector Control, Fresno

It seems appropriate to open this session by pointing out that imagination and cooperation have been the most important factors in the formula which during the past four years has brought us to the knowledge of how we may effectively, efficiently, and economically apply very low volumes of insecticide for the control of mosquitoes. Included among the cooperators were mosquito control agency personnel, representatives of the insecticide and aircraft industries, representatives of the armed services, and personnel of both the University of California and the California State Department of Public Health. You will hear from a number of these people today, so I shall not now recite the very long list of persons who have been involved. However, I have been asked by some of those who made the 1967 Colusa Project a success to comment briefly about Mr. William C. McDuffie, former chief of the branch of the U.S. Department of Agriculture which has responsibility for research concerning insects which affect man and animals. Bill McDuffie was a very old friend. I first met him in 1945 at the old Orlando, Florida laboratory of the USDA, when I went there to attend a training course on the use of the then new DDT. Bill McDuffie had been pressed into service as one of the instructors.

Our paths crossed many times in the intervening years, and it was always a pleasure to meet him again. It is indeed easy for me to appreciate why he had a host of other friends in California, and in every state where he was known. He had retired from his post with the USDA a short time earlier and, in the spring of 1967, we were delighted to hear that he had accepted a part time post with the Dow Chemical Company, in which capacity he planned to spend most of the summer at Colusa, California, attempting to define the strengths and weaknesses of Dursban®, the product which was to be one of the two insecticides used in the Colusa Project.

It so happened that most of the individuals active in the Colusa Project either had not met him before, or had known him only casually or by his professional reputation. Perhaps they expected him to sit in the office, to consult the data, and to make learned pronouncements! But by the end of the first day, they all knew better. Here was a likeable man, knowledgeable to an exceptional degree, yet as comfortable to have around as an old shoe. And, like an old shoe, he was the one always ready for the job where the going was toughest. He was a human dynamo—early to work in the field, often staying as long as the light would allow, then returning to the laboratory to work late into the evening, or to discuss the day's findings. The results of his studies will be presented by Harold Lembright later in this panel, for Harold worked very closely with him during the entire summer.

If you wonder how one man could have accomplished so much in one season, I think we can supply an answer—he loved every minute of it, from the first day of collecting and examining the mosquitoes in the steaming rice fields, through his observations at dawn of the airspray techniques, and going to dinner in the evening with the rest of the crew after the unbelievably long, hot and humid days of putting on experimental plots in the rice. There were also the heated discussions where strong opinions were voiced by the dynamic crew involved in this operation, with Bill always intent upon hearing the fullest possible presentation of ideas and frequently drawing upon his great wealth of background knowledge of mosquito behavior to present another view in an incisive yet homespun fashion.

In the small controversies which arise during such a dynamic program, he often charmed the assembled company by being able to hold firm to a different point of view, yet never giving offense in the doing. The group involved in the project was prepared in advance to respect Mr. McDuffie because of his past accomplishments, but the warm, personal friendships for him which developed during the stress of an exceptionally trying experimental project are perhaps the most valued aspect of his participation in the project.

When we learned that he had died of a heart attack at his home in Orlando, Florida on October 8, 1967, a stilling sadness beset this entire group. A fine friend and a fine scientist was lost. But we are thankful that he spent his last active summer with us. We shall long remember William C. McDuffie.

The panel assembled here will devote its primary emphasis to a report of the 1967 tests of very low volume larviciding for mosquito control. However, for orientation, it appears desirable to comment briefly on some other low volume insecticide applications which have been made in recent and past times.

This Association has heard papers in other years detailing the progress made in the development of granular larvicides for use by hand equipment, by ground-vehicle-mounted power equipment, and by aircraft, for both immediate results and for pre-hatch treatments with delayed effect. These are very good materials for specific uses and are still employed in particular situations, However, the higher cost of manufacture and the fact that there has been no technique developed by which very wide swaths can be obtained tends to keep the total cost relatively high. Also, dust and liquid sprays have an added advantage in that they simultaneously kill adult mosquitoes which may be in the fields that are larvicided.

The first effective use of aircraft for the application of dust larvicides in mosquito control was the application of Paris green to control *Anopheles*. In due course, dosage rates as low as ½ lb per acre of actual Paris green and as little as 5 lbs per acre of carrier dust became standard for air application. Dusts were widely used in this way until the more economical and universally effective liquid sprays came into use. However, dusts still have a considerable potential for use in mosquito control and much more development effort should be applied to them.

It is of interest that the mosquito control agency in Jefferson County, Texas has for several years reported opera-

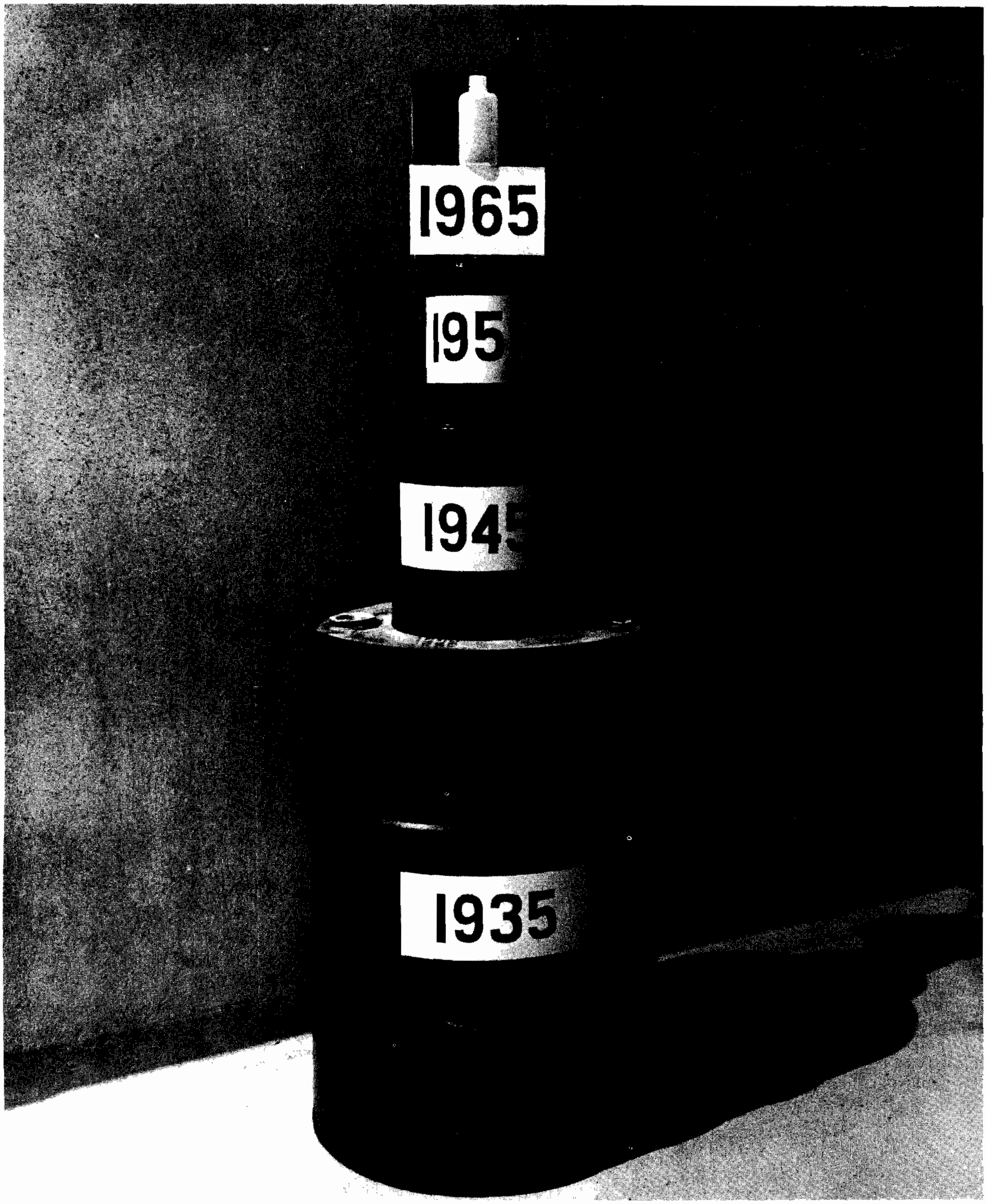

Figure 1. A graphic illustration of the reduction in volume of spray required for the control of mosquito larvae, achieved through development of more effective pesticides and improved equipment and techniques. From 50 gallons of oil per acre in 1935, the introduction of D D T allowed a reduction to 5 gallons per acre by 1945. Aircraft application of 1 gallon per acre was not unusual in California by 1955, and by 1965 effective techniques for using 8 fluid ounces per acre were well developed. The tiny vial at the top of the picture shows the amount of undiluted technical concentrate needed to treat one acre today.

tional use of large volumes of BHC and malathion dusts, primarily as adulticides, at various application rates. In 1963 several of us in the California State Department of Public Health cooperated with the Merced County and the Kings mosquito abatement districts in small scale field trials of light weight (37 lbs. per cu. ft.) and heavy (67 lbs. per cu. ft.) malathion dust for both air and ground applications. These preliminary trials gave effective swaths over a minimum distance of 400 feet. Dust insecticides at that time were very unpopular in agricultural areas because of their drift and residue characteristics, so this line of investigation was temporarily suspended.

In 1965, a trial was executed at Fallon, Nevada, in cooperation with personnel of the Alameda Naval Air Station. The technology of this trial may be called "cross-wind drift dusting, with vertical stacked swaths". A heavy malathion dust provided by American Cyanamid was used. The swaths were flown over a single, predetermined flight line but at successively higher altitudes, to allow the wind to carry the dust over a planned total swath width of one mile. Unfortunately, variable winds and an electrical storm with rains during the test made it necessary to abort after only 1/3 of the planned passes had been made, so that evaluation over the planned distance was not possible. However, high mortality occurred in the test stations over which the dust was observed to drift, indicating that further trials of this technique should be made under more favorable conditions.

A quick look at what has happened to liquid larviciding in the past may be helpful in stimulating our imagination to predict what may take place in the future. In the past 30 years, the cost of labor and of almost everything we do or use in mosquito control has increased at least 300%, yet during this same period the cost of operational larviciding has declined steadily. In 1935 it was common practice to apply a minimum of 50 gallons of oil larvicide per acre and the oil cost would total about $4.50. Equipment used were compression or knapsack sprayers, with an average cost of about $1.00 or more per acre for the labor. The total for material and labor might be at least $5.50 per acre.

This may be compared with a present day cost of less than $0.50 per acre, with parathion costing about $.12 and aircraft application costing $0.30 to $0.38. Taking into account the depreciated value of the dollar, the present cost is only 1/27 as great as in 1935. Further economies are promised by the reports you will hear today.

In 1935 the oils were the principal larvicides, and they required about 50 gallons per acre for effective control. By 1945, DDT was available and very quickly application rates dropped to five gallons per acre. Ten years later, many trials and much study and evaluation allowed most California mosquito control agencies to reduce aircraft application rates to a standard of one gallon per acre, using mainly emulsifiable sprays diluted with water. Efforts to lower this application rate further by using finer orifice nozzles were not successful, and it was only when sprays of low volatility came into use that the rates were substantially reduced.

The Colusa studies demonstrated that swath widths can be increased greatly by using the low-volatile, low volume sprays. Preliminary tests were run last fall, and will be continued this spring, using a "HI-LO" technique. This term refers to a high altitude application, perhaps at 1000 feet, and low volume. Three tests were run in Kern County at 1000 feet elevation for the plane, using two insecticides. Effective control of both larvae and adults was obtained at swath widths of 1600 feet to more than 3000 feet, with winds of one to two miles per hour.

THE ROLE OF THE DEPARTMENT OF AGRICULTURAL ENGINEERING IN INSECTICIDE APPLICATION

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Work has continued the past year on machines and application techniques for mosquito control with emphasis on aircraft methods. Several chemicals are available for low volume application techniques, and when applied at such low levels as 0.1 pound per acre or less (depending upon the chemical), the danger of environmental contamination becomes minimal. Aircraft offer a unique means for covering large areas with low volumes of an ounce or two of liquid formulations, which appear to offer penetration and coverage potential approaching dusts, but by maintaining a particle volume median diameter of around 75 microns (as opposed to 25 microns for dust) much of the dust drift and loss to surrounding areas is overcome.

A further resemblance to dusts can be found with the low volume technical or near-technical formulations in that these are made up of liquids of relatively low volatility which, when atomized, do not evaporate to become smaller airborne particles but do tend to settle out within target areas.

Making use of prevailing winds to distribute fine-spray particles over very wide swaths of 1000 feet or more (for control of locusts, tsetse fly, etc.) has frequently been done in the past, but primarily where movement of the chemical would not cause damage to surrounding crops, animals, or humans. More recently, experimental techniques combining low velocity winds and applications from sufficient height to produce wide swath coverage have been made as emergency measures to control disease-bearing mosquito vectors. While use of very low application rates and low-toxicity chemicals keeps environmental contamination low, it certainly should be evident that thorough examination of the contamination and damage potential to crops and wildlife, as well as to human habitations, should be investigated along with the degree of mosquito control obtained. A weighing of one against the other—potential contamination and damage against the necessity for control—should be made before such programs are undertaken.

We hope to continue investigating the beneficial aspects of mosquito control as obtained by use of low volume techniques and aircraft applicators. However, in light of the ever present contamination danger from widespread applications of chemicals it is very important that a greater knowledge of the ultimate deposit and final fate in the environment of the chemicals being applied be thoroughly investigated. We hope to expand our investigations in this area to help establish some reliable reference points which will aid in guiding chemical use.

AIRCRAFT AND SPRAY EQUIPMENT USED IN THE 1967 COLUSA MOSQUITO CONTROL EXPERIMENT

William E. Burgoyne

University of California
Department of Agricultural Engineering, Davis

The United States Department of Agriculture contract with the Department of Agricultural Engineering, U. C., Davis, began its third and final year in July, 1967. Previously, a series of field plots containing *Culex, Aedes* and *Anopheles* mosquito larvae had been sprayed with a Pawnee 235 aircraft using equipment and techniques developed during the early months of the contract. Application rates were near eight fluid ounces per acre. Dursban® and fenthion (Baytex® showed the most promise of the chemicals tested for larval control at these low rates.

In December, 1966, a Bell 47 G-5 helicopter was brought to Davis for swath pattern determination at low volume rates. Its mission weight is 2850 pounds, including a useful maximum load of 1300 pounds. Without agricultural equipment the cruising speed is 84 miles per hour. The range is 340 miles with two fuel tanks, and the service ceiling is 10,500 feet.

This helicopter is powered by a Lycoming VO-435 piston engine rated at 265 hp, and has a 12-volt electrical system powered by a 70-ampere alternator. Starter, alternator and voltage regulator are all automotive type.

Bell AgMaster spray equipment was used for all rotary-wing aircraft tests. Two 60-gallon fiberglass tanks are standard. The spray boom consists of five sections, and may be varied in length from 35 to 50 feet. The 35-foot boom was used in Colusa. The pump, a standard part of the agricultural spray kit, operates by direct drive from the engine. The pump, pressure regulator, spray valve and dump valve are contained in one unit. A series of spinner nozzle devices were tested on the aircraft and a Turbaero disc-type spinner was found to be the most acceptable.

Four Turbaero spinners are mounted on the boom, nine and seventeen feet from the aircraft center line, and usually are operated at 7000 to 8000 rpm. Speeds are controlled by four rheostats. The Agmaster boom supports the spinners, and a half-inch flexible line supplies them from a pump manifold designed by Transland Aircraft Company—distributors of the unit. The spinners are multiple-disc type and are fed through a standard SS nozzle body via a flooding nozzle feeding along the axis of the discs.

In and near Colusa there are game refuges operated by the U. S. Fish and Wildlife Service. These grow several thousand acres of rice and duck food. The manager generously allowed us to spray large plots of this rice. Through the cooperation of the Colusa, Sutter-Yuba and Tehama mosquito abatement districts, and interested local ranchers, we were given permission to spray 7500 acres of rice and pasture. We hoped to spray this entire area in one working day, using a 250-foot swath.

A Piper Pawnee 150 aircraft was used to spray smaller acreages and test plots. The swath produced by this plane was 150 feet wide. The low volume spray equipment used on this Pawnee was described in *Mosquito News* 27:2, June 1967.

THE MOSQUITO CONTROL PROBLEM AND A POSSIBLE SOLUTION

Kenneth G. Whitesell

Colusa Mosquito Abatement District, Colusa

The Colusa Mosquito Abatement District comprises 140 square miles in the eastern one-third of Colusa County, and 20 square miles in Sutter County. The principal mosquito producing areas are in rice fields, pastures, and duck clubs. One very large duck club area is called the Butte Basin. It is the last of the large, natural wildlife habitats on the Pacific Flyway in this area. It includes 8,000 acres in the Colusa Mosquito Abatement District and 4,000 acres in the Butte County Mosquito Abatement District. One-fifth of the area of the Colusa District, about 20,000 acres, is in rice plantings. Elsewhere in the county there are 74,000 acres. In 1968 there will be a 20% increase in rice allotments, increasing the total to 112,800 acres. The principal mosquitoes are *Aedes* from pastures and duck clubs, and *Culex* and *Anopheles* from the rice fields.

The Colusa Mosquito Abatement District has been in existence for ten years and has directed its primary efforts toward the control of the *Aedes* species, which attack freely in the daytime, as well as at night. Very little effort has been devoted to the control of the *Culex* and *Anopheles* which occur in rice. Although the District has the third highest mosquito control tax rate in the State, the assessed value of the land is low, and the tax income therefore is insufficient to provide for adequate mosquito control. The potential economy of the low volume method offers definite promise to this District of large problems and low assessed valuation. With lowered unit costs, it is obvious that more mosquito producing area can be larvicided without increasing the total costs.

On a typical spray day, one helicopter would treat 7,500 acres in a 6-hour spray day. The first area treated was a 1,750 acre pasture located south and east of the City of Marysville, in the Sutter-Yuba Mosquito Abatement District. Then the aircraft ferried to the Colusa National Wildlife Refuge, a distance of 36 miles, where 550 acres were sprayed. After ferrying 7 miles to the Delevan National Wildlife Refuge, 650 acres were sprayed. After another 7-mile ferry, a 100-acre commercial seed rice field was sprayed. Then, without reloading, the aircraft ferried another 12 miles to a pasture in Sutter County, north of the Sutter Buttes, where a 660-acre area was sprayed. The aircraft then returned to the western edge of the Butte Basin to reload. Three loads of diesel oil were then applied on 3,700 acres of dry duck clubs, to complete the projected acreage for a single 6-hour flying day. Spraying operations were performed on July 25, August 10, and August 29 with the helicopter, and on September 14 with the Piper Pawnee 150. Six thousand five hundred acres were sprayed on July 25 and August 10, 1,300 acres on August 29, and 925 acres on September 14. The effectiveness of Dursban® on rice and pasture mosquito sources, at dosages of 0.05 and 0.025 lb/acre was compared with Baytex® at 0.1 lb/acre.

At the beginning of the summer, test stations were set up in the areas to be treated and in similar areas which were not to be sprayed. At each station weekly readings were recorded, including water depth and temperature, larval counts, and red box adult mosquito counts. All predators taken during the larval sampling were preserved and later counted and identified by Dr. Robert Washino, U.C., Davis. Data from the sampling stations show that there is less variation between the minimum and maximum water temperatures as the rice gets higher and shades the water. The adult counts in red boxes tend to increase as the season progresses.

An outstanding problem in rice fields is the operators' inability to properly sample a field and determine the need for spraying, by reason of the vastness and inaccessibility of the fields, and because the distribution and behavior of the *Anopheles* larvae in the rice fields make it very difficult to collect a valid, representative sample. It may be possible that rice field problem areas can be treated on a time basis rather than on the basis of periodic inspections. In discussing this possibility with various workers, there was presented for consideration a graph that summarized the accumulation of many years of hard, hot, and humid rice field sampling by Dr. Stanley F. Bailey, Professor of Entomology, U.C., Davis. This graph shows a mosquito population peak at the end of May, another about July 18, and a third about August 28. It would thus appear that 3 timely applications of spray might substantially reduce the population through an entire season.

I will summarize by saying: We have a trial procedure, we have a new dispersal technique, and we have experimental chemicals that are effective. Now we need a label to legalize this procedure for operational field trials.

THE USE OF DURSBAN® IN THE ULTRA LOW VOLUME SPRAYS IN CALIFORNIA MOSQUITO CONTROL, 1967

Harold W. Lembright

Plant Science and Research
Dow Chemical Company, San Francisco

(ABSTRACT)

DURSBAN® insecticide was one of two materials used for 1967 ULV mosquito control studies in the Colusa, Sutter-Yuba areas of California. Although some of the data have yet to be analyzed, promising control was obtained utilizing the technological advances under development with ULV spraying. It was found that against pasture mosquitoes, principally *Aedes* spp., 0.05 pound of the insecticide was needed to control the late fourth-instar larvae. Against the rice field mosquitoes, principally *Anopheles* and *Culex* spp., 0.0125 pound was sufficient through July, but because of the increase in vegetation density and cover, 0.025 appeared necessary in August.

A concurrent but separate ground application study of ponded water using Dursban insecticide at 0.05 pound per acre, resulted in residual control of 3 to 10 or more weeks, where normal practices required retreatement on a 1 to 2 week basis.

BIOASSAYS OF AIRCRAFT SWATH PATTERNS AND RICE-CANOPY PENETRATION OF INSECTICIDES

Don J. Womeldorf and Patricia A. Gillies

State Department of Public Health
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During the 1967 tests of low-volume mosquito larvicide application at Colusa, it was necessary on several occasions to measure insecticide depositions and resultant concentrations in rice-field water. Since chemical and physical techniques were not readily available, bioassay was substituted. The method used (Gillies, Womeldorf, and Walsh, 1968. Mosquito News: in manuscript) involved placing mosquito larvae in water containing unknown amounts of insecticide, then observing the rates at which the larvae are knocked down as compared with the rates at which larvae are killed by known concentrations. Larvae of *Culex pipiens quinquefasciatus* were obtained from a colony maintained by the University of California mosquito research station at Fresno.

Several swath-pattern analyses were performed using Dursban® and fenthion as indicator chemicals. The procedure was to place a series of cups, spaced at chosen intervals and filled with equal volumes of water, in a line or lines perpendicular to the aircraft's line of flight. After the insecticide was applied the cups of water were brought to a laboratory for bioassay.

The assumed 250-foot swath width of the Bell 47G-5, equipped as described by Burgoyne earlier in this panel, was confirmed on four separate occasions. Two of these involved measuring adjacent swaths as well as a single swath. The resultant distribution was reasonably uniform across the multiple-swath recovery line, although the pattern of a single swath was quite variable. It was also demonstrated that the fixed-wing PA-25 airplane was capable of producing an operationally useful 150-foot swath under the Colusa study conditions. The magnitude of apparent insecticide recovery was low with both aircraft, sometimes being only a small percentage of the expected average. Possible explanations of this observation were not investigated.

Spray penetration tests were performed by comparing the amount of insecticide that fell into cups suspended at the top of rice plants with that which fell into cups held at water level below the canopy. The results showed that a considerable loss occurred (roughly two-fold in many cases), but it is suspected that conventional application rates (0.5-1 gallon per acre) of water-mixed sprays would have resulted in an even greater loss.

The concentration of Dursban deposited in rice-field water was measured one time. Water samples dipped from stations in the rice field were transported to a laboratory for bioassay. The amount of insecticide available to kill larvae 3 hours after spraying was compared with that which was available in samples taken 24 hours after spraying. The loss of effectiveness of the insecticide after remaining in the field for 24 hours was great, with only very slight mortality of test larvae placed in the day-old field water. The fate of the insecticide was not determined, nor were the tests extended past 24 hours.

EFFECTS OF LOW VOLUME AERIAL SPRAYING OF DURSBAN® AND BAYTEX® ON FISH[1]

Jack D. Linn

California State Department of Fish and Game, Sacramento

The Department of Fish and Game first became involved in the Colusa study in the spring of 1967. There were two wildlife agencies included in the study and to avoid duplication of effort, the U.S. Fish and Wildlife Service assumed

[1]Prepared by Calif. Dept. Fish and Game, Federal Aid Project FW1-R, February 1968

responsibility for evaluating the effects on wildlife while the California Department of Fish and Game concentrated on fisheries aspects.

We were primarily concerned with the possible effects of Dursban® on fish; although evaluations of experimental applications of fenthion (Baytex®) were also made. We had made evaluations of a conventional application of fenthion in 1964 and found that this particular treatment had no acute effects on fish and wildlife. The effects of low volume applications of fenthion were unknown.

The toxicity information on Dursban indicated that concentrations in water above 5 parts per billion (ppb) would be hazardous to fish. The application rate being considered at that time was 0.05 pound per acre. This rate would theoretically produce a concentration of 37 ppb in a rice field 6 inches deep. Thus, the Dursban that would be applied in the Colusa study could conceivably cause extensive fish losses. It was decided that some preliminary tests should be made to see if Dursban applied at 0.05 pound per acre would in fact kill fish in rice fields. Tests were made with both Dursban and fenthion. It was early in the year and there were no rice fields available so some shallow ponds on the Colusa National Wildlife Refuge were used in the study.

Green sunfish were placed in cages in three different ponds. One pond was treated with Dursban at 0.05 pound per acre, one with fenthion at 0.1 pound per acre, and an untreated pond was used as a control. In the Dursban treated pond, the caged fish died within 80 hours. There was no mortality in the control or the fenthion pond after treatment. However, the weather was extremely hot during the study and water temperature in the Dursban pond reached 97 degrees F. This temperature would be lethal to fish in most cases. The temperature in the control pond and the fenthion pond did not exceed 90 degrees F.

Because of the temperature problem and the need to test a lower dose rate of Dursban, a second test was made after the rice had been planted. In this test Dursban was applied at the rate of 0.05 pound per acre and 0.025 pound per acre to separate rice fields in which caged green sunfish were placed. An untimely rain storm flooded most of the test area but two cages were relatively unaffected. Luckily these represented both dose rates. All fish in the cage in the field treated with 0.05 pound per acre were killed. Twenty percent of the caged fish in the field treated with 0.025 pound per acre died. The results of this test indicated to us that 0.025 pound per acre of Dursban was the highest rate that could be used without causing extensive fish losses.

Three applications of Dursban were made in the full scale program. The chemical was applied July 25, August 10, and September 14.

Approximately 7,500 acres were treated although 3,700 of these were sprayed with oil only. The Department of Fish and Game concentrated its evaluation of the low volume spray on 1,200 acres of rice within the Delevan and Colusa National Wildlife Refuges.

Two rice fields totaling 550 acres on the Colusa National Wildlife Refuge were sprayed at a rate of .0125 pound per acre. No fish losses were expected and the evaluation of the spray application consisted of placing a stop net at the outlet of the rice fields and making periodic checks to see if any of the wild fish in the fields were killed. Only one dead fish was found and this was probably not caused by Dursban. It appeared to have been caught in the stop net by the current.

At the Delevan National Wildlife Refuge 650 acres were sprayed at the rate of .025 pound per acre. In evaluating the effects of this spray application, caged green sunfish and black bullheads were placed in the rice fields and in the drains from the fields. Stop nets were placed at the outlets from the fields to collect any wild fish that might have been killed in the field by the spray. The only mortality observed in either caged or wild fish was the loss of one bullhead and one green sunfish 72 hours after the first spray July 25. No other fish mortality was observed.

Water samples were collected periodically after each spray application at Delevan. The results of the analysis for Dursban residue in these samples are not yet available.

OBSERVATIONS ON THE EFFECTS OF LOW-VOLUME SPRAYING ON WILDLIFE

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The loss of marshlands and the general plight of wetland wildlife has become critical in many areas of the western United States. Populations of many marsh birds have seriously declined, and some have reached an endangered status in certain areas. Reclamation projects and the diversion of water for other uses have drastically decreased the number and acres of marshes. Currently, more wetlands are being drained each year than are being restored.

With the loss of wetlands, management of the remaining marshes must be intensified to maintain and, hopefully, to improve their quality. Management should strive to minimize conflicts with other human activities, but not at the expense of providing safe and desirable habitats for waterfowl and other wetland wildlife. The use of mosquito larvicides on marsh habitats presents potential hazards to various kinds and species of wildlife. Applications also could temporarily decrease the abundance of some organisms used as foods, though this possible effect has not been studied in detail.

The hazards of mosquito larvicides to wildlife are primarily determined by the degree to which animals are exposed to residues on their foods. Not only the amounts of actual insecticide applied, but the amounts reaching the ground, the relative deposits on different food items, and the persistence and biomagnification of residues can all be important in determining the exposure of animals. Theoretically, when the same amount of insecticide is applied to the same area, the exposure of wildlife should remain relatively constant, but changes in application techniques and in the insecticides used both inject new factors into a consideration of wildlife hazards.

Most mosquito larvicides are quite toxic, but they are effective at extremely low rates of application. The low rates needed for effective control tend to minimize the disadvantage of toxicity to wildlife. Still, toxicological and field studies indicate that many treatments for mosquito suppression create conditions that approach the threshold of hazard to wildlife (Keith and Mulla, 1966). Wetlands appear to be among the habitats that are most sensitive to the indirect effects and biomagnification of insecticides.

Studies of aqueous formulations of mosquito larvicides applied with conventional techniques have provided some information about the exposure of wildlife. The greatest deposits reaching the ground seldom approach theoretical application rates (Mulla et al., 1966). Drift from sprayed areas can contaminate other wildlife habitats, but highest residue levels probably occur on the areas treated.

The pattern of deposits on various substrates in the environment is quite important, but is poorly understood for most habitats. In general, the different species of animals in a marsh are adapted to feed on different kinds of foods, and their relative exposure is directly related to the residue levels on the various plant and animal foods that they consume. As the environment is more uniformly contaminated, more species are exposed to residues.

Since the persistence of a specific larvicide in the environment is governed by the combined influence of physical, chemical, and biological factors that differ on each occasion, it is never a constant factor. However, organophosphates generally are less persistent than the chlorinated hydrocarbons, and the change to use of organophosphates in mosquito control has probably resulted in a decreased exposure of wildlife to larvicides.

The advent of low-volume spraying has injected a new variable into a consideration of the hazard of mosquito larvicides to wildlife. Low-volume formulations consist of the technical grade insecticide with no diluents except those needed to dissolve or carry it. The formulations are applied in volumes from several ounces to one gallon per acre. Low-volume concepts and techniques were developed only recently, and much remains to be learned about their utility and effects. However, already it appears that low-volume sprays could result in a more intense exposure of wildlife to insecticides.

Low-volume applications are feasible only with larvicides that have a high density and a low volatility. Such restrictions may result in a new group of products being produced especially for control of mosquitoes in low-volume formulations. In the evaluation of any program, the toxicity and other innate qualities of the insecticide applied are among the first factors to be considered. Naturally, it is impossible to predict what the toxicological properties of these new larvicides will be.

Up to now, low-volume treatments have used about the same rate of actual insecticide per acre as that applied in conventional formulations, but the rates will probably be reduced as low-volume techniques are perfected because of their greater effectiveness in the control of pests. A decrease in the amount of insecticide applied for pest control would be desirable, but amounts applied are not as important as the behavior of the insecticide after it leaves the airplane.

Studies show that low-volume application enhances the efficacy of insecticide treatments by increasing deposits and persistence of the insecticides. Prolonged action of an insecticide might be helpful in achieving more complete control of target insects, but could result in increasing the exposure of wildlife from minimal to hazardous levels. More of the insecticides applied is deposited on treated areas with low-volume applications than with conventional spray methods. Initial residues are often more than twice as great with low-volume sprays; and of even greater importance, the persistence of residues can be more than three times as long. For instance, Dorough and Randolph (1967) applied malathion in a water emulsion at a rate of 0.5 lb/ac and found initial residues on oats of 30.76 ppm, which completely degraded in 7 days. In a concurrent treatment at the same rate, but in a low-volume formulation, initial malathion residues were 98.20 ppm and 1.63 ppm remained on oats 21 days later.

Himel and Moore (1967) discussed the pattern of deposits for low-volume and conventional sprays, and concluded that conventional sprays are largely deposited in the upper layers of the plant canopy on treated areas. The fine droplets in low-volume sprays more uniformly cover and contaminate the various surfaces in the environment. This factor potentially increases the kinds of animals that are exposed to insecticides, and could increase the hazard to some species.

Biomagnification of organophosphorus insecticides in food chains has not been demonstrated, although high residues have been detected in animals. Mulla et al. (1966) found levels up to 22.5 ppm of parathion in fish (*Gambusia affinis*) from a pond treated four times at biweekly intervals with 0.1 lb/ac of parathion, but the residues rapidly disappeared from the fish after the last treatment. Low-volume applications may result in a greater initial accumulation of residues in food organisms, but should not influence the ability of predatory animals to assimilate residues from their foods.

There has not been any experimental work specifically on the relation of low-volume techniques to wildlife hazards. Still, a consideration of the factors involved suggests that they may increase the exposure of wildlife. The greater deposits, more thorough coverage, and longer persistence all increase the probability that hazardous contaminations will occur after applications of mosquito larvicides to marshes.

Marshlands can be prime producers of mosquitoes, and control of larvae should be undertaken if it is compatable with marsh management objectives. Chemical control often can be the most desirable method of mosquito suppression, but the effects of treatment with larvicides should be thoroughly investigated. Low-volume spraying of larvicides deserves special study to determine if the technique is desirable for use on wetland habitats.

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Discussion

J. R. Walker: Has anyone tried to define the language relative to low volume, very low volume, and ultra low volume?

T. D. Mulhern: It appears to me that "ultra" means the greatest—the very extreme. We know that some applications of insecticides have been made with a concentrated insecticide at one-half fluid ounce per acre. We have not been using rates that low, and I prefer to speak about "very low volume" or even "low volume".

G. F. Smith: What were the maximum and minimum wind conditions during the Colusa Project, and how did they affect the results?

W. E. Burgoyne: Before starting the project, we arbitrarily said that we would not spray when winds exceeded four miles per hour. The tests extended from the middle of June to the middle of September, and we had to stop spraying only once, for a total of one hour. We had unusually favorable wind conditions. The four-mile-per-hour figure is arbitrary, but I believe it to be satisfactory.

T. D. Mulhern: What effect does relative humidity have on low volume spraying?

H. W. Lembright: Relative humidity would be expected to be important if we were dealing with aqueous sprays. With LV we were using oil or solvent, or other nonaqueous material. One contributor in the Colusa study was the U.S. Forest Service. The Forest Service had been using a Dow product, Dowanol TPM, as a carrier for the ULV spraying against spruce budworms. The Forest Service was interested in comparing this carrier with one we were using in the Colusa Project, namely, diesel oil. At Colusa we ran two tests at the same rate, using the two different carriers. The Dowanol TPM resulted in three times as many droplets and more volume of spray reaching the ground. An inconsistency, however, was in the bioassay, which did not show a major difference between the two treatments. Nevertheless, when we are working with low volume, we should use low volatile carriers. Malathion is a liquid, not requiring a carrier, but other materials which are solids do require a solvent carrier.

PANEL:

VARIATIONS IN HERBICIDE APPLICATION POLICIES

Howard R. Greenfield, *Moderator*

OPERATION ALISAL SLOUGH

Howard R. Greenfield

Northern Salinas Valley Mosquito Abatement District

and

Homer W. Marion

U.S.D.A. Soil Conservation Service

An ancient drainage system, known as the Alisal Slough, has provided a unique opportunity to demonstrate the valuable benefits to be derived from the cooperative efforts of landowners, county agencies, and the Federal Soil Conservation Service in Monterey County.

Historically, the Alisal Slough was a wide, deep channel which provided adequate drainage for an area in excess of six thousand acres of dry-farmed land. Urban developments and changes in land usage reduced the area of drainage to approximately two thousand acres and the length of the slough to less than eight miles. Originally, the slough's primary purpose was to handle runoff from the winter rains. In the summer months, the drainage system was usually dry. However, with the advent of irrigated, year-round agricultural crop production, the slough gradually became a silt-filled, tule- and cattail-burdened channel unable to handle irrigation runoff, much less storm runoff; and in the summer months, the standing water produced hordes of mosquitoes.

Fourteen local landowners, fearing ever-increasing flood problems and high water tables which made it difficult to remove undesirable salts from their lands, approached the Elkhorn Soil Conservation District and the Northern Salinas Valley Mosquito Abatement District for assistance in solving their problems.

With the approval of the agencies' boards of directors, field surveys were conducted jointly, and the following program was proposed and accepted:

1. The Elkhorn Soil Conservation District would obtain a cooperative group agreement with the fourteen landowners and their tenants for rights-of-way and the replacement of C.M.P. culverts on their properties.
2. The Soil Conservation Service would provide the engineering design and layout of the project.
3. The Monterey County Road Department would replace or reset the existing county road culverts to the engineered grade.
4. The Mosquito Abatement District would do the dredging and provide the manpower necessary to reset the farm road C.M.P. culverts.

With one-fourth of the project completed to date, benefits already have been derived by agricultural interests and the Mosquito Abatement District. The most obvious benefit has been the reduction of mosquitoes and a reduction in the amount of insecticide used. Less obvious are the increased efficiency in the disposition of agricultural waste water, deepened and more efficient farm drainage channels, and the reduction of perched water tables.

With the eventual removal of an estimated 1,126,000 cubic yards of silt, peat muck, and tules, the ultimate results promise even greater benefits than originally contemplated.

WEED CONTROL IN THE DELTA MOSQUITO ABATEMENT DISTRICT

George R. Whitten

Delta Mosquito Abatement District

First, let me say that the Delta MAD does have a permanent weed control program and we do feel that weed control and mosquito control are compatible.

Our total weed control program involves 90 dairy drains and 9 sewer treatment plants. We have restricted the program to dairy drains and sewer ponds because the high organic content of these waters encourages weed production to such an extent that high quality mosquito control is impossible in this environment.

We employ the equivalent of one man full time and have just purchased a new one hundred gallon capacity, low profile, custom made weed control unit which is mounted on a Jeep. In 1967 we applied 6,365 gallons of Richfield A weed oil and 120 pounds of atrazine at a rate of 20 pounds per acre. The Delta MAD also owns a propane weed burner which is mounted on a Jeep pickup. We consumed 336 gallons of propane with this unit in 1967.

One of the questions which we are involved with here is: "Is this a legitimate mosquito control technique?"

In mosquito control we have in the past and will in the future avail ourselves of any tool or technique which we feel will help in our mosquito control operations. Weed control is a technique which, if used judiciously, offers us the opportunity for more precise control in areas where in the past years in the Delta MAD we had not been able to even assess our problems properly, let alone do an adequate job of control. Many gallons of insecticide and many man hours of labor had been expended in a futile attempt to control mosquitoes in areas heavily overgrown with weeds. Conversely, many gallons of insecticides and many man hours have been saved by the proper use of modern weed control methods.

What is of prime importance to us is that we now have a well organized control program for *Culex quinquefasciatus* which we can depend on to achieve up to 100% control in these sources. Previously no matter how conscientiously we attempted control, we could not prevent heavy emergence.

The next question we might ask is "Who is going to pay for this program?" In the Delta MAD we have accepted the responsibility for weed control on dairy drains. We don't feel that each dairyman should own a weed control unit when one unit owned by the district can cover 90 dairies. We also do not feel that we can charge the dairyman for this service anymore than we can charge him for the application of insecticide. The day may come when a charge may be made for the services performed by the mosquito abatement districts, but until this time we feel that weed control, as we utilize it, is a direct function of our mosquito control program and could not be charged for separately but only as a part of the overall program. After all, we control weeds only to achieve mosquito control.

We have 9 sewer treatment plants in our district. Before the development of our weed control program several of these sewer treatment plants were a considerable problem to the district. We were applying insecticides routinely but due to the dense weed cover, control was spotty and adults invaded the cities causing many complaints.

Weed control has enabled us to relegate this problem to a routine, twice-a-week spraying which gives us complete control.

On large sewer lagoons when weeds are eliminated from around the edges, our breeding area is also eliminated, consequently weedicide is substituted for insecticide.

On these sewer treatment plant problems we do urge the cities involved to supply the weed control material and the district will assume the responsibility for application.

To summarize our policies in the Delta Mosquito Abatement District, I will say we are flexible. We will use any technique which we feel is useful and we do feel that weed control is not only useful but necessary. We do feel that a weed control program is a serious step and should be considered on the basis of establishing a precedent which might be embarrassing in the future. The present still takes precedence over the future. We have a job to do today and if weed control will help, then we should make use of it.

WEED CONTROL POLICIES AND WEED CONTROL PROGRAMS IN THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

Gardner C. McFarland

Southeast Mosquito Abatement District

The Southeast Mosquito Abatement District, since its formation in 1952, has had to become involved in the control of unwanted vegetation which provides a favorable environment for the breeding of several species of mosquitoes. Principal species of mosquitoes involved are *Culex quinquefasciatus, C. tarsalis,* and *C. erythrothorax.* The usual type of vegetation that causes problems includes:

1. Woody plants such as willows, sagebrush, and mesquite.
2. Semi-submerged plants such as cattails, sedges, tules, and irises. (Domestic irises are planted along the edges of golf course water hazards, then subsequently proceed into the water edges).
3. Grasses such as Johnson grass and Bermuda grass.
4. Submerged plants such as alligator weed and filamentous algae.

Unimproved channels usually have a great amount of various types of vegetation, with masses of cattails and tules. Improved channels can also pose problems since the concrete bottoms fill with silt and debris which provide the soil for weed growth development. Lakes and ponds, both natural and artificial, provide ideal environments for growth of various types of aquatic and semi-aquatic vegetation. Water conservation spreading grounds, under the jurisdiction of the Los Angeles County Flood Control District, cause unusual aquatic weed-type problems, as well as problems caused by ordinary vegetation. Such spreading grounds are periodically emptied at which time luxuriant growth of terrestrial-type vegetation appears. Unless subsequent reflooding is at sufficient depth, the top portions of this terrestrial vegetation provides an ideal environment for breeding of *Culex tarsalis.*

Our salt marsh problems are now minimal, since 98% of the salt marshes have been eliminated by virtue of recreational, commercial, and housing development.

Several hundred dairy drains, varying in size from one acre to ten acres, cause major weed problems due to the favorable environment of temperature and nutrients. Two species of mosquitoes are involved in this environment, *C. quinquefasciatus* and *C. peus.*

After the District was formed, it was immediately determined that effective control of mosquito breeding was not possible without good control of aquatic vegetation. Since the vegetation problem in large part was located in areas under the jurisdiction of various agencies, it was determined that conference with these agencies was the necessary order of business. The various agencies involved include:

1. U. S. Army Corps of Engineers
2. Los Angeles County Flood Control District
3. Los Angeles County Parks and Recreation Department
4. Los Angeles County Road Department
5. City Agencies such as the Los Angeles Bureau of Water and Power, Street Department and Public Works Department
6. Golf Course Management

One example of such conferences, consultation, and program involved the control of vegetation in the Los Angeles

River. The responsible agency at that time was the U. S. Corps of Engineers. The problem involved control of lush vegetation in a ten-mile portion of the Los Angeles River, with a width of 300 feet. Water in this portion of the river was heavily polluted with organic solutes, providing ideal environment for *C. quinquefasciatus*, *C. erythrothorax*, and to a lesser extent, *C. tarsalis*. In fact, the problem caused by this stretch of river was the principal reason for the formation of the Southeast Mosquito Abatement District. Since the Corps of Engineers was the responsible agency for maintenance of this channel, contact was made with the District Engineer. The District was advised that the vegetation present did not impair the flood control value of the channel, and, therefore, no responsibility was accepted by the Corps. The problem of proper maintenance of this channel was then brought to the attention of the congressional representative of the District by the Board of Trustees through a letter pointing out the serious situation and the threat to the public health and comfort caused by the mosquitoes and poorly maintained channel. Within a few months, the District Engineer advised the District that $25,000 maintenance funds were earmarked for immediate channelization and removal of unwanted vegetation. To this date, similar problems, after suitable conference, are corrected by the Corps of Engineers. Similar cooperation with other agencies such as the Los Angeles County Flood Control District are in effect.

The Los Angeles County Counsel ruled several years ago that the Los Angeles County Flood Control District was responsible for proper maintenance of all channels under its jurisdiction which included some responsibility for control of situations that provided a favorable environment for the breeding of mosquitoes. Since this ruling, the Flood Control District is very cooperative in following the District's recommendations for leveling, grading, and construction of low-water channels to reduce mosquito breeding areas.

Of considerable importance in reduction of problem areas have been the actions by the taxpayers of Los Angeles County for the control of flood waters. To date, three bond issues have been passed amounting to $679,000,000, the bulk of which money has been spent in the proper channelization with concrete structures.

The plus of this work is the reduction of water area by channelization with suitable concrete inverts. Even though channels are properly constructed, problems still occur from the deposition of silt on the concrete inverts. This silt and debris provide an ideal environment for the growth of aquatic and semi-aquatic vegetation as well as ponding of water. On our recommendation, the Flood Control District corrects this situation by contracting with haulers to remove the silt and debris free of charge for its value as fill.

Of particular interest is our work with golf course management and Parks and Recreation Departments. Golf courses and many ornamental pools and ponds in parks provide an ideal environment for filamentous algae. These algae grow profusely in the summertime and decompose causing two problems. One is the odor caused by decomposition of the dead algae and the other is the increased growth of chironomids, whose food is provided by decomposed algae. The District currently recommends the use of common German carp, both for the control of the filamentous algae and chironomids. To date, filamentous algae control has been successful. It has been reported in the literature by other workers that Israeli carp, a strain of the common carp, is particularly successful in the control of filamentous algae.

In summary, our program is to first survey in order to determine the problem. The next step is to enlist the aid of the appropriate agency or property owner responsible for the problem and the responsibility of maintenance of the problem area. Elimination of weed situations by the appropriate agency is taken care of in 90% to 95% of the cases. The other 5% to 10% of the situations are handled directly by the District.

Your attention is called to a complete, up-to-date guide for weed control: "Guide For Weed Control for 1967", Agricultural Handbook 332, of the Agricultural Research Service of the U.S. Department of Agriculture, issued by the Superintendent of Documents for $0.40.

MORAL AND LEGAL ASPECTS OF WEED CONTROL IN MOSQUITO ABATEMENT PROGRAMS

Robert H. Peters

Northern San Joaquin County Mosquito Abatement District

My theme is centered around "What is Proper?" In the Health and Safety Code are two references which might be used to guide us in the area of weed control. Under Article 4, District Powers, Section 2270K, we may "do any and all things necessary or incident to the powers granted by, and to carry out the objects specified in, this chapter". This appears to be a general authorization to do weed control if necessary for mosquito control.

Section 2270D states "if necessary or proper, . . . maintain necessary . . . cuts, canals or ditches upon any land." I believe that in the word "maintain" we have justification for doing weed control.

There are several potentially adverse effects of weed control which we should consider:

1. We must recognize that the lack of or limited knowledge which we possess of herbicides may result in improper use and unsatisfactory control.

2. Drift is a factor we must consider. The problems of application are appreciable.

3. There may be a residual effect from the chemical.

Where weed control programs are carried out, there is potential public liability. We are public servants, carrying out programs benefiting the public, using the public's money, and doing much or most of our work on private lands. How does the public react to this? What are the moral considerations?

"Mr. Proper" is the person who asks questions, and wants answers. He may ask such questions as "why do we control mosquitoes and weeds, instead of abating them?" Or "How do we separate public and private responsibility in weed control?" or "Why should the public agency assume the potential liability for weed control, particularly on private lands?"

Where and how do we stop nursing the public? I believe we are guilty of following a path of convenience, of least resistance. Just where weed control fits into this picture is something we should all ask. We all recognize that for the past 20 years or so we have participated in an era of insecticide usage.

During the next 5 to 10 years we should review carefully our responsibilities. I hope that we will not have occasion to refer to the period ahead as an era of public liability.

CONCURRENT TRUSTEES' SESSION

TUESDAY, JANUARY 30, 8:00 A.M.

JAMES W. BRISTOW, *President-elect, Presiding*

REPORT OF THE 1967 TRUSTEE CORPORATE BOARD

FRED DEBENEDETTI, *Chairman*

There were three meetings held during the year; (1) to review the hiring of a legislative lobbyist; (2) considering a paid C.M.C.A. executive secretary; (3) to define the objectives of the Association, and (4) the term of office for a trustee on the Board. After a general discussion, it was the opinion of the Trustee Corporate Board that it was not necessary to hire a legislative lobbyist to represent the mosquito abatement districts in legislative matters. The Board strongly believed the best approach was the cooperative effort of all mosquito abatement districts. Some of the board members have had experience with legislative lobbyists and were of the opinion that costs would be prohibitive. It was recommended to the C.M.C.A. Board of Directors that when preparing the Association budget, $225.00 be approved, in order to receive notices of proposed legislation, and the Chairman of the Legislative Committee be designated as the person to receive such material. Further, the Chairman of the Legislative Committee be instructed to notify all officers of the Association and the Trustee Corporate Board of any bills that might be detrimental or beneficial to mosquito abatement districts. If this recommendation is followed, the communications on legislative matters would certainly be improved. Most of the time in the past, we have been chasing the horse after it has gotten out of the barn.

Regarding a paid C.M.C.A. executive secretary, it was recommended to the C.M.C.A. Board of Directors that further study be conducted on the methods of financing, duties of the secretary, and the objectives of the Association. It is estimated that if a paid executive secretary were employed the cost of this office could range from $30,000.00 to $35,000.00 per year. From the investigation made, it appears it would be prohibitive for members of the Association to sustain such a cost.

After a general discussion of the term of office for a trustee, it was moved by Mr. Price that the term of office for a trustee corporate board member is not to exceed two consecutive years, and such two-year term of office is not to apply to the alternate candidate. This was seconded by Mr. Brown and unanimously passed.

In the field of legislature, the Trustee Corporate Board strongly opposed Assembly Bill No. 2462, introduced by Assemblyman John Stull. This bill authorized boards of trustees of mosquito abatement districts to call an election of the electors of a district to provide for the election of trustees by special election. Trustees would serve for four years and would be limited to a five man board. Just imagine what the cost would be for holding an election in some of the different districts. Under this proposed legislation it would be possible for candidates to be elected from one area of the district. Also when you consider the remuneration for such an elective office it hardly justifies the election expense for the candidate. Letters were sent to the Assembly Municipal and County Government Committee, Assemblyman John Stull, author of the bill, and to our local legislators, stating reasons why the C.M.C.A. opposed the bill and expressing appreciation for what assistance they could give toward defeating this particular legislation. Much credit is to be given the combined efforts of the Trustee Corporate Board, mosquito abatement districts and their local representatives for their success in persuading the author, Assemblyman John Stull, to withdraw the bill.

Now we would like to introduce the members of the 1967 Trustee Corporate Board; Harold Jolliff, alternate for the Northern San Joaquin Valley Region; Marion Bew, Sacramento Valley Region, Harold Olson, alternate; Arthur Breed, Coastal Region, Thomas Ryan, alternate; Jack W. Chezick, South San Joaquin Valley Region, alternate, I. R. Machado; Wm. S. Brown, Southern California Region, alternate, Jay Price.

There is one more duty as Chairman of last year's Board that I should perform. I would like to give you the names of the representatives of each region for 1968. Northern San Joaquin Valley Region, Harold Jolliff, alternate, Winfield Montgomery; Sacramento Valley Region, C. Wesley York, alternate, Harold Olson; Coastal Region, Arthur H. Breed, Jr., alternate, Thomas F. Ryan; South San Joaquin Valley Region, Jack W. Chezick, alternate, I. R. Machado; Southern California Region, Wm. S. Brown, alternate, Paul Larsen.

According to the by-laws the 1968 Trustee Corporate Board has selected a Chairman and Vice-Chairman for the ensuing year:

Wm. S. Brown, Trustee Corporate Board Chairman, and

Jack Chezick, Trustee Corporate Board Vice-Chairman

Thank you, ladies and gentlemen, for giving me the opportunity to serve you this past year.

THE TRUSTEE AND CONFLICT OF INTEREST

JAMES A. NICKLIN, *City Attorney*

Cities of El Monte and South El Monte

At the very outset let me point out that my knowledge of mosquitoes and mosquito abatement is extremely limited. All I know about mosquitoes is that the critters don't like me, and the feeling is mutual, and my knowledge about their abatement is limited to the use of a flyswatter and the aerosol spray can. However, I have had a little experience with public agencies, and all public agencies that have the power to tax, to contract, or to spend money, have at least one thing in common, namely, the inevitable possibility of conflict of interest in some of their business dealings. Accordingly, your President-Elect asked me to talk to you on the universally known, completely understood and entirely uncontroversial subject of conflict of interest on the part of public officials generally.

All of which is something like being asked to talk about sex. Everyone has heard about it; most everyone engages in it according to his desires, capabilities and opportunities; everyone's knowledge of the subject is derived more from personal experience than from formal education; nearly everyone thinks his own idea on the subject is the correct one and that everybody who differs therefrom must be just a little abnormal; most everyone thinks that if enough people engage in a certain course of conduct, it must be right; all too many think that rules of conduct on the subject are necessary, but only for others who need guidance on the subject; and lastly, there seems to be a certain element of pleasure in cheating just a little bit, so long as you don't get caught. Apply each of these statements to the assigned topic and you will readily see the analogy.

Perhaps some of you have had much material on this subject forcibly or voluntarily injected into your systems. Apparently the vaccine is of short duration and the preventive treatment must be repeated at frequent intervals. I use the term "preventive treatment" advisedly, because in each instance the situation is somewhat like rabies and the treatment therefor. If you are bitten by a dog and you cannot capture the animal to test it for rabies, you had better start the Pasteur treatment without delay, for your days are numbered, few and horrible if you postpone the Pasteur treatment until the evidence of rabies appears in your system. Similarly, it is impossible to undo a mistake in the area I am about to discuss after the mistake has been discovered, and belated attempts to cover one's tracks will usually make the trail all the more easy to follow.

The statutory law concerning prohibited interest of public officers generally, may be found in the California Government Code, Title 1, Division 4, Chapter 1, Article 4, entitled PROHIBITIONS APPLICABLE TO SPECIFIED OFFICERS. Do not, however, be misled by the apparent simplicity or clarity with which the Legislature has set down the basic law and the exceptions thereto. You would do much better to keep in mind that the basic rule on conflict of interest was not only a well-defined common law doctrine, but is traceable even to the Bible wherein it is said: "No man can serve two masters, for either he will hate the one and love the other; or else he will hold to the one and despise the other." (Matthew 6:24; Luke 16:13).

So far as you district trustees are concerned, Section 1090 of the Government Code states that members of a special district shall not be financially interested in any contract made by them in their official capacity, or by any body or board of which they are members. This sounds simple enough, but the courts have not treated the matter so lightly. The older cases would scare you to death, for the courts have taken a consistent position in finding a prohibited conflict of interest to exist wherever it can find a trace of it. If you were to read only the older cases on the subject, most of you would promptly tender your resignation—unless you committed hara-kiri first—for the old case law was strict and harsh. A few examples will suffice to illustrate the point. Most of the reported cases and opinions on the subject deal with city councils, supervisors and school boards, and only a lesser number refer to special districts of one kind or another. However, the principles apply universally, and this is true even though there are additional statutes that deal particularly with cities and schools.

For example, in Stockton Plumbing and Supply Company vs. Wheeler (68 Cal. App. 592; 229 P. 1020) the Court invalidated a contract for plumbing, heating and ventilating work in a memorial civic auditorium for the sole reason that one of the councilmen was employed by the low bidder as a sheet metal foreman. The councilman was a member of the "building committee" of the city council, which committee supervised a revision of the plans for said auditorium building, but he was not present at the meeting of the council at which the contract was awarded. In Hobbs, Wall and Company vs. Moran (109 Cal. App. 316; 293 P. 145) a councilman of Crescent City was employed on a salary as manager of a mercantile business from which the city bought supplies; he was not a stockholder and had no direct pecuniary interest in the company. The District Court of Appeal held that the purchase of supplies from such a company was illegal. In Miller vs. City of Martinez (28 Cal. App. 2d 364; 82 P.2d 519) the Court invalidated a city agreement for purchase of its gasoline supplies from Shell Oil Company because one of the councilmen was the manager of Shell Oil Company's Martinez office. In Berka vs. Woodward (125 Cal. 119; 57 P. 777) (June 17, 1899) the Supreme Court upheld rejection of a claim against the city for lumber and materials received by the City of Santa Rosa from one of its councilmen. In Moody vs. Shuffleton (203 Cal. 100) the Supreme Court voided a printing contract by the county when one of the supervisors held a chattel mortgage on the printing plant.

And just in case you think the foregoing cases all have moss on them by reason of their age, let's take a look at Stigall vs. City of Taft (25 Cal. Rep. 441), decided by the California Supreme Court on October 23, 1962. In this case the court invalidated an award of a contract in a situation where a former councilman owned three percent of the shares of a corporate sub-bidder of the low bidder on a civic center project. The councilman in question had been a councilman and a member of the building committee for several years. While he was still councilman, bids were received and the councilman's company was the low bidder for the plumbing work. Upon objection being made, the Council rejected all bids and re-advertised for new bids, which were received and opened on June 5, 1961. At the June 8 meeting, the councilman in question resigned and the Council awarded the contract to the lowest bidder, the Bakersfield Construction Company, which said contract included the sub-bid by the Taft Plumbing Company, Inc. for the plumbing work. The former councilman owned three percent of the stock of the Taft Plumbing Company, the sub-bidder. Keep in mind the former councilman's company was not the prime contractor but only a sub-bidder of the successful prime contractor. Likewise the former councilman owned only three percent of the sub-bidder company's stock. The Supreme Court stated in part: "The legislation with which we are here concerned seeks to prohibit a situation wherein a man purports to deal at arm's length with himself and any construction which condones such activity is to be avoided . . . We are persuaded, if not compelled, to reject in the case at bar the narrow and technical interpretation of the word "made" and construe its statutory meaning to encompass the planning, preliminary discussions, compromises, drawing of plans and specifications and solicitation of bids, in all of which Councilman Black participated and which here were, in the broad sense, embodied in the making of the contract." Again this is an area where it doesn't pay to play with fire.

Doubtless the great number of restrictive decisions and opinions led the Legislature to enact some of the exceptions to the statutory rule and the harsh pronouncements of the courts thereon. I refer you to sections 1091, 1091.1 and 101.5 of the Government Code for the details of the exceptions. "Remote Interests" are excepted, and are briefly defined as employment of a board member by a contracting party under specified and very limited conditions, the relationship of parent and minor child, landlord and tenant or attorney and client, and ownership of three percent of a corporation's stock where the board member's total income from such corporation does not exceed five percent of his total annual income.

Of particular importance is Section 1120 of the Government Code which was just added in 1967. It reads as follows:

"1120. Disclosure

Members of governing bodies, boards and commissions of any local public agency shall disclose any direct personal financial interest other than proscribed by Articles 4 and 4.5 in any matter coming before such governing body, board or commission of any local public agency who knowingly fails to disclose such interest shall be guilty of misconduct in office."

The subtlety of this Section lies in the fact that although certain interests are not prohibited, they must nevertheless be disclosed by reason of Section 1120. The verb "to proscribe" is defined by Webster as meaning "to interdict" or "to prohibit". Accordingly, although an interest may not be prohibited, it must nevertheless be disclosed, and a failure to do so constitutes misconduct in office. The term "direct personal financial interest" is not defined and accordingly it must be taken to mean precisely what it says. In case an official has the slightest doubt, he had better disclose whatever interests he may have and not rely too heavily on the three words "direct", "personal" and "financial".

The Section likewise does not state when the disclosure should be made, nor even how it should be made. It certainly must be disclosed publicly, and must be disclosed at or prior to the time that the matter in question officially comes before the governing body, board or commission of which the person is a member. The individual involved should make certain that the disclosure is reflected accurately and completely in the official minutes of the official body of which he is a member. To insure such accuracy and completeness, he would do well to file with the Clerk or Secretary of such body a dated statement, signed by him, setting forth the full particulars, and requesting that the statement be made a part of the official records and minutes of the body. An added precaution would be to request the Clerk or Secretary of such body to acknowledge receipt of the statement by endorsing a copy thereof, showing the date it was received by such clerk or secretary.

Your special attention is directed to the provisions of Section 1091 which states that the remote interest exception "shall not be applicable to any officer interested in a contract who influences or attempts to influence another member of the body or board of which he is a member to enter into the contract". Accordingly, if you have even a permitted interest in a matter that comes before your board, you must make a full disclosure of that interest and then keep your mouth shut. Your arguing for a matter even at the board meeting can be construed as an attempt to influence another member of the board to enter into the contract, and this is what is specifically prohibited. Furthermore, the vote of the member with even a permitted interest in the matter cannot be counted, because the board must, *after* the full disclosure, approve or ratify the contract in good faith by a vote of its membership sufficient for the purpose without counting the vote of the member with the remote interest.

It must be borne in mind, however, that it is difficult if not impossible to achieve morality or intellectual honesty by legislative fiat. Accordingly, the courts are very scrupulous in ferreting out any technical evasion of the statutory law and of the legislative intent, and will seek and usually find an appropriate remedy whenever corruption, dishonest or reprehensible conduct is shown or even suspected. The courts have in fact been much more sensitive on the subject than has the Legislature.

Most of the reported cases and opinions deal with the purely civil aspects of conflict of interest, wherein the award of the contract is set aside, payment of the amount otherwise due is enjoined, a person is restrained from further contracting and the like. Decisions of this kind probably won't jar you very much so let us try on a criminal case for size. Sometime take a look at People vs. Darby (114 Cal. App. 2d 412, 250 P2d 743) (November 26, 1952) (appeal dismissed in 73 SCt 833) wherein a school board member was indicted and convicted of having an unlawful interest in a contract executed by the school board of which he was a member. Darby owned a vacant store in Los Angeles and with a little pursuasion rented it to an ice cream vendor. He then pulled strings to get himself appointed as chairman of the purchasing committee of the school board and thereafter the board awarded a contract for the purchase of ice cream for the schools to the low bidder. You guessed it—the low bidder was the tenant of Darby. This case went all the way to the Supreme Court of the United States but Darby remained convicted.

Lest you still get too complacent, take a look at Section 1097 of the Government Code which punishes an officer with a prohibited interest in a contract by a fine of $1,000.00, imprisonment in the state prison for not more than 5 years, ***and perpetual disqualification from holding any public office in the state.*** This kind of language should get your attention real quick.

There are other sections scattered throughout the State Codes that deal directly or indirectly with this subject, and this paper does not purport to totally exhaust the subject. Take for example Section 70 of the Penal Code which states:

"70. EMOLUMENTS, GRATUITIES, OR REWARDS; EXECUTIVE OR MINISTERIAL OFFICERS, EMPLOYEES, OR APPOINTEES; ASKING OR RECEIVING. Every executive or ministerial officer, employee or appointee of the State of California, county or city therein or political subdivision thereof, who knowingly asks, receives or agrees to receive any emolument, gratuity or reward, or any promise thereof excepting such as may be authorized by law for doing an official act, is guilty of a misdemeanor."

Though violation of this section is only a misdemeanor, keep in mind that under Section 182 of the Penal Code it is a felony to conspire to commit a mere misdemeanor.

Statutes and cases like the ones herein discussed make it imperative that you fully and honestly disclose to the attorney that represents you in your official capacity whatever indirect business connections you might have in any contractual matter that might come before you. No one can properly advise you unless there is a full disclosure of your relationship to a given business operation, irrespective of how remote that connection might be. The thing that makes the law really tough is the fact that moral innocence alone is not enough. If an official has an interest that is in fact prohibited by law, it matters little that his conscience is clear.

At the Mayors' and Councilmen's Institute held in Monterey during May of 1966, Richard Carpenter, Executive Director and General Counsel of the League of California Cities, gave an excellent and very detailed paper on the subject of conflicts of interest. Though this address was directed primarily to mayors and councilmen, the principles therein announced, particularly by the courts, apply equally to all of you. Mr. Carpenter's paper is recommended reading for those of you who either need more convincing or who like to read gruesome stories just before going to sleep.

You may wonder why attorneys in the field of public law get gray hair. Perhaps the foregoing will give you the answer. But with all of the strength at my command I urge that you actively seek and conscientiously follow the advice of competent counsel assigned to you, for he will be of immeasurable help in keeping you out of a legal trap from which there is no escape. Once you have taken official action, your conduct is thereafter branded as having been either right or wrong, and nothing you can do thereafter can change the nature of a previous act. If you must make a mistake, for your own sake make it on the conservative side. This is no place to practice "Brinkmanship".

Thus far I have spoken only of the civil and criminal aspects of the conflict of interest on the part of public officials. To me there is another aspect much more important than the hide of the individual offender, and that is the tarnishing of the image of public officials. At least those of you who are from the south of the State have been reading and hearing about the indictments handed down by the Los Angeles County Grand Jury in connection with the award of a contract for a trade center building at the Los Angeles Harbor. It is unfortunate that there were sufficient facts to warrant the handing down of these indictments. It will be even more unfortunate if the facts as ultimately proven sustain a conviction. I do not mean that the defendants should go free if they are in fact guilty, because the worst punishment that can be meted out under the law is not drastic enough for the deliberate breach of the public trust for purely private gain. It will be unfortunate because the image of public officialdom will again be smeared, and all of us public officials have to wash some of the egg off of our faces every time some other public official makes the headlines in an uncomplimentary way. In this day of mounting taxes and questionable expenditures of public funds, Mr. John Q. Voter is getting more and more suspicious and more and more disenchanted with the conduct of public business and the persons conducting it. All of this must be a great pleasure to our enemies both abroad and within.

I submit to you that it is not enough just to be technically right. The law now exempts from prohibited interests contracts between a public board and the minor son of a board member. It likewise exempts contracts between a public board and the attorney for a member thereof, and likewise exempts contracts between a board and a tenant of a board member, somewhat like the situation in the Darby case above referred to. Do you think for one minute that the public is going to be satisfied when you raise the taxes in one of your special districts and then award a very lucrative contract to a firm that pays a handsome rent on its place of business to a member of your board, when that business is represented by an attorney who is the personal attorney for one of the board members, when two of the minor children of such board member hold well-paying but utterly worthless positions with that company, and when such board member's wife and brother-in-law own all of the stock in such a company? Do you think that just a public disclosure is going to make that situation smell like a bed of roses rather than skunk cabbage just because it is technically lawful? I don't think so.

Is the almighty dollar so damned important that one has to jeopardize the reputation and happiness and political life of every member of his board—and of public officials generally—just to favor some person for such reasons as family relationships, lodge affiliations, church connections, political ambition or otherwise? If the answer is other than an immediate and unqualified "NO", then a person is not worthy of public office. One pays a pretty price to hold public office. Over and above the daily subjection to unbridled and unfair but usually privileged criticism is the almost daily necessity of sacrificing personal convenience and suffering financial loss. The overwhelming majority of public officials make these sacrifices every day of their life, and I take my hat off to every one of you who serves the public properly in the light of the pronouncements that I have made. Your reward is not very tangible, but it is very valuable to those who serve with the right spirit, namely the inner knowledge that you have served your fellow man to the best of your ability, at great personal sacrifice and without thought or hope of personal or pecuniary gain. There can be no greater reward than that for those who deserve it.

In closing, I should perhaps remove the halo from my own profession and tell you the story about the attorney who was giving a witness a bad time on the witness stand. He shook his finger in the witness's face and said: "Now let me remind you that you are under oath to tell the truth, the whole truth and nothing but the truth. This I expect you to do, because you appear to be a reasonable man, a truthful person, a conscientious individual and a responsible citizen," to which the witness replied, "Thank you, Mr. Attorney. If I weren't under oath, I would return the compliment."

COOPERATIVE RESEARCH PROGRAM ON MOSQUITOES

PAT COHEN, *Trustee*

Coachella Valley Mosquito Abatement District

Gentlemen, you are trustees of mosquito abatement districts, and when you became trustees you assumed a great deal of responsibility. You are responsible for the health, safety and comfort of the people within your districts. If it were not for men like you, and your mosquito abatement districts there would be little, if any, progress and development in the State of California. Looking into the past, and forward into the future of California, we see a tremendous job ahead for mosquito abatement districts.

As the population increases it will be necessary for districts to achieve a much higher degree of control. There will also be requests and pressures from the public that other insect pests be controlled. As trustees your responsibility is to furnish the management and the personnel with sufficient money and equipment, and to set the general policy under which the district is to operate. If there is a disaster it will come back on the shoulders of the trustees.

One of the most important problems of concern to us is the insecticides with which mosquitoes and other insects are controlled. It is felt by most mosquito abatement personnel that a good insecticide will last approximately five years before tolerance or resistance makes it useless. Continuous research programs must be maintained to cope with problems. New insecticides are tested too, so they can be used under government and state regulations without danger to the public, wildlife and other beneficial life.

Some 12 years ago our district set up a working agreement with the University of California, granting the University funds to carry on research on the *Hippelates* eye gnats. They have done an utterly fantastic job with their research. It hurts to put out such large sums of money, but it is now beginning to pay off in that our chemical bill for control of the gnat has dropped approximately two-thirds. This type of arrangement for expanded research can be similarly put into effect by other districts. We feel that to be in a safe position the districts should contribute matching funds to the University research program through CMCA, to continue this research into many needed areas. Recently, Regents of the University of California told the farmers in the State of California that they may have to contribute funds for research on a matching basis—matching the budget the state puts up. Now as you know, a sum slightly over $100,000 is used for various efforts in mosquito research. This does seem like a large sum of money but we must remember this, that our District alone is giving to the University on the average of $16,000 to $26,000, along with supporting services, equipment, laboratory space that could amount to approximately $50,000. We feel that this can be counted towards the $100,000 as a matching fund, so that the districts in the State of California, of which there are some sixty, will need to put up only $50,000 toward the support of mosquito control research. Gentlemen, if you are going to stay in mosquito abatement successfully, as we have in the past, this must be done. Whatever agency we have through which to give the money is not particularly important so long as the University gets it to carry on research.

They have the greatest team of research men in the entire world. We have worked with them over these past years and I assure you that they have not in this time ever embarrassed the District or tried to tell us how it is to be run. They will ask what you need and try their level best to bring it out.

We are faced with a serious problem of resistance in mosquitoes to the larvicides we use. It is of the utmost importance that we work toward a solution to the resistance problem. Development of new compounds which will kill eggs, larvae, and pupae alike should be accelerated. Compounds of this type have already been tested but a lot of research is needed to put these materials and techniques in our hands. We are quite excited about these new developments. I think we should move forward on expanding research as rapidly as possible. I am sure we will all reap the benefits of such cooperative research programs.

PANEL: SOURCE REDUCTION POLICIES

Fred DeBenedetti, *Moderator*

Jack W. Chezick, *Trustee*

Madera County Mosquito Abatement District

The Madera County Mosquito Abatement District, as with so many other districts throughout the state, has a small operational budget. Our budget is $145,000. This leaves little funds available for the extensive and expensive mosquito source reduction work that is being carried on by larger and better financed districts. We know that mosquito source problems within the boundaries of our District are caused by improper water management, both rural and urban. These conditions exist in spite of many public agencies designed and established by federal and local government to assist all people with water problems. Not only do some of these agencies provide excellent technical engineering, but financial assistance as well.

You are all acquainted with the fine engineering service provided by the U.S.D.A.'s Soil Conservation Service, and funds they make available to farmers through their Agriculture Stabilization and Conservation A.C.P. incentive program. To aid in the distribution of this information, our trustees approved the printing of a brochure to be distributed directly to individual farmers by District personnel.

In order to coordinate the activities of agencies concerned with water use, our trustees several years ago assisted in the formation of a countywide Water Conservation Committee to aid in mosquito source reduction. A complete account of this activity was reported in "California Vector Views" by our manager, Gus Augustson. The prime outgrowth of this committee's action has been the continuous liaison between key personnel of participating agencies.

Recently another committee has been formed in Madera County that extends inter-agency cooperation. This, the Madera County Natural Resource Planning and Development Committee, includes not only agencies directly concerned with water use, but also city and county planning and recreation commissioners, Road Commissioner, Agriculture Commissioner, Health Department representatives, and city administrators. This greatly augments the original group of representatives from irrigation districts, Bureau of Reclamation, Soil Conservation Service, Agriculture and Stabilization and Conservation Service, Extension Service, and of course, our own Mosquito Abatement District personnel. The Board of Trustees of the Madera County Mosquito Abatement District feels that by continuous inter-agency cooperation many tax dollars can be saved as well as provide more complete service to taxpayers by all public agencies concerned with water use. The elected Chairman and Vice-Chairman of this group are M.A.D. trustees, so you see the MAD is important in our committee. This group has caused a review of the countywide drainage problem and our Board of Supervisors is now impressed with the problems and has authorized more study, with recommendations for drainage correction.

Recently inter-agency cooperative planning eliminated a serious mosquito breeding source in our District. An old creek used by the M.I.D. for limited water distribution had become overgrown with weeds and brush. Tail water from bordering farms frequently flowed into the creek. After reviewing the problem during one of our Board meetings, the management was instructed to carry out a planned program of clearing this creek bottom. The local Soil Conservation District supplied a track layer with dozer; the M.I.D. the operator; and our District the mapping, fuel, and maintenance of equipment. Approximately one and one-half miles of creek bottom were cleared at a cost of less than $100 from our District funds.

Low cost source reduction work can also be aided by constantly keeping our District residents aware of their important role in preventing creation of mosquito breeding sources. All news media are utilized to keep information concerning mosquitoes before our people. This includes direct lecturing by our Manager-Entomologist to service clubs, Farm Bureau centers, high schools, and the numerous schools of lower grade levels. These lectures are supplemented with slides of our District problems and movies supplied by the State Health Department.

In summation, it should be noted that working together has alerted all public agencies to the importance of early planning in new construction projects to prevent mosquito breeding sources. For example, the City of Madera officials screen all new applications and ask for our recommendations for building permits where extensive water use is involved. Also, new County subdivisions come under careful analysis by our management for the same purpose.

FRED A. COMPIANO
San Joaquin Mosquito Abatement District

I am pleased to have the opportunity to serve on this panel before the Trustee Session at this C.M.C.A. Conference. We have found that a list of policies has worked best in our District; i.e., "Source Reduction Policies and Regulations" as adopted and passed by the Board of Trustees in March, 1955, the year the District was organized.

The policy was written to provide guidance for the District in solving problems of man-made mosquito sources, and to make clear and legal the responsibility of the land owner in reducing or eliminating these sources.

Last year District personnel inspected 27,215 home areas and found 1,950 potential sources, making it necessary to issue 450 inspection reports, resulting in approximately 400 corrections. At the present time industrial waste and sewage total approximately 1,450 acres of pond water in our District. From 1955 to 1960 approximately 95% of the industrial and sanitary sewage were major mosquito sources. Through proper management of waste water and weed control procedures, mosquito production has been reduced and in most cases eliminated.

In the past it has been necessary to utilize the legal processes as provided by the Health and Safety Code in order to abate a nuisance when it appeared to be in the interest of the public. In several cases is was also necessary for agencies to consider the budgeting of money for control of mosquitoes and other insects in the event the responsible company or agent failed to cooperate after being given a reasonable length of time to make the necessary corrections. At the present time the District may resort to such action; however, every effort is made to solve these problems through education or other procedures.

Last year the District rented one dozer and cleared approximately 75 acres of river bottom and other low swales. In addition, where tide water created a mosquito source, structures were installed, and heavy equipment used to fill sloughs.

A large portion of San Joaquin County is under irrigation. Agriculture in San Joaquin County consists principally of row crops such as tomatoes, sugar beets, milo, corn and orchards, which are of little or no consequence in mosquito control. However, irrigated pastures and a certain percentage of alfalfa fields create a major problem due to impervious soils, lack of proper drainage and poor water management. Each year approximtely 900 agricultural sources are treated during the summer months. Last year source reduction personnel contacted over 450 property owners and requested their cooperation in reducing or eliminating such sources. In addition, each property owner received a written letter of cost pertaining to larviciding on their property where cost exceeded fifty dollars. Property owners are informed of District services available to them, such as engineering services, technical advice and legal information.

The San Joaquin Mosquito Abatement District has been instrumental in the formation of drainage districts by providing engineering and legal services. Last year it was necessary to survey 75 different agricultural sources in order to make recommendations for correction of mosquito sources. In compliance with District policy, two experimental drainage projects were completed in the past two years. One project containing 320 acres, and involving twelve different property owners, has been in operation for one year (1967), resulting in a reduction of 95% of standing water. Another, containing 420 acres, was completed in the fall of 1967, but will not be in operation until spring, 1968.

In summary, the policy adopted by the San Joaquin Mosquito Abatement District has been helpful in approaching source reduction problems, such as cooperative projects between property owners and the District. It also aids source reduction personnel on planning day-to-day activities.

The following is a resolution adopted by the Board of Trustees that pertains to the source reduction program for the San Joaquin Mosquito Abatement District.

STATEMENT OF SOURCE REDUCTION POLICIES

San Joaquin Mosquito Abatement District

A. The primary objective of the San Joaquin Mosquito Abatement District shall be the progressive elimination of mosquito breeding places. The objective will be accomplished by an educational service on control measures, performing services of temporary relief control, establishing projects of source reduction, using abatement procedure methods when necessary, and by a general policy of cooperation.

B. Stress will be given to cooperation with individuals and organizations to solve mutual problems involving mosquito breeding sources. Particular attention will be paid to water management, irrigation and drainage problems, and problems of household and industrial waste disposal.

C. Larviciding and adulticiding, which are temporary comfort control measures, will be carried on in the most efficient and economical manner possible insofar as available funds will permit.

D. In cases where cost of temporary control is prohibitive and when all means of eliminating the source fails, the District will take the necessary steps to abate the nuisance when such action appears to be in the public interest.

STATEMENT OF POLICY

WHEREAS, the San Joaquin Mosquito Abatement District, in carrying out its responsibility to reduce the mosquito population, has found that there exists many unnecessary sources of mosquitoes; and,

WHEREAS, the success of the District's operational program depends upon the cooperation of the property owners in eliminating and reducing such sources; or preventing the creation of breeding places of mosquitoes; and,

WHEREAS, the majority of the mosquito breeding places on private properties are man-made sources, which are a potential menace to the health and safety of this County, since such sources produce the mosquito vectors of malaria and encephalitis; and,

WHEREAS, the Health and Safety Code, Division 3, Chapter 5, Section 2271, specifies that any source of mosquitoes which comes from the use of the land is a public nuisance, thereby places upon the owner direct responsibility for the elimination or correction of such mosquito source, now, therefore, BE IT RESOLVED, that the Board of Trustees of the San Joaquin Mosquito Abatement District wishes to advise all owners of the responsibility to abate mosquito sources on their properties, and recommends that all practicable steps be taken to eliminate these mosquito breeding sources wherever they may exist; and,

BE IT FURTHER RESOLVED, that written notification be sent to all owners of properties upon which the San Joaquin Mosquito Abatement has performed extensive and costly mosquito control measures during the past, together with an invitation to discuss with the representatives of this District the ways and means of accomplishing correction measures.

Source Reduction Regulations

For the purpose of clarification, source reduction regulations are divided into the following classifications:

A. Natural Sources:

As defined, means any rain pools, seepage areas, flood waters, natural depressions holding water, or any breeding places of mosquitoes on land which is in its natural condition.

The District may assume the financial responsibility when it is economically justified, in reducing or eliminating natural mosquito sources when such conditions are adversely affecting the control program. Power equipment may be hired or rented for brush clearing, constructing ditches, and filling in natural depressions. The approval of the Board of Trustees will be necessary for any projects when the cost of renting such equipment or supplies exceeds $500.00 on any one project in any one year.

B. Industrial Sources:

As defined, means any liquid waste pond, sewage disposal system liquid waste from food processing plants, or any other industrial waste material causing mosquito breeding sources. The District may assume the mosquito control cost of such industrial sources, providing such facilities are designed, operated or maintained in such a manner as to keep mosquito breeding at a minimum. Where such industrial sources are not operated to minimize mosquito production, the District shall advise such Company or Agency and request their financial assistance in a cooperative mosquito control project. Should the responsible Company or Agent fail to cooperate after being given a reasonable length of time to make the necessary corrections, the Board of Trustees may utilize the legal processes as provided by the Health and Safety Code to compel same.

C. Residential Sources:

As defined, means household drains, leaky faucets, faulty septic tanks, ornamental ponds, fish ponds, drains from evaporative cooler, unused swimming pools containing stagnant water, artificial water containers, or any other condition around the home where water is standing. The District will require the correction of all residential sources and will allow a reasonable length of time for these corrections. The District will cooperate with the San Joaquin Local Health District in requiring correction of illegal septic tank systems or any other conditions contrary to State laws and local ordinances.

D. Agricultural Sources:

As defined, means any agricultural irrigation waters which stand on land a sufficient length of time to produce mosquitoes. The District may assist financially when it is economically justified, in reducing or eliminating agricultural mosquito sources. The Board of Trustees shall review all source reduction projects and authorization will be required for expenditures of District funds when the cost exceeds $100.00 on the land of any one land owner in any one year. If the District shares in the cost of a source reduction project, the land owners shall assume the responsibility for yearly up-keep and maintenance of such project. Further, the District may require a written agreement with the land owner, spelling out the terms of the work as described, before any District expenditure is made on the project. The District may furnish engineering services, technical advice and legal information to successfully make correction of existing problems. District personnel may be used on private property to construct ditches, remove vegetation, or any other type of work necessary to reduce or eliminate mosquito sources.

William S. Brown, *Trustee*
Orange County Mosquito Abatement District

The Orange County Mosquito Abatement District basically is not an agricultural area, but one that is urban; we have 25 cities. Our problems, therefore, are appreciably different from those of districts in the Central Valley.

In practice we are not as harsh as it may sound from the statements which follow. The program is carried on by the District's manager and staff. They use a soft-sell, public relations approach with a huge stick behind them in the Health and Safety Code. Only in one case since the formation of the District have we come close to using the legal notification, and that proved to be a matter of failure in communications. Once the proper people were notified, the matter was resolved without resort to legal provisions.

The property owner responsibility clause and theme have worked exceptionally well in our area. We are fortunate in that we are a growing community and we are in on the very beginning of the preparation of the land, from natural to the forthcoming unnatural conditions. We are there early with the information that is necessary to prevent sources from occurring.

Here are the policies which our District has adopted.

Statement of Source Reduction Policies
Orange County Mosquito Abatement District

Definition of Source Reduction

The interpretation of the term "source reduction" is not limited to the physical act of reducing in size or eliminating a body of water, large or small, by the conventional methods of filling or draining. Source reduction methods in Orange County include any effort or act that will aid in the reduction or elimination of adult mosquito production from any body or container of water that is conducive to the breeding of mosquitoes.

These source reduction methods include the following practices by the person or agency responsible for the prevention of mosquito production.

1. Physical control by design and construction of new facilities and by draining or filling of existing facilities.
2. Biological control by use of mosquito fish.
3. Operational control by management and maintenance of agricultural irrigation and waste water disposal facilities in combination with weed control.
4. Chemical control by use of mosquito larvicides.

Summary of Basic Policy

"Property Owner Responsibility" is the term that best describes the source reduction policy adopted by the Orange County Mosquito Abatement District Board of Trustees. The District expects the legal owner of the property (2), including all public agencies (3), (4) and (7), to prevent mosquito production as the result of his operation or use of the land. The District does not charge the property owner for services rendered. The District does, however, furnish certain services free of charge, such as technical information, mosquito fish and emergency larviciding and adulticiding required to prevent a public nuisance resulting from an operational failure by the property owner. The District does furnish routine larviciding services to those public agencies (4) which operate street drainage and flood control facilities that are constructed and maintained according to good engineering practice. Legal abatement procedures are instigated when the property owner ignores his responsibility (5). Legal enforcement has never been required since a formal letter or an appearance before the Board has satisfied the property owner that the Board's source reduction policy is both necessary and equitable.

Authority For Policy

The laws relating to Mosquito Abatement Districts and Mosquito Control are included within Division 3, Chapter 5 and 5.5, Sections 2200-2426 inclusive of the California Health and Safety Code (1). The District powers are listed under Article 4. The specific powers which delegate to the Board of Trustees the authority to abate a nuisance are quoted below:

Extermination of Mosquitoes & Abatement of Sources

Section 2270. The District Board may:

(a) Take all necessary or proper steps for the *extermination of mosquitoes,* flies, or other insects either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other insects from such territory migrate into the district.

(b) Subject to the paramount control of the county or city in which they exist, *abate* as nuisances, all stagnant pools of water and other *breeding places* for mosquitoes, flies, or other insects either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies or other insects from such territory migrate into the district.

Definition & Limitation of a Mosquito Breeding Nuisance

Section 2271. Any breeding place for mosquitoes which exists by reason of *any use* made of the land on which it is found or of *any artificial change* in its natural condition, is a public nuisance.

Notification of Record Owner to Abate Nuisance

Section 2274. Whenever a nuisance specified in this chapter exists upon any property either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other insects from such territory migrate into the district, the district board may in writing *notify the record owner,* or person in charge or in possession of the property, of the existence of the nuisance.

Section 2275. The notice shall direct that the owner shall, within a specified time, *abate* the nuisance by destroying the larvae or pupae that are present.

Section 2276. The notice shall further direct that the owner shall, within a specified time, perform any work that may be necessary to *prevent the recurrence* of breeding in the places specified in the notice.

Need for Policy & Subsequent Success

The source reduction policy referred to as "Property Owner Responsibility" was formally adopted by the Board of Trustees at their 92nd meeting, held September 17, 1954 (2). This policy was needed because the former policy of charging landowners for labor and materials did not result in source reduction or in the prevention of unnecessary mosquito breeding conditions. During the past 13 years, the property owner responsibility policy has been responsible for effective mosquito breeding prevention and control factors within the design, construction, operation and maintenance of major water use and disposal facilities as well as for the acceptance by the property owner, large or small, of his responsibility to prevent mosquito production on his property (8).

Policy Applied to Land in Natural Condition

Since a public nuisance is limited by Section 2271 to land that is being used or has been changed from its natural condition, the owner of land which has not been changed or used cannot be held responsible for the abatement of any mosquito breeding source that may exist thereon. Section 2270, however, permits the District to exterminate mosquitoes and to abate sources if it so desires.

The District's policy on land in its natural condition is to exterminate the mosquitoes as necessary by routine larviciding operations. Where practical, the District reduces or eliminates the mosquito breeding by planting fish, controlling weeds, providing access and by improving drainage through minor hand-dug ditches. The following types of natural conditions exist in Orange County:

1. Salt marsh
2. Land depressions which fill with storm water
3. Natural streams in the foothills
4. Ravines which receive community street and yard drainage

Policy Applied to Land in Unnatural Condition

The District holds the legal owner of the property, whether it be a public agency or a private person or corporation, to be primarily responsible for the prevention or abatement or control of any mosquito breeding source which exists by reason of any artificial change in its natural condition or by reason of any use made of the land on which it is found.

The District will work directly with the owner's designated representative; the lessor of the land; the occupant; or the person in charge of the operation, but the formal notification is addressed to the legal owner of the property.

The legal owner is advised of his responsibility by the District Manager. Communication is accomplished by personal visit; by telephone; or by letter depending on the type and importance of the problem (7) & (8).

The communication makes the problem a matter of record and notifies the legal owner of his responsibilities and informs him of the services available to him from the District. The communication includes the following statements:

1. The existing or planned development has created or will create a public nuisance by the production of mos-

quitoes if the facility is not properly designed and constructed, or is not properly operated and maintained on a continuous basis.

2. The legal owner is responsible to abate the nuisance and to prevent its recurrence in accordance with the provisions of the California Health & Safety Code (Sections 2275 & 2276).
3. The District will provide technical information on mosquitoes and mosquito control methods which may be helpful to the owner in designing, constructing and operating the facility without creating unnecessary mosquito breeding conditions.
4. The District, as part of its District-wide mosquito abatement program, will provide the following services as needed by the legal owner:
   (a) furnish and deliver whatever quantity of mosquito fish are necessary for adequate control within suitable ponds and holding reservoirs;
   (b) maintain surveillance of all potential mosquito breeding sources and inform the responsible party of any breeding that requires control to prevent a public nuisance;
   (c) furnish information and training on routine mosquito control methods to the person in charge of the facilities;
   (d) furnish emergency mosquito control services, using the District's special spraying equipment and mosquito larvicides, to prevent a public nuisance whenever mosquito breeding conditions are created by operational failures.

Policy Applied to Land Owned & Operated by Public Agencies

The District's policy of "Property Owner's Responsibility", as outlined above, is applied to all public agencies, the most important being the agencies which operate the following types of facilities:

1. Sewage treatment and disposal
2. Recreational parks and schools
3. Underground water replenishment
4. Domestic or irrigation water reservoirs and facilities
5. Military establishments

Public agencies which operate community drainage systems and flood control works are exempted from the responsibility of controlling mosquito production from breeding sources that cannot be prevented by good engineering design and construction and by good engineering maintenance and operation (4). In Orange County, these agencies include the following:

1. Twenty four municipalities
2. County of Orange Road Department
3. State Division of Highways
4. Orange County Flood Control District
5. Corps of Engineers, U. S. Army (three dams)

The District provides and carries out a routine mosquito larviciding program in all drainage and flood control facilities as needed throughout the year.

List of References Concerning Source Reduction Policy Formation

(1) Laws Relating to Mosquito Abatement Districts and Mosquito Control. Excerpt from the California Health and Safety Code, 1963.
(2) Private Property Owner Responsibility. Excerpts of the Minutes of the Board of Trustees from September 17, 1954 through March 4, 1955 in connection with the Irvine Company. (See Trustee's Reference Manual)
(3) Public Agency Responsibility. Excerpts of the Minutes of the Board of Trustees from March 18, 1955 through April 14, 1955 in connection with the Orange County Water District. (See Trustee's Reference Manual)
(4) Public Agency Responsibility. Excerpts of the Minutes of the Board of Trustees from September 21, 1956 through February 1, 1957 in connection with the Orange County Flood Control District. (See Trustee's Reference Manual)
(5) Legal Approach to Mosquito Control in Orange County by Jack H. Kimball. Proceedings and Papers, California Mosquito Control Association, 1956.
(6) An Educational Approach to Mosquito Abatement Via School Curriculum by Jack H. Kimball. Proceedings and Papers, California Mosquito Control Association, 1959.
(7) Integration of Sewage Disposal and Mosquito Control in Orange County, California by Jack H. Kimball. California Vector Views, February, 1965.
(8) Vector Control in Orange County by Jack H. Kimball. Pest Control Magazine, July, August and September, 1965.

Abel P. Machado, *Trustee*
Merced County Mosquito Abatement District

The Source Reduction program in the Merced County Mosquito Abatement District began in 1948. Month after month, and year after year, we reviewed the progress of this program. At one time we had 3 drag lines. We observed in the reports that we were repeating on some of the land owners. Instead of going into new areas, we found that after a couple of years we were back to clean the ditches we had constructed earlier. We were not moving forward, we seemed to be providing a continuing personal service, and we wondered if we were following a proper set of policies.

Recently we invited a mosquito control specialist of the Bureau of Vector Control, Richard Husbands, to make a survey of our Source Reduction program and to make recommendations for our future program. We were concerned about so much new land coming into production; we were concerned about new agricultural-related industries and the problems they were creating; we were concerned about drainage problems from the West Side Canal and the proposed West Side Drain. We needed to determine the objectives of our total mosquito control program. We wanted to plan for a source reduction program that would be practical and within the District's budget.

The Source Reduction program should be coordinated closely with the chemical control program. It should have as its goal a reduction in the cost of chemical control as well as improvement in efficiency in treating the sources. We saw that we needed a better system of record keeping, so that we could measure the results of our Source Reduction program. We needed expert technical knowledge. We needed coordination of all aspects of the program, so that everybody could work together. Interagency cooperation needed to be developed. When we studied our cost records, we found that areas drained by ditching did not necessarily show a savings in chemical control. The "in field" mosquito source was not necessarily reduced by the tail end drain. Priorities needed to be assigned to construction jobs.

We developed a number of recommendations for our program. Source Reduction should be considered as an essential part of mosquito control and should be supported by an active program. A new statement of policy should be developed. An adequate staff should be hired to conduct the operation. A record-keeping system should be developed that relates mosquito sources with the needs for reduction or elimination. It should specifically show the amount of reduction made in an area requiring insecticide treatment. Further, it should show priorities for jobs, and every effort should be made to solve high priority jobs first. Reports of progress should be made at regular intervals to the Board of Trustees. These reports should show dollar savings, whether accomplished by direct or indirect methods. New concepts should be explored and should be designed to meet the needs of Source Reduction as well as chemical control.

We are hoping an educational program directed towards the land owners and the water users will help us eliminate or reduce many sources. We plan to increase our contacts with other governmental or private agencies, with Irrigation Districts, Soil Conservation Districts, etc., and to promote activities that will prevent mosquito breeding sites. We plan to provide consultation and technical assistance to farmers and others engaged in water management. We will provide the schools with educational materials, stressing mosquito biology and control. We will provide study kits, live materials, films, personal appearances, etc.

Since mosquito prevention is a function of all district personnel, inservice training concerning land and water management and information on specific problems will be made available to all employees. Mosquito prevention information will be disseminated in newspaper articles, local bulletins, and other available publications.

An accurate and meaningful record-keeping system must be maintained to provide the Board of Trustees with regular progress reports. Why does the policy Board want reports on operational matters? We need to assure that all phases of the District's program will be available for analysis by the Manager and the Board.

We believe the Source Reduction program at all times must be directed towards the prevention of mosquito breeding, with the resultant enhancement of public health, economic status, and personal comfort of the people of Merced County. In conducting this program, we will make every effort to prevent any damage to the wildlife and other natural resources in Merced County. We have a lot of wildlife in Merced County—one of the largest duck club acreages of any county in California—and we must work closely with the naturalists. We very seldom spray any of our duck clubs if we can avoid it. Only when they are too close to one of our cities will we spray them.

We hope, with these policies, that we will get the people to be concerned about our problems and to help us prevent mosquito sources. If we can achieve this, we will have met with success.

W. Donald Murray

Delta Mosquito Abatement District

Source Reduction (S.R.) is a fully accepted term by mosquito abatement districts, and the principle of S.R. for the benefit of mosquito control is an acknowledged fact. Boards of trustees of mosquito abatement districts have the responsibility of establishing policies for their respective districts. Management and staff have the responsibility of determining what measures are needed for the operational and technical phases of an agency's program, and of assisting and guiding the Board in the framing of proper policies.

When a mosquito abatement district decides to initiate a formal S.R. program, it may have some preconceived concepts of what this program should accomplish. After several years of development of the program, a review by the management and the Board may reveal that some of the preconceived concepts were quite erroneous, and that some of the original goals were incapable of fulfillment. Boards and staff must be able to accept revised concepts and to maintain a flexible approach to the S.R. program, because a rigid attitude may result in an unfair appraisal of its value. It is especially important that reviews of the S.R. program be undertaken during periods of relative calm. Such reviews should be avoided during periods of heavy mosquito populations, extreme resistance problems, situations of gross water mismanagement, etc., because the best of intentions may be ignored in the heat of looking for an immediate solution to a frustrating problem.

The Delta Mosquito Abatement District (Delta MAD) is located in an area of diversified agriculture, with no large cities or large industries. Irrigated pastures are a dominant crop, grown for the benefit of beef cattle, dairy heifers and dry cows. Roughly eighty percent of the district's expenditures are for inspections and control of mosquitoes in irrigated pastures. The experiences of the Delta MAD may illustrate the reactions of this district to some of the concepts originally promulgated by this or other agencies or persons.

Preconceived Concept 1: "The S.R. program should set up a priority schedule, concentrating on the biggest and most important mosquito problems first."

Result: This did not work. Had the Delta MAD held to this concept, it either would have given up its S.R. program completely or it would have been unable to retain its S.R. engineer. Working with the worst farmers accomplished little. It proved much more fruitful to work with better farmers, and to establish the S.R. jobs done for them as examples for everyone to see. Poor farmers are indeed frustrating, but the economic squeeze on them will eliminate many of them and their mosquito problems in due time.

The Delta MAD has done considerable work on irrigated pastures and their drainage, with varying results. No appreciable breakthrough has occurred in reducing the acreage of pastures treated for control of the pasture mosquito. The original concept of priority based on severity of the problem had to be abandoned.

Preconceived Concept 2: "Farmers produce mosquitoes because they are careless and ignorant. They can be compelled by law to stop wasting water and raising mosquitoes."

Result: This was a concept of several districts in California a number of years ago. Many years ago the Delta MAD determined that a program of law enforcement was incompatible with a professional S.R. program. Only a couple of flagrant cases have been handled by this district during the fifteen years of its S.R. program. Farmers are, to a large extent, individualists, but they have been very cooperative in their relations with the Delta MAD, insofar as they were capable. Farmers as a group are in a state of stress in today's society. The wielding of legal powers against them is not believed to be a wise policy by the Delta MAD Board and staff.

Preconceived Concept 3: "Farmers can be encouraged by repeated contacts by S.R. personnel, or by money grants, to stop raising mosquitoes."

Result: Early in this district's S.R. program, numerous routine contacts were made with individual mosquito-producing farmers. Results were not satisfying—generally these contacts failed to bring about a significant change in the farmer's basic attitudes or practices. Rather than making contacts based on severity of the mosquito problem or other priority factors, this district has worked most effectively by contacting farmers who were ready for a change in their irrigation management. Very frequently, these farmers approached the district for assistance.

Several districts have paid farmers to undertake projects which might be classed as S.R. The Delta MAD has worked closely with the county Agricultural Stabilization and Conservation Office, which agency has assisted farmers in pipeline and return flow installations, projects of unquestioned conservation value. However, this district has not believed that cash payments to farmers by mosquito abatement districts was technically sound. In fact, all equipment work by this district on private property requires the farmer to pay the district for the use of the equipment. It may be noted that the Delta MAD equipment has a continuing backlog of jobs to be done, indicating that the farmers are willing to pay for work they understand and believe in.

Preconceived Concept 4: "A source reduction program will result in a gradual reduction of control costs."

Result: Mosquito abatement districts have adopted the term "Source Reduction" for this program, not "Source Elimination". In some cases a source may be eliminated and all costs stopped. There are certain circumstances, however, in which costs are not reduced but mosquito control is greatly benefited. For example, in the Delta MAD before S.R. dairy drains were the most important producers of the house mosquito, *Culex quinquefasciatus*. Many of these drains were weedy swamps, and were so inaccessible that they were not treated at all. The S.R. program assisted in cleaning up almost all the bad drains by constructing well-defined reservoirs with easy access to the mosquito control equipment. The water was not eliminated, but it was confined. It still needed to be sprayed. Today, the district operators can cover all these drains, achieving essentially perfect control of mosquitoes in them. Costs for control have not been reduced, because the water is still there to be sprayed, but the mosquitoes have been virtually eliminated from this type of source, thanks to S.R.

Preconceived Concept 5: "The mosquito abatement district does not need any of its own equipment, because the farmer, or an official agency, or private enterprise, have equipment which can be used."

Result: Comprehending the total management of water, especially including waste water, is a highly complex matter. The Delta MAD has observed private enterprise moving into a few jobs of the type done by this district, and almost invariably the work was inadequate. On at least a few of these jobs this district has been invited to finish the work properly. The adage "if you want something done right, do it yourself" has proven to be very appropriate to this district. This district floundered in its Source Reduction program until it took the step to obtain its own specialized heavy equipment.

Preconceived Concept 6; "An area-wide drainage program is essential to S.R."

Result: Area-wide drainage may be essential for ground salt control, but it is of no major value to mosquito control, at least not in the Delta MAD. There have been several efforts to encourage the Delta MAD to spend time and effort on area-wide drains, but all such efforts have been rejected. The major source of mosquitoes for this district is the irrigated pasture. An area-wide drain, or even a field drain in many cases, will not remove excess water from a pasture before a hatch of mosquitoes has occurred—it takes only 4 days for this to happen.

For effective mosquito control, it may not be necessary to get rid of water, or to drain it away from the area. Rather, there must be sound water management based on ecological principles which may render potential sources unavailable to mosquitoes even though water may be present.

Preconceived Concept 7: "An agency initiating a source reduction program needs to write down a detailed list of policies."

Result: The Board and staff of the Delta MAD have rejected the thought that lengthy, detailed policies were essential for the guidance of or for the protection of its S.R. program. This district has established a broad framework in which management and staff may operate with appreciable discretionary latitude. Every job with which this district becomes involved is a separate, new situation which requires independent analysis. Detailed policies may restrict unwisely the ability of a trained S.R. man to accomplish a needed job. The S.R. engineer knows that his decisions may come up for review, so he exercises discretion at all times. Above all, the S.R. engineer must have the right to say "yes" or "no" and be supported by the management and the Board. The Delta MAD has two basic S.R. policies:

1. The area in which work is to be done must be an actual or a potential mosquito problem.

2. The work to be done must be reasonably economical and effective.

The S.R. program of the Delta MAD has been extremely effective and worthwhile. It has constructed thirty-nine dairy drains, almost half the total of dairies in the district, and has influenced a considerable number of others so that mosquito control in this type of source is effectively accomplished. It has constructed ninety return flow systems and has influenced the construction of many more. While these have not brought about a major reduction in the control cost of the pasture mosquito, they have confined many water areas and they have eliminated many long-standing water areas which produced the encephalitis mosquito, *Culex tarsalis*. Mosquito fish are planted in the reservoirs themselves, eliminating the need to spray them.

A major benefit of the S.R. program has resulted from one area project which has included the construction of reservoirs, internal field drains, area-wide drains and related projects in the rather compact water use area in the foothills and valley about the City of Woodlake. Production of both encephalitis and pasture mosquitoes has been greatly reduced in this area. Still another valuable effort has been made towards the flood water mosquito, *Aedes vexans*, in the bottomland of the Kings and Kaweah Rivers, as well as in a few sloughs. Many sources have been eliminated; others have been made accessible for spray treatment.

A very major benefit, but one which cannot be measured directly, is the educational program presented to the community by the S.R. program. Movies, slides, and other visual aids have been developed for presentation to many civic groups, newspapers and professional magazines. The entire program of the district is better supported by the public because of the effectiveness and excellent stature of the S.R. program.

CONCURRENT GENERAL SESSION

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

JAMES ST. GERMAINE, *Vice President, Presiding*

STATUS OF THE MIDGE PROBLEM AT LAKE ELSINORE, CALIFORNIA

E. C. Bay

University of California
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ABSTRACT

The refilling of Lake Elsinore, California, in 1964 after nearly fourteen years in which it was a dry lake bed created a chironomid midge problem similar to that which existed when the lake was going dry. The midge, a new species similar in size and appearance to *Chironomus plumosus* L., increased in seasonal peak population from 1500 larvae per M^2 in July, 1964, to 16,000 in July, 1966. Population decreased abruptly, almost to extinction, during the first week of August for each year. In 1967 larva populations remained less than 1,000 larvae per M^2 throughout the season and no midge problem occurred. No explanation for this is available. That larva population decline was not due to fish predation was demonstrated by fish exclusion cages in which larva populations were the same as outside. Similar fish exclusion cage studies in 1966 produced more than twice as many (39,000 vs. 16,000 larvae per M^2) larvae within these cages as without, indicating that fish were at least somewhat suppressant at that time. Also, however, in 1966 the seasonal population exhaustion of midge larvae occurred at the same time inside as outside fish exclusion cages.

The possibility of seasonal self destruction of midge larva populations by their accumulated waste products was also considered but thought unlikely as this should involve an inverse relationship of population duration and intensity that did not occur. Instead peak larva populations lasted nearly four months during both 1965 and 1966.

A seasonal disease epizootic, although another possibility, would be unlikely to respond at one population threshold of infection one year and at another threshold, several times higher, the same time the next year. Also, this would not explain the deviation by which midge populations failed to develop at all in 1967.

Whereas relatively hard Colorado River water was used to refill Lake Elsinore in 1964, most of the water entering the lake since February, 1966, has been extremely soft well water. This may eventually have a marked impact on the biology of the lake but this cannot account for the midge population changes that have so far occurred.

The findings of these four years of observations on the progressive rise and sudden decline of a midge problem in Lake Elsinore should be of considerable significance to workers concerned with midge problems developing in similar new water impoundments in the state of California and elsewhere.

EXPERIMENTAL USE OF *LEMNA* TO PREVENT MOSQUITO BREEDING IN ORGANICALLY POLLUTED WATERS

Robert D. Sjogren

Northwest Mosquito Abatement District
Riverside

Numerous reports occur in the literature relating the value of various species of aquatic plants in preventing mosquito breeding. Jenkins (1964) offers an excellent annotated list and bibliography of papers dealing with plants in relation to mosquitoes. He grouped the literature into three categories; algae, carnivorous plants capturing larvae, and plants that cover the water surface and control larvae. He lists 9, 3, and 8 genera for the respective groups. In addition to the papers containing quantitative data on *Lemna* cited by Jenkins, Bentley (1910), Johnson (1902), Howard, Dyar & Knab (1912), Regnault (1919), Ancona (1930) and Matheson (1930), also make mention of the relative value of this plant for mosquito control. Hillman (1961) presents a thorough review of the descriptive and experimental literature pertaining to the Lemnaceae or Duckweeds.

In conducting mosquito control operations during the past seven years, the author has noted instances in which mosquito breeding rarely occurred in the presence of complete surface mats of *Lemna minor*. Several of the waters in which *L. minor* grew well were polluted with organic material and would not support populations of *Gambusia affinis,* despite repeated introductions. Hicks (1937) and Rao (1953) similarly observed *Lemna minor* occurring in waters rich in organic matter.

Recognizing the need for an effective preventive or control means for mosquitoes in highly organic waters incapable of supporting known effective biological control agents, *Lemna minor* was chosen for introduction to a range of polluted waters. The study was conducted from April through August, 1967, within the Northwest Mosquito Abatement District, Riverside, California.

Procedures

Twenty-two field sites were selected representing varying degrees of organic pollution. The degree of pollution was empirically assessed in each case based on a combination of suspended organic matter, color, odor and the presence or absence of indicator organisms. Vigorously growing *L. minor* parent stock was netted from a single source for all introductions. The plants were strained, weighed and applied the same day to each field site at the rate of 1 lb./500 square feet of surface area. All applications were made during the month of April. Observations were subsequently conducted and results recorded for each site. Several waters were replanted when it appeared that rains had washed out plants which had been initially introduced.

Results and Discussion

During the first several weeks of observations following planting, the degree of plant growth was quite variable in those areas in which survival occurred. However, it was usually possible to determine within two weeks whether the plant would survive and reproduce. Plants soon became chlorotic or disappeared in unsuitable sites. Table 1 relates the types of sources planted and degree of growth or surface coverage in each. While it can readily be seen that the plants did not grow sufficiently well in the majority of areas planted to form the complete surface mat needed to prevent mosquito breeding, exceptional growth occurred in several cases.

In one instance *Lemna* was applied to a wind-protected 1,100 $ft.^2$ pond formed by runoff from a septic tank system serving a small group of homes. Forty-seven days later, a dense mat had grown over 95 percent of the pond. This growth occurred prior to the occurrence of seasonal mosquito breeding in adjacent waters. Particularly dense mats occurred in and adjacent to the marginal Bermuda grass, which in past years had provided excellent harborage for populations of *Culex quinquefasciatus* and *Culex peus* as high as 400/dip. Periodic inspections for larvae during the mosquito season resulted in an average of .2/dip. In an exclusion area which lacked *Lemna,* populations of the above-mentioned species occurred in numbers approximating those reached in past seasons. The results of an analysis of a water sample taken June 13 are related in Table 2. In similar introductions to less protected sewage waters, the plants either did not survive or formed incomplete surface mats.

Table 1.

Summary of water types and the results obtained from the introduction of *Lemna minor* to waters with varying degrees of organic pollution.

Water Type	No. Planted	Maximum surface coverage achieved[1] 0%	25%	50%	75%	100%
Dairy Barn Wash	6	2	1	3	—	—
Sewage Effluent	5	1	2	1	—	1
Feed Lot Seepage	2	2	—	—	—	—
Duck Ranch Runoff	1	—	—	—	1	—
Chicken Ranch Runoff	3	2	—	—	1	—
Santa Ana River[2]	5	—	1	2	1	1

[1] Maximum growth was achieved in most cases prior to the onset of seasonal afternoon breezes.

[2] Receives sewage effluent discharged from surrounding communities.

Introductions of *Lemna* to concentrated barn wash ponds produced variable results. In one 12,000 $ft.^2$ reservoir, planted on April 6, *Lemna* growth was marginal during the first month, but grew rapidly thereafter covering more than 50% of the surface area on May 23. By June 9, this coverage had substantially diminished and remaining plants were windrowed along the downwind side of the reservoir. These plants died in mid-summer. The results of an analysis of the above barn wash water are shown in Table 2. Fox and Albrecht (1958) report *Lemna minor* to exhibit boron toxicity at concentrations as low as 0.1 mg./L., (mg./L approx. = ppm). Boron tested 0.41 ppm and above in the dairy waste water and other barn wash waters analyzed. Boron, therefore, may have been an important factor influencing plant survival.

An attempt to explain the variation in survival and growth in similar appearing types of sources in the absence of extensive water analyses aimed at the physiological requirements of the plant would be valueless. Several factors are believed however, to have had an influence. The degree of protection from wind appeared important. With the onset of seasonal afternoon breezes in late May, several instances were noted in which vigorously growing mats of *Lemna* were disrupted. Davison et al. (1965) cite wind action as a means of preventing the growth of *Lemna* where it has become a pest.

Lemna apparently does not favor prolonged hot weather and intense sunlight. During July and August, the majority of the plants that were only marginally surviving died. With two exceptions, all of the study areas were in direct sunlight. In the septic tank runoff water and several less polluted waters, the near exponential rates of growth exhibited in the spring decreased, but the plants survived throughout the summer. Ashby and Oxley (1935) found that the optimum multiplication rate for *L. minor* was 84°F, with the growth rate falling off sharply at 95°F. The air temperatures recorded during the study, Table 3, show an average maximum temperature during July and August above that reported to be detrimental. The occurence of unfavorably high temperatures concurrent with the observed plant die-off in areas of previous marginal growth and survival is believed to be important.

TABLE 2.

Results of water analysis of two highly organic waste waters planted with *Lemna minor.*[1]

	pH	B (ppm)	Ca+ (me/1)	Na (me/1)	Mg (me/1)	K (me/1)	CO_3+ HCO_3 (me/1)	C1 (me/1)	NO_3-N (ppm)	NH_4-N (ppm)	Org.N. (ppm)	PO_4-P (ppm)
Sewage Pond[2]	7.5	0.07	3.4	3.9	1.4	0.08	8.8	1.7	< 1.0	24 (27)	4.9 (8.0)	20.
Barn Wash[2]	8.0	0.41	9.7	10.9	2.7	3.6	22.2	12.7	< 1.0	119 (113)	0.5 (35)	1.2

[1] Water analyses performed courtesy of Dr. E. C. Bay, Department of Biological Control, and the Agricultural Extension Laboratory, University of California, Riverside.

[2] pH, HCO_3 and C1 run on unfiltered sample; all others run on filtered sample. N figures in parentheses are values obtained on unfiltered sample.

Table 3.
Record of climatological conditions during the period of study.[1]

Month	Temperature °F Maximum	Minimum	Mean	Mean 8:00 A.M. Relative Humidity (%)	Total Rainfall (In.)
April	63	39	51	76	3.00
May	80	48	64	62	0.03
June	80	51	65.5	68	Trace
July	96	60	78	59	0.00
August	99	80	89.5	62	0.14

[1] From the files of the Riverside County Flood Control and Water Conservation District.

Based on the information obtained in the course of study, the operational use of *Lemna minor* in Southern California to control mosquito breeding in highly organic waters appears unfeasible. Further investigation on the use of *Lemna* for mosquito control in certain organically polluted waters in regions in which maximum summer temperatures do not exceed the tolerance limits are believed warranted. Related work on the possible use of fertilizers in source manipulation efforts to encourage survival and growth in waters lacking detrimental waste products could be beneficial.

Summary

A study was conducted from April through August, 1967, in Southern California, to determine the value of Common Duckweed, *Lemna minor,* as a biological control agent for mosquitoes in highly organic waters. Twenty-two waters of varying organic content were planted in early April. Subsequent observations revealed wide variation in degree of plant growth and survival. Maximum growth occurred during the months of April and May. Growth in optimum and survival in marginal waters decreased with the onset of 95°F+ weather. Wind action was detrimental to the formation of continuous surface mats.

Complete coverage of the water surface occurred in only two test areas, however it resulted in the absence of mosquito breeding for the entire season. The inability of *Lemna minor* to survive and form entire surface mats in a wide range of polluted waters under summer temperatures indicate its use in operational programs in Southern California is limited.

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PREDATOR PREY STUDIES IN RELATION TO AN INTEGRATED MOSQUITO CONTROL PROGRAM A PROGRESS REPORT

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This is a report summarizing efforts since 1965 to integrate those chemical and biological control methods applicable to the rice field mosquito problem. During the initial year the aquatic insects commonly found in rice fields were studied in the laboratory and under field conditions to evaluate their role as predators of mosquitoes (Hokama and Washino, 1966). Of prime importance was the finding that most aquatic insects of that habitat reached their peak numbers in early, rather than in mid- or late summer. Perhaps the importance of this information to the operational aspects of mosquito control is open to question. The most valid answer is that a number of mosquito abatement districts include such extensive acreages of rice that it is not economically feasible for these districts to apply insecticide to all of the rice fields throughout the entire rice growing season. If a chemical control program must be limited to only a part of the summer, the question may then become one of selecting the most opportune time (early, mid- or late summer) to carry out the operation. Our findings indicate that since aquatic insects which may serve as mosquito predators are most abundant in early summer, this time would be the least advantageous to apply insecticide because it would prevent the possibility of natural control. However, a general recommendation to apply insecticide for mosquito control in rice fields only during mid- or late summer cannot be made either, because every rice field may not support enough insect predators to accomplish the early seasonal natural control.

In 1966 and 1967, studies were directed towards the vertebrate predators in a rice field habitat. Although the emphasis was on feeding habits of *Gambusia affinis,* efforts were made to study the food of other species of fish as well. The results of preliminary work on *G. affinis* and *Cyprinus carpio* were discussed at the previous annual meeting (Washino and Hokama, 1967). In addition, bluegills (*Lepomis macrochirus*) were also collected from our study fields both in 1966 and 1967, but examinations of their digestive tracts have just begun. A study of a fourth species, the hitch (*Lavinia exilicauda*) is also incomplete, but 181 fish collected in the two years have been examined so that some preliminary comments can be made about their feeding pattern.

Our initial interest in the hitch stemmed from the fact that when *G. affinis* are stocked in rice fields by local abatement districts, there is a lapse between the time of introduction into the field and the time when the fish become sufficiently well established to serve as mosquito predators. The time lapse may or may not be sufficiently long to affect mosquito production in different rice fields. Since natural populations of hitch had been observed in relatively large numbers in certain rice fields soon after flooding, one of the objectives during 1966 and 1967 was to evaluate the possibility that this species may serve as an interim mosquito predator during the early summer period before *G. affinis* becomes established. The results of examinations of 99 hitch collected in 1966 are summarized along with results of *G. affinis* (197) and *C. carpio* (104) in Table 1. The consumption of cladocera by hitch was considerably greater than by either *G. affinis* or *C. carpio.* Feeding by hitch on chironomids was comparable to *G. affinis,* but considerably less than that of *C. carpio.* As was stated previously (Washino and Hokama, 1967), cladocera and immature chironomids were found to be the predominant food organisms in the field studied. None of the hitch dissected from 1966 (99) or 1967 (82) contained mosquito larvae. Pending the examination of an additional 200 or more fish, the results so far do not support the possibility that hitch serve as mosquito predators.

Studies on *G. affinnis* were also continued in 1967. Observations made during the previous year had indicated that the greatest number and variety of food organisms consumed by these fish occurred in the early summer, and that predation on mosquitoes was intensified during the late summer period when these other food organisms became relatively scarce. On this basis, it was planned to observe two rice fields, one of which would receive an insecticide treatment when most of these food organisms reached their seasonal peak abundance. It was anticipated that with the exception of the fish most, if not all, of the organisms in the rice field would be killed by the insecticide, and that mosquitoes would reinfest the field more rapidly and to a greater extent than would the other organisms. If these events occurred as anticipated, the conditions would then be similar to those of late summer when organisms other than mosquitoes would be relatively uncommon. If there was a noticeable increase of mosquito consumption by the fish under these conditions, it was hoped that a significant reduction in the mosquito population might occur early in the summer. The second field was to be observed as a control.

Unfortunately, the abnormal weather during the spring and early summer in 1967 delayed rice planting and appeared to have disrupted the normal seasonal succession of plants and animals in the rice fields. For this reason, the possibility of regulating the fish-mosquito interaction by insecticide treatment for what are essentially nontarget organisms could not be realistically evaluated. However, preliminary results with *G. affinis* indicated that greater predation on mosquitoes might have occurred in mid-summer of 1967 than in 1966. There were indications that food organisms other than mosquitoes were less abundant during this period so that the original plan of ridding the environment of these organisms to promote greater fish-mosquito interaction may have been accomplished as a result of the abnormal early summer weather conditions. Nevertheless, these results will have to be confirmed and attempts made to repeat the evaluation under controlled conditions during the coming summer.

The anticipated increase in rice acreages for the coming year will add impetus for continued investigation of mosquito problems associated with rice farming.

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Table 1. Average number of food items per fish in alimentary tract of three species of fish in a rice field, Sutter, California, 1966

	C. carpio 104 fish				*G. affinis* 197 fish				*L. exilicauda* 99 fish			
Food items	June	July	Aug.	All months	June	July	Aug.	All months	June	July	Aug.	All months
Cladocera	3.9	11.8	0.0	5.2	0.0	16.8	0.4	6.3	38.5	51.4	0.0	28.9
Podocopa	1.2	2.0	0.0	1.3	0.0	1.8	0.4	0.7	2.7	2.3	0.0	1.7
Eucopepoda	0.3	0.7	0.0	0.3	0.7	1.4	0.4	0.9	0.1	0.3	1.9	0.6
Chironomidae	59.7	13.0	4.7	47.5	3.6	2.4	11.9	4.2	19.8	0.6	0.4	7.7
A. freeborni	0.0	0.0	0.0	0.0	0.0	0.1	4.5	0.6	0.0	0.0	0.0	0.0
C. tarsalis	0.1	0.0	0.0	0.1	0.0	0.1	0.2	<0.1	0.0	0.0	0.0	0.0
Others	2.6	0.3	0.0	2.0	2.4	5.3	0.0	3.2	2.1	0.7	0.5	1.2

midges. Table I lists Diptera collected during one visit to Westlake Village (near Thousand Oaks) last autumn, where a 150 acre lake was being dredged and was partially completed. A heavy algal bloom had already developed concurrent with a developing midge population.

These lakes are usually stocked early with several species of fish. These fish, together with other predators, probably exert some degree of control. Midge populations seem to become lower and tend to level off after a few years. However, we do not yet know the number of midges the urbanites will tolerate. Continuing studies of midge ecology and control in these lakes are needed.

More lakes will be built, and these lakes will have to be maintained as midge-free as possible. I am therefore giving some tentative recommendations concerning design and operation that should help reduce midge and mosquito problems; most pertain to vegetation management and minimizing the phosphorus and nitrogen intake. Some of these suggestions developed from discussions with Dr. E. C. Bay, University of California at Riverside, sanitarians and entomologists from several health departments, and members of our own staff.

Lake Design

1. Sides: cement, gunnite, or asphalt-lined to a depth of 4 feet below low water line; the shoreline should be curved (no sharp angles), self-draining, subject to wave action.
2. Depth: minimum of 10 feet.
3. Slope: Shallow ledge (primarily a safety feature to prevent drownings). Suggest 1-inch to 5-foot slope.
4. Bottom: flat; no hummocks.
5. Drainage system constructed to allow for complete drainage of water.
6. Mechanical filtration and circulation device to remove debris, algae, and other aquatic vegetation.

Table 1. Westlake Village midge and mosquito collections September 14, 1967.

Westlake dredge samples:

Chironomus attenuatus (midge) larvae
Chironomus plumosus (midge) larvae
Chironomus fulvus (midge) larvae
Procladius sp. (midge) larvae
Chaoborus astictopus (Clear Lake gnat) larvae

Drainage ditches:

Anopheles franciscanus (mosquito) larvae
Culex tarsalis (mosquito) larvae
Chironomus sp. (midge) larvae
Ceratopogonidae (small biting fly) pupae

Homes under construction:

Ablabesmyia monilis (midge) adults
Procladius sp. (midge) adults
Chironomus attenuatus (midge) adults
Chironomus plumosus (midge) adults
Chironomus californicus (midge) adults
Tanytarsus viridiventris (tiny midge) adults
Chaoborus astictopus (Clear Lake gnat) adults

Lake Operations

1. Community sewage systems for all homesites.
2. Select water sources low in nitrogen and phosphorus.
3. Design land and street drainage system to by-pass lake if feasible; otherwise, intake water should be processed to remove oils, scum, dirt, insecticides, suspended solids.
4. Elimination of emergent and submerged vegetation should be a continuous program.
5. Control of algae should be instituted by physical and chemical means before full algal bloom develops.
6. Control of snails: use of molluscides should usually be confined to shore areas.
7. Insecticides for midge and mosquito control should be applied in such a manner as to be harmless to swimmers, as well as to fish and other wildlife.
8. Conduct a year-round biological survey within the confines of the lake and maintain adult midge sampling stations. This will provide an increasingly valuable source of information on vector ecology, basic to any control work to be undertaken.

Biological Control

1. Select fish species which are compatible with the desired lake fauna and which will feed on bottom-dwelling midge larvae as well as on free-living midge larvae within open water zones.
2. Use top-feeding fish, such as *Gambusia affinis*, for mosquito larval control.
3. Consult with the State Department of Fish and Game before introducing any predatory fish.

CONSIDERATIONS IN CONTROLLING CHIRONOMIDS

Gail Grodhaus

Bureau of Vector Control
California State Department of Public Health

Chironomid midge control has become a rather familiar subject to vector control and mosquito abatement workers in California. Chemical larvicides have been shown to be effective against chironomids in various kinds of ornamental ponds, in waste stabilization lagoons, and in lakes ranging up to several hundred surface acres. Although nonchemical control concepts are also under study, organophosphate larvicides such as fenthion and Abate® appear to offer the best prospects for midge abatement. Reports of recent studies on larviciding can be found in papers by von Windeguth and Patterson (1966), Mezger (1967), and Hitchcock and Anderson (1968).

Entomological investigations are essential where the larviciding of various kinds of water impoundments is contemplated. For this discussion I have selected a number of points that I think the entomologist should keep in mind when making his evaluations.

Recognition of Chironomid Species Differences

More than 150 species of chironomids are known to occur in California, many of them known only as taxonomic entities. It would be most difficult to obtain a practical knowledge of each of these species. It is more realistic to focus on the species most apt to be a nuisance. The following is an updated version of a previously compiled list of chironomids considered potentially pestiferous in California (Grodhaus, 1963).

Chironomus attenuatus Walker
Chironomus plumosus (Linnaeus)
Chironomous stigmaterus Say
Chironomous utahensis Malloch
Glyptotendipes barbipes (Staeger)
Glyptotendipes lobiferus (Say)
Goeldichironomus holoprasinus (Goeldi)
Paralauterborniella subcincta (Townes)
Phaenopsectra profusa (Townes)
Polypedilum digitifer Townes
Tanytarsus spp.
Cricotopus sylvestris (Fabricius)
Procladius bellus (Loew)
Procladius denticulatus Sublette
Procladius freemani Sublette
Tanypus grodhausi Sublette

This list was compiled from the collection records of the Bureau of Vector Control. There is some taxonomic uncertainty with respect to members of the genus *Chironomus,* which means that the list may eventually have to be revised to include additional species in this genus.

In a short discussion it would be impossible to give all applicable biological information on even the above species. However, it may be helpful to give examples of the pertinent differences among species or genera of these midges.

Our experience indicates that the listed members of the genera *Chironomus, Glyptotendipes,* and *Goeldichironomus* are our principal pest species. Emergence of these midges may take place over an extended period annually, especially when there is a mixture of species. The adults are relatively long lived and tend to travel considerable distances from their sources. Generally the larvae are found at the bottom in soft mud in a wide depth range. Although subtle differences in larval habitat have been noted among these species, they appear to overlap greatly in this respect. Most of the literature reports of larvicide field trials refer to members of these genera. Results with granular larvicides have been encouraging. However, certain large lakes, with *Chironomus plumosus* as the pest species, are still considered untreatable, because of high insecticide costs and possible danger to non-target organisms.

The listed representatives of *Paralauterborniella, Phaenopsectra, Polypedilum, Tanytarsus,* and *Cricotopus* are comparatively restricted in occurrence, though any one of them may dominate the midge fauna under suitable conditions. The species in this group probably have rather narrow larval habitat requirements. For members of the genus *Tanytarsus,* the habitat relationships will remain obscure until the species have been identified. In California *Phaenopsectra profusa* and *Polypedilum digitifer* have occurred abundantly in certain new reservoirs, seemingly adapted to conditions attendant to the change from a riparian to a lacustrine environment. The larvae of both species are benthic. *P. profusa* has been collected on firm substrate, overlaid with plant debris, whereas *P. digitifer* has been found in silt. *Cricotopus sylvestris* larvae are found on various substrates but are restricted to the extreme upper littoral zone. *Paralauterborniella subcincta* larvae are usually attached to aquatic vegetation. Little has been published on the control of this group of species. Mezger (1967) reported the successful control with granular applications of malathion in water averaging 2.5 ft. deep, where a species of *Tanytarsus* was the predominant chironomid. According to E. G. Mezger (personal communication) the larvae were prevalent on aquatic vegetation as well as at the bottom. A granular formulation of fenthion (at 0.25 lb/acre), which was effective against benthic *Chironomus* spp., did not appreciably reduce a concurrent, epiphytic poplation of *P. subcincta* (unpublished results of a field trial conducted by the Bureau of Vector Control and the San Luis Obispo County Health Department). In this case the *P. subcincta* larvae were on pondweed (*Potamogeton pectinatus*) in water ranging from 6 to 8 feet in depth.

The remaining genera on the list, *Procladius* and *Tanypus,* have been pestiferous mainly in combination with other chironomids. By themselves they might not have been considered a nuisance. For the most part, the larvae of *Procladius* and *Tanypus* are benthic. *Tanypus grodhausi* appears to be restricted to shallow, phytoplankton-laden habitats. The preferences of the *Procladius* species are poorly understood, because species identification of their larvae has been difficult. The two genera belong to the biologically distinctive subfamily Tanypodinae. Patterson and von Windeguth (1964) noted that tanypodine larvae were among the first organisms to re-appear after fenthion treatment. Some species of *Procladius,* at least, are probably somewhat tolerant of this and other insecticides.

Operational Sampling of Midge Populations

Elaborate ecological studies are not ordinarily feasible with the manpower and equipment available to abatement agencies. However, operational work of these agencies may require special surveillance of midge populations, larval and adult. Surveillance is the recording of population changes in a particular environment over a period of time; the population is to be compared only with itself and not with other populations. Southwood (1966) has distinguished between *absolute* and *relative* population estimates, the latter more applicable to surveillance than the former. Essentially, an absolute estimate is derived from the number of organisms collected per unit of area, whereas a relative estimate is obtained from the number collected per unit of effort. For relative estimates one may sample the population with traps or other devices such as nets, if operated with uniform effort. Dredges, though ordinarily considered area-unit samplers, might also be employed for relative sampling. Results of the dredge sampling would then be expressed as specimens collected *per sample,* so that it is not implied that an absolute estimate was obtained, as would be indicated by number *per square foot* (or other area-units).

Although the requirements for relative sampling are somewhat less demanding than those of absolute sampling, it is desirable that the results be as accurate as possible. While a subjective appraisal of the adequacy of the material can sometimes be determined retrospectively from the consistency of the results, it is generally impractical to attempt to establish accuracy standards. It will be assumed that reasonable resources will be made available for the sampling. Within resource limitations one must attempt to get as much information as possible by judicious planning of the sampling program.

Selection of stations plays an important part in determining the adequacy of the sampling. Some exploration should be done in order to distinguish productive from unproductive areas. For example, a particular substrate or depth zone may be found to be a more important midge habitat than any other region of an impoundment. It is practical to concentrate future sampling in this area.

How frequently to sample is a highly controversial subject (Kajak, 1963). It is clear that, unless we undertake elaborate studies we cannot hope to measure the details of population fluctuations. However, we might reasonably expect to detect multifold changes occurring from season to season or from year to year. For this modest purpose it is probably unnecessary to sample more often than once a month.

To evaluate a larvicide application it is necessary to record sudden population changes. In this case it is desirable to take samples immediately prior to the application and to take the first post-treatment samples after about three days, allowing this much time for the dead larvae to decompose, so as not to be counted.

Standard sampling devices and their uses are discussed by Southwood (1966). Included are several that have been used for the collection of adult midges—various kinds of light traps and the malaise trap. Sticky traps are commonly employed for the collection of other insects and may also have application in chironomid surveillance. Standard devices for taking samples of midge larvae and other benthic organisms include the Ekman dredge (for deep or shallow water) and the Dendy inverting sampler (for shallow water). Several types of dredges have been developed especially for sampling midge larvae in shallow water (Anderson, Bay, and Ingram, 1964; Spiller, 1965; and Bay and Frommer, 1965).

In limnological work it has been customary to use dredges that encompass a subtrate area of at least ¼-ft^2 (the area sampled by the standard Ekman dredge). However, the large amount of material taken in a ¼-ft^2 sample often requires laborious sieving and often includes more larvae than can be counted easily. There is a case for the use of smaller samplers where feasible. Kajak's (1963) studies indicate that small tubular samplers are as efficient as the Ekman dredge, provided organisms are numerous. Kajak's data indicate that it is not even necessary to take a large number of samples with the smaller devices provided there is an abundance of organisms. Tubular devices of relatively small diameter include the Dendy and Spiller samplers. A simple scoop dredge (Anderson, et al., 1964) has received considerable acceptance in California. Although in its original design this dredge takes a ¼-ft^2 sample, it can also be made smaller.

For sampling midge populations attached to aquatic plants, we have employed an aquatic net (125-mesh Pond Life Dip Net, Turtox Products). The net is swept through the submerged vegetation a specified number of times for each collection.

After the collections have been made there remains one of the most important aspects of the sampling program—the sorting of the specimens to genus or species. Unless the sampling results are recorded at least to genus, the final interpretation is apt to be misleading. This is especially true of investigations where the results of sampling adult and larval populations are to be correlated. In assessing larvicide field trials it is desirable to record comparative data on different midges so that the benefits of the trials may be employed elsewhere.

Chironomid identification is still somewhat difficult at the species level, but generic identification is entirely feasible under most circumstances. In combination, the keys provided by Wirth and Stone (1956), Darby (1962) and Grodhaus (1967) include most of the genera that are likely to be collected in nuisance investigations in California.

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CHIRONOMID MIDGE CONTROL IN WATER STABILIZATION LAGOONS AT STOCKTON, CALIFORNIA, BY USE OF QUICK BREAKING EMULSIONS

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ABSTRACT

Chironomid midges attained record nuisance densities in the City of Stockton water stabilization lagoons during the early operational development of the lagooning system. Satisfactory control of the larval forms has been obtained through the application of specially designed quick breaking phosphate emulsions. Costs of liquid application of insecticides are considered reasonable as compared to the higher cost of granular treatment where high frequency of application is a requirement.

DRIP APPLICATION OF THREE ORGANOPHOSPHORUS INSECTICIDES FOR MOSQUITO CONTROL

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ABSTRACT

Field studies were conducted to evaluate Dursban®, fenthion and Abate® emulsifiable concentrates applied by drip to flowing and impounded waters. Dursban provided complete control for 57 days at 0.47 lb./acre in raw sewage lagoons. Dursban, Abate and fenthion were applied at 0.23 lb./acre on three occassions to 17 acres of ponded sewage effluent. The residual control duration of each material was 43, 15 and 12 days, respectively. Fenthion at 0.2 ppm for 240 and 100 minute periods gave good control over a 3-mile irrigation ditch. When applied at 0.15 and 0.20 lb/acre to the inlet of duck ponds, good control was also obtained.

EXPERIENCES WITH AERIAL DUSTING IN THE KERN MOSQUITO ABATEMENT DISTRICT IN 1967

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A record volume of water from the Kern River watershed in 1967, more than three times normal, flooded several thousand acres south and west of Bakersfield for long periods of time. Much of this acreage developed into ideal sources for production of *Culex tarsalis,* the vector of encephalitis in California.

As temperatures increased with the advancing summer season, we experienced ever increasing larval populations of *C. tarsalis.* We found it necessary to apply liquid larvicides by air at weekly to ten day intervals over much of the flooded region. Vegetative canopies consisting of grass, brush, and trees became quite dense, affecting the results of our larviciding applications. These were made as aqueous solutions at ½ gallon per acre or as ULV sprays at 2½ to 8 ounces per acre. Of the two spraying techniques, the ULV applications proved superior to the aqueous. Neither, however, was adequate in many locations because of the dense vegetative canopy.

In June, the *tarsalis* larval density had reached a level of 50 per dip under a heavy canopy of mesquite and grass over hundreds of acres. Obviously, the aerial spraying was not getting the job accomplished.

These circumstances indicated the necessity of changing our approach if we hoped to attain any degree of control of *tarsalis.* Following discussion with pesticide formulators and regulating agencies, we decided to try a parathion dust formulation. This we obtained as a 2% ethyl parathion from Wilbur Ellis Company, Fresno, California. The dust was prepared from a local anhydrous, alkali, aluminum silicate with a pH of 5.4 - 6.5, known as friamite. It was screened through a 325 mesh screen to provide an average of 44 micron particle size. In preparing the dust, a 98½% technical parathion is sprayed within a ribbon blender to impregnate and coat the particles.

The airplane used in applying the dust was a Call Air A-9, equipped with a Standard Swathmaster, Jr. Spreader. In application, the dust is gravity-released from the hopper to the spreader.

Limited swath pattern evaluations indicated a swath of 220 to 300 feet. The first application made with the dust and equipment described, was over a location where we had previously failed to obtain satisfactory results with our liquid sprays. Flying at 90 miles per hour at heights of 30 to 50 feet necessary to clear the trees and brush, the dust was applied at 2.5 lbs. per acre across swaths of 220 feet with a parathion dosage of 0.049 lb. per acre.

Results were more than surprising. No live larvae could be found where, prior to treatment, counts up to 50 per dip were common. In addition to numerous dead larvae, adult *tarsalis* were found floating upon the water surface where vegetative canopy was most dense. In subsequent applications, we continued to obtain results similar to those experienced with the first trial. Highly effective results were later, on occasion, obtained at a parathion dosage of approximately .033 lb. per acre at a gross of 1-2/3 lbs. per acre.

More than 20 tons of 2% parathion were used by the district during 1967 with excellent results. Trials were also made with equally good results for control of *Aedes nigromaculis* larvae and adults. One such application was made over a 420-acre area containing all aquatic stages plus a heavy infestation of adults. Control was complete on all stages except the pupae.

Trials with 4% malathion, 4% parathion and 2% Baytex® were made. A malathion application of particular interest to us was made over 20 acres of duck clubs containing a heavy aquatic population of all stages of *Culex tarsalis.* Twenty-four (24) hours following the application of .16 lb. of malathion per acre, only fourth stage larvae and pupae could be found. Obviously, this could be interpreted as an insufficient dosage and this we could expect at such a low dosage of malathion.

As with all things, larviciding and adulticiding with dust have not proven to be a panacea. In a few instances we have had applications turn out to be complete failures. These, however, have occurred only a few times. We do not know why we experienced these failures but suspect it is a mechanical problem; one of not getting the dust to the target. We have observed that wind drifts will move the dust completely off the intended swath and suspect that under certain weather conditions the dust will not settle upon open water. On the contrary, however, we have had successful dusting applications in winds exceeding 10 mph when allowance is made for an adequate margin of drift. Over wooded areas when allowing for drift, winds actually seemed to improve results.

ULTRA LOW VOLUME AERIAL APPLICATION OF NALED TO CONTROL ADULT MOSQUITOES IN CALIFORNIA PASTURES

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ABSTRACT

Tests conducted by Kern Mosquito Abatement District in cooperation with Chevron Chemical Company show that aerial application of 0.055 lb/acre of naled (0.56 fluid oz/acre of undiluted DIBROM® 14 Concentrate) will effectively control adult *Aedes nigromaculis* (Ludlow) in irrigated pastures.

A COOPERATIVE APPROACH IN CONTROLLING MOSQUITOES ON DUCK CLUB LANDS

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Mass emergence and migration of mosquitoes into populated metropolitan areas in California resulting from the flooding of duck club lands has been well documented by Lopp (1965) and Whitesell (1965).

The Solano County Mosquito Abatement District has within its boundaries approximately 118,000 acres of salt marsh. Approximately 12,000 acres are unreclaimed and subject to flooding by monthly high tides. Nearly 106,000 acres have been reclaimed to the extent of being enclosed and protected from the high tides by levees. A large segment of this acreage is privately owned by duck clubs. The majority of the clubs are located in an area known as the Suisun Marsh.

The climate of the Suisun area has winters that are mild and wet, while the summers are warm and dry. The rainy season usually commences in November and continues to mid-April. The average annual rainfall is nearly 20 inches. Frosts occur and temperatures range from a low of about 26 degrees to well over 100, although cool moist winds blowing inland from the ocean and bays during the summer months keep the temperatures usually below 100 degrees.

Vegetation in the marsh consists primarily of dense stands of salt grass (*Distichlis spicata*) and pickleweed (*Salicornia pacifica*), with lesser stands of cattails (*Typha* sp.) and bulrushes (*Scirpus* sp.)

Prior to the reclamation of the Suisun marsh and the formation of the mosquito control district in 1930, tremendous populations of adult *Aedes dorsalis* Meigen and *Aedes melanimon* Dyar emerged after each monthly high tide. These two species inundated the marsh and the surrounding area containing the cities of Suisun, Fairfield, Benicia and Vallejo causing great discomfort and annoyance. After reclamation and during the middle 1930's, the board of trustees of the mosquito control district formulated and adopted a policy whereby the duck clubs were to keep their lands dry during the late spring, summer and early fall months. Flooding of the lands could only be done by written notification from the district and only prior to the opening of the California duck hunting season. The hunting season usually opens during the middle of October. After the California State Fish and Game Commission establishes the opening date for the hunting season, the district establishes the date of flooding of the club lands and sends a written notice of same to each club. This date is usually 2 to 3 week before the opening of the hunting season and corresponds with a monthly high tide. By the adoption and enforcement of this policy, the district has kept the production of the two pestiferous mosquito species on the duck club lands to a minimum.

The exception to this policy is the flooding of the club lands in the fall and the resulting emergence of usually high populations of the two mosquito species migrating into the cities in the area. Due to district budgetary deficiencies no attempt was made to control the mosquitoes on the club lands because of the large acreage involved. Control was therefore restricted to controlling the adult mosquitoes in the cities by ground rig aerosoling. These efforts were and are largely futile due to the continuous migration of the species into the cities. Ultimate control is established over the adult mosquitoes with the appearance of the first frosts. These frosts usually occur during early November and 6 to 8 weeks after the initial emergence of the species.

During the late 1930's, Travis Air Force Base was constructed approximately 4 miles northeast of the cities of Suisun and Fairfield, and within 1 mile of the northern perimeter of the Suisun marsh. This air base is now one of the largest in the United States in men and material. Like the cities in the area, it is also subjected to the two pestiferous mosquito species resulting from the annual fall migration from the duck clubs.

Work stoppages on the maintenance of the aircraft and an abundance of secondary infection cases at the air base medical dispensary soon necessitated action for relief from the mosquitoes. Accordingly in 1962, management personnel from the Civil Engineering Squadron, Travis A.F.B., and the Solano County Mosquito Abatement District commenced negotiations on the ways and means to alleviate the annual fall mosquito infestation. After a series of meetings it was decided to control the mosquitoes in the larval stage by aerial larviciding on the duck club lands, the air base to provide the aircraft and insecticide, and the district to provide legal wavers absolving the U.S. Air Force from any damage that might arise from the application of insecticides on private lands. The district also would provide flagmen and entomological evaluation of the control program.

Materials and Methods

A master map of the duck clubs in the Suisun marsh showing acreages plotted for each club was developed. From the map, those clubs selected for larvicidal treatment had to be within a 15 to 20 mile semiradius of Travis A.F.B. and the cities of Suisun and Fairfield because of the migrating habits of the two species (Loomis 1967). Total acreage to come under control as determined by this method of selection was approximately 5,700 acres.

Because of the lack of prominent land marks on the marsh lands, 4 ft. by 4 ft. fiberboard panels were constructed and painted an international orange so they could be easily seen from the air. These panels were utilized as boundary markers on the clubs to be treated and delineated the whole treatment area. Weather balloons inflated with helium to attain a size of 3 ft. in diameter and also painted orange were used by the flagmen walking the levees to show swath widths.

The insecticide utilized in the control programs in 1962, 1964, and 1965 was fenthion applied as a liquid spray. In 1966 and 1967, fenthion again was used, but was applied as a pre-treatment in a granular formulation. No control program was instigated in 1963, because larval surveys showed inadequate densities on the club lands.

The California State Department of Fish and Game was invited to participate and monitor the 1964 control program to ascertain whether there would be any deleterious effects upon the fish and wildlife by using fenthion as a liquid spray. Their field observations showed no adverse effects of the toxicant on caged pheasants, pigeons and live cars with striped bass, tule perch and flounder. Whitesell (1965), using granular parathion applied as a pre-treatment on duck clubs reported on similar field tests conducted by the Calif. Fish and Game on caged pheasants and doves. Their field observations indicated no adverse effect on either bird species.

A C-123 cargo type aircraft was placed at the disposal for the control programs. This aircraft was calibrated to deliver as a liquid larvicide 0.1 pound actual fenthion per acre in 1 gallon of water over a 150 ft. swath. The granular formulation applied as a pre-treatment was calibrated to deliver 5 pounds of 2% fenthion sand core granules per acre over a 100 ft. swath resulting in 0.1 pounds of actual toxicant per acre.

Observations on Control

In 1962, 1964 and 1965 when the liquid applications were made, the resulting larval mortalities were somewhat erratic. The mortality rate in 1962 was 61%, 1964 78% and 1965 73%. These fairly low larval mortalities were probably due to the low gallonage delivered per acre and the resultant failure to penetrate the dense vegetation of salt grass and pickleweed. Observations on the untreated duck club lands during these years showed average larval densities of approximately 4 to 9 larvae per dip of water. Some adults of the two species were noticeable after treatment during these years at the air base and the cities, but were of such low densities as not to cause too much discomfort.

In 1966 and 1967, granular fenthion was applied as a pretreatment. Excellent penetration of the granules into the vegetation and onto the soil surface was observed. The resultant flooding of the club lands showed larval mortalities of 98% for both years. Larval surveys on the untreated club lands in 1966 showed that the resultant adult population would be fairly low and the migration of these mosquitoes from the uncontrolled lands into the air base and cities would be negligible. The year 1967 proved to be just the reverse of 1966. Larval surveys on the uncontrolled club lands showed extremely high larval densities, the average number of larvae per dip of water being 27. The resultant adult population migrated into the air base and cities and caused great annoyance and discomfort to the populace of the area.

For 1968 and succeeding years, tentative plans have been made to expand the controlled acreage of 5,700 acres to approximately 20,000 acres. This increased acreage would bring those duck club lands not now under control to a controlled base. The extension of the control acreage would also extend the present semi-radius of 15 miles to approximately 23 miles, thus possibly limiting further migration of the mosquito species into the air base and cities.

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OBSERVATIONS ON THE HATCHING OF *AEDES NIGROMACULIS* (LUDLOW) EGGS (DIPTERA: CULICIDAE)

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The pasture mosquito, *Aedes nigromaculis* (Ludlow), is one of the most abundant and noxious mosquitoes in Central California. Because of the development of extensive insecticide resistance in this species, there is a need for self-propagating colonies for use in laboratory investigations.

As a first step in obtaining self-propagating colonies, a colony of this species was established in the laboratory by the induced-mating technique (Miura, 1967). This report summarizes observations on the hatching of *A. nigromaculis* eggs obtained while maintaining this colony.

Materials and Methods

Eggs were obtained in the laboratory from field-caught females collected in the vicinity of Fresno, California, and from females in a laboratory colony maintained by induced mating.

Adult females were held in a one cubic foot, screened cage in the insectary at 23°C and 85% relative humidity. The caged females were provided with food, in the form of raisins, and were allowed to take blood from a chicken twice

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Table 1.

Percentage of hatch of *Aedes nigromaculis* eggs obtained from females collected in the vicinity of Fresno, California in August, 1967.

Date females collected	No. of Eggs	Percent of hatch at each flooding: 1st	2nd	3rd	4th	Total Hatch
August 2	1,878	99.15	1.48	0.16	—	100.00
August 8	2,142	98.18	1.68	0.09	0.05	100.00
August 10	1,901	99.47	0.21	0.16	0.16	100.00
August 16	7,327	97.98	1.57	0.35	0.10	100.00
August 18	1,289	98.91	0.85	0.00	0.23	100.00

Table 2.

Comparison of the hatchability of *Aedes nigromaculis* eggs obtained from females collected in the vicinity of Fresno, California from June to October, 1967.

Date females collected	No. of Eggs	Percent of hatch at each flooding: 1st	2nd	3rd	4th	5th	6th	Total Hatch
June 27	525	94.86	5.14	—	—	—	—	100.00
July 24	3,103	98.74	0.87	0.06	0.32	—	—	100.00
August 16	7,327	97.98	1.57	0.35	0.10	—	—	100.00
September 6	425	98.82	0.94	0.24	—	—	—	100.00
October 5	1,337	42.03	4.94	1.80	0.90	1.35	0.37	51.39
September 25*	805	95.28	4.47	0.00	0.25	—	—	100.00
October 19*	361	98.61	0.83	0.28	0.28	—	—	100.00

*Eggs obtained from induced mating.

a week. A paper cup containing wet moss as oviposition media was also kept inside the cage.

Embryonated eggs were washed from the oviposition media, collected on moist filter paper, and stored in a chamber having 100% relative humidity. Eggs on the filter paper were hatched by flooding them with deoxygenated water to a depth of 1 cm. After 24 hours the first instar larvae were transferred to a rearing pan (40x25x6.5cm) for further study. The filter paper with remaining, unhatched eggs was removed and then air-dried in the laboratory; these remaining eggs were reflooded at three-day intervals for six consecutive times. The total number of eggs and of larvae were counted at each flooding.

Results

During August, over 95% of *A. nigromaculis* eggs obtained from field-caught females hatched at the first flooding; however, to get 100% hatch, at least three or four separate floodings were required (Table 1). This phenomenon of delayed hatch was also noticed in eggs obtained during June, July, and early September, as well as in the eggs produced by the females which were maintained by induced mating (Table 2).

The results obtained from eggs produced by females collected from the field in early October were significantly different; the first flooding produced approximately 42% hatch; the second, 5%; the third, 2%; the fourth, 1%, the fifth, 1%; and the sixth, 0.4%. At the end of six floodings, only 51% of the total eggs had hatched (Table 2).

Discussion

Husbands (unpublished data) noticed delayed hatch of *A. nigromaculis* eggs in the field during his ecological study of pasture mosquitoes during the 1951-1952 seasons. Also, Rosay (1956) reported that only 80 to 90% of *A. nigromaculis* eggs had hatched in an environment of optimum temperature, but that the remaining viable eggs hatched after subsequent floodings. The results obtained in this study showed that only about 95 to 99% of eggs obtained from females collected during June to September hatched at the first flooding; the remainder of the eggs showed a delayed hatch.

The delayed hatch is probably a common phenomenon among aedine mosquitoes (Gillett, 1955); it has been indicated in the work of Miller, 1930; Gjullin et al., 1950; Travis, 1953; Newkirk, 1955; Horsfall, 1956; Telford, 1963; Breeland, et al., 1965; Moore and Bickley, 1966; and Breeland and Pickard, 1967.

The delayed hatch mechanisms may play a signifcant role in the successful development of *A. nigromaculis* in transient waters. Since most embryonated eggs will hatch in shallow, temporary irrigation water during the spring and summer, unhatched eggs provide a safety factor for the survival of the population if the first hatch is destroyed. As the percentages of eggs showing delayed hatch are small (Tables 1 and 2), this mechanism is not apparent unless sufficent numbers of egg are used in the hatching experiments. When very large numbers of eggs are present, such as under field conditions, small percentages become quite significant.

Telford (1958) suspected that *A. nigromaculis* eggs enter a facultative winter diapause; he documented his hypothesis by laboratory hatching experiments and by field observations (1963) and concluded, "its (*A. nigromaculis*) hibernation in Central California constitutes a true facultative diapause of the mature embryo within the egg. Temperature plays a major part in the development and termination of this diapause".

Eggs obtained from females collected on the 5th of October, 1967 (Table 2) were probably in a state of facultative diapause; though these eggs were stored and flooded in the same manner as eggs collected from females caught in the summer and spring, only 45% hatched after the first flooding.

The data obtained in this study indicate that seasonal changes, such as low temperature and shortened photoperiod or both, may play an important part in inducing diapause. It was not determined whether seasonal changes directly affect the embryo or whether the effect is indirect, and initiates in the immature or adult stage.

Eggs obtained from females collected from the colony maintained by induced mating showed the delayed hatch but facultative diapause was not apparent (Table 1).

Summary

Field observations and laboratory experiments on hatchability of *A. nigromaculis* eggs obtained during the season from June to October, 1967 and from females maintained in the colony by induced mating, strongly indicate the presence of a delayed-hatch. In order to obtain 100% hatch, at least three or four separate floodings were required.

The eggs obtained in late season (October) were probably in a state of diapause, since 49% of the eggs tested did not hatch at the end of six consecutive floodings.

Mosquito control agencies will find this information useful, since it helps to explain the continued production of mosquitoes in fields subjected to intensive treatment with larvicides. Ovicides developed specifically for diapausing eggs could materially reduce subsequent populations.

We wish to express our appreciation to Dr. D. P. Furman and Dr. C. H. Schaefer for suggestions and comments on the manuscript.

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CONCURRENT OPERATIONAL SESSION

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

ROBERT E. TURNER, *Moderator*

PROBLEMS WITHIN THE MARIN COUNTY MOSQUITO ABATEMENT DISTRICT

Allan D. Telford

Marin County Mosquito Abatement District

ABSTRACT

Problems confronted by the coastal and highly residential Marin County District were presented. Various methods of larviciding marsh mosquitoes were discussed. In Marin County, control of *Aedes sierrensis,* the tree-hole mosquito, is difficult in the larval stage and frequently adulticiding programs must be relied upon.

THE OPERATIONAL PROGRAM OF THE SAN MATEO COUNTY MOSQUITO ABATEMENT DISTRICT

Calvin J. Rogers

San Mateo County Mosquito Abatement District

The impact of California's rapid population growth in recent years and the accompanying land development have been acutely felt in the San Francisco Bay Area. The bay side of San Mateo County, once comprised of a series of small, isolated, residential communities bounded on the east by tidal marsh and surrounded by native woodlands, has become an almost solid block of highly urbanized residential and industrial developments. As the demand for land increases, hill area development and marshland reclamation are proceeding at an astonishing rate. For example, two current marina developments, Foster City and Redwood Shores, encompassing a total of 6,900 acres will have populations estimated at 35,000 and 60,000, respectively, by 1980. This rapid growth has pushed human habitation into areas of existing pestiferous insect populations while drastically changing drainage patterns and increasing both water flow and organic deposition in the waterways.

These factors have combined to vastly alter insect habitats and to produce new or enhance existing insect problems. This, in turn, has precipitated public requests for this district to provide services in addition to mosquito control. In response to these requests the San Mateo County Mosquito Abatement District is now engaged in four programs: mosquito control, midge control, black gnat research and control, and yellow jacket control. The various phases of "mosquito abatement" outlined below are the direct result of the accelerated human activity within the district boundaries.

Mosquito Control

The mosquito control program has shifted from one of large acreage sources (salt marsh) to the smaller, but more numerous, sources associated with urban development. Although some marsh remains, producing the salt marsh mosquito, *Aedes dorsalis,* the major problems arise from catch basins, creeks, drain ditches, fish ponds, and miscellaneous backyard sources producing *Culex* and *Culiseta* mosquitoes (especially *C. pipiens* and *C. incidens*). *Culex tarsalis* occurs in both brackish marsh and fresh water sources. In some of the older residential areas and in new hill area developments the tree-hole mosquito, *Aedes sierrensis,* is a problem. The program may be divided into four categories: chemical control, biological control, source reduction, and surveillance.

Most chemical application is by ground spray equipment with John Bean sprayers, mounted on Jeeps and pickups, forming the basic units. A tractor mounted mist blower is used on large areas, and shoulder mounted mist blowers are used on smaller areas, for dusting drain lines, and for the application of granules. A unit for catch basin treatment has been developed using compressed nitrogen as a power source which provides quiet operation in the residential areas; a wand tip which treats both the water surface and the basin walls is used. Of course the ever-present hand cans and back pumps are used for small and inaccessible source treatment.

Fenthion, applied at 0.1 lb./acre in both liquid and granular formulations, serves as our basic insecticide. For catch basins a nonemulsified diazinon and oil formulation is used which provides both a larvicide and a residual adulticide on the basin walls; however, diazinon and oil is not used in areas with drain lines feeding into bodies of water of good quality where the pollution factor of the material would produce harmful results.

Biological control consists of routinely checking and stocking all bodies of water which will support fishlife with the mosquito fish, *Gambusia affinis.* Such sources as fish ponds, lakes, ponds, unused swimming pools, creeks and ditches are included in this program.

Source reduction by district personnel is largely a matter of light tractor and hand work in ditching and in the maintenance of drainways and water control structures. Major effort is expended in working with municipalities, developers, and private individuals in providing and maintaining adequate and proper drainage systems and waterways designed to reduce mosquito production potential.

Standard surveillance procedures (larval collections and light trapping) are used for population sampling and program evaluation. Special surveys are provided from time to time as needed.

Midge Control

Along with the increasing organic deposition in our waterways, establishment of marina developments, and the rising population, a chironomid midge problem has developed. Although midges are nonbiting insects their resemblence to mosquitoes and the enormous numbers in which they often occur serve to initiate numerous service requests. The control program has three main phases, chemical control, control by water management, and habitat surveillance.

Chemical control is usually by 1% formulations of granular fenthion applied with shoulder mounted mist blowers which can be adapted for use with dusts and granules. In some shallow water areas liquid emulsifiable fenthion, applied as either a mist or a spray has been used. The dosage rate, in all cases, is 0.2 lbs./acre.

To facilitate treatment of large expanses of shallow water a pontoon raft, powered by an outboard motor, has been developed. For storage and transportation the raft is in four parts which can be quickly assembled at the treatment site. It will operate in water depths as shallow as nine or ten inches with a 550 pound payload.

Along the bay front, dual purpose marina developments are presenting serious potential midge problems. During the summer months the lakes and lagoons are filled with bay water for recreational purposes; in the winter, levels are dropped and they serve as flood basins for fresh water runoff. As long as the specific gravity (salinity) remains at 1.017 or above, midge production is inhibited. When the salinity falls below this level (especially during warm periods in early spring) midge populations are quickly established. Water management procedures have been worked out between the district and those responsible for the systems, whereby a desirable salinity is maintained by flushing with bay water. As increasing amounts of fresh waste water (currently 700,000,000 gals./day + runoff) are dumped into the bay, continual freshening occurs, especially marginally where flushing water is obtained, and may eventually render this procedure ineffective. In this event, new control methods will have to be found.

Aquatic source surveillance and habitat studies are being carried out to provide more information on the habitats, development, and control of both mosquitoes and midges, as well as other aquatic insects. These studies include water analysis (specific gravity, temperature, turbidity, pH, ammonia nitrogen, dissolved oxygen (DO), biochemical oxygen demand (BOD) and routine environmental evaluation associated with nuisance problems of algae, odor, and esthetic desirability compatible with recreation, fishing and related activities.

Black Gnat Research and Control

The valley black gnat, *Leptoconops torrens,* is a tiny black fly belonging to the family Ceratopogonidae and is associated with certain deep-cracking clay soils which provide the larval habitat. *L. torrens* should not be confused with the related species, *Leptoconops kerteszi,* which occurs in the surface layer of sandy soils. The larvae of *L. torrens* are found at soil depths ranging between 12 and 40 inches with most occurring between 18 and 30 inches. The adults usually begin emergence between the middle and the end of May and persist six to eight weeks, with the population peak occurring two to three weeks after the onset of emergence. The females are vicious and persistent biters but are not known to be disease vectors to man.

Gnat nuisance problems arose as land developments began invading gnat producing areas within the district. The soil depth at which the larvae occur, the relatively short period of adult activity, and the lack of basic biological knowledge made control all but impossible. As a result of this situation, research was started by the District in 1957 with the development of control techniques as the ultimate goal.

Research on this difficult organism has necessitated the acquisition, modification, and development of specialized equipment over the years. Modified Dow emergence traps, placed over cracked soils, are used to determine source areas, and to measure adult emergence. A sticky cylinder, CO_2 attractant trap was developed to measure airborne populations. Both traps are used in several phases of biological study and control approach evaluation. A meter employing buried soil cells is used to detect fluctuations in soil moisture and temperature in the larval zone. A cup anemometer provides wind velocity measurements for studies of adult habits. An incubator and development of rearing chambers were required for life cycle and other biological studies.

Much of the effort has been directed toward biological studies necessary to provide background information and a firm basis for control approaches. From this research has emerged control techniques of two types; cultural and chemical.

Cultural control (i.e., the manipulation of soil conditions to suppress gnat development) may be accomplished by either irrigation or discing. Maintenance of a high soil moisture prevents cracking, thereby hindering both adult emergence and egg depostion. Addition of supplementary water for this purpose (6 to 10 inches depending upon rainfall) may be applied either by flooding or overhead sprinkling. Discing apparently discourages egg deposition (but not adult emergence), and after two or three successive annual discings a marked reduction in the gnat population occurs. In both of these techniques proper timing is necessary for effectiveness.

Chemical control efforts have been directed toward adult populations. Residual insecticide formulations, either as mists or sprays, are applied to the soil and vegetation in producing areas where gnats seeking shelter will come in contact with it. Various formulations of fenthion and diazinon (at 0.5 lbs./acre) have provided control in both experimental plots and field usage. The adult gnats tend to rest in hard-to-get-at places necessitating the addition of spreaders and stickers to the formulations. Recent tests indicate that the addition of a polyvinyl alcohol (P.V.A.) sticker to oil or water emulsion carriers significantly increases effectiveness at practical treatment levels for immediate relief.

Although the normal tendency for control usually entails a larvicidal approach, extensive testing of chemical applications to soil in a variety of ways for such larval control, by a number of different agencies, has demonstrated the impracticality of this approach for *L. torrens.*

Since the broad powers provided for mosquito abatement do not apply to black gnat control, the cooperation of the public is necessary in the development of control procedures.

Yellow Jacket Program

The increasing usage of public picnic and camp facilities has focused attention on the yellow jacket problem in these areas. In 1962 the district undertook a study project to develop standard population sampling and control techniques, from which evolved the program now employed. In 1967 the program was expanded to include treatment of individual nests causing public nuisances. Three yellow jacket species produce this problem; two ground nesting, ***Vespula vulgaris*** and ***V. pensylvanica,*** and one aerial nesting, ***Vespula*** *(Dolichovespula) arenaria.*

Population measurements (evaluative trapping) are made by placing standard traps (modified B.V.C. fly traps) in the areas to be sampled and plotting the resulting collections as the average number of yellow jackets per trap per week. By comparing the results of controlled areas to those of similar uncontrolled areas the program effectiveness may be determined. The traps are also used to test new bait and insecticide combinations for attractiveness, and in biological studies such as annual population dynamics, flight range, etc.

A standardized bait of fresh, ground, cooked horsemeat is used as an attractant. The same bait with 1% chlordane (wettable powder) added is used in the toxic baiting program.

The toxic baiting control technique is based on the food requirements of the developing larvae. Protein materials are sought by adults and carried to the nest for larval food. Bait containers, permitting entry and escape of yellow jackets while protecting larger animals from the bait, are distributed throughout the area to be controlled. Larvae feeding on and adults handling the bait are killed resulting in the destruction of colonies working the bait containers. Control efforts are usually started when the annoyance level (50-60/trap/week) is reached.

Initially the bait was put out at the rate of one bait/2 acres and replaced once or twice a week throughout the entire season. Subsequent investigation showed that increasing the rate to one or more bait/acre and replacing it on each of three successive days gave better control at less cost. In years having unusually long season or low colony density a second baiting may be necessary.

Individual nest destruction by direct chemical means is simply a matter of spraying a toxicant (D.D.V.P. is currently used) into the nest opening with a hand can. Of course protective clothing is recommended for this operation.

In summary, the increase in population and the accompanying land development in San Mateo County are shifting the emphasis of our mosquito control efforts and, by public demand, expanding our program to include other insect pests. The program currently includes phases devoted to mosquitoes, midges, black gnats, and yellow jackets. Each phase is undergoing constant study, evaluation, and modification as new information becomes available and new situations arise.

HELICOPTER NURSE RIG

Lonnie E. Johnson
Merced County Mosquito Abatement District, Merced

One of the latest and most worthwhile developments in our District's spray program has been the development of a dependable nurse rig for our helicopter. The nurse rig is the "right arm" of our helicopter spray operations. With this rig and the establishment of heliports throughout the County, ferry and refueling time is reduced to a minimum.

Our first step in planning what we wanted in the way of a support vehicle was to carefully study the terrain involved in our operations. Then we decided on the weight, size, load capacity and maneuverability which would be best suited to our needs. We didn't want a cumbersome vehicle which would be useful only on paved roadways, yet we wanted something with an adequate load capacity.

Bearing these factors in mind we made inquiries into the cost of building a completely new rig. Needless to say, it proved to be an expensive proposition. So we began searching the used truck market in hopes of finding a suitable vehicle. Fortunately, we came across a used 1953 Chevrolet, Series 6400, gasoline tanker that a Standard Oil distributor in Waterford, California, had for sale. The price seemed appropriate and with the season fast approaching the District purchased the tanker for $1500. The initial cost, including truck and parts, came to a total of $2,011.92, plus 160 man hours for labor.

This unit has certainly performed well in 1967, and has greatly increased the efficiency of our helicopter operations.

OPERATIONAL APPROACH TO MOSQUITO CONTROL IN THE KINGS MOSQUITO ABATEMENT DISTRICT

Edward O. Lewis
Kings Mosquito Abatement District

Kings Mosquito Abatement District is located in the northern part of Kings County. There are approximately 553 square miles within the district's boundaries. With five population centers, Hanford, Corcoran, Lemoore, Armona and Stratford, the county's total population is approximately 70,000.

There are four different soil series within the district:
1. Grangeville series: Grangeville series is located in the northern part of Kings County, extending along the Kings River. This is where our fruits and vineyards are located, which are relatively free of mosquito production.
2. Foster series: Foster series lies in the central area of the district and consists of general farming; corn, cotton, permanent pature and alfalfa. This area produces large numbers of *Aedes* and *Culex* species.
3. Traver series: In this area, which is located along the east side of Kings County, large field-type farming is carried on; cotton, corn, some sugar beets and large fields of permanent pasture, all of which are large producers of *Aedes nigromaculis*. Our largest insecticide resistance problem also exists in this area.
4. Lethent series: This area, which is located along the west side of Kings County, was practically all dry farming many years ago. It consists mostly of large land holders and you'll find cotton and grain grown here with very little mosquito problem. To the east of this area, is a wide belt of perched water, extending south to Tulare Lake basin, causing seepage problems, also sloughs, and natural area type mosquitoes are in this area.

The mosquito on which the district spends the most money for control is *Aedes nigromaculis*. The soils, extensive irrigation, large acreages of permanent pastures and alfalfa are natural for this species of *Aedes*.

We also find these other species of *Aedes* somewhat troublesome: *Aedes vexans* in our slough and seepage area along the Kings River; *Aedes melanimon* develop in our native pasture areas, and bring about a greater problem in the spring. Many of our permanent pastures, corn and slough areas produce *Culex tarsalis* as well as *Culiseta inornata* during the spring and fall.

Dairy drains that are not kept free of weeds and grasses produce great numbers of *Culex peus* and *Culex quinquefasciatus*. Street catch basins, gutters and drains in our towns and cities also produce these species. These street problems are treated weekly. Ethyl parathion granules are applied with a right-hand drive jeep, equipped with a compressed air dispensing system.

During the 1966 season, our district-owned aircraft treated 176,549 acres, using ½ gallon liquid spray per acre. This was applied by two Piper Pawnee 235's, owned by the district.

Insecticide used was as follows: methyl parathion, 114,069 acres; fenthion, 56,537 acres; and EPN 5,943 acres. M-parathion was used largely on *Culex* species and adult mosquitoes and in nonresistant areas or fields. Fenthion and EPN were used on *Aedes nigromaculis* in resistant areas and fields.

In the 1967 season, 202,728 acres were treated, an increase of 26,179 acres over 1966. This was largely due to late winter rains and heavy snow pack in the Sierra. This made a heavy runoff until midsummer causing many natural areas that are normally dry to have standing water all summer. Of the 202,728 acres treated, 107,291 acres were treated with M-parathion, 45,935 acres with fenthion and 49,000 with EPN.

The Kings district owns a PA 18-A Super Cub, as well as the two previously mentioned Piper Pawnee 235's. This aircraft was fitted with a low volume spray rig. It applied Baytex® at a rate of 6 oz. per acre, using an aircraft electrical fuel transfer pump and four T-jet nozzles, spraying with approximately 20 pounds of boom pressure. The system was installed and used primarily for *Culex tarsalis* in corn fields; however, it was used satisfactorily on all types of mosquito sources, and 34,000 acres were treated with this aircraft from mid-June to October 1.

For the 1967 season, a daily average of 100-125 individual sources were treated by district pilots, adding up to 2,302 sources treated for the season, of which 746 of these were permanent pasture and 512 were alfalfa fields. Three hundred thirty-eight native areas, and 202 canals and ditches were among the greatest number of sources treated.

The Kings district is also engaged in an active source reduction program, concentrating mostly on dairy waste water and natural area problems. The district owns an International TD-9 with a dozer and a 4½-yard speed haul scraper. Drain sumps or reservoirs are constructed by the district and property owners are charged on a cost basis. Construction of these sumps greatly reduces mosquito production and dairy waste water. Sumps are kept weed free with soil sterilants which discourage mosquito breeding and also keep water confined to an area which can be treated by hand or power equipment or even by aircraft if necessary.

Filling seepage holes and cleaning sloughs of undesirable brush without disturbing the natural cover for wildlife aids in controlling these areas with aircraft or hand equipment, and is another phase of our source reduction program. Many of our *Aedes vexans* and *Culex tarsalis* sources are eliminated or reduced by our source reduction personnel.

Another phase of source reduction in Kings MAD is our urban and domestic program, which is directed at control of *Culex quinquefasciatus* and other *Culex* species. Household problems include cesspool and septic systems which are faulty or are open or poorly contructed. Personnel work with the Health Department and property owners in getting problems corrected or eliminated.

The district is divided into nine control zones, each with a permanent full-time operator. Working as an operator-inspector one inspects and checks sources to be treated by aircraft, and fills out or makes the aircraft request maps used by the district pilots in getting to each source that is to be treated on any given day.

Since 99.3% of spraying is done by aircraft, no field or problem is considered too small; only safety and accessibility determine whether aircraft is to be used.

The control season begins as early as the last week in March, spraying *Aedes melanimon* to spraying *Culex quinquefasciatus* in the middle of November; *Culiseta inornata* usually begin showing up again in August. This is one species which we do not control, since it is not considered a biting pest in our area. *Culex tarsalis* begin showing up in late February but no control is begun until the last of March. *Aedes nigromaculis* and *A. vexans* control starts the last of March or the first of April and continues through the 15th to the 20th of October, all contributing to a long and busy mosquito control season.

OPERATIONAL APPROACH TO MOSQUITO CONTROL AND OTHER VECTORS IN THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

E. L. Geveshausen

Southeast Mosquito Abatement District

The Southeast Mosquito Abatement District lies wholly within the boundaries of Los Angeles County and was founded in 1952. At the time of formation, it included three incorporated cities, Huntington Park, Maywood, and Bell, and unincorporated area for a total of 170 square miles. The assessed value at the time was $406,000,000.00 and a tax rate of $0.00183 per $100.00 assessed valuation. Today there are 23 cities and unincorporated area of 510 square miles, with an assessed valuation of $4,600,000,000.00, a tax rate of $0.0065, and a population of 2,500,000.

The philosophy of the District is to provide 100% control of all species of disease-bearing and pest mosquitoes and chironomids. The operational aspect of this program places great emphasis on prevention of emergence of adult mosquitoes and midges. The District has arrived at such a level of control, that the presence of one or two mosquitoes around a home results in a call to the District for service. Consequently, we must maintain a year-round program. This program is not just a routine spray program using various chemicals and larvicide oils, but includes the heavy use of mosquito fish (*Gambusia affinis*). These fish are planted in various water sources such a ponds, lakes, flood control channels, water troughs, and reservoirs. The District also furnishes mosquito fish to the public from its main headquarters in South Gate and from its North Hollywood office that services the San Fernando Valley.

Source reduction is also stressed in the District's program. Over the years, we have maintained a source reduction program in the most highly concentrated dairy area in the world. However, due to the rapid urbanization of Los Angeles County, this program is becoming less important. The District also works very closely with the U. S. Army Corps of Engineers and Los Angeles County Flood Control District in the design of flood control channels, so as to minimize the area of water in such structures by designing the channel bottoms to include inverts and low-flow channels.

The operational control program of the District over the years has searched for and tested many different types of equipment to increase the efficiency of the man in the field and at the same time reduce the cost of the program for the taxpayer. One example of this is the 100% use of right-hand drive vehicles. For example, in a typical summer month for the District, 145 miles of roadside ditches, 7280 miles of gutters and 7362 catch basins were sprayed. If we were using standard left-hand drive vehicles, the District would have had to employ a minimum of 20 more men to make up two-man crews to accomplish the same amount of work. With the use of right-hand drive vehicles, the driver does all the spraying and at the same time observes all the traffic laws and safety regulations. The saving in salary alone justifies the reduced trade-in or resale value of such a vehicle. All of our spray equipment is air supplied by a 12.5 c.f.m. Wagner compressor driven off the vehicle engine.

The District is also charged with the control of chironomid midges, and we have found that the source of a large part of our chironomids originates in the bottoms of the improved channels in the District. We have 170 miles of this type of channel. By using solid rubber tires on two of our vehicles, we are able to control midges by driving in the bottom of the channel. Using a boom mounted across the rear of the vehicle, one man is able to do the job as compared with 4 men required to do the spraying from the top of the bank. The cost of a set of solid rubber tires is about $450.00 and these will last for 2 or 3 seasons.

We also have large, permanent areas of water such as golf course lakes, reservoirs, water reclamation, and percolation basins. When chironomids emerge in tremendous numbers, they are a cause of great concern to nearby homeowners and can cause financial loss to nearby industrial and commercial complexes. Unlike mosquito larvae, midge larvae are usually not free swimming, but inhabit the mud layer just below the surface. Because of the habitat of the midge larvae, it has been found that German carp and channel catfish, due to their bottom feeding habits, will control midge emergence. In certain selected areas of this type, we do a small amount of chemical control, using 2% parathion granules or 1% Abate® granules.

An important aspect in the control of mosquito breeding with which we are faced is the tremendous number of swimming pools. The District has an estimated 100,000 swimming pools and at any given time we will have 75 to 150 pools that are not properly maintained and are breeding mosquitoes. The District is usually not aware of the individual pools that are causing a problem until a service request is received. The complainant usually states that they have mosquitoes; and they think they are coming from a pool in the neighborohood, or through questioning about their mosquito problem, we learn there is a pool nearby that could be causing a problem. Proper steps then will be taken to have the problem corrected by notice to the owner or occupant or by the District. The location of the pool will then be entered on a card file and followup inspection will then be made. These cards will also be used for future reference in relation to any mosquito problem that may arise later.

The District maintains a continuous safety program, with emphasis on safe driving habits, handling of insecticides, and application of insecticides, with particular emphasis on safety to the public. For safety to the operator, the District furnishes uniforms, boots, gloves, hard hats, respirators, and goggles. All operational personnel are, without exception, required to take a shower and change clothes at the end of the daily work period. The District in its safety program conducts training sessions periodically during the year for all of the personnel.

The Southeast Mosquito Abatement District is always on the lookout for labor-saving ideas and devices. We are most anxious to hear from any District that has some ideas or equipment that we might adopt for our needs. Also, we are most happy to have anyone use any idea or adaptation that we might come up with. The exchange of ideas or development of equipment is very important if we are to maintain a high level of service to citizens of our respective districts.

AFTERNOON GENERAL SESSION

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

HIGHLIGHTS OF UNIVERSITY OF CALIFORNIA MOSQUITO CONTROL RESEARCH

JOHN H. BRAWLEY, *Manager, Presiding*

NEW TECHNIQUES AND MEASURES FOR MOSQUITO CONTROL

MIR S. MULLA

University of California
Department of Entomology, Riverside

The research program on the development of new techniques and measures for mosquito control was intensified at the Riverside Campus during the 1967 season. Two long range experiments were initiated on the effects of a pesticide and a predator on the equilibrium level of selected species of zoo- and phytoplankton. Effects of Dursban®, a new promising mosquito larvicide, on nektonic, planktonic and higher organisms were studied in the Bakersfield area, using experimental ponds. Effects of the introduction of a predator—mosquito fish—on the abundance and diversity of aquatic organisms were studied in Riverside. Due to lack of time results of these studies will not be presented here.

Similarly, the effects of new mosquito larvicides including petroleum oil on several nontarget aquatic insects were studied in experimental ponds located near Oasis in the Coachella Valley. Speed of kill and then recovery time for several species of aquatic insects were determined. Results of these studies will also be excluded from this report.

Studies directed toward the control of several species of mosquitoes—*Culex quinquefasciatus, C. tarsalis, Aedes aegypti, A. nigromaculis* and *Anopheles albimanus* are discussed below.

LABORATORY STUDIES

1. Laboratory Screening of New Compounds.—A large number of new compounds were evaluated against 4th stage larvae of *Culex quinquefasciatus.* Among those evaluated, Bay 78182, Dursban, SD-9098, AC-72499, Bay 76960, Bay 69047, Bay 77488, and Bay 78755 proved highly effective. All of these compounds were more effective than fenthion. Neo-pynamin®, a chrysanthemumate related to pyrethrins, showed mediocre activity, but it was highly effective against pupae.

NIA-17370 also a chrysanthemumate proved much more effective than Neo-pynamin. This compound was highly effective against the pupae, too, This compound holds great promise particularly for the control of OP resistant *Aedes nigromaculis* in irrigated pastures.

Other organophosphate larvicides having interesting chemical composition were also evaluated. Two CIBA compounds, C-9491 and C-8874, containing iodine in addition to chlorine proved highly effective. The mammalian toxicity of the former compound is about 2000 mg/kg (LD_{50} for rats) and the latter compound also has favorable mammalian toxicity and good residual activity in soil.

2. Ovicides.—Investigations on the effectiveness of aliphatic amines, neo-pynamin and petroleum oils as mosquito ovicides were conducted in the laboratory. Eggs of two species—*Culex quinquefasciatus* and *Anopheles albimanus* were used in these studies.

When 16-20-hour-old eggs were exposed to 1 and 10 ppm for 3-5 days, some compounds were more effective against one species than the other. For example, Alamine 11 was more effective against *C. quinquefasciatus* than against *A. albimanus,* killing 100% of the eggs of both species at 10 ppm. Alamine 15 at 10 ppm killed all the eggs of *A. albimanus,* but none of the eggs of *C. quinquefasciatus.* Alamine 21 and 26 showed a similar trend. Armeen L-15 was more effective against the former species than the latter species.

Age of eggs and period of exposure to treatment influenced egg mortality. As the age of eggs increased, the level of mortality decreased. This inverse relationship between age and mortality was true for both species. Length of exposure period, however, was directly related to susceptibility. As the exposure period increased, level of mortality also increased.

Similar relationship between age, exposure and mortality existed for Neo-pynamin. This compound, although having some ovicidal activity, was not as effective as some of the aliphatic amines.

Petroleum oil with some surfactant (1%), caused egg mortality of *C. quinquefasciatus* by causing them to drown. In all those concentrations where the egg rafts drowned, complete mortality was obtained. Mechanical drowning of eggs produced similar results. It might be possible to develop a technique for drowning *Culex* eggs under field conditions and thus eliminate hatching.

N1A-17370, a chrysenthemumate has some ovicidal action. Additionally this compound is a very good adulticide, larvicide and pupicide. Compounds of this type are likely substitutes in area of OP resistance and elsewhere.

Field Studies

3. Field Evaluation of New Mosquito Larvicides.—Several new materials were evaluated against *Culex tarsalis* and *Aedes nigromaculis.* The tests against *C. tarsalis* were conducted in breeding ponds in the Bakersfield and Coachella Valley areas. Studies on *A. nigromaculis* were conducted in irrigated pastures in the vicinity of Kern National Wildlife Refuge. All materials were applied as aqueous sprays at the rate of 4-8 gallons per acre.

Culex tarsalis (Coachella Valley ponds). Bay 69047 at 0.05 and 0.1 lb/acre yielded complete control of the larvae one day after treatment. Larval populations recovered a week later and reached pre-treatment levels 2 weeks after treatment. Bay 77488 gave complete control of larvae one day after treatment, but the population was back to pre-treatment level a week later. Bay 78182 at 0.05 and 0.1 lb /acre yielded complete control of larvae one day after treatment. Recovery to pre-treatment level took place one week and two weeks later for the two dosages, respectively. Bay 78755 also produced complete initial kill at 0.05 and 0.1 lb/acre, but full recovery occurred 2 weeks later.

GC-6506 was applied at 0.05, 0.1 and 0.25 lb/acre. At all these rates almost complete control was achieved for 2 weeks. Three weeks after treatment, good recovery of the larval populations occurred.

Akton at 0.01, 0.05 and 0.10 lb/acre produced almost complete control within a week after treatment. Good control was achieved up to two weeks after treatment at all three dosages. Presence of all stages of larvae was noticed at the lower rate, 3 weeks after treatment. No breeding was apparent at the two higher rates at this interval, at which time the studies were terminated.

Neo-pynamin with synergist gave good control of larvae at 0.25 and 0.5 lb/acre. Without the synergist the level of control was poor. Larval population recovered at the higher rate but no recovery took place at the lower rate where heavy predator population prevailed.

It is interesting to note from these studies that the lower rate of a given compound gave essentially the same (may not be complete) level of control as the higher rates. The duration of control was almost the same. Due to economic circumstances and nontarget safety requirements and in light of these findings it would be desirable to make larvicidal treatment at the lower rates achieving good but not complete control of larval populations. It seems that in most cases there hardly seems to be an appreciable difference in terms of long term control between effective lower and higher rates. The lower rates will more likely interfere to a lesser extent with major predators and nontarget organisms in the treated area.

Field studies with several materials against *Culex tarsalis* were made in breeding ponds near Bakersfield, California. Furadan granules (2% sand coated) yielded excellent control of this mosquito at 0.05 to 0.1 lb/acre. This material did not appreciably affect diving beetle larvae and adults, belostomatids and ostracods. Mayfly naiads were adversely affected.

Neo-pynamin did not yield appreciable control of *Culex tarsalis.* These results were similar to those obtained in the Oasis ponds. This is in contrast to the activity of this compound against *Aedes nigromaculis* (see below).

Bay 69047 yielded complete control of *Culex tarsalis* at the rates of 0.05 and 0.1 lb/acre. Bay 77488 produced 87% and 90% at similar rates, respectively. Akton produced 88% and 93% kill of larvae at these rates, respectively.

Aedes nigromaculis. Furadan granules (2% sand coated granules) gave 100% control of this species at the rate of 0.25 lb/acre of Furadan. Both pre- and post-hatch treatments gave this level of control. Although this type of treatment cannot be readily compared with those against *Culex tarsalis,* it is nevertheless obvious that this compound is more effective against *A. nigromaculis* than *Culex tarsalis.* Furadan, being a carbamate insecticide, seems to have a negative coefficient of activity against resistant species. Therefore, this compound offers some good possibilities for the control of resistant *A. nigromaculis.*

Neo-pynamin was also highly effective against *A. nigromaculis.* At 0.25 and 0.5 lb/acre this compound gave 98-99% control of both larvae and pupae of *Aedes nigromaculis* It is interesting to note that this compound did not prove too promising against *Culex tarsalis* when tested in the Bakersfield and Oasis ponds. Again it seems that this compound may have a negative correlation with resistance. Definite information on this aspect is yet to be developed.

4. Drip Application in Irrigated Pastures and Sewage Streams.—Application of emulsifiable concentrates (usually containing 2 pounds of active ingredient per gallon) by the

drip technique yielded excellent control of *Aedes nigromaculis* in irrigated pastures and *Culex* spp. in sewage oxidation ponds and lagoons.

In the irrigated pastures, Abate® dripped at the rate of 0.1 ppm in irrigation water did not yield complete control of *A. nigromaculis*. However, dripping at the rate of 0.17 ppm produced complete kill of the hatching larvae.

Methyl parathion at both 0.14 and 0.23 ppm (0.17 and 0.3 lb/acre respectively) produced complete control of larvae. In another test this material when dripped at 0.15 and 0.16 ppm (0.10 and 0.15 lb/acre respectively) also produced complete mortality of the larvae.

Dursban proved highly effective when applied by the drip technique. This material was dripped in irrigation water at the rates of 0.08 ppm (0.07 lb/acre), 0.13 ppm (0.14 lb/acre), 0.3 ppm (0.25 lb/acre), and 0.3 ppm (0.3 lb/acre). In all these tests complete control was obtained. It is very likely that Dursban dripped at the rate of 0.05 ppm will produce satisfactory control of *A. nigromaculis* larvae.

Fenthion dripped at the rate of 0.14 ppm (0.15 lb/acre), 0.2 ppm (0.25 lb/acre), 0.2 ppm (0.19 lb/acre) and 0.5 ppm (0.59 lb/acre) produced almost complete control of mosquitoes.

There are indications that one drip application of larvicides, especially Dursban, will yield control during the succeeding irrigation cycles. This point needs further investigation. Even if the control is for only one irrigation cycle, the drip application technique has some obvious advantages over other methods of application. Although cost of material is going to be high, the savings from inspection labor and repeat treatments will more than offset this increase in cost of control. Cost analysis of this technique, however, has not been carried out.

5. Larvicidal Oils.—Three mosquito larvicidal oils were evaluated in field ponds in the Coachella Valley against *Culex tarsalis*. Toxisol FLC and TB (both supplied by Atlantic-Richfield Corporation) were formulated by adding 1% of Atlox 1256, a non-ionic surfactant. Flit® mosquito larvicidal oil (Humble Oil Co.) was 99% pure with 1% additive of unknown nature.

Toxisol FLC, an aromatic base oil, at the rates of 2 and 4 gallons per acre produced excellent kill of 1st, 2nd, 3rd and 4th instar larvae and pupae, 24 hours after treatment. Control was more pronounced one week after treatment, although first instar larvae just hatched from eggs were numerous in the samples. There were no 3rd or 4th stage larvae or pupae a week after treatment. Two weeks after treatment, the population density of 3rd and 4th instar larvae was quite high. In these studies, 0.5 and 1.0 gallon per acre produced slight to moderate control of the immature mosquitoes.

Toxisol TB an iso-paraffinic oil at 4 gallons per acre produced excellent control of immature stages within 24 hours. This level of control remained effective up to two weeks after treatment. All stages of mosquitoes were back, 3 weeks after treatment. The 1 and 2 gallons per acre rates did not yield appreciable control.

Flit MLO yielded moderate to high level of control at 2 and 4 gallons per acre, 24 hours after treatment. The level of control was almost 100%, a week later. Breeding of mosquitoes occurred in these ponds but none of the larvae passed the 1st stage up to 3 weeks after treatment. Beyond this period the tests were discontinued. At 1 gallon per acre this oil resulted in moderate level of control.

Appearance of 1st and 2nd instar of *Culex tarsalis* is no cause for initiating control measures. It was shown in these studies, that appreciable numbers of 1st instar larvae were found in most of the treated ponds at intervals after treatment, but not many of these transformed into succeeding stages. There is need for more critical evaluation of the breeding potential of certain mosquito species before suppression treatments are initiated. Education of applicators in this regard cannot be over emphasized.

Field tests were also conducted on larvicidal oils in sewage oxidation lagoons at Ontario, California, against *Culex tarsalis* and *Culex quinquefasciatus*. The tests were made in sheet metal cylinders having a surface area of 2 sq. ft. The data obtained are presented in Table 1.

Table 1. Field tests at Ontario Ponds (8-11-67 through 8-30-67) made in cylinders with surface area of 2 sq. ft. Larvae were those of *Culex tarsalis* and *Culex quinquefasciatus*.

Oil and Surfactant	% Mort.[1] at various rates of application (ml./cylinder)				
	0.1	0.2	0.25	0.4	0.5
Toxical FLC 1% A1256,	13	—	72	—	—
Toxisol TB 1% A1256,	19	68	80	99	100
WSX 6981	76	86	—	99	—
WSX 7231 (Flit MLO),	38	96	—	100	—

[1]Mortality was read 24 hours after treatment.

6. Resistance.—Studies on the level of resistance of *Aedes nigromaculis* larvae collected in Kern and Kings Counties were conducted during the past 4 years. Fourth instar larvae were collected from fields infested and brought to the laboratory for bioassay. Acetone solutions of the toxicants were evaluated in 6-oz. treated paper cups holding 100 ml tap water and 25 mosquito larvae. Each dosage was replicated 2-3 times. Mortality was assessed 24 hours after treatment.

Table 2 indicates that *A. nigromaculis* larvae from Coberly West pasture (Kern District) are tolerant to methyl parathion. They were highly susceptible to Dursban. In Smith pasture (located near the corner of Kern, Kings, and Tulare Counties), the larvae were tolerant to ethyl parathion but little tolerance if any, was shown to methyl parathion. Larvae from this pasture were susceptible to the remaining materials tested. This pasture has not been under intense treatment schedule during the past few years.

In the Roberts pasture (Kern District) the larvae were quite tolerant to ethyl and methyl parathion. The level of susceptibility to the other materials tested was also low.

Larvae from Bakers alfalfa (Kern District) were tolerant to ethyl parathion, malathion and to some extent to methyl parathion. Abate, however, was quite effective against this strain.

Larvae from the City Sewer Farm in Bakersfield were susceptible to almost all the organophosphates. Some tolerance was indicated to dieldrin and DDT though.

In Blaise pasture (Kern District), there was a good level of tolerance to ethyl parathion, malathion, dieldrin and DDT. Some tolerance was also acquired to methyl para-

Table 2. Susceptibility of field collected *Aedes nigromaculis* in the southern San Joaquin Valley to various organophosphate insecticides.

Compound	24-hr. avg. % mortality at ppm .005	.01	.05	.1	
	Coberly West Pasture (July 1966)				
Abate	85	98	100	100	
Fenthion	45	100	100	100	
Dursban	100	100	100	—	
Methyl parathion	5	12	20	35	
Check	No Kill				
	Smith Pasture (July 1966)				
Abate	95	100	100	100	
Fenthion	100	100	100	—	
Dursban	100	100	100	—	
Meth. parathion	88	95	95	—	
Eth. parathion	—	45	95	98	
Check	No Kill				
	Roberts Pasture (May 1964)				
Eth. parathion	8	26	44	94	
Meth. parathion	2	22	58	98	
Fenthion	27	62	100	100	
SD-7438	28	60	100	100	
Guthion	0	18	54	92	
Check	No Kill				
	Bakers Alfalfa (October 1963)				
Eth. parathion	—	1	1	14	
Malathion	—	—	8	15	
SD-7438	5	51	100	—	
Abate	61	100	100	—	
Sumithion	3	7	96	—	
Meth. parathion	12	40	100	—	
Fenthion	16	44	100	—	
Check	No Kill				
	City Sewer Farm, Bakersfield (August 1963)				
Fenthion	95	—	—	—	
Abate	100	—	—	—	
Meth. parathion	100	—	—	—	
Sumithion	88	100	—	—	
Eth. parathion	100	—	—	—	
Malathion	—	50	96	96	
Dieldrin	—	10	50	70	100(0.5)
DDT	—	—	—	50	100(0.5)
Check	No Kill				
	Blaise Pasture (August 1963)				
Fenthion	38	100	—	—	
Sumithion	8	42	100	—	
SD-7438	52	98	—	—	
Meth. parathion	20	58	100	—	
AC-43913	22	100	—	—	
Eth. parathion	0	0	26	50	88(0.3)
Malathion	0	0	28	76	100(0.3)
Dieldrin	0	0	30	60	78(0.5)
DDT	—	—	—	—	50(0.5)

thion. The remaining materials had good activity, but lower than that against susceptible strains.

With the exception of the City Sewer Farm and Smith pastures, high level of resistance was manifested by *A. nigromaculis* larvae to ethyl parathion, malathion, dieldrin, and DDT in Kern County and the neighboring areas.

Seasonal susceptibility of larvae in two pastures was studied in 1964 (Table 3). In one pasture (Pala) there was a slight decrease in tolerance as the season progressed to most of the materials studied. In the other pasture (Roberts) the reverse was true. Seasonal trend could obviously be influenced by many factors such as frequency of treatments, larvicides used and influx of susceptible genes from adjacent fields.

Aside from Smith pastures, the activity of ethyl parathion against all strains lies within a 5 fold concentration. The range of methyl parathion is only 2½. The range of the other materials except dieldrin and DDT follows a similar pattern.

It should be noted that most of the areas studied for tolerance had experienced failure of control with ethyl parathion treatments.

Time mortality relationship of larvae from Pala pasture (see Table 3) is presented in Table 4. It was the aim of this study to determine genetic composition of this strain in regard to resistance to various larvicides. With the exception of dieldrin showing breaks in the dosage response line, the remaining materials do not manifest a stepwise dosage response line.

Although these studies were conducted in an area where a moderate level of acquired resistance exists, it nevertheless shows the development of tolerance to DDT, dieldrin, ethyl parathion, methyl parathion and malathion. It can be concluded that resistance to substitute organophosphates is likely to develop in *Aedes nigromaculis.* Development of compounds having different mode of action or destroying the eggs, pupae, and adults should be emphasized.

7. Horizontal Distribution of Mosquito Larvae.—In testing permanent and semi-permanent ponds, it is important to know the distribution of mosquito larvae and pupae. Studies on this problem were conducted in replicated experimental ponds. The mosquito species abundantly breeding in these ponds was *Culex tarsalis,* the encephalitis mosquito. Some *Anopheles fransiscanis* were also breeding, but its numbers were very small.

Mosquito larvae and pupae were sampled in two areas of the ponds which were ecologically different. Equal number of dips were taken along the edges of the ponds where emergent vegetation was present, and in the center of the ponds devoid of emergent or any significant amount of submergent vegetation. Water from each category was strained through a fine mesh strainer and all larvae were transferred by washing with water into plastic vials to which 95% ethyl alcohol was added. The material was brought to the laboratory and the larvae and pupae were counted under a dissecting microscope.

In the open area of the pond the density of 1st and 2nd instar larvae of *Culex tarsalis* was essentially the same as the number of 3rd and 4th instar larvae. In the open area of 6 ponds studied, 54.2% of the immature stages were in the 1st and 2nd instars. The 3rd and 4th instar larvae comprised 44.3% of the pre-imagoes. Pupae constituted only 1.5% of the pre-imaginal stages.

Pre-imaginal mosquitoes sampled along the vegetated edges of the ponds, showed a trend very different from that

Table 3. Seasonal susceptibility of field strains of *Aedes nigromaculis* from southern San Joaquin Valley to various insecticides as assessed by the LC_{90} in ppm.[1]

Location (Kern County)	Date	Para-thion	Me. Para-thion	Fenthion	SD-7438	Abate	Guthion	GS-13005	Ronnel	Mala-thion	Diel-drin	DDT
Pala pasture	6/ 5/64	0.6	0.1	0.02	0.04	0.01	0.01 ·	0.04	—	—	—	—
	6/23/64	0.5	0.09	0.02	0.04	0.015	0.15	0.04	—	0.4	>5.0	>5.0
	8/21/64	0.2	0.06	0.017	0.25	0.009	0.04	0.015	0.7	0.5	>3.0	>5.0
Roberts pasture	5/13/64	0.3	0.07	0.02	0.02	—	0.1	—	—	—	—	—
	9/10/64	0.3	0.06	0.007	0.025	0.007	0.07	0.012	0.4	0.14	>5.0	>5.0
	9/20/64	1.0	0.15	0.02	0.15	—	—	—	—	—	—	—
Blaise pasture	10/ 2/64	0.5	0.1	0.01	0.015[3]	—	—	—	—	—	—	—
Bone pasture[2]	10/ 2/64	1.0	0.1	0.015	0.02	<0.02	0.1	0.04	0.7	0.3	—	—
Thompson pasture[2]	10/21/64	0.5	0.1	0.02	—	0.02	—	—	—	—	—	—
City Sewer Farm	10/ 1/64	0.5	0.15	0.009	0.04	0.025	—	0.03	1.0	0.3	—	—
Smith pasture	9/23/64	0.01	0.015	<0.005	0.015	0.004	—	—	0.04	0.15	0.15	0.5

[1]In all locations except Smith pasture treatment failures with Parathion had occurred.

[2]Bone pasture and Thompson pastures are locted in the same area.

[3]This figure is based on little evidence.

found in the open water. Along the edges, 85.2% of the pre-imaginal mosquitoes were as 1st and 2nd instar larvae, and 12.6% were as 3rd and 4th instar larvae. The pupae comprised only 2.2% of the population.

Based on the total population of pre-imaginal mosquitoes sampled in the ponds only 12.1% of the larvae were in the open water as compared to 85.6% of the larvae in vegetated areas. The number of pupae recovered in the vegetated area was 10 times the number found in the open water.

From the data it is apparent that population density of pre-imaginal mosquitoes near the edges is quite high. About 88% of the total population sampled existed in the narrow vegetated area, while only about 12% was recovered in the open water. It should be emphasized that the total open area in the ponds was greater than that of the vegetated margins. However, due to the very low density of pupae in the open water, it appears that very few immature mosquitoes make it to the adult stage in open water.

Table 4. Time mortality relationship of *A. nigromaculis* from Pala pasture (June 23, 1964).

Material	conc. ppm	Cumulative % mortality after hrs. 2	4	6	9	13	21	25
Parathion	0.5	5	20	40	57	79	89	—
Me. parathion	0.05	0	1	4	17	28	53	56
Fenthion	0.025	0	15	48	72	88	96	100
SD-7438	0.025	0	3	13	33	43	61	69
Abate	0.025	0	21	57	81	92	99	100
Guthion	0.10	1	9	15	32	56	72	81
GS-13005	0.05	1	11	21	44	83	91	93
Malathion	1.0	17	77	93	99	—	—	—
Dieldrin	2.0	0	0	13	28	—	40	45

From these studies it is apparent that treatment of the total surface for mosquito control may not be necessary. It is assumed that the low level of yield of mosquitoes in the open water does not create a pressing problem. This is an aspect that merits a critical and sophisticated investigation.

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A STUDY OF THE EFFECT OF WATER TEMPERATURES ON RICE FIELD MOSQUITO DEVELOPMENT

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It has been over 50 years since Freeborn (1917) made the first study of the biology of anopheline mosquitoes and Herms (1917) reported on the first statewide malaria survey in California. Aitkin (1945) included many valuable ecological observations in the first comprehensive study of California anophelines. In recent years the Bureau of Vector Control of the State Department of Public Health has maintained an active research project on rice field mosquito ecology and various workers have published their findings. Important contributions on the larval habitat of *Anopheles freeborni* in rice fields were made by Markos (1950, 1951) and Markos and Sherman (1957). Stone (1953) appears to have been the first to report records of water temperature in relation to rice field mosquito production.

Hardman (1947) was the first worker to rear *A. freeborni* over a period of time in the laboratory in large numbers and to note their idiosyncrasies. Barr (1952) carefully studied the upper limits of temperature on the aquatic stages of this western anopheline. More recently Bailey and Baerg (1966, 1967) have undertaken field ecological studies of the factors limiting the distribution and abundance of anophelines, specifically the flight habits.

Since *Culex tarsalis* Coq. was shown to be a major vector of viral encephalitis many articles have appeared reporting upon special studies of this vector. Notable, in relation to the larval habitat, have been those of Brookman (1950), Markos (loc. cit.), Loomis (1959), and Washino and Bellamy (1963). In recent years much attention has been devoted to flight range studies of this important mosquito (Dow, *et al.* 1965 and Baily, *et al.* 1965).

Mosquito abatement district personnel for years have observed many facts that now are common knowledge concerning the seasonal cycles of these two important rice field mosquitoes. However, there has been little attempt to conduct specific experiments—either in the laboratory or field—to determine the rate of growth and mortality of these two mosquitoes in relation to water temperature. This ecological factor has a very important influence on the rate of development of the larvae and results in high or low total "production" of the species from week to week and seasonally. We commonly hear such statements as "*C. tarsalis* normally reaches a seasonal peak earlier than *A. freeborni*" or "Some rice fields produce more mosquitoes than others." The relative abundance of mosquitoes is the result of many factors such as the location and density of the initial infes-

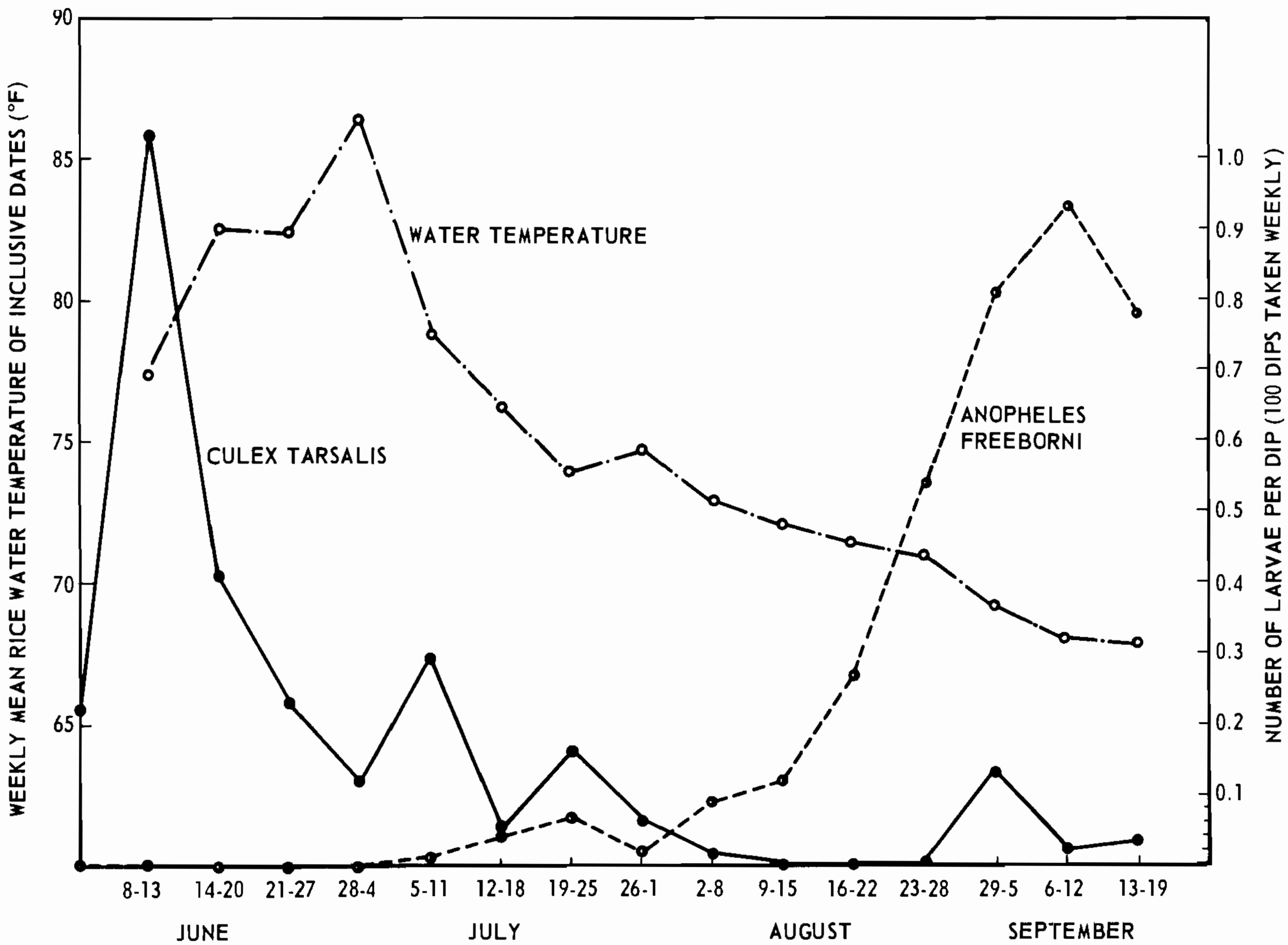

Figure 1. Seasonal trend of mosquito larval population in an unsprayed rice field. Grimes, California. 1967.

tation of a specific rice field, as well as the kind and abundance of predators and algae. Also, the rate of growth and density of stand of the rice has an important effect on the water temperature as well as the source of water itself, i.e. river, wells, shallow ditches, etc. Some research workers have studied the effects of algae and predators and have determined the relative abundance of larvae in various parts of a rice field and the seasonal trends in populations. During the past year or more we have set out to determine (a) the rate of growth of the larvae of these two mosquitoes in the laboratory at constant water temperatures, together wih the mortality occurring at these temperatures and (b) the rate of growth and seasonal development of the larvae in the field along with a record of water temperature.

Methods and Procedure

Newly-hatched larvae, from maintained stock colonies, were used in the experiment. No attempt was made to condition the larvae prior to their placement at a given temperature. The larvae were reared in white enamel pans partially filled with tap water. *A freeborni* was fed finely-ground "Friskies" or Gaines dog food. *C. tarsalis* was fed ground alfalfa pellets. At temperatures of 50-70° F., Brewer's yeast was added. The water in the pans was changed as needed, usually every other day in the case of *freeborni*. No aeration of the water was practiced. Twenty lots of 50 larvae each were employed at each temperature. Many *Anopheles* trials were discarded because ot disease or excessive pellicle formation on the water surface which "suffocates" the early stages. Occasionally a "weak" lot of larvae were produced by the colony and many died in the first instar. These larvae also were discarded. The date of pupation of each individual was recorded. All averages (Table 2), both of mortality and length of time in days required to reach pupation were based on 1,000 larvae. The gross constant temperature conditions were not always alike since various facilities of the department had to be employed such as a walk-in cold room, constant temperature boxes and ovens. The tests labelled as "checks" were reared at ambient room temperatures in an air-conditioned building with a 16-hour light cycle. In the field, temperature records were obtained with thermographs. (Model 1000, Marshalltown Mfg., Inc.)

There appeared to be no difference in the rate of growth between larvae utilized from the laboratory colony and those obtained from wild females. Some seasonal differences were noted in the behavior of the adults of the laboratory colony even though maintained in an air-conditioned building. The larvae did not exhibit any pronounced seasonal differences in behavior with the exception that bacterial diseases appeared to be more prevalent in the winter and spring and at 80° water temperature.

Table 2 summarizes the laboratory rearings which extended over a period of about 15 months. A total of 14,200 *A. freeborni* and 10,250 *C. tarsalis* larvae were utilized in the

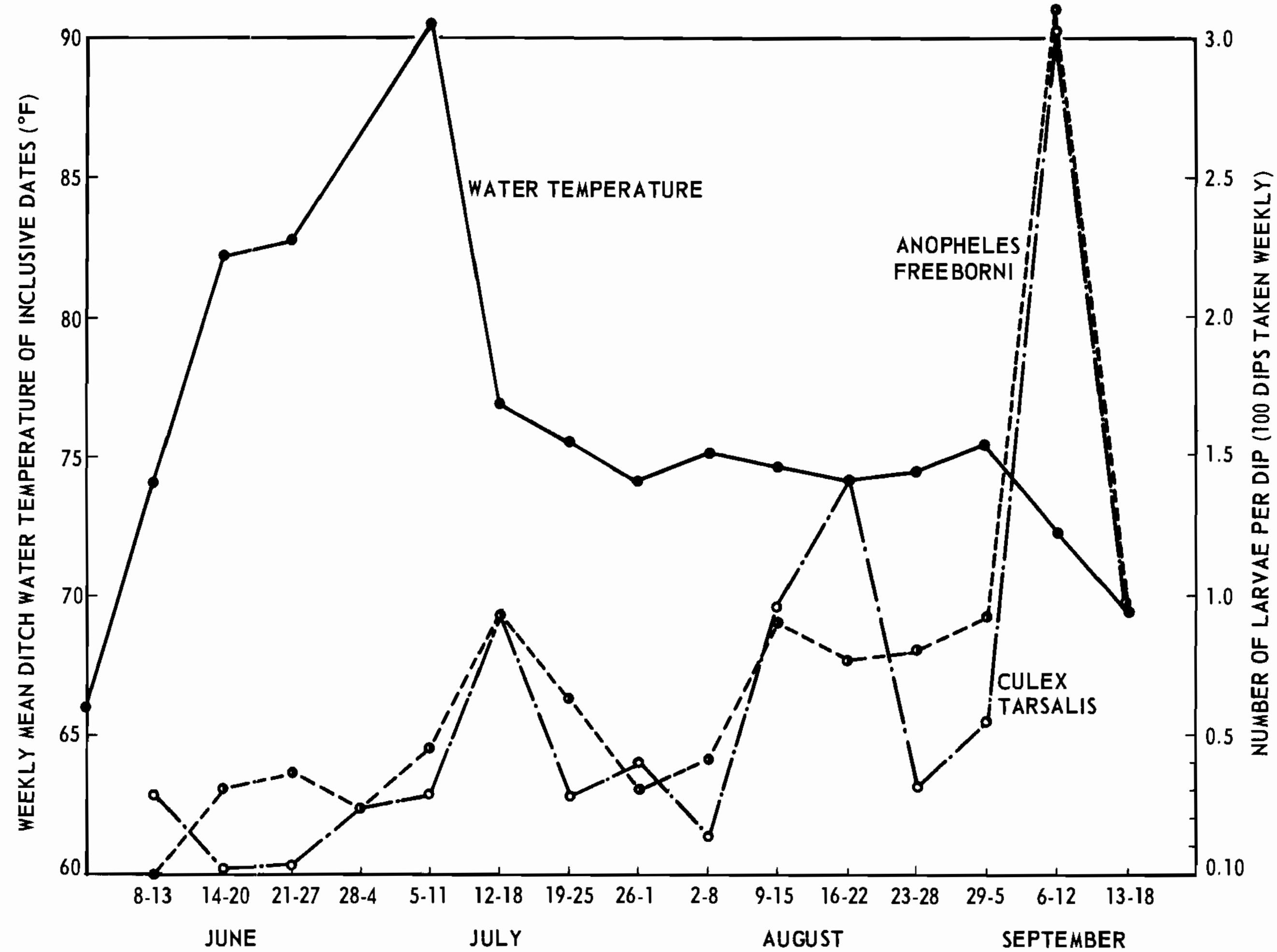

Figure 2. Seasonal trend of mosquito larval population in seepage ditch at margin of rice field. Grimes, California 1967.

experiments here reported. Only those tests that were free of disease and excessive pellicle growth were included.

The field study was divided into parts: (a) At Davis: observations were made on the rate of growth of the larvae in floating wooden boxes with a fine cloth screen bottom in a simulated seepage ditch partially covered with weed growth into which well water flowed constantly (at 67° F during the summer and about 54° F in the winter). The ditch was 15 feet long, 3.5 feet wide and had a depth of 9-10 inches. A continuous temperature record of the water was obtained from May 27, 1967 to February 13, 1968. In this ditch newly-hatched larvae from the laboratory colonies were introduced into the floating cages. Fifty larvae were used for each test. Records of the dates of pupation in each lot were kept, from which was determined the average length of the larval stage. From the thermograph record, the average water temperature for this period was determined. Table 1 summarizes the data obtained.

(b) In the Grimes area of Colusa County regular weekly dipping records of larvae were obtained in four rice fields and a seepage ditch. The study area was outside of the Abatement District's control zone. Continuous temperature records were obtained with recording thermographs in one rice field (Station D) and its adjacent seepage ditch. The probe was shaded and maintained at about 0.5-inch depth. At the other three stations (Stations A, B, and C) the water temperature was determined with a pocket thermometer at mid-morning when the larvae were collected. Figures 1 and 2 illustrate the weekly average of the mean water temperature in both the rice field and adjacent seepage ditch, together with the larval populations. The temperature fluctuated widely in the ditch due to the sudden filling of the ditch from the overflow of the initial flooding of the rice field with river water. The seepage ditch water then remained semi-stagnant and became quite warm. At irregular periods during the remainder of the season this water was pumped into the rice field and recirculated.

TABLE 1

Rate of growth of mosquito larvae in a simulated rice field seepage ditch. Davis, California. 1967-68.

Species	Period of test	Mean water temperature during larval stage (°F)	Water temperature range during larval stage (°F)	Range in larval stage (Days)
Culex	XII-9-XII-14	44	33-54	7+
tarsalis	XII-26-I-16	47.8	40-59	22+
"	XII-16-II-13	49.1	37-62	60+
"	XI-8-I-5	51.7	33-69	62+
"	X-12-XI-8	69.7	65-75	12-28
"	X-6-XI-8	69.8	65-75	18-34
"	X-11-XI-4	70.1	65-75	13-25
"	V-29-VI-11	72	61-85	12-14
"	VI-6-25	75	63-88	15-20
"	VI-11-29	76.7	63-90	13-19
"	VI-26-VII-9	79.9	71-91	12-14
"	VII-10-22	80.0	73-87	11-13
"	VI-30-VII-16	80.1	71-91	15-17
"	VIII-10-IX-5	80.2	78-83	11-16
"	VIII-18-IX-6	80.3	78-85	10-20
Anopheles	XII-8-XII-14	44	33-54	7+
freeborni	XII-26-I-16	47.8	40-59	22+
"	XII-18-III-14	52.6	40-72	81-84
"	XI-3-XII-7	59.2	55-77	35-35*
"	XI-8-XII-16	61.4	49-77	23-39
"	X-21-XII-6	68.1	55-77	28-47
"	X-6-XI-3	70.1	60-75	15-29
"	VI-5-26	75	63-88	18-22
"	VI-5-26	75	63-88	19-22
"	IX-6-23	77.5	73-82	13-18
"	IX-6-21	77.5	73-81	12-16
"	VI-27-VII-10	79.8	71-91	12-14
"	VI-30-VII-18	80.1	71-91	16-18
"	VII-10-22	80.2	73-89	11-13
"	VII-17-30	81.2	73-90	11-14
"	VII-19-VIII-1	81.6	74-90	12-14

* 1 pupa survived

\+ All died

Discussion of Experiments

From the laboratory experiments with constant temperature it can be seen (Fig. 6) that *C. tarsalis* develops faster throughout a wide range of temperature and with lower mortality (Fig. 7) in the medium range than *A. freeborni*. This adaptability undoubtedly accounts, in a large part, for the wider geographical distribution of the species and its more rapid development in the spring and early summer at lower water temperatures. It should be pointed out, however, that other factors, namely those affecting the adult stage, result in a cessation of breeding in the late summer even though the aquatic environment is still favorable. From the data gathered at Davis, out-of-doors, it is possible to make some comparisons in the rate of growth at fluctuating vs. constant temperature. For example, in the laboratory at a constant temperature of 70°, *C. tarsalis* larvae developed in 13.2 day average time with a range of from 9 to 24 days. In contrast, in the field (Table 1) the larval stage ranged from 12-14 days at 72° mean temperature. Such comparisons perhaps would be more meaningful if the hour-degrees of temperature above a given threshhold were calculated. These experiments were not designed to yield this type of data. Since constant temperatures are not found in the natural habitat of mosquitoes (and cannot be controlled) we must interpret liberally the field data in relation to the laboratory findings. Further, in the field the larvae move about constantly and no two individuals probably are exposed to exactly the same accumulative total of day-degrees within their larval life. Therefore, we must think in terms of the *average* in translating such information into practical aspects of predicting broods and timing control operations. The general observation to be made from these experiments is that the average rate of growth of the larvae under variable field conditions within a given range is not much different than under comparable constant temperature conditions in the laboratory. However, the extreme range in growth time is greater under the artificial conditions (Fig. 8). Further, in an air-conditioned building, at room temperature at which the water fluctuated over a period of nearly a year from 68 to 76° with an average of 73.5°, the average length of the larval stage of *C. tarsalis* was 12.2 days or one day less than at 70° constant temperature.

Another point should be made concerning this comparison. In the floating cages, from which predators were ex-

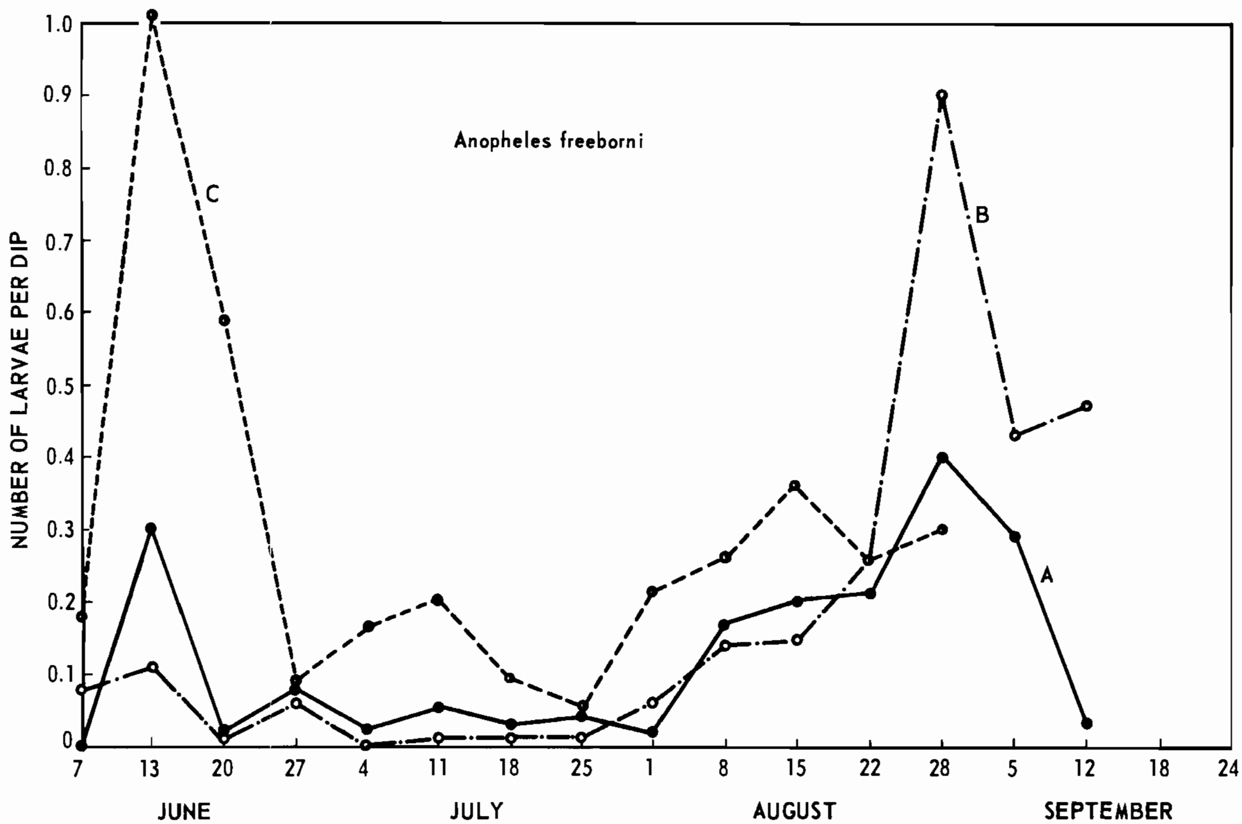

Figure 3. *Anopheles freeborni* larval population trends in three unsprayed rice fields. Grimes, California, 1967.

Table 2. Length of larval stage and mortality of two major rice field mosquitoes at constant laboratory temperatures.

	Anopheles freeborni						*Culex tarsalis*					
	Length of Larval stage (days)				Mortality (Per cent)		Length of larval stage (days)				Mortality (per cent)	
Temp. (° F)	Range	Greatest frequency	Weighted Avg.	Total No. Pupating	Gross Ave.	Range	Range	Greatest frequency	Weighted Avg.	Total No. Pupating	Gross Avg.	Range
50[1]	52		52	0	100		60-91		71.7	0	100	
55	31-62	43	43.6	337	66.3	32-98	20-54	36	36.4	423	57.7	22-100
60	21-42	30-31	31.1	685	32.1	4-60	16-33	23	23.5	641	35.9	10-60
70	10-30	20	18.9	755	24.5	8-48	9-24	12	13.2	845	15.5	2-40
80	9-21	13	13.6	748	25.2	2-42	6-18	9	9.1	803	19.7	4-38
85	9-19	13	11	368	63.2	28-82	5-16	11	9.8	808	19.2	2-38
90	7-17	10	10.3	190	81.0	35-98	6-13	8	9.1	617	38.3	12-66
95	9-12	11	10.8	8	99.2	95-100	7-15	8	9.3	63	93.7	78-100
100[2]	0	0	0	0	100		0	0	0	0	100	
Check[3]	11-34	18	18.8	825	17.5	0-40	10.18	12	12.2	884	11.6	0-46

[1]Many larvae reached the 4th instar but none pupated.

[2]No *A. freeborni* larvae lived more than 48 hours or beyond 2nd instar. Some individual *C. tarsalis* survived 6 to 8 days and reached 4th instar but none pupated.

[3]Room temperature of water = 72.5 avg. for *A. freeborni;* 71.0 avg. for *C. tarsalis.*

cluded, but not micro-organisms or algae or their by-products, the range in the length of the larval period was a great deal shorter than in the laboratory. The difference may be accounted for by either biological or physical factors producing stimulating food elements or an increased rate of growth from the diurnal fluctuations of temperature. Such factors are elusive and difficult to regulate and evaluate.

In the spring, late February and early March, when the earliest larvae are found, the water temperature is in the low 50's. In the fall, the lowest water temperature at which we collected *A. freeborni* was at 54° F. These last few fall larvae might be called "stragglers"; they are usually mature or nearly so. Many appear sluggish and abnormal and when brought into the laboratory they frequently do not pupate. In the rice-growing area the majority of the larvae are flushed out in the ditches, sloughs and by-passes when the rice fields are drained in September and early October. By early November only an occasional surviving larva can be found in undisturbed, clear water not muddied by the draining process. The water temperature normally is dropping weekly at this time of year and the rate of growth of these larvae is correspondingly reduced. It is rare to find a gravid female in October and the latest we have collected first instars was on November 22. In the spring, eggs and newly-hatched larvae can be found in February at which time also the water temperature is in the mid-50's to low 60's. These very early collections are made up of a very few individuals which are found in natural breeding areas such as grassy stream pockets and semi-permanent ponded water.

The larvae of *Culex tarsalis* on the other hand usually disappear earlier in the fall than the anophelines in the Sacramento Valley. Washino and Bellamy (1963) have studied the seasonal cycle in the San Joaquin Valley and found larvae present all year with only the larger instars present in January. The most unique record of this species the senior author recalls is that of making a collection of mature larvae frozen in the surface ice of Lake Vera, Nevada County on January 11, 1963.

From these experiments and field collection records we conclude that the adult anopheline mosquito production resulting from the residual larval population found in October and early November is minor. The major hatch which takes place in late August and early September results in the large numbers which cause great irritation to citizens during the fall migration.

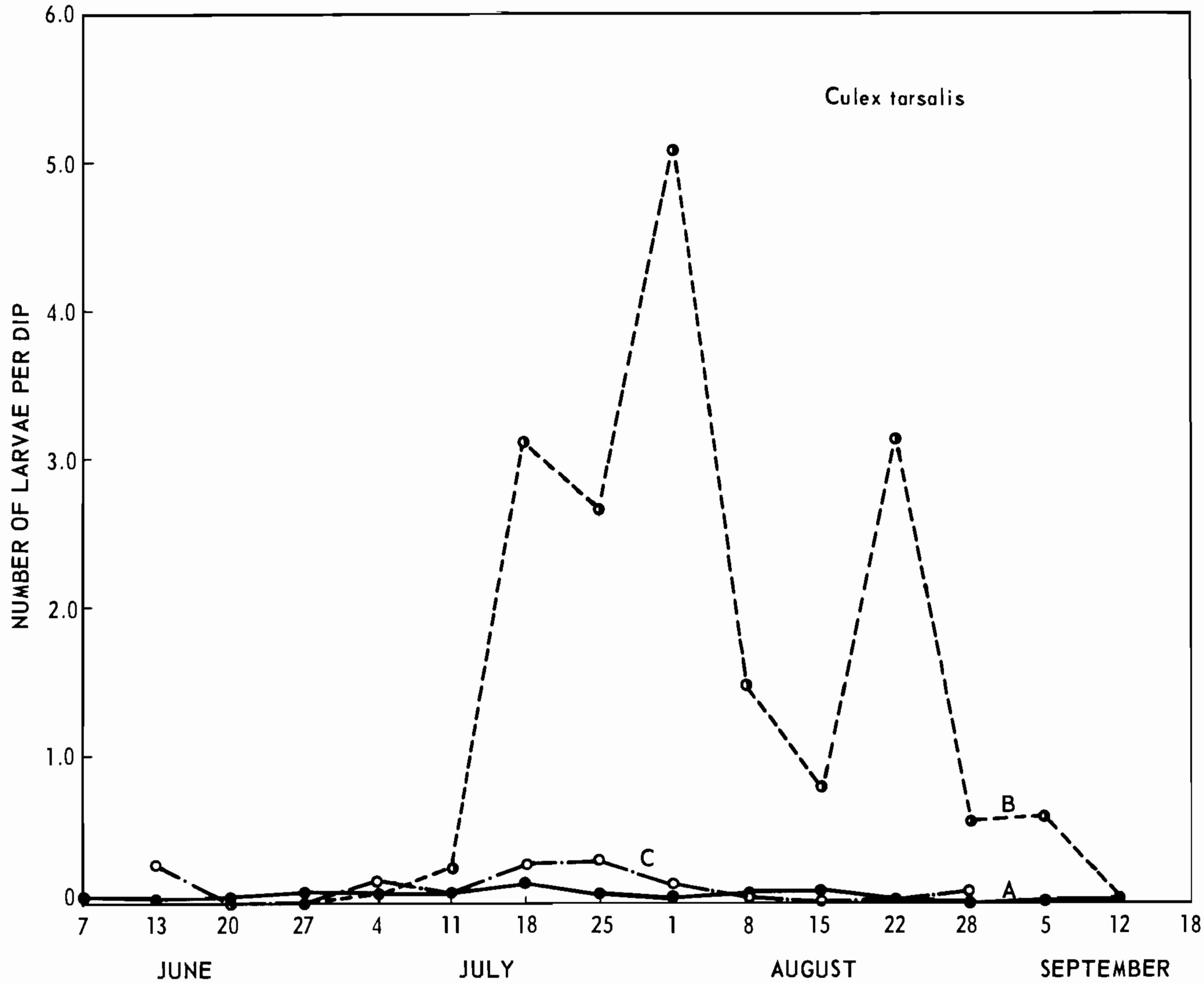

Figure 4. *Culex tarsalis* larval population trend in three unsprayed rice fields. Grimes, California 1967.

The field study in the Grimes area (Fig. 1) clearly shows the seasonal pattern of larval development in relation to the normal declining water temperature in the rice environment. This ties in very well with the laboratory study (Fig. 6) which shows that the maximum "production", i.e., the lowest mortality and shortest growth period, occurs in the 70-80° F range. The warmer temperature in the seepage ditch (Fig. 2) resulted in an early depression of the population. With almost no circulation and a rich "biological complex" of organisms present, the ditch supported many more mosquitoes than the adjacent rice field.

As one would expect, there was some variation from field to field in the area both in temperature and larval population. Stations A, B, and C, all planted and flooded at different times, also had different peaks and densities of population (Figs. 3 and 4) but the trend was generally the same as Station D at which the temperature recorder was in operation. In the early part of the season, before the rice plants became erect and shaded the water, we recorded temperatures as high as 96° F. Further, the difference in temperature on the west vs. the east side of grass covered checks (levees) was as much as 20 degrees in the afternoon. By mid-August all stations had very similar conditions and the water temperature between fields varied only five degrees from 68 to 73° F. On September 5 there was only one degree difference between all four fields.

It is worthwhile mentioning the percentage of the instars of larvae we found from week to week. Of all the collections made from the four rice fields and the ditch from July 5 to October 17, the average was 65 per cent small larvae (1st and 2nd instars). By chance, perhaps, the per cent was the same for both species. The smaller number of 3rd and 4th instar larvae may be accounted for by mortality and also by their tendency to quickly hide when a shadow is cast on the water or the water is disturbed. Examples of the variations in population can be illustrated by the collection of September 12. On this date 93 per cent of the collections of both species were small larvae and in comparison on July 11 only 23 per cent of the *tarsalis* larvae were small and 52 per cent of the *A. freeborni* larvae were small. In general a large per cent of small larvae would indicate the beginning of a brood but the balance between small and large instars varies considerably from field to field so an overall average is more indicative of the population in a district. However, as field operators know, now and then a specific field produces great numbers of larvae (which necessitates immediate treatment) whereas the composite dipping record shows the population to be low.

Evaluating the summer adult anopheline population in relation to the larval abundance always has been a difficult problem. Freeborn many years ago (1921) first noted the so-called "summer depression" from weekly collections made under a concrete bridge at Chico, California in 1919. In 1932 he studied the adults in the laboratory and wrote that the drop in numbers was the result of maximum daily temperatures in excess of 90° F and low humidity. The senior author discussed these records with Dr. Freeborn but the original notes had been lost and he could not remember the details of how the temperatures were taken. Bailey and Baerg (1966) tested the tolerance of both sexes of three species of laboratory-reared California anophelines to 110° F in a specially-constructed wooden box in the laboratory. The relative humidity in the chamber was 30-35 per cent. One hundred per cent mortality of male *freeborni* occurred at four minutes exposure and the females were all dead in less than eight minutes.

Temperature readings were taken in natural resting sites with a thermistor or pocket thermometer, in several hun-

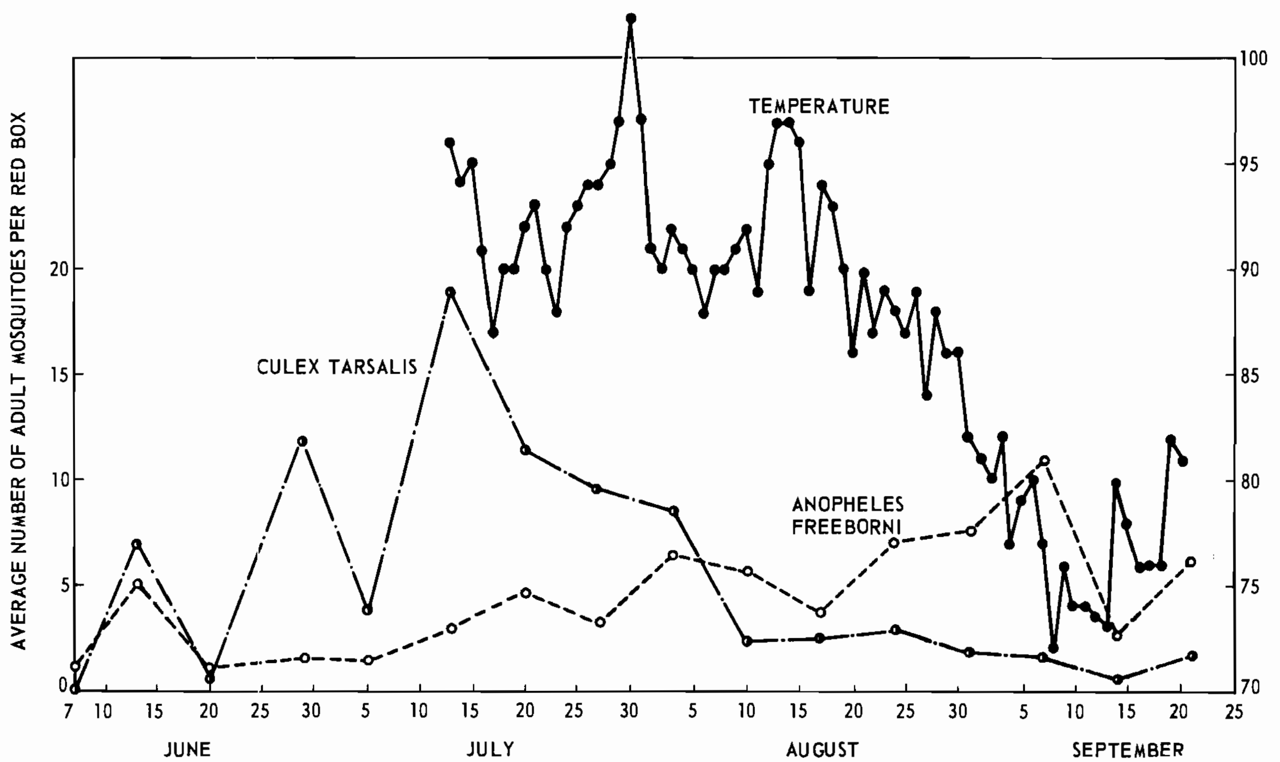

Figure 5. Adult mosquito population trend in artificial resting stations in rice-growing area. Grimes, California 1967.

dred instances, in northern California by Bailey and Baerg during 1964-66. The highest temperature we measured that *freeborni* tolerated was that of a blooded-gravid female resting under a concrete bridge at Davis on July 17, 1966 where the reading was 101° F.

During the summer of 1967 while conducting the studies herein reported, we also gathered data on the adult resting population in the rice fields. We employed the standard artificial resting unit commonly used in such studies, i.e., the foot square red box open on one side. A continuous record of the temperature inside one of the boxes was obtained by means of a recorder described above. This box was placed on a seepage ditch bank under a small willow tree. The thermograph probe was attached one quarter of an inch below the "roof" and inside the box. This section of the box is the preferred resting area of mosquitoes. Fig 5 illustrated the daily maximums from July 13 to September 20. The 1967 season was one of more high daily maximums than ever previously recorded in northern California. During a period of 40 days, July 13 to August 21, the maximum temperatures were recorded; on 34 of these days the maximum temperature was 90° or higher. This extended period of high maximum temperatures resulted in a low population of adult anophelines nearly all summer. June, likewise, had an extremely long series of high maximums, for example at Davis,

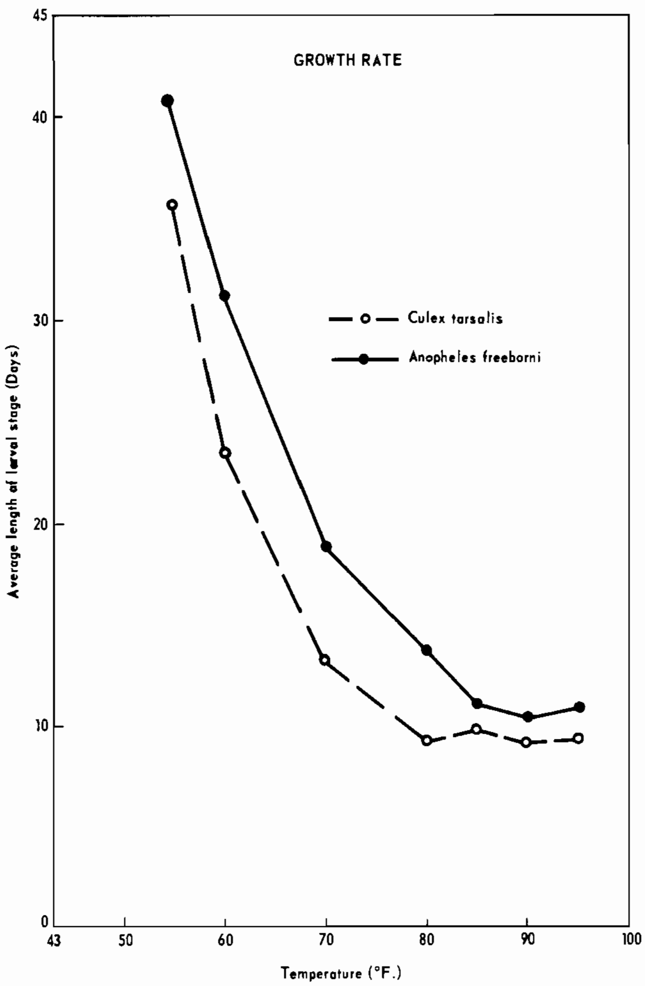

Fig. 6. Growth rate of the larval stage of *Anopheles freeborni* and *Culex tarsalis* at constant laboratory water temperatures.

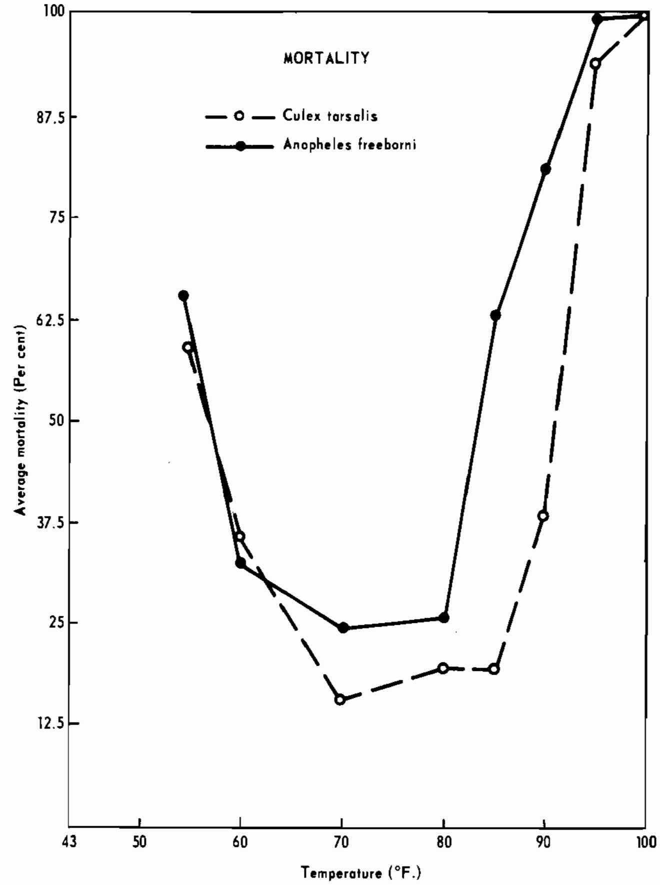

Fig. 7. Mortality of the larval stage of *Anopheles freeborni* and *Culex tarsalis* at constant laboratory water temperatures.

June 15-30 inclusive, on 12 of these 16 days, the daily maximum air temperature was 90° or over. It should be noted that the adult population of *C. tarsalis* does not seem to be as greatly affected by such maximum temperatures (Fig. 5).

At Davis, one box only was utilized; it was placed in the shade in the shelter of farm buildings near the experimental ditch which simulated rice seepage conditions. The seasonal peaks of adults in these resting stations were as follows:

	Grimes	Davis
Anopheles freeborni	Sept. 7	Sept. 13
Culex tarsalis	July 13	July 26

Summary

From the viewpoint of those responsible for mosquito control in the rice-growing districts, what have we learned from these ecological experiments over the years?

1. Early season water temperatures in rice fields before the plants shade the water (in May and June) are usually too high to be favorable to anopheline larval development. Nearby seepage ditches where tules and weed growth shade the water support early populations which build up to invade the adjacent fields.

2. As the water temperature in the rice drops progressively during the summer, it becomes more favorable to anopheline larval survival and a greater adult hatch results. This change, correlated with decreased maximum daytime air temperatures (below 90°), permits the adult *A. freeborni* to live longer which means a rapid buildup of this mosquito

and it reaches its seasonal peak at the end of the growing season.

3. We have shown that *C. tarsalis* larvae develop faster than *A. freeborni* at 70-85° F with a mortality only one-third that of *A. freeborni* at 85°. This capacity results in an earlier buildup of the *Culex* population in the rice fields in the warmer water (85°) of May and June. As a result, the *tarsalis* adult population reaches a seasonal peak in July in the rice area.

4. Maximum daily temperatures of 90° F and above depress the adult *Anopheles* population.

5. The adult *C. tarsalis* population trend in June is an important index as to what the maximum production might be in July. The number of days with maximum air temperatures of 90° and above in July seems to give a general idea of the expected numbers of *A. freeborni* in late August.

6. The length of the active larval season is determined by the adult stage. The length of day (photo-period) appears to be the major environmental factor that regulates egg-laying. As a matter of fact, water temperatures in the early spring are low and not too favorable to larvae development, but egg-laying begins in late February. In October and November minimal favorable water temperatures occur

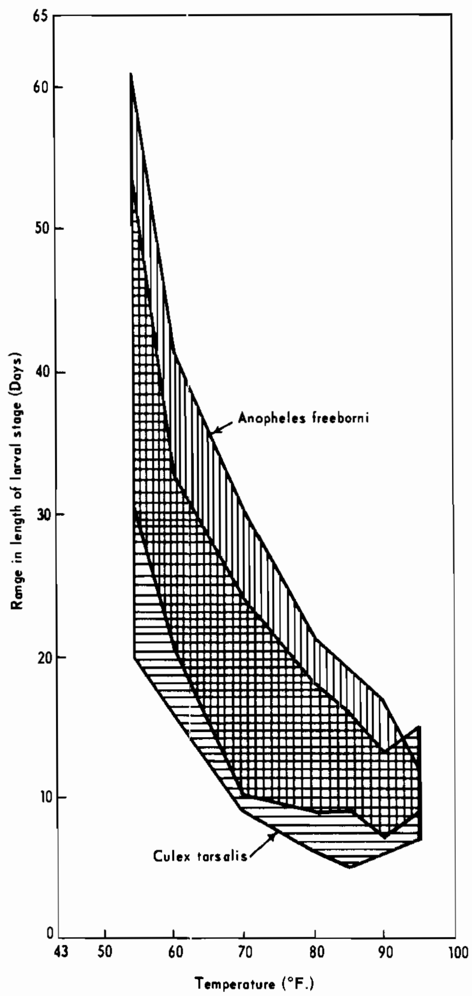

Fig. 8. Comparative ranges in length of larval stage of *Anopheles freeborni* and *Culex tarsalis* at constant laboratory water temperatures.

but *Anopheles* egg-laying largely ceases in September (and earlier by *Culex*).

7. The number of larvae (usually large instars) or "stragglers" found in ditches and sloughs after the rice harvest is relatively small. The flushing of the sloughs by draining the fields and the resulting turbidity are unfavorable particularly to *Anopheles* development. The relative number of overwintering adults produced in the October-November period is small compared with the last hatch from the rice fields.

8. Water management, in the future, to supplement other methods of mosquito control in this very difficult area should be directed towards increasing the water temperature. The warmer the water, the more the mosquito larval population is depressed. Naturally, cold water reduces the rate of growth of the rice as well as the mosquitoes. In May and June particularly, the use of shallow water in rice would result in maximum heating and a subsequent high mortality of the larvae. Later in the season this is more difficult to accomplish but holding the breeding to a minimum the first half of the season would result in a much lower total production of mosquitoes. This situation was very evident in 1967.

9. As most operators and experienced field men know, trends or indexes of populations are nice to have, but each field almost has to be considered by itself. Heavy breeding in a given field or a portion of a field can result from a number of strictly local factors, biological or physical, beyond the control of abatement personnel. Decisions to treat a specific field have to be made independently of the total mosquito population of the area.

10. Integrated control is the modern approach to pest control. In mosquito control in the rice-growing area the following measures are employed: (a) water managemen (b) the use of mosquito fish and/or other biological means, (c) larviciding casual water breeding sources in the spring, (d) ditch and rice field treatment with chemicals June to September as needed if funds permit, (e) fogging and/or residual spraying in the winter season (December and January). In any single method or combination thereof the old law of diminishing returns operates. Highly technical research can develop almost endless interesting facts about mosquitoes but their real usefulness must be determined by the agencies responsible for control.

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COMMENTS ON MOSQUITO AND GNAT RESEARCH ACTIVITIES AT BERKELEY

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The past year has witnessed a remarkable growth in research work on mosquitoes by staff based on the Berekeley campus of the University of California. This growth is all the more remarkable in that it has occurred despite any increase in financial support during the current fiscal year. In fact, the over-all budget for University research on mosquitoes has decreased.

As many of you know, the University of California Fresno Mosquito Control Research Laboratory was reorganized in July 1967 as a part of the Division of Parasitology on the Berkeley campus. Dr. Charles Schaefer was appointed as the Director in residence, and took charge of the laboratory in August 1967. Objectives and progress of this unit are being discussed separately at these meetings by Drs. Schaefer and Miura.

Research has continued at Berkeley and at the Hopland Field Station on the transmission of parasites among vertebrates by mosquitoes and other biting Diptera. Drs. Anderson and Weinmann have shown that the tree hole mosquito, *Aedes sierrensis*, is an intermediate host of the body cavity worm of deer, *Setaria cervi*. Studies on the potential role of various mosquito species as vectors of filarial worms are being continued in 1968.

In related work the same workers have incriminated two species of *Culicoides* as intermediate hosts of filarial worms of the California Valley Quail, but the actual transmission of the parasites from infected gnats to quail remains to be demonstrated.

In collaborative work, a graduate student, Steve Ayala, and Dr. Anderson have produced evidence incriminating for the first time in the Americas, sandflies, *Phlebotomus vexator occidentis*, as transmittors of protozoan parasites of the genus *Trypanosoma*. Details of this work soon will be published.

A major program on the nutritional requirements and feeding behavior of mosquitoes is being conducted by Dr. R. H. Dadd, who is here to tell you of recent progress.

WORK AT BERKELEY ON FEEDING BEHAVIOR AND NUTRITION OF MOSQUITOES

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Fundamental information on mosquito nutrition is essential for understanding many ecological problems pertinent to mosquito control and for developing culture methods suitable for rearing the standardized insects necessary for laboratory experimentation. The aim of the work at Berkeley is to expand and consolidate the already considerable body of knowledge in this area. Although most of the qualitative nutritional requirements of *A. aegypti* larvae have been determined, discrepancies still remain between the findings of various workers, and growth on the wholly synthetic diets so far developed is far inferior to growth in culture media based on natural organic materials. A few studies deal with adult requirements for egg production. However, recent information on gorging stimuli suggest that until female gorging behavior is better understood in relation to the ingestion of synthetic diets, requirements for optimal egg production cannot be fully evaluated. It is well known in a general way that the food requirements of female mosquitoes are very dependent upon their prior nutritional history as larvae. This is an important relationship awaiting detailed investigation, but which necessarily entails prior knowledge and control of larval nutrition for its elucidation.

The majority of previous studies of mosquito nutrition, as of mosquito physiology in general, have dealt with *Aedes aegypti*, largely because of the ease with which this species may be cultured. The Berkeley project will stress other species in order to examine the general applicability of ideas derived from work with *A. aegypti*. Initially, *Culex pipiens* is being used; cultures of it are as simple to maintain as those of *A. aegypti*, and previous work showing that *Culex* larvae may be reared on sterile, semi-synthetic diets affords a firm expectation that it would be amenable to rigorous nutritional experimentation. It is hoped, when appropriate methods and a basic body of information have been worked out with *C. pipiens*, that points of difference that emerge between this species and the previously studied *A. aegypti* may be examined in other species, and that specific nutritional problems arising from the work of other people dealing directly with control problems in California may eventually be taken up.

It is implicit in nutritional studies with synthetic diets that feeding rates on treatments being compared should be similar, so that differences in performance between treatments may be assumed to result from differences in the metabolic adequacy of nutrients, rather than from variations in the overall ingestion of food. It is therefore prudent to begin nutritional experimentation with some consideration of feeding behavior, to establish whether or not special dietary characteristics, physical and chemical, are necessary to ensure normal or optimal feeding rates. This is especially the case with mosquito larvae, since it is not at first sight clear precisely how and upon what the larvae feed (solids? liquids? suspended materials? colloids? gnawed bulky materials? living? dead?). Work on feeding behavior as such indicates processes of some complexity. Surprisingly little attention has been devoted to this aspect of the problem in the writings of previous workers in mosquito nutrition, and it is quite possible that some of the effect of diets explained in nutritional terms were in actuality the outcome of abnormal feeding behavior. I therefore began by studying feeding behavior, seeking an insight into any dietary factors that might influence the rate of feeding, and attempting to develop a simple method for assessing comparative rates of feeding that could be routinely used to monitor the suitability of various artificial diets for use in subsequent nutritional studies.

In nature, the principal food of mosquito larvae comprises particulate material suspended in or sedimented from the water in which they live, or abraded by their mouthparts from bulky solids in the water. Although solutes must be utilizable to some extent, since larvae have been reared completely in media containing most nutrients only in solution, solid material is necessary as well, since without it, malfuncton of the gut occurs and the larvae fail to grow. All successful larval diets have contained a solid phase, sometimes a nutrient, sometimes nutritionally inert, and it therefore seemed reasonable to study the rate of ingestion of solid particulates as an index of rate of feeding as a whole.

The work I now discuss depends upon the fact that the progression through the midgut of solid material, contained as it is within a peritrophic membrane surrounded by fluid separating it from movement of the midgut wall, depends upon the ingestion anteriorly of additional solid material. If larvae are placed for several hours in Chinese ink (a suspension of fine carbon particles) their filter-feeding activity results in the gut becoming packed from end to end with ink particles, completely displacing the original solid food contents. On transfer to clear water devoid of particulate material, no rearwards displacement of the black column of carbon in the midgut occurs, even after several days. However, if a suitable particulate such as kaolin is placed in the water, particles are filtered into the gut and displace the ink column rearwards, while black fecal pellets are expelled at a rapid rate. No mixing of ink and the new particulate is evident, and the progress rearwards of the boundary between the two may be observed through the transparent body wall.

Such observations provided three criteria that could be used to compare rates of ingestion of different particulates, namely: the time taken for complete displacement of ink from ink-glutted larvae; the distance travelled by the boundary between ink and an experimental particulate in a given access time; and the number of black fecal pellets expelled in a given access time. All three criteria have been used, but as the timing of complete displacement required continuous observation for more than five hours with some particulates, it was soon relinquished in favor of methods involving a set access time of one hour. At first, both displacement of the boundary and pellet counts were recorded, but as pellet counting necessitated that larvae be set up individually, and was, moreover, shown to be a less reliable index of the amount of particulate ingested, most experiments latterly involved recording displacement of the boundary only. Detailed accounts of the experimental methods and the data obtained are being published elsewhere. What follows is a synopsis of results so far obtained, and some comment on their implications for research on practical control measures.

An initial series of experiments was devoted to comparing the times taken for carbon to be completely displaced from ink-glutted 4th-instar larvae by diverse particulates. Mean displacement times of about one hour were recorded with three broadly nutritive particles, namely: dried brewer's yeast powder; a live culture of the alga, *Chlorella;* and samples of the turbid infusions in which stock cultures of larvae were maintained. In these three cases virtually all larvae displaced the ink completely within 90 minutes, many in as little as 30 minutes or less.

Two non-nutritive particulates, Chinese ink itself (tested on kaolin-glutted larvae) and kaolin, gave mean displacement times of about two hours. Displacement was as rapid with some individuals as for the nutritive treatments, as little as 35 minutes, showing that the physical properties of kaolin and ink were no bar to rapid ingestion. In others, however, displacement was still incomplete at four hours when observations were terminated. Like the nutritive treatments, these two particulates were readily dispersed in water, with some material remaining in suspension indefinitely.

With mean displacement times of about three hours, brick dust and microcrystalline cellulose were next in terms both of speed of ingestion and tendency to remain in suspension; no larvae cleared the ink in less than one hour, and in about half of them, displacement was still incomplete at four hours. With the remaining inert particulates, all of which sedimented rapidly, the majority of larvae showed incomplete displacement at the end of the four-hour observation period, although with diatomaceous earth, neutral alumina, chromatographic cellulose, and silica gel, most larvae had ingested some material, and a few had completed displacement in two to four hours. Some particulates (coarse ground casein, certain chromatographic resins) were not ingested at all, even though the larvae appeared to be filtering over them as actively as for the ingested particulates; it was presumed that these materials were of a particle size too great to allow ingestion.

The considerable differences in rates of ingestion amongst the group of inert particulates was clearly due to their different physical characteristics, and since rapidity of ingestion seemed to be related roughly to slow sedimentation, it appeared likely that particle size and the physical density of the material might be important factors in governing rate of ingestion. It proved possible to determine the range of particle size resulting in optimal rates of ingestion by comparing displacement values for synthetic latex particles of specified diameter when presented to glutted larvae in a standard liquid phase of 0.5% yeast extract solution. Samples of uniform particles ranging in mean diameter from 0.1 to 100 mircrons were used at equal concentrations on a weight per volume basis. With 4th-instar larvae, optimal ingestion occurred over a range of particle diameters of about 1 to 10 μ. Particles of mean diameter of 25 μ were readily ingested (as were all particle sizes down to 0.3 μ), but ingestion fell off sharply for mean diameters of 45 and 90 μ. A similar result was obtained in one experiment with 2nd-instar larvae, except that essentially no ingestion of the largest sized particles occurred.

The consistently rapid ingestion of nutritive particulates suggested that something more than physical characteristics was involved in the regulation of feeding rate. Since nutritive treatments would have been characterized by the presence in the liquid phase of nutrient and sapid solutes, the possibility that such materials might influence feeding rate was investigated by comparing displacement values for series of treatments in which the same nonnutritive particulate was presented in fluid phase containing soluble yeast extract in concentrations ranging from 0 to 2%. With one particulate, silica gel, yeast extract had no influence on the rate of ingestion over the whole range of yeast extract concentrations tested, but for five others, concentrations of up to 0.8% increased the rate of ingestion. With neutral alumina the increase in displacement values was 4- to 6-fold. With kaolin, Chinese ink, microcrystalline cellulose, and diatomaceous earth, increases of 20 to 100% were obtained, but with decreased ingestion as concentrations of yeast extract exceeded 1%.

From these results it is evident that both physical and chemical factors are involved in the regulation of the overall rate of feeding of larvae of *Culex pipiens*. It seems probable that physical characteristics of particulate material, such as size and physical density, must automatically affect the instantaneous rate of ingestion during filter-feeding in a purely mechanical way; the use of polystyrene particles of specified diameters showed that size is indeed crucial, and allowed the optimal size range for rapid ingestion to be determined. I believe the effect of yeast extract solutes to be most likely a result of gustatory regulation of feeding behavior. Some individual larvae provided with a readily suspensible inert particulate, such as kaolin, ingested as rapidly as on yeast powder; on average, however, ingestion was slower, and observation indicated that this was because larvae on kaolin tended to cease filtering more often and to remain quiescent for longer periods than larvae with yeast powder. The introduction of yeast extract into water containing quiescent larvae was frequently observed to reactivate filtering movements. Most probably the effect of yeast extract solutions in increasing the rate of ingestion of inert particulates was to stimulate active filtering movements for a greater proportion of the access time than would be the case with water alone.

Although this study of feeding behavior was initiated with the particular purpose of gaining information to help in the formulation of synthetic diets for use in nutritional experiments, it has become clear that data on the relative ingestibility of inert particulates may be pertinent to certain aspects of work more directly related to mosquito control. When larvicidal control measures involve the use of insecticidal or bacterial dusts, differing kill efficiencies might result from differential ingestion of the dust particles in relation to solids already suspended in waters being treated. Should this be so, it would be desirable to ensure that size and other characteristics of the dust were optimal for maximal preferential ingestion. The sort of data being accumulated in this study could perhaps assist in this.

Another practical problem in which feeding behavior may be involved concerns the location of liquid or emulsified insecticide after release into breeding waters. A considerable portion may be adsorbed onto solid material suspended in the treated water, and variability in kill might then depend upon the extent to which such bound insecticides came into contact with larvae. It can be imagined that if adsorbed to silt or other particles that were preferentially fed upon, the effectiveness of the insecticide would be enhanced; conversely, if adsorbed to materials that tended to be rejected during filter-feeding, the effectiveness would be reduced. Possibly a consideration of the characteristics of suspended solids in waters treated with insecticide in relation to the factors that make particles readily ingestible might clarify some aspects of the variable responses sometimes got with particular larvicidal treatments. If these conjectures prove to have substance, it might eventually be worth adjusting insecticidal dosages to take account of the type of suspended solids in particular waters. In such an approach, data on feeding mechanics would be essential.

THE UNIVERSITY OF CALIFORNIA MOSQUITO RESEARCH PROGRAM AT FRESNO

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As most of you are aware, the University of California, Fresno Mosquito Project has been entirely reorganized. Effective July 1, 1967, funds for this Project were transferred to the Division of Parasitology, U.C., Berkeley. During August to December 1967, a careful evaluation of the overall program was conducted. The objective of the Fresno Project is to conduct research on problems that are of direct importance to the Mosquito Abatement Districts. Because of this objective, the U.C. Fresno Mosquito Project has been renamed as the University of California, Mosquito Control Research Laboratory, the inclusion of the word "Control" in the title is self-explanatory.

During the past six months, an analysis of the needs for mosquito control research has been made. Discussions have been held with personnel of many of the Mosquito Abatement Districts, the U.C. Entomology Departments at Berkeley, Davis and Riverside, the U.C. School of Public Health at Berkeley and Bakersfield and the Bureau of Vector Control at Berkeley and Fresno. Also, the previous recommendations of the C.M.C.A. Research Committee and the published works, relating to California mosquito problems, were reviewed. Several generalizations became apparent with respect to this overall analysis. The best control program is one that takes maximum advantage of all available methods for "regulation" of pest populations. The University of California is well known as a strong advocate of the integrated control approach. The use of this approach requires a thorough understanding of the life history and ecology of pest species, their natural enemies and their competitors. It is also important to understand the relationship between pest population density and economic damage (Smith, 1962); this last consideration is difficult to determine but is necessary for defining the pest density that can be, and should be, tolerated.

While chemical control causes problems through the selection of resistant strains, toxicity to non-target organisms and deposition of residues on crops and in water and air, it remains the most important tool presently available to the M.A.D. manager. Perhaps chemical control retains this importance because of our lack of knowledge about other methods; in any case, we cannot discount its present necessity. The challenge is not to try to entirely eliminate chemical control but rather to learn how to use it more efficiently. As Metcalf (1965) has pointed out, the problem of resistant organisms to chemicals is not unique to insects; the challenge to find new chemicals to combat resistant organisms is also a continuous problem for the drug industry. As long as realistic economic incentives are present, we can expect new, effective compounds to be developed. This, however, is no excuse to ignore the development and use of other tools, which hopefully will lower the extent of present insecticide use, and the corresponding degree of insecticide-resistance. Other approaches that have been explored for insect control include the use of environmental manipulations, pathogens, parasites, predators, sterilants, hormones and sex attractants; while all of these have potential, it appears that none, alone, will solve present problems.

One of the biggest problems in the San Joaquin Valley is, unquestionably, the pasture mosquito, *Aedes nigromaculis*. During the past 15 years, a great amount of effort has been put into ecological studies (Husbands, 1953, 1955). These studies have not revealed any practical solution to the *Aedes nigromaculis* problem, but have pointed out the complexity which makes this particular problem so difficult. For example, the above studies showed that production of *Aedes nigromaculis* occurs over much of a given field and is not restricted to the tail waters; thus, even if it were economically feasible to drain off tail waters, production of *Aedes nigromaculis* would still not be reduced to an acceptable degree. There is still a great deal to learn about the life history and ecology of *Aedes nigromaculis,* and while there is no guarantee that this information will solve any practical problem in the short-term, it is essential for the integration of control methods.

Obviously we need to utilize all practical methods that will control mosquitoes. The importance of one method in comparison to another will change with time and under different environmental conditions. We must learn which combination of tools is best for us under a given set of conditions. Is the integrated control concept too complicated to be reduced to practice? Although this approach requires that many different variables be taken into account simultaneously, so do other phases of our present technology. The successful launching, orbiting and recovery of a space vehicle is a good example of man's present ability to manipulate numerous variables in order to achieve a practical end. I see no reason why this same degree of sophistication cannot be achieved by applied biologists.

Factors Limiting the Research Program at Fresno

With respect to any research program at Fresno, several factors have important bearing. First the laboratory is small (4 full-time and 2-part-time personnel) and it can only be effective as part of a combined University of California program. For example, it would be pointless to set up a general insecticide screening program, since one is already functioning at U.C. Riverside. Secondly, location has an important influence on efficiency; we cannot make important contributions on the mosquito control problems in all areas of the State. Our main effort will be related to the mosquito problems of the San Joaquin Valley, but we will be involved to a lesser extent in cooperative studies in other areas. Thirdly, we must retain flexibility in our program in order to cope with current problems. There is not any limit on the amount of research that can be done on a given problem. Our program is being set up so that emphasis can be shifted as required. Lastly, the available funds for the Fresno Laboratory are limited, and while all of our operating costs are increasing, our funds are not likely to be increased for some time. Our revised program requires that we purchase new types of equipment; without this new equipment, we will be limited to the types of approaches that have already been taken. We must utilize the most powerful tools available if we wish to advance with modern technology.

The Revised Research Program at Fresno

The research program at Fresno will consist of two main studies. One study will be primarily concerned with chemical control of mosquitoes; there are two general objectives: (1) to help find better chemical control agents and (2) to learn how to use chemicals more efficiently. Laboratory and field evaluations of new materials will be done in cooperation with U.C. Riverside. For new compounds that show promise, we plan to study the hydrolytic and photostability, sorption onto organic matter as well as mosquito toxicity. We also will study various techniques for predicting the potential of mosquito strains for developing resistance to new compounds. We hope to be able to provide information to industry on compounds that are in the 'early research stage'. While the mosquito insecticide market is relatively small — 6 million lbs. in U.S., in 1965 (Anonymous, 1966,) it is steadily growing and therefore, is becoming of greater industrial interest. Thus, the mosquito control market is reaching the point where it alone can justify the development of a promising compound.

The relationship of water quality to insecticide stability is an area where more information is needed; experiments on the hydrolysis and photostability of promising insecticides in various types of water, are planned for this year. Tests on stability and sorption will indicate conditions where a given compound would not be expected to show a high degree of performance, and should thus allow better interpretations of field trials.

Another area which needs attention is the relationship between chemical deposit into water, following aerial applications, and that on other surfaces which are commonly used to assess deposits. It is important to know the extent to which small particle size impinge into water as compared to MgO layers or onto spray sensitive cards.

The analytical equipment which is needed for analysis of insecticides in the studies mentioned has been purchased and presently is being calibrated.

The other major studies at Fresno deal with mosquito biology. While there is much that we must learn about chemical control, there is an even bigger gap in our knowledge of mosquito biology. For example, *Aedes nigromaculis* develops exceedingly fast under field conditions but it is difficult to rear in the laboratory. Adults will not mate in captivity and conditions most favorable for oviposition, and for holding early-instar larvae, are unknown. Dr. Takeshi Miura has been hired to work full-time on mosquito biology. Initial priority for his research is to develop rearing methods for pasture mosquitoes. There is a great need to have strains of *Aedes nigromaculis* that will reproduce normally under laboratory conditions. Self-propagating, laboratory strains or susceptible and resistant *A. nigromaculis* can be fully characterized and can serve as a basis of comparison to tests conducted with field-collected insects. Also, if we can provide laboratory colonies to toxicologists and geneticists, we will be able to get research done on the nature of the insecticide-resistance mechanisms; however these people will not conduct such studies without the availability of strains which are relatively easy to rear. Dr. Miura has already succeeded in getting reproduction to occur under laboratory conditions through induced-mating methods; although this achievement has been a breakthrough, it is very time-consuming and is not a convenient rearing method. The oviposition behavior of *A. nigromaculis* is being investigated in order to improve egg production in the laboratory and to learn which factors provide oviposition stimuli in the field.

A cooperative study on the overwintering biology of *Culex tarsalis* and *Anopheles freeborni* is being done between our Laboratory and U.C. Davis. We are studying the changes in stored lipids of adults during the course of the winter months. We are particularly interested in determining what fatty acids are utilized for energy. This study will provide preliminary information that is needed for designing further studies on the prediction of oviposition potential, following certain types of weather, e.g., a relatively cold versus warm winter. This is one type of study which might yield results that are of general importance to California and, also, is one type of research that can be conducted during the winter.

The number and types of mosquito colonies at the Fresno Laboratory have also been critically re-evaluated. Because of the amount of labor involved in rearing, strains, or species, which are not normally of economic importance in California and for which there was no expected use, were discontinued. The mosquito strains which we plan to continue rearing are shown in Table 1.

Table 1. Mosquito strains maintained at the Fresno Laboratory as of January 1, 1968.

Susceptible Strains	Resistant Strains
Culex pipiens quinquefasciatus	*Culex pipiens* - fenthion
Culex tarsalis	*Culex pipiens* - malathion
Culex peus	*Culex tarsalis* - malathion
Anopheles freeborni	*Culex peus* - fenthion
Aedes sierrensis	

Strains Maintained by Induced-Mating Techniques
Aedes nigromaculis - susceptible
Aedes nigromaculis - O-P resistant
Aedes melanimon
Aedes dorsalis
Aedes vexans

Finally, we hope to have the Fresno Laboratory serve as a field base for U.C. researchers from the various campuses.

A tremendous challenge faces all of us involved with mosquito control. Our efforts will have to be completed within the next 32 years if we are to keep Secretary Freeman honest; in a recent publication (1967), entitled "Agriculture/2000", he states, "Americans of the year 2000 never will see—much less swat—a housefly or a mosquito."

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A REVIEW OF DEVELOPMENTS ASSOCIATED WITH THE CONTROL OF WESTERN EQUINE AND ST. LOUIS ENCEPHALITIS IN CALIFORNIA DURING 1967[1]

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The University of California started intensive research studies on the mosquito-borne encephalitis viruses in Kern County in 1943. At that time we knew very little about vectors, hosts, or environmental factors that provided exposure of human and equine populations to these infections. We quickly found that *Culex tarsalis* was the primary vector of both western equine (WEE) and St. Louis (SLE) encephalitis viruses in California. This finding soon resolved earlier debates at meetings of mosquito control personnel on whether or not this mosquito bit man, as we found that *C. tarsalis* readily fed on both man and horse. Subsequently, we have learned much about the biology of *C. tarsalis* and its relationship to WEE and SLE viruses and have clarified the role of avian hosts as sources of vector infection. Pest observations have documented that excess flood water in the Central Valley of California was associated with increased encephalitis attack rates in man and horse. In the spring of 1967, all records indicated that once again there would be sufficient excess runoff in the river systems to support the development of an encephalitis epidemic. Mosquito abatement agencies were alerted by the State Department of Public Health to this potential threat and the control agencies greatly accelerated their abatement activities. I am certain that these actions had a material effect on subsequent developments, which is the purpose of this discussion.

Studies in Kern County over the past 24 years have resulted in extensive data that reveal a positive correlation between excess river flow, high *C. tarsalis* populations, and excess risk of encephalitis in people and horses. Hower, it is only recently that data have been obtained on the levels of *C. tarsalis* populations that must be achieved if we are to minimize man's risk of exposure to infection or if we are to stop the basic cycles of virus transmission. In the past four year, SLE virus has disappeared from the areas of Kern County that are under mosquito control. The cessation of detectable SLE virus activity occurred when indices of female *C. tarsalis* populations still were above 10 per light trap or bait trap collection. SLE virus continued to be active in other areas of the state that were reporting higher indices of *C. tarsalis* than was Kern County. Meanwhile, WEE virus persisted in the Kern County area. We now have evidence concerning the minimal population level of *C. tarsalis* that will maintain WEE virus transmission.

In the intensively controlled urban area of Bakersfield over the past three years the population index for female *C. tarsalis,* as measured by bait or light traps, has averaged less than one female per trap night through the summer (Table 1). In the urban area we have been unable to detect the presence of WEE virus either by virus isolations from mosquitoes or by demonstration of antibody development in

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sentinel chickens, and we have had no human cases. In the first 10 years of study in Kern County, 1943-1952, we could assume that over half the human cases each year would be in residents of this urban area.

TABLE 1

Annual relationship of *Culex tarsalis* population indices to viral activity indices in urban, rural community and agricultural environments, Kern County.

Year and area	*Culex tarsalis* Population seasonal avg./trap night		Infec. rate /1,000	Immunolc conversion rate/100 sentinel chickens
1965				
Urban	< 1	< 1	0	0
Rural community	6	5	5.6	13
Rural agricultural	80	23	3.4	29
1966				
Urban	1	1	0	0
Rural community	5	1	2.7	19
Rural agricultural	84	38	3.9	38
1967				
Urban	< 1	< 1	0	0
Rural community	1	2	0	0
Rural agricultural	11	16	0.2	1

In rural communities of Kern County, the indices of female *C. tarsalis* have become very low in recent years, one or two females per trap night in 1967 (Table 1). In spite of the impact of vast acreages of surplus surface water that prevailed through the summer of 1967, mosquito control efforts kept the *C. tarsalis* indices at very low levels in both urban and rural areas. The only evidence of WEE virus activity was at 1 of 15 rural sites where there was a high *C. tarsalis* index.

Data on mosquito populations, virus isolations, and infections of sentinel chickens collected over a three year period at 15 locations in Kern County are summarized in Table 2. Only one chicken became infected at the 18 stations where the vector index was one or less, and it is suspected this represented infiltration of an infected mosquito into the environment. At an index of two to nine *C. tarsalis* per trap night, the proportion of infected chickens remained low. When the vector index increased to 10 to 19 females per trap night, virus activity was high and at indices of over 20 vectors per trap night, there were very high levels of WEE virus transmission.

TABLE 2

Summary of relationships between *Culex tarsalis* population indices and WEE virus activity observations at 15 stations, accumulated 1965-1967, Kern County.

Average bait trap index for summer	No. stations	Stations Virus from *C. tarsalis* No.	%	Stations Chickens infected No.	%
1 or less	18	0	0	1	6
2-9	9	2	22	3	33
10-19	3	2	66	2	67
20+	15	13	87	14	93

From the preceding data, we can now establish definite goals for control programs. If the female *C. tarsalis* population can be held to one or less per trap night, WEE virus will probably disappear from the environment. If vector levels are 10 or less per trap night, we appear to be at or near a threshold level where virus transmission is interrupted or barely maintained and there is no significant risk of human or horse infection with WEE virus. It should be recalled that SLE virus disappeared from the environment when vector indices still were above 10 per trap night.

Without presenting additional detailed data, the general historical picture of the occurrence of clinical cases of encephalitis in Kern County can be restated briefly. Until 1967, there was a strong correlation between years of excess water in the Kern River and an increased number of encephalitis cases in man and horse. In a year with a great surplus of water, such as 1952, we had an encephalitis epidemic. In 1958, when the river was high, an epidemic began but an intensive control effort reduced the vector population early in the summer and the incidence of human cases was well below that expected. In 1967, there was a near record flow of river water that continued throughout the summer, an intensive *C. tarsalis* control program was initiated in the spring, the vector population index was held at a very low level, and there were no proven human or horse encephalitis cases and almost no evidence of virus acivity in vector or avian populations. I do not know of any factor other than mosquito control that supressed the vector population and prevented an encephalitis outbreak. The only other factor of possible significance was the unusually high temperatures that prevailed through the summer and this might have shortened the life span of the vectors. However, in past experience, high temperature alone did not suppress vector populations or virus activity to the extent observed in 1967. I do not believe that the low levels of virus and vector populations "just happened" and mainly credit the results to the control effort.

It is of interest to turn now to a review of the statewide experience with encephalitis in 1967. The Bureau of Vector Control received records of light trap collections from control agencies throughout California. These data are summarized on a state map (Figure 1). In 1967, there was a low index of female *C. tarsalis* through most of the San Joaquin Valley. There were also low indices in parts of the Sacramento Valley. Mosquito abatement districts in all the state made every effort to intensify control efforts from spring through the summer. If the preceding information and interpretation of data from Kern County are correct, relative to the correlation of low *C. tarsalis* population levels with low risk of clinical encephalitis in man and horse, we would have expected very few or no proven human or horse cases of WEE and SLE in the San Joaquin Valley but at least some cases would have been expected in the more northern areas. The Viral and Rickettsial Disease Laboratory and Bureau of Communicable Diseases of the State Department of Public Health receive diagnostic specimens and reports of suspected cases of encephalitis in California each year. They have allowed me to make reference to their records as of January 31, 1968 for purposes of this meeting, and these records are indeed most interesting. The distribution pattern of proven WEE cases in horses parallels very closely the

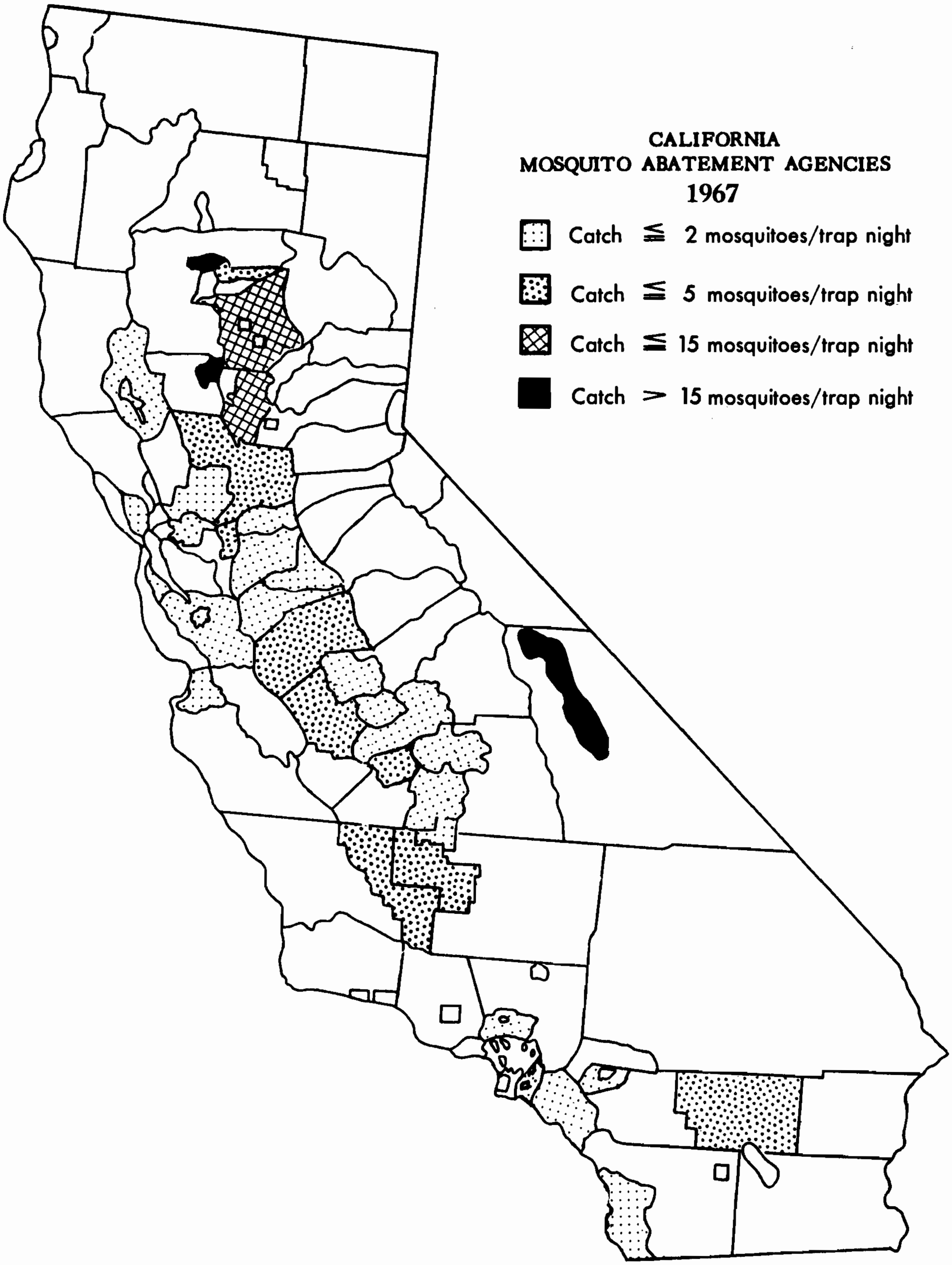

Figure 1 - Culex tarsalis adult occurrence.

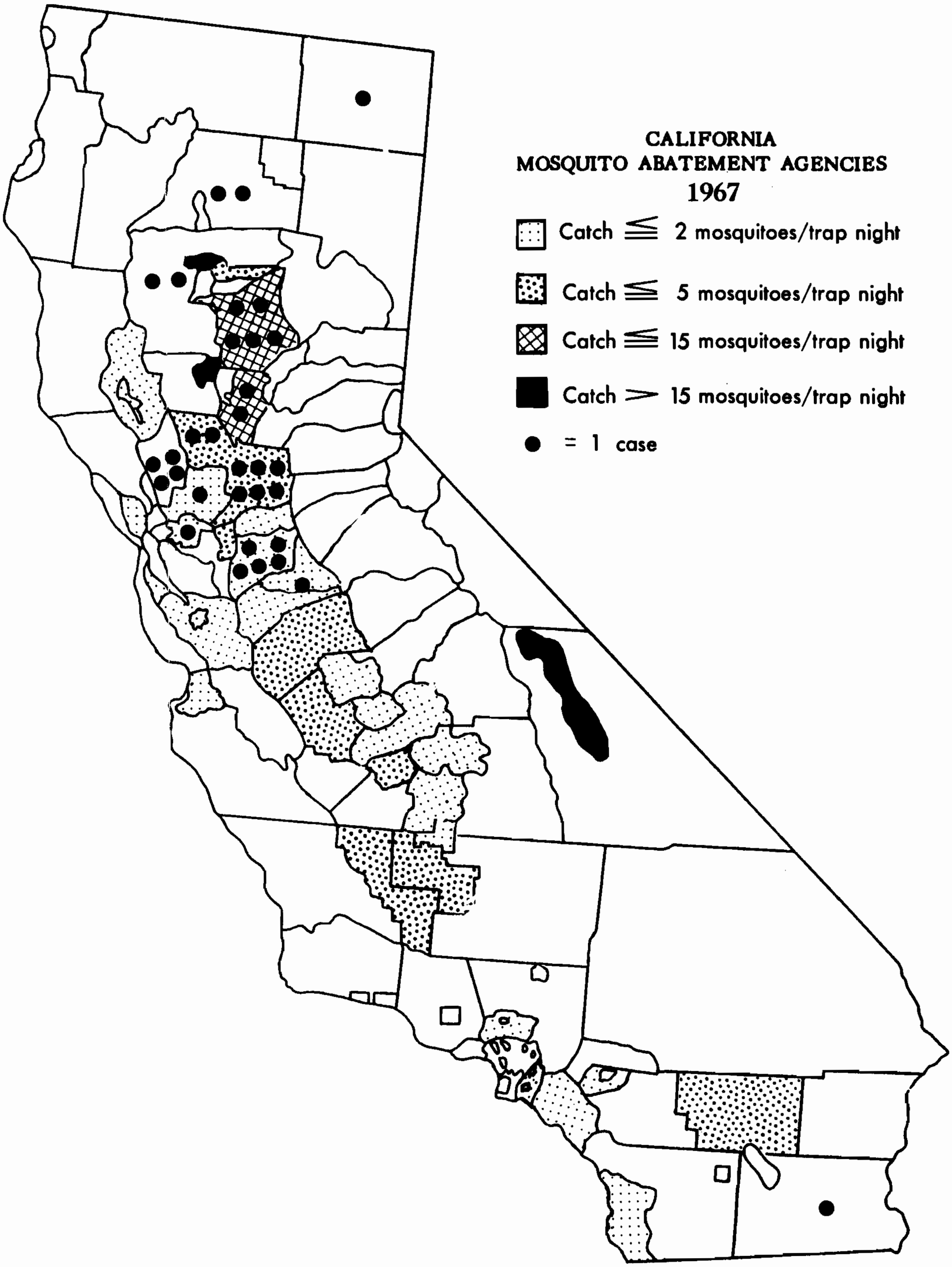

Figure 2 - *Culex tarsalis* adult occurrence.

Horse - Western Equine Encephalitis

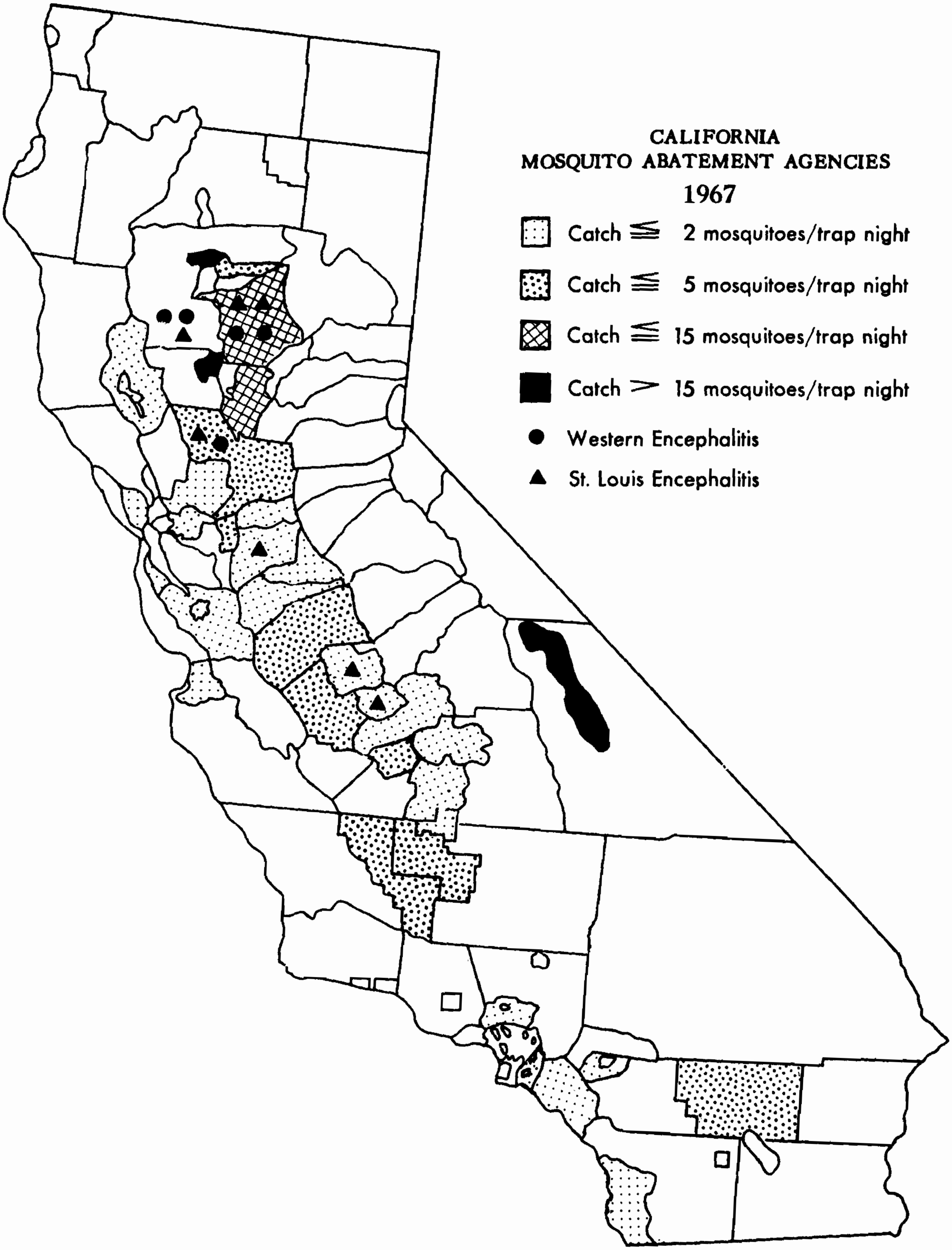

Figure 3 - *Culex tarsalis* adult occurrence.

Human Encephalitis

areas of high indices of *C. tarsalis* populations (Figure 2). There were no proven horse cases south of Stanislaus County, with the exception of a single case in Imperial County. Almost all cases occurred in areas of reported medium or high densities of *C. tarsalis* or in uncontrolled areas where no records were available on vector densities.

In 1967, seven SLE and five WEE cases were proven in man (Figure 3). Almost all cases were residents in the northern part of the state. A case living in Contra Costa County, in the middle of Richmond, deserved analysis. His case history revealed that he spent each weekend fishing on a lake in the outskirts of Yolo County. A SLE case hospitalized in Fresno also did not fit the expected pattern. This person had spent the previous two weeks in Pueblo, Colorado and undoubtedly was infected while on this trip. The case from Madera County lived in a foothill area outside the boundaries of any control agency.

In summary, we can now state that we have a target with reference to levels of *C. tarsalis* populations we wish to achieve through abatement programs. If control can reduce the *C. tarsalis* female population to 10 or less per light trap night, the risk of WEE encephalitis in man is essentially nil and SLE virus probably will disappear from the environment. We can aim at a more difficult target which would be to reduce the *C. tarsalis* population to a lower level of one or less per trap night, and if achieved over a sufficiently wide area, this would lead to the disappearance of both WEE and SLE viruses from the environment. I do not foresee any need to attempt to eradicate *C. tarsalis* as this probably would be impossible. We do not need to be unduly concerned about the avian and mammalian hosts of these viruses as infection will disappear from these sources in the absence of a transmitting vector population.

THE THREE R'S OF VECTOR CONTROL

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It is popularly acknowledged in the field of education that considerable disparity of thought exists as to what should be the proper emphasis upon the three R's. In vector control also, a revision of emphasis has been taking place during the past several years which is tending to alter the complexion of the state vector control program. My title "The Three R's of Vector Control" was chosen in order to explain the transition under way and to apprise this mosquito control oriented audience of the reasons behind our receding activities in your chosen field.

Two of the three R's I shall talk about are signs and symptoms of California's burgeoning population and our rapidly changing environment. I refer to Refuse and Rats, both of which are demanding growing amounts of vector control program time. The third R could be any of a number of words beginning with the 18th letter of the alphabet, but which I shall postpone stating for the moment.

Refuse

Solid organic wastes are to domestic flies and rats what water is to mosquitoes and midges. Our nearly twenty million population generates approximately one hundred million pounds of refuse each day within its communities. Annually, this volume of community by-products reaches over 20,000,000 tons. In addition, agriculture accounts for at least another 20,000,000 tons of plant and animal wastes annually. Projecting to the year 2000, we in California will then be generating a total of over 90,000,000 tons of solid waste annually. The disposal of present day wastes is becoming critical in many parts of the state, but with the population and land use pattern that is visualized for the year 2000, and without drastic change of practices in order to accommodate this environmental loading, the disposal of wastes would be virtually impossible. Yes, something must be done and soon, lest we become buried by our by-products.

Focusing upon the public health aspects of solid waste, vector control acquired program responsibility in this ignored environmental area principally because of the significance of domestic flies which originate from the putrescible organic portion of this heterogeneous accumulation. Whether it be the vinegar fly, house fly, little house fly, green or blue bottle fly, stable fly or any of the 100 or more species that are domestic pests or potential disease vectors, the public dislikes flies at least as much as it does mosquitoes. The flight range of domestic flies is comparable to mosquitoes, with certain species normally inclined to short flights and others capable of easily exceeding twenty miles. One pint (a pound) of moist solid waste of either plant or animal origin is capable of producing upwards of 4,000 flies. Referencing this fly production potential to the daily generation of solid wastes, it is conspicuously evident that flies are a major threat in our future; that is, unless they are prevented. Such a happy solution, however, is more easily stated than accomplished.

Solid wastes are becoming increasingly significant as a public problem because of the rapidly depleting land space required for disposal by landfill or inglorious dump site, either of which may be a threat to underground or surface water pollution. Owing to the susceptibility of California to air pollution, disposal by incineration, at this stage of technological development, is questionably feasible if economically possible. Consequently, better ways must be found to resolve this growing problem, and thereby prevent the unwelcome public health effects. Hopefully, when solid wastes become regarded by the public from a conservational standpoint as salvageable and utilizable resources, we will be approaching a genuine solution. It is with such positive thinking that vector control is advancing on the task of bringing about effective solid waste management.

In 1965 a significant development occurred when Congress passed the Solid Waste Disposal Act. This Act appropriated funds to stimulate state-local solid waste management planning and to underwrite sorely needed technical development in this field by government, educational institutions and industry. Our Department immediately took advantage of this opportunity and since the summer of 1966, the Bureau of Vector Control has been conducting a statewide solid waste management planning survey in direct collaboration with local health departments. We also made application for and received a demonstration grant in order to conduct a comprehensive systems-oriented, regional study of the economic feasibility of integrated agricultural, industrial and community solid waste management in a selected area of the state. This study, a substantial part of which has been contracted with Aerojet-General, is under way here in the greater Fresno area, covering 1,200 square miles. The project will be completed this year.

The state planning study includes both a qualitative and quantitative inventory of all solid waste being generated throughout California. Such amounts and kinds of waste will soon be subjected to analysis and, accordingly, the most feasible courses of handling refuse and other wastes will be proposed within the framework of a state plan. In the near future, a major federal subsidy program is expected to develop which will observe the state plan in making specific local allocations. A premium will be given to regional solid waste management plans over those proposed by individual municipalities.

I am sure I need not elaborate further the demanding nature of this important program. We have been obliged to commit a sizeable segment of vector control staff to the objectives of vector prevention by improved solid waste management. Perhaps your agencies will be performing a part of the solid waste management program of the future. It keeps turning over in my mind that your statutory charge is the abatement of mosquitoes, *flies* and other insects.

Rats

It is estimated with some degree of credibility that the American public sustains one domestic rat for every two persons. If true, there are approximately a hundred million rats throughout the United States taking advantage of our accommodating community conditions. California, while acknowledging below the national average of Norway rats, must face up to a roof rat density which is second to none.

Rats in addition to being filthy animals which contaminate and destroy many millions of dollars worth of foodstuffs and fiber annually, also are a threat to the public health for a wide range of reasons. Although human plague has not occurred in our port cities for several decades, the potential remains high for outbreaks if domestic rat densities in our communities are not checked. While it has not been widely publicized, a plague epidemic has been occurring in Vietnam for some time and the cargo continuously reaching our seaports and international airports carries the possibility of introducing infected rats or fleas. Furthermore, our sylvan rodents maintain plague even on the fringes of our communities, making transfer to domestic rats entirely possible. In fact, our domestic rats in California also frequently occur in sylvatic situations, thus enhancing this possibility.

To bring this matter into program perspective, I'm certain that everyone has followed the drama of the rat bill in Congress. Last year, after being rejected, in fact laughed out of passage, it became no laughing matter and was subsequently approved and funded in the amount of $20,000,000. The Bureau of Vector Control made application for a comprehensive Health Planning Grant for a statewide Community Rat-Vector Control Project in behalf of all local health departments and the pest control industry. As a result, we may be engaged in coordinating a $2,000,000 per annum statewide program on the control of rats, house mice, cockroaches, ectoparasites, spiders, pigeons and bats as early as March 1, 1968. Needless to say, preparing for such an undertaking and carrying it out has already and will continue to require considerable program time, likewise diversionary from mosquito-midge functions.

Reduction

It is with great remorse and regret (words also beginning with R), that I now identify the third R—Reduction. It's true what you have been reading in the papers, state program has been experiencing reduction. With the Bureau program, reduction began in 1966, when $115,000 was transferred to the University of California to enable the several campuses to reinforce their mosquito control research activities and to continue a modified program at Fresno. While these funds are now all being put to excellent use, the effect on our program has nonetheless been in the category of "major amputation". In 1967, the Bureau also receipted for a reduction of over $66,000, most of which was at the expense of our mosquito-midge program. Unhappily, all of our temporary help funds were lost in this cutback, which has now reduced our flexibility in coping with seasonal and emergency program developments. In short, our capability of performing the level of technical services formerly available to assist local mosquito control agencies has been severely impaired.

Rather than dwell on the negative side of the word "reduction", I now choose to consider it in its positive connotation. By thinking constructively, it is possible to shift to a subject of growing need in mosquito control, namely source reduction. Like the weather it is widely discussed, but too little is done about it. With economy in government becoming a popular expectation at all levels, mosquito source reduction is one sure way to comply with interest returns compounded.

Source reduction is basic to the philosophy of mosquito control, requiring a kind of religion-like application. Its prerequisites include precise and comprehensive awareness of water sources, distribution, and utilization, as well as land management and residual water recirculation and ultimate disposal. It depends upon keen administration and technical guidance supported by fine timing and sound cost accounting. It necessitates meaningful record keeping, both biological and operational. Expressed as program action it presupposes performing the proper function in the proper place at the appropriate time.

Source reduction is not a magical process which calls upon occult powers to achieve its objectives. Instead, it is the most direct form of mosquito prevention, realized by modifying conditions that are conducive to mosquitoes to make them in fact inhibitory. Every mosquito source must be analyzed and neutralized by one or a combination of physical, chemical, biological or management methods aimed at eliminating or reducing the size of each source to its smallest fraction, or otherwise making the source untenable to mosquito survival.

Returning to the mention of source reduction being a kind of religion, the key individual in this concept is the operator. He, best of all, can begin the thought process referenced to each source which must be transferred in a chain-like action through his foreman to the administration in order to facilitate management decisions, many of which will be far reaching in water manipulation. Others can be accomplished directly by the operator as a means of lessening his work load.

The source reduction specialist should have the role of planning and performing technical services to reach decisions and bring about action by both administration and operational staff. His ultimate goal is to assist in diminishing the repetitive operations and to accomplish overall program economy with greater effectiveness.

Source reduction offers local mosquito control agencies the greatest promise, as well as the lasting satisfaction of providing genuine solutions to mosquito problems—with maximum governmental efficiency and economy. I urge you one and all to get this source reduction religion. In a matter of a few years you could then be ready and able to give us an assist with our other two R's—Refuse and Rats. Are you willing?

BLOW FLY CONTROL IN RESIDENTIAL AREAS

W. Donald Murray

Delta Mosquito Abatement District, Visalia

The garbage blow fly, also known as the copper blow fly, *Phaenicia cuprina,* has been brought under effective control in the city of Visalia. Costs for establishing and maintaining this control program have been very light. The procedures followed by the Delta Mosquito Abatement District and the City of Visalia, together with other coordinating agencies, can be used in other areas where this species of fly is a severe problem.

A number of years ago, outdoor living in the Visalia area was frustrating or almost impossible due to mosquitoes. Mosquito control improved steadily so that by about 1960 barbeques could be held with little concern about mosquitoes. But another pest then became dominant and proved to be almost as frustrating to the barbequers as mosquitoes had been—the garbage blow fly. Exposed food frequently could not be protected from the swarms of adult flies, creating a situation repugnant to the senses. This fly had been present in tremendous numbers previously, but it obviously was not conidered to be as severe a pest as mosquitoes. Now, however, the Delta Mosquito Abatement District (MAD) received more and more calls for assistance in fly control. Typical requests noted that the District had used its talents so effectively againt mosquitoes—surely these same talents would be equally effective in achieving fly control.

What was the fly problem in the Visalia area? Textbooks, educational films and scientific publications almost universally considered the house fly, *Musca domestica,* to be the number one pest domestic fly throughout the country. The Delta MAD, receiving invaluable technical assistance from the Bureau of Vector Control of the State Department of Public Health, made surveys of many types of fly problems within the District. Dairies, which surround Visalia, were producing tremendous numbers of house flies, as well as a number of other species of flies. It was presumed that these flies were migrating continually into Visalia, and that a total fly control program would be essential in order to provide relief for barbequers and other urban dwellers. This presumption, as well as some comments or statements in educational literature, were demonstrated to be incorrect or misleading. Over most of the City of Visalia, up to 98% of the fly problem was caused by the garbage blow fly. As facts were gathered, it became apparent that the Delta MAD, working cooperatively with other agencies, especially the City of Visalia and the Tulare County Health Department, could develop a specific fly control program which would produce valuable benefits.

About 1960, the City of Visalia, because of swarms of flies bothering picnickers at the city recreation park, urged the district to spray insecticide about the garbage cans serving the park. These cans were heavily infested with both larvae and adults. The spraying was done with the expected poor results. The district in turn encouraged the city to cooperate in some garbage can larval fly trap studies.

In 1963 the city, coordinating with the recreation park and several firemen, provided park and domestic garbage cans for the larval fly trap studies. Cooperation was complete including fulfilling the request that no change be made in the existing garbage disposal practices for the cans tested during the course of the study. These traps were loaned by the Bureau of Vector Control of the State Department of Public Health (S.D.P.H.). Six traps were used. Both before and since the trap studies were run, surveys have been run in other areas of the state by the B.V.C. and other agencies, sometimes using many dozens of traps. However, the interpretations of the results of the six traps provided the information which resulted in the effective control in Visalia of the most important pest fly in this city.

Is it proper or wise for a mosquito abatement district to engage in fly control? Most districts have shied away from the field of fly control, claiming lack of time, money, technical know-how, public interest, etc. Several agencies in California have officially adopted fly control programs. Mosquito abatement districts and vector control sections of county health departments are in an excellent position to conduct at least certain phases of fly control. They already possess many basic records and procedural patterns. The State Health and Safety Code gives legal authorization for inspection and control of flies. The Delta MAD Board of Trustees has never authorized all-out fly control, but it has agreed to a conservative program in which one or two summer students, with administrative support, might make studies. This policy has resulted in the present control program against the garbage blow fly.

Control of the garbage blow fly has been possible because the breeding cycle has a very weak link which can be broken. This species is a container breeder. While it will lay eggs on food exposed in the open, for all practical purposes the household garbage in the garbage can is the only important larval medium. Adult flies swarm over fresh dog droppings, more eagerly than on any other item observed. Undoubtedly some eggs are laid on such, but it appears that these droppings serve mostly as an attractive food. Flesh fly larvae, of the family Sarcophagidae, have been found frequently in dog droppings, but *P. cuprina* larvae have not been found in such. A few years ago this blow fly was found abundantly on fallen fruit under backyard fruit trees. No larvae were ever found, although this species was sometimes abundant as larvae on fruit in garbage cans. As it has been brought under control, adults are seldom observed on fallen fruit.

A peculiar habit of the larvae has made this species well adapted to survival in a garbage can habitat. The larvae, after developing for 4 or 5 days in the summer, crawl in large numbers up the sides of the can, out under the lid, and fall to the ground, where they find a drier location and pupate. If these larvae remained in the can, they and the pupae would be carried to the dump with the weekly pickup and would be largely removed from the city. By remaining in the city near the garbage can, they maintain a very effective continuing population. The garbage can larval fly trap studies demonstrated that most fly larvae emerged from the can during the last three days of the week. Twice a week collection, therefore, was an obvious solution to the control of this blow fly.

A private agency has handled garbage collection in Visalia for many years. A city ordinance had required all householders to use the garbage collection service, but authorized a choice of once or twice a week collection. About ten percent chose twice a week service. Perhaps fifteen percent of the city residents did not comply with the requirement for subscribing to the service.

As a result of the studies by the Delta MAD, and with the full cooperation of the City, the collection service was enforced on all residents by making an automatic charge on everyone who had water service. The new city ordinance specified that collection would be twice a week for all residential homes. Some commercial locations, such as restaurants and stores, have daily collections.

There was concern about the need for a county ordinance for the extensive fringe area about Visalia. After several years of experience, it has been observed that there was no need to fret over such an ordinance. The same collection agency provides voluntary service for these fringe areas, but it provides only twice a week service. Almost all the people in these areas are now subscribing to this collection service, so control of the blow fly has been almost as good as in the city.

The direct cost to the people has been fifty cents per month, from the former rate of one dollar and fifty cents to the present two dollars. For this payment, all trash as well as garbage is collected, and there is no need to separate wet garbage from miscellaneous paper, cans and other trash. There are many sink disposal units in the city, and sometimes these residences have little significant wet garbage. Surveys by the Delta MAD, however, determined that flies were produced in appreciable numbers in households with sink disposal units, from bones, residues in can, and other organic items not run through the disposal units. Some persons with sink disposal units indicated their cheerful willingness to pay for twice a week collection in order to assure that their neighbors' garbage cans did not produce flies to infest the community.

The garbage can larval fly trap studies had indicated that twice a week collection alone was not enough. Observations and a little common sense indicated that the only significant additional need was to assure that *all* the garbage was dumped twice a week. Residual garbage which stuck in the can could be appreciable and produce many flies. It stuck because the householder failed to clean the can and keep it clean. A paper liner, careful disposal of grease into tin cans or milk cartons to avoid spilling into the garbage can, and wrapping of each garbage deposit, all would contribute to a clean can which would almost never produce a fly.

The problem the District needed to solve was: "which cans were dirty?". Maintaining a dirty garbage can is a way of life, like keeping a dirty house, an unkempt yard, or having BO. If this practice can be identified by an economical procedure, perhaps these people can be encouraged to keep a cleaner garbage can, even if they never wash the car or take a bath. The effectiveness and simplicity of the inspection procedure which the District developed, and with which the City coordinated every step of the way, made it possible to approach the elimination of all breeding cans and provide true control of the garbage blow fly.

During 1967, two summer student operators, among other duties, inspected virtually every garbage can in Visalia at least once, and problem cans were reinspected up to five or more times. These operators followed the garbage collection truck from 7:30 a.m. to 12:00 noon, inspecting 500 or more cans in this time. A survey form was used, permitting the recording of the total number of clean cans, the cans with residue but no larvae, cans with light breeding (up to about one dozen larvae), medium breeding (one dozen to about six dozen larvae), and heavy breeding. A special long handled trowel is used to turn over any residue in the can.

When breeding is found for the first time, a green tag is fastened on the can. On another record sheet, the address, and name if evident, is recorded, plus the date of the tag and the degree of breeding. One week later, a check is made of the cans which were tagged. If still breeding or excessively dirty, a red tag is applied. These tags are not threatening; they note that fly breeding has been found, they give procedures which will eliminate the breeding, and they urge the help of the householder. One week later, another inspection is made. If the can is still breeding, the report is submitted to the District office and a personal letter is written. In some cases the letter may be sent by the City. Finally, if satisfactory results are not obtained, a personal visit is made. A member of the City staff has made these personal visits. These procedures, when organized, take a minimum of time. As noted in the accompanying chart, most corrections are made before any personal visit is necessary.

Number of	Green Tags Used	Red Tags Used	Letters Written	Personal Visit Made
Each	274	106	51	9

This procedure was under development in 1966, however the first significant use was in 1967. Results have been outstanding! It was true that several personal visits failed to achieve a correction, also that a few of the corrected cans returned to a dirty condition and produced flies again. This situation is not different from many found in the mosquito control program, and there is no solution except continued inspections to keep bad situations from getting out of hand.

What are some of the evidences of control?

1. Larval populations: Preliminary spot surveys in 1962 indicated that about twenty percent of the garbage cans in Visalia were breeding at a given time, and that almost every can produced flies occasionally. Further, about eleven percent, or approximately half the cans which were found breeding, contained heavy populations of larvae. In 1967, 8,354 cans were inspected and only 3.2% contained larvae. Only 23 cans, or .27%, contained heavy larval populations.

2. Adult populations: A standard procedure was adopted in 1962 which has proven more effective and consistent than any reported in the literature. *P. cuprina* is not attracted to sugar bait or to slats of wood as is the house fly. The strongest attractant which has been observed has been fresh dog droppings, but these cannot be handled conveniently. Canned dog food is reasonably good when there are high populations, but fresh liver is better. Scrap liver is usually available free or at a minimal charge from local butchers. Several liver pieces, equalling about one square foot in size, may be handled conveniently on heavy butcher paper. The liver may be stored in a refrigerator or on ice and used for several days. When exposed, fly populations build up to a maximum on it in about two minutes.

When adult flies were bad in Visalia a few years ago, the comments of barbequers were "we wait until dark, then the flies leave". The daily activity of the fly in relation to daylight may be seen in Figure 1 which was made from observations in the community of Ivanhoe.

Not one fly was observed until thirty minutes after sunrise. Populations then rose rapidly to a peak about one and one-half hours after sunrise. In the hottest part of the day, flies were reduced in the open sun but remained about as abundant as ever in the shade. About fifteen minutes before sunset the population dropped rapidly to zero.

In 1962, fly counts up to sixty were recorded at the home of the Delta MAD manager. In August, 1967, many minutes of sampling resulted in zero flies most of the time, and a maximum of two adjacent to heavy deposits of fresh dog droppings. A special survey by the inspection crew recorded

Table 1 — Fly Breeding in Garbage Cans. Comparison of Visalia with other communities in the Delta Mosquito Abatement District, 1967.

	Total Cans Inspected	Percent Cans Breeding	Percent Cans Breeding Heavy	Heavy Breeding Cans- x worse than Visalia
Visalia	8,354	3.2%	.27%	
Dinuba	2,644	7.7%	.94%	3.5x
Woodlake	549	11.7%	6.37%	23.6x
Exeter	1,046	12.1%	2.95%	10.9x
Ivanhoe	398	12.5%	7.03%	26.0x
Farmersville	688	16.7%	4.93%	18.3x

only two flies in five test sites in the southern part of Visalia. Five flies were recorded in six test sites in central Visalia, and ten flies in seven sites in north Visalia. In the last case over half the flies were obtained at one site where the resident had moved and left garbage scattered about the garbage can.

One survey of adults, using five or more sites in each community, produced the following results:

Visalia	.94 average flies per two minute count
Dinuba	2.27 average flies per two minute count
Woodlake	6.64 average flies per two minute count
Exeter	7.5 average flies per two minute count
Ivanhoe	7.5 average flies per two minute count

All these communities except Ivanhoe have twice a week collection. Except for Visalia, none has taken action to obtain clean cans.

As noted previously, there are errors and deficiencies in the literature relating to *P. cuprina.*

1. The California Mosquito Control Association Fly Guide, 1963: "There is some evidence that *P. cuprina* is the predominant green blow fly in southern and south central California, while *P. sericata* is more common in coastal areas and northern parts of the state.

"However, there is little apparent difference in their ecology, and for practical purposes the two species can be considered one and the same."

2. University of California Agricultural Extension Service Identification of Common Flies Associated with Livestock and Poultry 1967. "The bronze (*P. cuprina*) blow fly is more prevalent in southern and central California; the

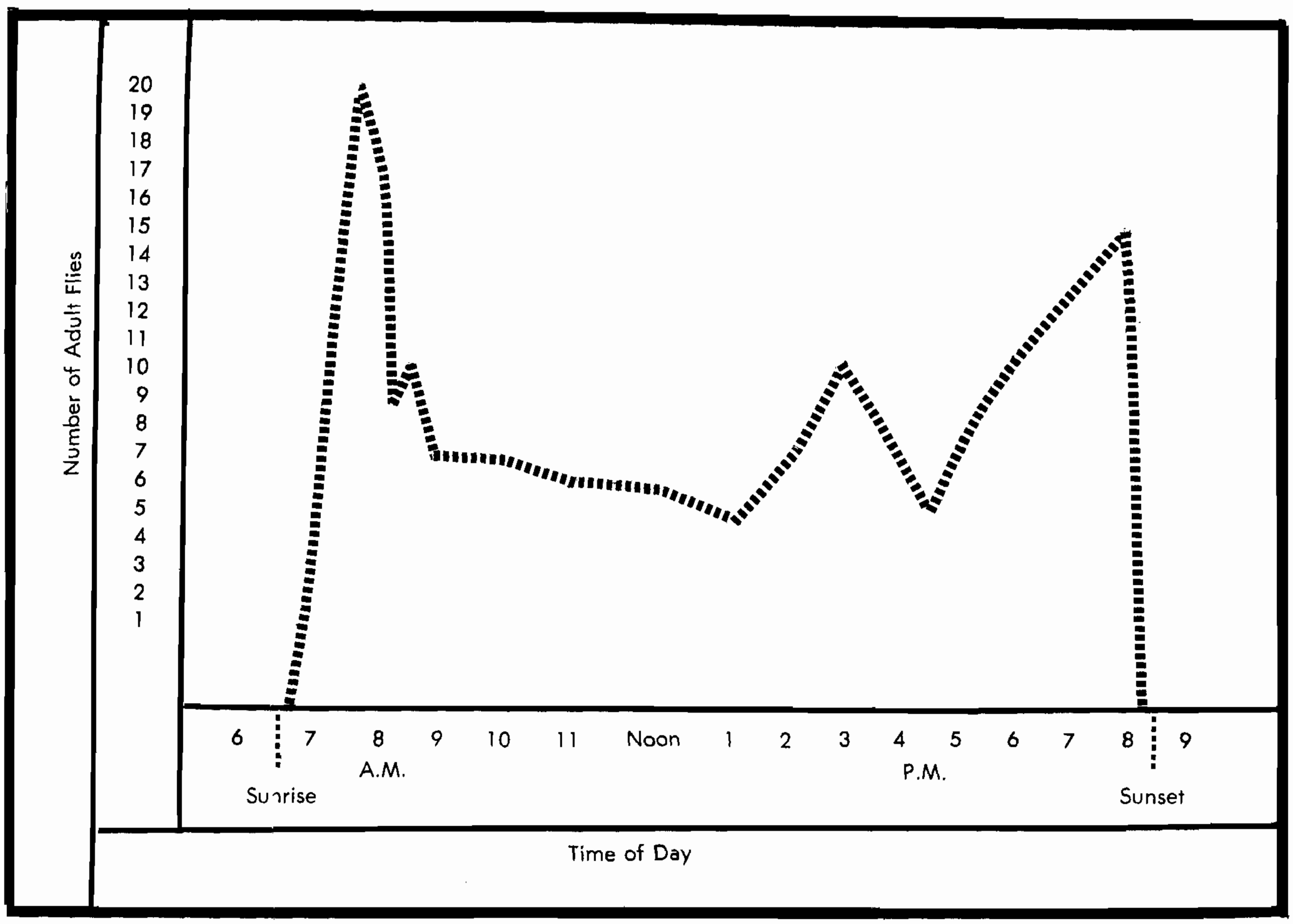

Figure 1. Activity of Adult Flies in Relation to Daylight in Ivanhoe, California, 1967.

CARP PLANTING PROGRAM FOR CONTROL OF CHIRONOMIDS

JACK H. KIMBALL

Orange County Mosquito Abatement District

Public annoyance from chironomid midges has rapidly increased over the past fifteen years. Chironomids thrive in the silty bottoms of flood water drainage facilities and water impoundments of all types. Southern California's mild climate permits continuous breeding throughout the year. Breeding activity is diminished only during the three winter months of December, January and February when the average daily temperature drops to a minimum of 52°F. Breeding in the drainage facilities is interrupted only by the scouring action of run-off from our infrequent winter storms. The chironomid's breeding cycle may be as long as 40 days during the winter months and as short as 15 days during the long summer season. Breeding intensity quickly builds up to over 500 larvae per sq. foot of bottom surface. The daily emergence of adult midges is so great that walls, windows, doors and shrubbery are covered by the resting insects. At night, they are attracted to light and readily enter the home. Since chironomids are weak travelers, public annoyance has resulted from the location of residential and commercial developments contiguous to the breeding sources. Orange County's phenomenal record of urbanization over the past 15 years has developed the need for the precise control of chironomid midges as well as of mosquitoes. Over one million people are now living in an area laced with some 250 miles of major drainage facilities and dotted with 143 water impoundments.

The use of chemical larvicides is, by necessity, the method used to control chironomid breeding in the drainage facilities. Baytex® granules, applied at the rate of 0.2 lb/acre have been effective over the past five years. During the 1967 season, Abate® granules, applied at half the rate for Baytex, gave equally good control. These larviciding operations are designed and timed to control mosquitoes as well as the chironomids. Dosage rates for chironomids, however, are double the rate required for mosquitoes.

A method of drying up special impoundments used as water spreading facilities at frequencies determined by the entomological evaluation of the development of the chironomid larvae has been successful over the past five years by a cooperative project between the Mosquito Abatement District and the Orange County Flood Control District. Four impoundments are used to sink imported Colorado River water into the underground basin at the rate of 100 second feet. Mosquito production was prevented by regulation of water depth, marginal weed control and the use of mosquito fish. The intensity of the public nuisance from the chironomid midges and the desirability of excluding any possibility of contaminating the underground water supply by a chemical larvicide dictated the necessity to shut down this entire operation every 30 days for a 7-day drying period. At the present time, water management facilities are being constructed by the Flood Control District to permit one-half or all of each impoundment to be removed from service and dried up while the other three remain in operation.

A method of water quality control has been successful in the complete elimination of chironomid breeding in a 200-acre tidal marsh lagoon filled with storm water run-off and located adjacent to a beach community. The operation of existing tide gates was programmed to permit free access of ocean water during periods of high tides. Gradual dilution of the fresh water quickly eliminated the ideal environment for chironomid production.

In addition to the control methods mentioned above, the District has started a program of biological control of chironomid midge production in several types of water impoundments that are closely associated with the urban development in Orange County. These types are mainly sewage effluent oxidation basins, irrigation water storage reservoirs, wash water clarification lagoons used for rock and sand production, and ornamental ponds and lakes in golf courses and other recreational areas.

The use of a biological control method for chironomids in small impoundments has been developed recently to avoid the unnecessary use of chemical insecticides as well as to eliminate the high cost of repetitive spray operations. Some 143 small impoundments in Orange County are potential breeding sources for both chironomids and mosquitoes. During the past twenty years, however, the District's source reduction program, in coöperation with the property owner and other public agencies, has established conditions which eliminate any significant mosquito production from the small impoundments. The adoption of standards for design, construction and maintenance, and the use of the well-known mosquito fish, *Gambusia affinis,* has eliminated the use of chemical larvicides for many years.

The encroachment of urbanization around these impoundments dictated the need for chironomid control, and chemical larvicides had to be employed in spite of the fact that mosquito production had long been prevented by the source reduction program. The present program of using carp and mosquito fish as biological control agents in conjunction with the source reduction program provides an effective and economical control program for both mosquitoes and midges, the only two pest insects which breed in the small impoundments.

The biological control of chironomid midges by the use of the common carp is well-known. Although carp, *Cyprinus carpio,* is widely distributed throughout California and elsewhere, the California State Department of Fish and Game has the responsibility of protecting sport fishing waters from contamination by this so-called "pest". It destroys aquatic plants utilized by waterfowl, roils the water, causing silt-sensitive fish to disappear, and competes directly with game fish for food and space. Because it is an extremely hardy fish, it often overpopulates waters and depresses game species.

The State Department of Fish and Game has recently recognized the public nuisance problem created by chironomid midges and is aware that the carp is the only fish currently available that will control midge production in small impoundments. Consequently, the Department has approved the District's program to use carp for this purpose. Applications for a permit to transport and plant carp must be submitted by the District for each impoundment. Permits are issued by the Department if the impoundment meets the following criteria: (1) There be no sport fishery which the introduction of carp would disrupt, nor a migration route into a sport fishery; and, (2) that the area either be fenced or clearly posted against public use so that anyone entering the area would realize he was trespassing. Before applying for a permit, the District reviews the program with the owner of the impoundment and secures his written permission to plant the carp.

The District accepts the responsibility of protecting existing or potential sport fishing waters in Orange County from contamination by carp. It depends on the Department of

Fish and Game for training in the identification, salvage and transportation of fish. The District is guided by the recommendations of the Department of Fish and Game so that the use of carp for the control of chironomid midges will not be detrimental to the public interest.

VECTOR AND NUISANCE PROBLEMS EMANATING FROM MAN-MADE RECREATIONAL LAKES

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The development of recreational lakes as focal points of new subdivisions is one of the more recent real estate promotional activities in southern California. We now know of at least 13 of these lakes from San Diego County to San Luis Obispo County (Figure 1). The number of these developments will undoubtedly increase.

These lakes can be located almost anywhere. Porous soils can be sealed with bentonite, plastic membranes, or cement. Water is available from wells, natural runoff, or can be imported from the Colorado River, Owens Valley, or the Feather River.

Mosquito control agencies may expect an addition to their workload where these developments occur inasmuch as these lakes usually become sources of chironomids, chaoborids and mosquitoes. I anticipate that the tolerance threshold of nuisances thus created will be much lower than that generally true near mountain lakes of natural origin. Many homes will be separated from lake fronts by but a few steps—some less than 30 feet. The success of six lakes at Santee, San Diego County, suggests that reclaimed sewage effluent may well be the water source for future lakes and associated vector problems. Most artificial lakes use well water or surface runoff from winter rains. Surface runoff is usually high in phosphates, often in nitrogen, producing rich phytoplankton growths in a very short time—a major source of nutrient for midge and mosquito larvae.

Some of the smaller midges, such as *Paralauterborniella subcincta,* can pass through 16-mesh screens, causing a nuisance inside homes. Midges are attracted to lights, will stain house stucco and paint jobs, ruin laundry, increase spider webbing, soil automobiles, and reduce driver visibility through windshields. Some are strong fliers and can create nuisances over wide areas.

In swimming areas of some of these lakes we may have to contend with control of *Physa* and *Gyraulus* snails, the principal local intermediate hosts of trematodes causing schistosome dermatitis.

Lakes developed from natural sloughs, such as Laguna Lake in San Luis Obispo County, will likely have vegetation along the shoreline and emerging from shallow waters. In summer vast areas of submerged sago pondweed, *Potamogeton pectinatus,* cover this lake. Lakes with such vegetative growths can provide much more surface area as substrates for tube-building midges than can clean lakes. At Laguna Lake we have collected large numbers of *P. subcincta* and *Cricotopus* larvae from tubes built in this pondweed. After full growth of the pondweed we have also found large numbers of *Anopheles occidentalis* and *Culex tarsalis* mosquito larvae in the weed beds.

Most of these waters become eutrophic in one season and can be expected to produce many species of Diptera, mostly

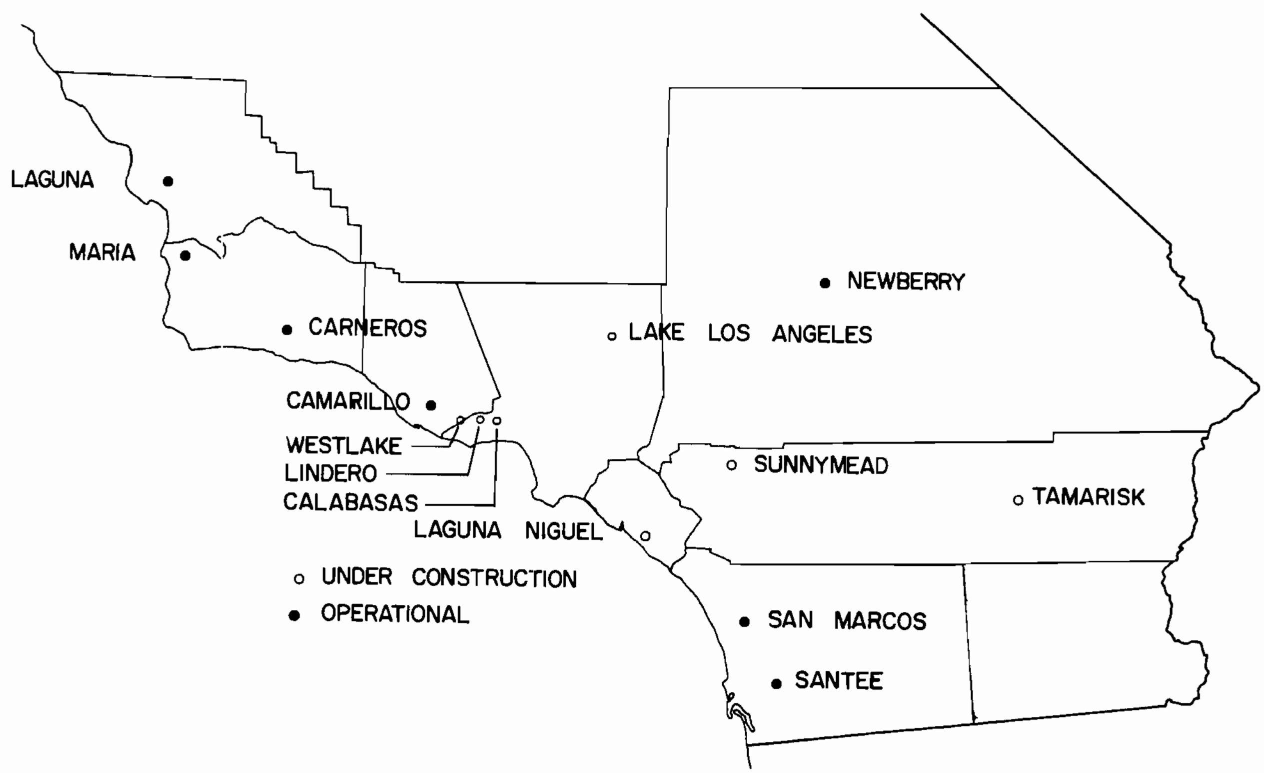

Figure 1. Recreation lakes at new urban developments in southern California.

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Keith Kraft

Santa Clara County Health Department, San Jose

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3. Spread newspaper or other suitable material under the swarm to catch the dead bees.
4. Clear the area of spectators.
5. Spray the swarm using a coarse spray setting to obtain rapid penetration of the mass.
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Douglas C. White
Merced County Mosquito Abatement District

Abstract

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Cost of operations during 1967 as compared to the District's fixed wing aircraft, is discussed. The cost per acre of the helicopter was $0.06 higher than the fixed wing. Advantages of helicopter over fixed wing not reflected in cost figures are discussed; more acres per hour, working legally and safely in congested areas, and surveillance.

Future plans for increased use and efficiency are: additional heliports, increased inspection work and mosquito fish planting by air.

THE IMPORTANCE OF SAFETY IN AERIAL SPRAYING

Irma West
California State Department of Public Health
Bureau of Occupational Health, Berkeley

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1959	6	5	1	0
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Total	117	50	43	24[4]

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dential homes. Some commercial locations, such as restaurants and stores, have daily collections.

There was concern about the need for a county ordinance for the extensive fringe area about Visalia. After several years of experience, it has been observed that there was no need to fret over such an ordinance. The same collection agency provides voluntary service for these fringe areas, but it provides only twice a week service. Almost all the people in these areas are now subscribing to this collection service, so control of the blow fly has been almost as good as in the city.

The direct cost to the people has been fifty cents per month, from the former rate of one dollar and fifty cents to the present two dollars. For this payment, all trash as well as garbage is collected, and there is no need to separate wet garbage from miscellaneous paper, cans and other trash. There are many sink disposal units in the city, and sometimes these residences have little significant wet garbage. Surveys by the Delta MAD, however, determined that flies were produced in appreciable numbers in households with sink disposal units, from bones, residues in can, and other organic items not run through the disposal units. Some persons with sink disposal units indicated their cheerful willingness to pay for twice a week collection in order to assure that their neighbors' garbage cans did not produce flies to infest the community.

The garbage can larval fly trap studies had indicated that twice a week collection alone was not enough. Observations and a little common sense indicated that the only significant additional need was to assure that *all* the garbage was dumped twice a week. Residual garbage which stuck in the can could be appreciable and produce many flies. It stuck because the householder failed to clean the can and keep it clean. A paper liner, careful disposal of grease into tin cans or milk cartons to avoid spilling into the garbage can, and wrapping of each garbage deposit, all would contribute to a clean can which would almost never produce a fly.

The problem the District needed to solve was: "which cans were dirty?". Maintaining a dirty garbage can is a way of life, like keeping a dirty house, an unkempt yard, or having BO. If this practice can be identified by an economical procedure, perhaps these people can be encouraged to keep a cleaner garbage can, even if they never wash the car or take a bath. The effectiveness and simplicity of the inspection procedure which the District developed, and with which the City coordinated every step of the way, made it possible to approach the elimination of all breeding cans and provide true control of the garbage blow fly.

During 1967, two summer student operators, among other duties, inspected virtually every garbage can in Visalia at least once, and problem cans were reinspected up to five or more times. These operators followed the garbage collection truck from 7:30 a.m. to 12:00 noon, inspecting 500 or more cans in this time. A survey form was used, permitting the recording of the total number of clean cans, the cans with residue but no larvae, cans with light breeding (up to about one dozen larvae), medium breeding (one dozen to about six dozen larvae), and heavy breeding. A special long handled trowel is used to turn over any residue in the can.

When breeding is found for the first time, a green tag is fastened on the can. On another record sheet, the address, and name if evident, is recorded, plus the date of the tag and the degree of breeding. One week later, a check is made of the cans which were tagged. If still breeding or excessively dirty, a red tag is applied. These tags are not threatening; they note that fly breeding has been found, they give procedures which will eliminate the breeding, and they urge the help of the householder. One week later, another inspection is made. If the can is still breeding, the report is submitted to the District office and a personal letter is written. In some cases the letter may be sent by the City. Finally, if satisfactory results are not obtained, a personal visit is made. A member of the City staff has made these personal visits. These procedures, when organized, take a minimum of time. As noted in the accompanying chart, most corrections are made before any personal visit is necessary.

Number of	Green Tags Used	Red Tags Used	Letters Written	Personal Visit Made
Each	274	106	51	9

This procedure was under development in 1966, however the first significant use was in 1967. Results have been outstanding! It was true that several personal visits failed to achieve a correction, also that a few of the corrected cans returned to a dirty condition and produced flies again. This situation is not different from many found in the mosquito control program, and there is no solution except continued inspections to keep bad situations from getting out of hand.

What are some of the evidences of control?

1. Larval populations: Preliminary spot surveys in 1962 indicated that about twenty percent of the garbage cans in Visalia were breeding at a given time, and that almost every can produced flies occasionally. Further, about eleven percent, or approximately half the cans which were found breeding, contained heavy populations of larvae. In 1967, 8,354 cans were inspected and only 3.2% contained larvae. Only 23 cans, or .27%, contained heavy larval populations.

2. Adult populations: A standard procedure was adopted in 1962 which has proven more effective and consistent than any reported in the literature. *P. cuprina* is not attracted to sugar bait or to slats of wood as is the house fly. The strongest attractant which has been observed has been fresh dog droppings, but these cannot be handled conveniently. Canned dog food is reasonably good when there are high populations, but fresh liver is better. Scrap liver is usually available free or at a minimal charge from local butchers. Several liver pieces, equalling about one square foot in size, may be handled conveniently on heavy butcher paper. The liver may be stored in a refrigerator or on ice and used for several days. When exposed, fly populations build up to a maximum on it in about two minutes.

When adult flies were bad in Visalia a few years ago, the comments of barbequers were "we wait until dark, then the flies leave". The daily activity of the fly in relation to daylight may be seen in Figure 1 which was made from observations in the community of Ivanhoe.

Not one fly was observed until thirty minutes after sunrise. Populations then rose rapidly to a peak about one and one-half hours after sunrise. In the hottest part of the day, flies were reduced in the open sun but remained about as abundant as ever in the shade. About fifteen minutes before sunset the population dropped rapidly to zero.

In 1962, fly counts up to sixty were recorded at the home of the Delta MAD manager. In August, 1967, many minutes of sampling resulted in zero flies most of the time, and a maximum of two adjacent to heavy deposits of fresh dog droppings. A special survey by the inspection crew recorded

Table 1 — Fly Breeding in Garbage Cans. Comparison of Visalia with other communities in the Delta Mosquito Abatement District, 1967.

	Total Cans Inspected	Percent Cans Breeding	Percent Cans Breeding Heavy	Heavy Breeding Cans- x worse than Visalia
Visalia	8,354	3.2%	.27%	
Dinuba	2,644	7.7%	.94%	3.5x
Woodlake	549	11.7%	6.37%	23.6x
Exeter	1,046	12.1%	2.95%	10.9x
Ivanhoe	398	12.5%	7.03%	26.0x
Farmersville	688	16.7%	4.93%	18.3x

only two flies in five test sites in the southern part of Visalia. Five flies were recorded in six test sites in central Visalia, and ten flies in seven sites in north Visalia. In the last case over half the flies were obtained at one site where the resident had moved and left garbage scattered about the garbage can.

One survey of adults, using five or more sites in each community, produced the following results:

Visalia	.94 average flies per two minute count
Dinuba	2.27 average flies per two minute count
Woodlake	6.64 average flies per two minute count
Exeter	7.5 average flies per two minute count
Ivanhoe	7.5 average flies per two minute count

All these communities except Ivanhoe have twice a week collection. Except for Visalia, none has taken action to obtain clean cans.

As noted previously, there are errors and deficiencies in the literature relating to *P. cuprina.*

1. The California Mosquito Control Association Fly Guide, 1963: "There is some evidence that *P. cuprina* is the predominant green blow fly in southern and south central California, while *P. sericata* is more common in coastal areas and northern parts of the state.

"However, there is little apparent difference in their ecology, and for practical purposes the two species can be considered one and the same."

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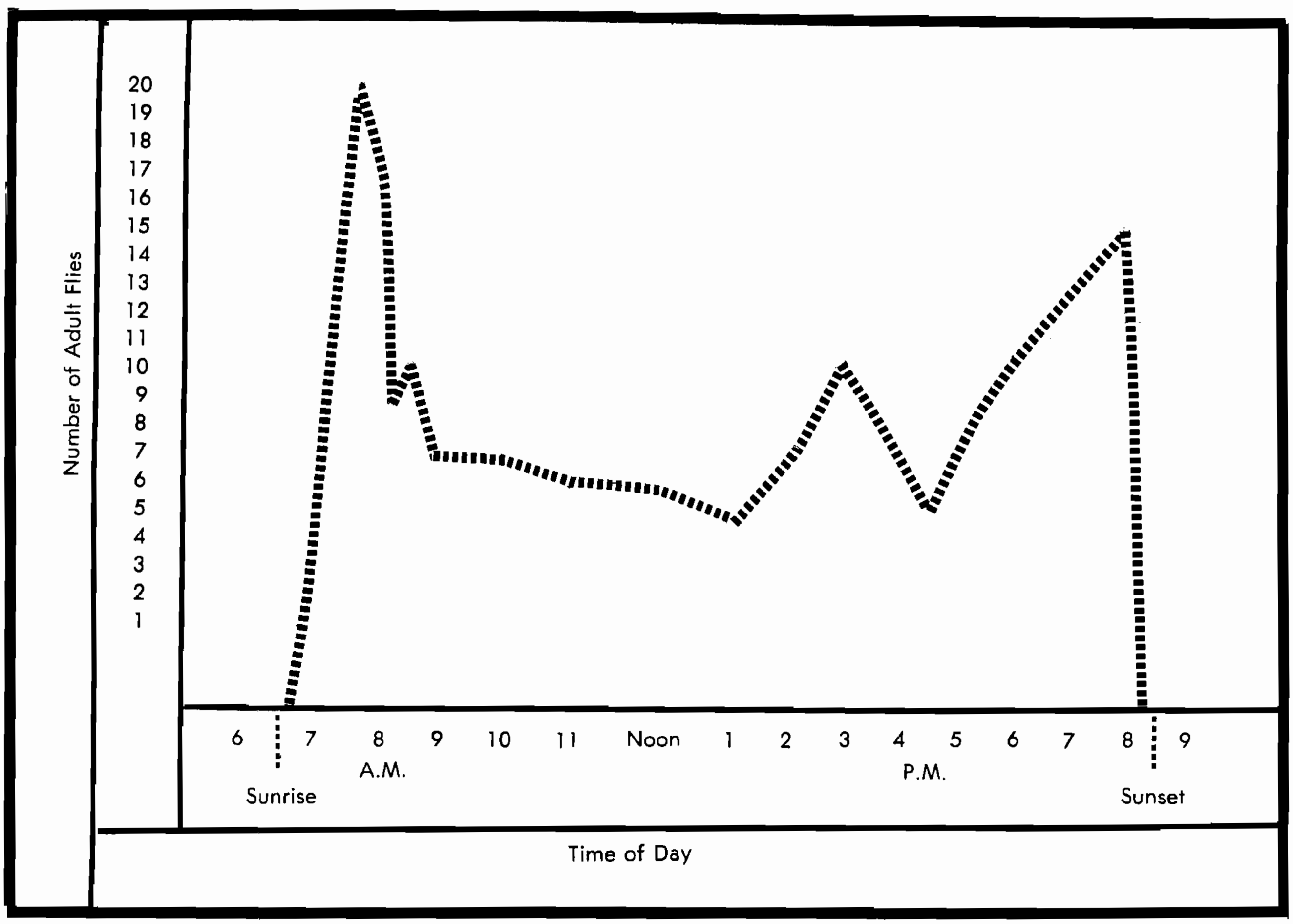

Figure 1. Activity of Adult Flies in Relation to Daylight in Ivanhoe, California, 1967.

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es. Face shields or goggles should always be considered in hazardous areas.

You should know proper first aid when an eye splash occurs. It may save an eye. Proper treatment is to wash the eye continuously for fifteen minutes with clean water. It will not hurt the eye.

Although there have been fewer accidental poisonings recently, there have been two suicides among employees who swallowed the pesticide while at work. This is an unusually high incidence in any kind of employment. If you detect someone who is unusually disturbed, or who has threatened suicide before, he is not a good candidate to be around toxic chemicals. Consider this in your selection and supervision of employees.

People not only in this state but in other countries have had difficulties in the transportation, storage and disposal of pesticides. There have been wide-spread poisonings from accidents in transit. In California in one fifteen month period recently, six people died because they mistook pesticides for a beverage. Fortunately, the mosquito districts have not been involved in any of these cases, but they should exercise great care to avoid troubles. In what kinds of vehicles do you transport pesticides? Can the vehicle in which you transport them be safely decontaminated if a spill occurs? Wood, for example, cannot be decontaminated from most pesticides. Do you have procedures set up for taking care of a spill should it occur? Do you know how to decontaminate a spill of the pesticides you use? One objective is to make it difficult to spill toxic chemicals in the first place by using proper containers. Another is to transport them in such a way that they will not contaminate other items.

Someone should review the potential health problems arising from low volume aerial spraying. People trained in industrial hygiene should work closely with those who are developing low volume spray procedures. A chemical which formerly was sprayed from an aircraft at ½ or 1 gallon per acre, when reduced to 6 ounces, becomes 10 to 20 times more toxic than the original. Perhaps you have failed to appreciate these increased toxicities in low volume work. For example, Baytex® as you have known it will be more like 1% parathion when you apply it in low volume concentrations. It must be treated as 1% parathion. Dursban® would be more toxic than 1% parathion in oral toxicity. DIBROM® probably would be about ½ as toxic. Methyl parathion on the other hand would be many times more toxic than 1% parathion.

In addition to the use of low volumes of the toxicant itself, there are plans to use different solvents to decrease the specific gravity or volatility. What may the solvent do to the insecticide? Solvents notoriously increase the skin absorptability of many chemicals. Thus we could produce a product that would be 3 or 4 times as easily absorbed through the skin than before. Some solvents are quite irritating to the skin and could increase the risk of dermatitis and eye irritation.

There may be some aspects of low volume application which would decrease the hazard—it may decrease the flying time, and loading may be more safely accomplished. However, it is well to consider areas of potential greater risk so that proper plans can be developed to assure safety. Where does the pilot get his breathing air? If it comes through a filter, make certain this filter is clean and properly maintained. How about residue on the exterior of the aircraft? There will be much more chemical on it in low volume work. How about more frequent medical tests, if you are using an organic phosphate? One might be able to get by with the normal use of Baytex without routine tests, but if you consider the low volume material as equivalent to 1% parathion, you may need more frequent cholinesterase tests on the pilot and other exposed persons. Under an unusual situation, the air load may have to be dumped, or if there is an accident, the more concentrated chemical will be a greater hazard to the pilot and the public. These safety matters should be given careful consideration in the plans to develop low volume application procedures.

A REVIEW OF THE ACTIVITIES OF THE COORDINATION COMMITTEE ON MOSQUITO SUPPRESSION AND FISH AND WILDLIFE MANAGEMENT

Eugene E. Kauffman

Sutter-Yuba Mosquito Abatement District, Yuba City

In 1964, at Yosemite National Park, a meeting of interested parties involved in mosquito suppression and wildlife management was held. A decision was made to form a statewide committee to handle affairs dealing with this subject. Oscar Lopp accepted the responsibility of forming the committee which included:

Ben Glading: California Department of Fish and Game
John E. Swift: University of California
James O. Keith: Bureau of Sport Fisheries and Wildlife
Richard F. Peters: California State Department of Public Health
Oscar V. Lopp: California Mosquito Control Association

Mr. Lopp called an organizational meeting January 25, 1965, at Riverside, California. Ben Glading was elected Chairman and James Keith was elected Secretary. Other assignments included constitution and by-laws, committee objectives, research problems, fish and game, and mosquitoes. Regional meetings were approved as the best way to stimulate interest in coordination, a need for letterhead stationery was discussed and another meeting set for May, 1965.

The next meeting was held in August, due to exceptionally full schedules of committee members and the death of Mr. Lopp. At this time the committee was composed of the following members:

Frank Kozlik: Department of Fish and Game, Chairman
Richard F. Peters: Department of Public Health
John E. Swift: University of California
James O. Keith: Bureau of Sport Fisheries and Wildlife
Eugene E. Kaufman: California Mosquito Control Association

Oscar Lopp's desire to have a member of the agricultural community represented on the committee was formalized, and it was agreed that a letter concerning this would be written to the Department of Agriculture.

Previous responsibilities were reassigned:
Constitution and by-laws: Frank Kozlik
Objectives: John E. Swift
Research:
Fish and Wildlife: James O. Keith
Mosquitoes: Eugene E. Kauffman
Analysis of problems and regional coordination:
Richard F. Peters

It was formally agreed that a meeting would be held as close to May and November as possible. Preparation of the Proceedings of the Yosemite Conference were returned to Thomas D. Mulhern for completion and it was urged that the committee be represented at the Wildlife Society and Mosquito Control conventions.

On December 13, 1967 our winter meeting was held. All past members were present as well as a new member, Mr. Harry E. Spires of the California State Department of Agriculture. Committee assignments were presented, except for that which covered the "Objectives." Frank Kozlik was chosen to represent the Committee at the Wildlife Society meeting, and Eugene Kaufman agreed to be the committee representative at CMCA meetings.

The committee discussed coordination that presently exists, such as that between the Butte County Mosquito Abatement District and the Oroville Dam Dredge Pond area, and the Solano County Mosquito Abatement District and Grizzly Island.

Members agreed that they should give particular attention to those areas where coordination is poor and problems exist. They discussed the role of the Committee in stimulation of coordination and agreed to assist and advise agencies, and perform other functions that would effect needed coordination. It was noted that many managers of mosquito abatement districts felt that responsibiliy for coordination was part of their job. It was concluded that the main barrier to practical coordination was the lack of awareness and acceptance by both principals of the essential management practices of each other's fields. It was felt that the Committee, as a nonpartisan group might most effectively initiate and catalyze coordination.

The letterhead stationery has been printed, and a regional meeting in the Sacramento Valley is being planned for late spring. Committee activity is increasing and better results should follow.

FINAL SESSION

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

STEPHEN M. SILVEIRA, *Presiding*

PRESIDENT'S MESSAGE

STEPHEN M. SILVEIRA, *President*
California Mosquito Control Association

In the recent past, we have witnessed some fundamental changes in our California mosquito control research program. The State Legislature has directed that all mosquito research in California be accomplished by the University of California. The University has accepted this responsibility The Division of Agricultural Sciences has prepared a mosquito research proposal which clearly sets forth the research effort required for the survival of mosquito control in this State.

This program proposal was developed through the combined efforts of the University, the Bureau of Vector Control and California Mosquito Control Association. Many hours of plain hard work were devoted to this proposal, and I urge all of you to acquaint yourselves with its contents.

The major areas of research are, I feel, well defined and should serve as a guide for years to come. Specific items within the 6 major areas listed will undoubtedly change as new assessments of the program are made. University people have indicated a sincere desire to work closely with this Association and the BVC on any changes of emphasis or direction when indicated. The research staff at Riverside and the CMCA Research Committee have scheduled an informal workshop for mosquito abatement district and health department personnel on February 13th at Riverside (8:30-12:00 Noon, Room 217 B, Entomology Building). Members of the CMCA Research Committee, Officers and Trustees are especially urged to attend as well as other interested members of the Association. This is an example of the type of coordination that is developing.

Everyone in CMCA has long enjoyed a close working relationship with the BVC. This relationship must not only continue but also must be expanded. We are living in an age of rapid change. We see it everywhere. New technologies are demanding new approaches to old problems. To meet our obligations to the public we serve, we must incorporate these new techniques into our local programs as rapidly as possible. To do this efficiently and economically, we must have the technical assistance and guidance of the BVC. As control techniques become more complex, the need for technical assistance from the BVC will increase. This is only one example of our need for a close relationship with the BVC.

We must be prepared to effectively support both the University and the BVC in Sacramento when additional funds are needed to support their on-going programs in mosquito control or expand them when the needs become apparent.

Both the UC and the SDPH are known and respected throughout the world for their good works in the important field of mosquito control. We are indeed fortunate to have the opportunity to work with such fine institutions.

I wish to thank the Board of Directors for their faithful attendance at our board meetings and for the work they have done. I wish to also include our committees and their chairmen. They have taken their work seriously and I feel they have done a good job. I believe I speak for the Board and the committees when I say I hope we have added a little something to the successful future of this Association. Thank you one and all.

INTERPRETATION OF RESISTANCE IN CALIFORNIA *AEDES NIGROMACULIS* LARVAE

Patricia A. Gillies, Don J. Womeldorf, and Kathleen E. White

California State Health Department
Bureau of Vector Control

The resistance surveillance program conducted by the Bureau of Vector Control is based on testing field-collected mosquito larvae to determine their susceptibility to insecticides currently used for their control. Methods employed in the surveillance program have been described by Gillies and Womeldorf (1968). Results are reported to the control agencies as LC_{50} and LC_{90} estimate for each population tested. A general interpretation of the results as they apply to field control is included.

The failure threshold concept developed by Womeldorf, Gillies and Wilder (1966) uses the LC_{50} as a guide in predicting the response of a particular population to control efforts. Parathion, methyl parathion and fenthion are generally applied at 0.1 lb/acre. At this dosage, the possibility of control failure exists when the LC_{50} exceeds 0.005 ppm. When 50 percent or more of the population is able to withstand a concentration of 0.01 ppm, the chemical is virtually useless.

The failure threshold has proved to be valuable when applied to most populations and situations. An exception has been seen in populations just beginning to exhibit a lessening of susceptibility, which may have LC_{50} still below the threshold of failure. This paper discusses another interpretational concept useful in detecting incipient resistance against some insecticides as related to operation control of *Aedes nigromaculis* (Ludlow). Examples of laboratory test results are included to demonstrate the response of actual populations to parathion and fenthion.

The slope of the log concentration-probit (1c-p) line may be expressed as the ratio of the LC_{90} to the LC_{50}. Homogeneous susceptible populations of *A. nigromaculis* larvae generally have an LC_{90} approaching but not exceeding two times the LC_{50}. As the proportion of more tolerant individuals in a population increases, the LC_{90}/LC_{50} ratio increases to greater than two. This condition when shown graphically is represented by a flattening of slope (Brown, Lewallen and Gillies, 1963).

A progressive pattern of the 1c-p lines has been observed in resistance induced by field treatment. Initially, there is a change in slope with very little change of the LC_{50}. As the development of resistance progresses through the intermediate stage, an increase of the LC_{50} is accompanied by an increase in the LC_{90}/LC_{50} ratio. Then, in the final stages, the LC_{50} continues to increase and the LC_{90}/LC_{50} ratio decreases as the 1c-p lines become steeper, apparently due to

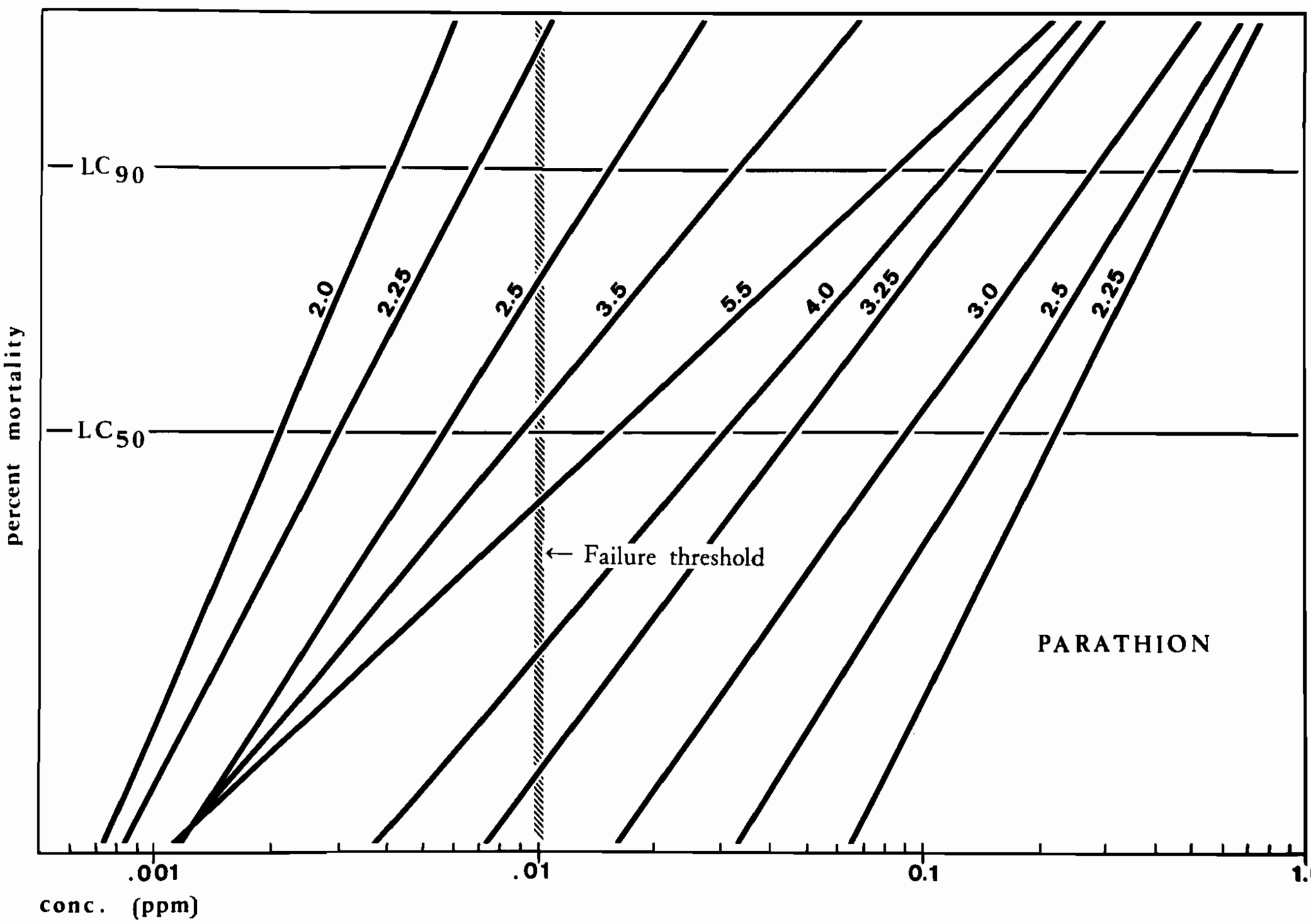

Figure 1. Log concentration—probit lines for Californian populations of *Aedes nigromaculis* ranging from susceptible to resistant to parathion.

the elimination of the more-susceptible individuals from the population.

Figure 1 shows a series of lc-p lines representing the responce of actual populations of *A. nigromaculis* larvae to parathion. LC_{90}/LC_{50} ratios are given for each line. The ultimate failure threshold of 0.01 ppm. is represented by the vertical line. Parathion would be ineffective as a control agent at 0.1 lb/acre against populations with an LC_{50} surpassing this threshold. A line representing the response of a typical susceptible population is shown at the extreme left of the figure. Lines at the far right are for highly resistant populations with 10-15 years of intensive treatment with parathion, methyl parathion and fenthion. Populations classified as control problems are those with an LC_{50} greater than 0.005 ppm, or with an LC_{50} greater than 0.003 ppm and an LC_{90}/LC_{50} ratio greater than two.

Methyl parathion treatment also has produced severe resistance problems in some areas. Line slopes for methyl parathion follow the pattern exhibited for parathion.

At this time, fenthion is the final chemical in the line of available replacements, and has been used as a substitute for parathion and methyl parathion against highly resistant populations. Figure 2 represents a series of lc-p lines for fenthion. The population responses shown range from those

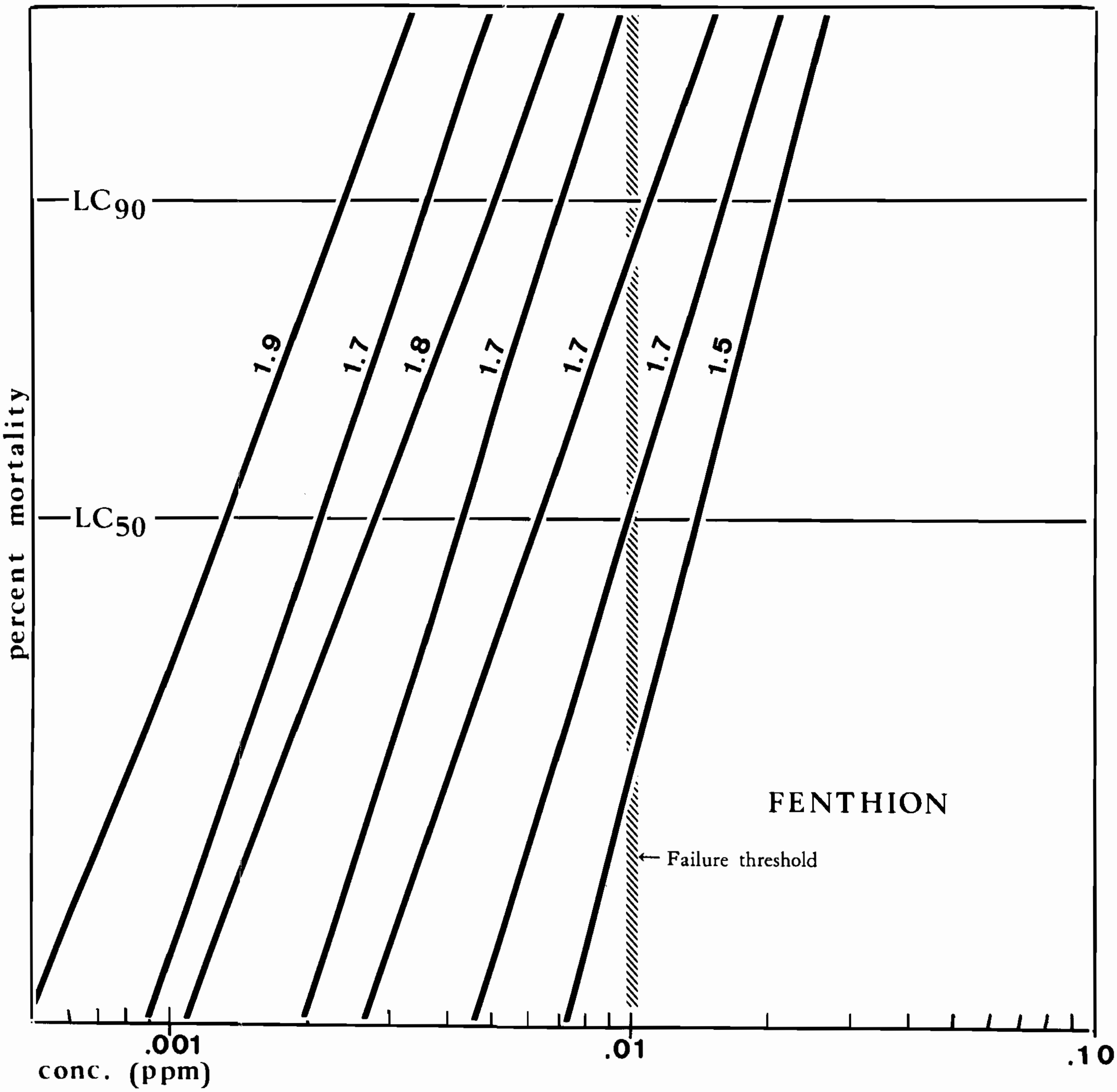

Figure 2. Log concentration—probit lines for Californian populations of *Aedes nigromaculis* ranging from susceptible to resistant to fenthion.

representing complete susceptibility, to those with the highest levels of tolerance yet determined for this species to this insecticide. The slopes are similar with LC_{90}/LC_{50} ratios all less than two. At this stage in selection, interpretation of developing resistance must be based upon the magnitude of the LC_{50} alone, not in combination with the slope.

Intermediate populations with fenthion LC_{50}*'s* in the range of 0.005 to 0.01 ppm are borderline. Control may be achieved when application conditions are optimum, but adverse conditions result in varying degrees of failure. The most tolerant populations have LC_{50}'s which exceed the higher failure threshold and cause consistent control problems.

The highest levels of tolerance to fenthion confirmed for *A. nigromaculis* have remained virtually unchanged since operationally-significant tolerance was first detected in 1964. However, more populations are achieving this enhanced tolerance. Fenthion levels are not high when compared to those for parathion and methyl parathion, but are high enough to cause control failures in limited areas. Failures with fenthion have thus far been confined to the same general areas of Kings and Tulare counties involved in the initial parathion failures (Lewallen and Brawley, 1968; Lewallen and Nicholson, 1959).

Development of high levels of tolerance to fenthion has certainly been influenced by intensive prior treatment with organophosphorus compounds. Tolerance of this nature has been witnessed in the response of highly resistant population of *A. nigromaculis* larvae to EPN, Abate®, and Dursban®, although none of the materials had been used routinely in control programs (Gillies, Womeldorf and White, 1968). The line slopes for these three insecticides were also steep (Gillies and Womeldorf, unpublished data).

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PRESENT STATUS OF INSECTICIDE RESISTANCE IN CALIFORNIAN MOSQUITO LARVAE

Don J. Womeldorf, Patricia A. Gillies, and Kathleen E. White

California State Department of Public Health, Bureau of Vector Control

Mosquito control programs in California utilize, almost exclusively, the organophosphorus compounds as larvicides. Parathion resistance was first found in *Aedes nigromaculis* a decade ago (Lewallen and Brawley, 1958). Since then resistance has developed against other organophosphorus compounds and in other species. This paper summarizes the resistance situation as it is presently understood and discusses changes that may be expected in the near future.

Mosquito larvae were tested as described by Gillies and Womeldorf (1968). Results were compared with failure thresholds (Womeldorf *et al* 1966), and were, when possible, substantiated by field observations.

Current Status

High organophosphorus tolerances in larvae of five Californian mosquito species were listed by Womeldorf *et al* (1966). Table 1 presents, by year of first laboratory confirmation, additions to the list, including some material omitted from the first summary. The same criteria as applied earlier have been used here: the population LC_{50} exceeded 0.005 parts per million parathion, methyl parathion, or fenthion; or 0.1 parts per million malathion. The levels listed are not necessarily the greatest that have been determined since high tolerance was initially found, but the highest level in the year of detection is included.

Table 2 summarizes the known presence of high organophosphorus tolerance to date, as listed in Table 1 and the 1966 paper. The table undoubtedly does not list all instances, because testing is not complete for all areas of the state. In some cases operational evidence exists for failure due to high tolerance, but the levels have not yet been laboratory-determined. On the other hand, some high levels have been found in agencies which do not use the insecticide in question, pointing to some other cause of high tolerance than developed physiological resistance.

Aedes nigromaculis, the most heavily-pressured mosquito in the Central Valley of California, has developed such widespread resistance against malathion and parathion in many agencies that the use of these chemicals as larvicides has become impractical for controlling the species. Methyl parathion resistance inexorably follows parathion resistance within a year or two (Brown *et al* 1963; Mulla 1966). In fact, it has been the experience of some agencies that, when parathion resistance has developed, it has been impossible to re-establish control of *A. nigromaculis* for more than a few months with methyl parathion.

The situation regarding fenthion is less clear. By the end of 1964, high fenthion tolerances and attendant operational failures in *A. nigromaculis* control had become commonplace in parts of Kings and Tulare counties after only about three seasons' use, and it was anticipated that the same problems would develop in other areas following methyl parathion's replacement by fenthion. However, by the end of 1967, there were no new areas added to the list. It does not appear, at present, that widespread fenthion failure is imminent for most of the Central Valley. The only high fenthion level measured outside of the two counties named above was in an area where fenthion had never been used for mosquito control.

Gillies *et al* (1967) discussed the potential resistance problem of three insecticides which may be used alternative to fenthion: EPN, Dursban®, and Abate®. Preliminary field observations indicate that the chemicals will provide control where fenthion is effective against larval *A. nigromaculis,* but may be expected to produce erratic results where fenthion levels are high.

A. melanimon is common throughout much of the Central Valley but is a secondary species to *A. nigromaculis.* Although parathion resistance is evident, insecticides are changed to combat resistance in *A. nigromaculis,* so little

Table 1. First laboratory demonstrated high organophosphorus tolerance in larvae of five Californian mosquito species — year and LC_{50} level with 95% confidence limits, by control agency and insecticide.

		MALATHION			PARATHION			METHYL PARATHION			FENTHION		
Mosquito species	Control Agency	Year	LC50	95% limits	Year	LC50	95% limits	Year	LC50	95% limits	Year	LC50	95% limits
Aedes nigromaculis	Fresno Westside							1966	.010	.0079-.014			
	Merced	1967	.12	099-.15									
	Turlock							1966	.011	.0081-.014			
	Eastside	1966	.31	.27-.35				1966	.010	.0085-.013			
	San Joaquin				1964	.0056	.0046-.0074				1966	.0061	.0052-.0073
	Colusa				1966	.028	.023-.034						
Aedes melanimon	Kern	1966	.13	.094-.42									
	Kings				1965	.0062	.0055-.0069						
	Delta				1964	.0058	.0048-.0069						
	Consolidated				1966	.0067	.0062-.0071						
	Fresno Westside				1964	.0060	.0056-.0066						
	Merced				1966	.0081	.0076-.0087						
	Colusa				1966	.0070	.0038-.013						
	Corning				1967	.0055	.0046-.0065						
Culex pipiens Subspp.	Southeast	1966	.14	.12-.15							1964	.0081	.0074-.0091
	Orange County	1966	.12	.10-.13							1966	.0072	.0064-.0080
	Ballona Creek										1967	.0055	.0048-.0063
	Northwest										1965	.0063	.0058-.0069
	Tulare	1966	.18	.15-.23							1966	.0080	.0073-.0090
	Kings										1965	.0057	.0052-.0062
	Fresno										1963	.0061	.0052-.0065
	No. Salinas Val.	1966	.24	.22-.26	1966	.0061	.0052-.0073	1966	.0065	.0057-.0072	1966	.027	.024-.031
	San Joaquin										1966	.0061	.0054-.0068
	Butte County	1966	.11	.089-.14							1966	.0070	.0062-.0079
Culex peus	Southeast	1963	.11	.10-.13	1966	.0074	.0065-.0084	1966	.01	.0094-.013	1963	.0067	.0062-.0074
	Orange County				1966	.0056	.0049-.0063	1966	.0096	.008-.013			
	Goleta Valley										1966	.0092	.0067-.018
	Kings				1966	.0059	.0049-.0071				1965	.0071	.0064-.0080
	Madera	1964	.10	.09-.11									
	No. Salinas Val.				1966	.0057	.0051-.0064						
	Solano	1966	.12	.10-.13							1966	.0064	.0058-.0071
	Sutter-Yuba							1966	.0055	.0052-.0059			
Culex tarsalis	Southeast										1966	.0069	.0053-.012
	Orange County										1967	.0073	.0063-.0097
	Carpinteria										1966	.0072	.0060-.011
	Kern										1964	.0055	.0048-.0064
	Tulare	1966	.25	.18-.40									
	Kings	1966	.26	.18-.41							1966	.0094	.0084-.011
	Consolidated	1966	.0075	.0064-.0091									
	Fresno										1964	.0078	.0068-.0089
	Madera	1966	.21	.15-.33									
	Turlock	1967	.11H	.050-.12							1967	.0052	.0046-.0061
	Solano	1966	.12H	.023-.95									
	Sacto-Yolo	1966	.11	.084-.19									
	Sutter-Yuba	1966	.41	.26-1.2									
	Butte County	1966	.10	.069-.25									

H: heterogeneous data

parathion is presently used against *A. melanimon*. The species appears to be generally susceptible to methyl parathion and fenthion. It is unlikely that resistance will be operationally significant in most *A. melanimon* populations in the foreseeable future.

Culex tarsalis, *C. peus*, and *C. pipiens* subspp. have all become resistant against malathion, and possibly against fenthion. Operational problems with these two chemicals may be expected to continue. The occasional high parathion and methyl parathion levels detected are probably due to factors other than developed physiological resistance. Abate, Dursban, and EPN all appear to be highly effective against all three *Culex* spp.

Other important species, including several *Aedes* spp. *Anopheles freeborni*, and *Culiseta* spp., exhibit high tolerance levels in some populations. The information regarding resistance is incomplete.

Acknowledgments

Personnel of the mosquito control agencies listed are thanked for their assistance. Several local agencies have established testing programs in cooperation with the Bureau of Vector Control, and have willingly made available the results of their work.

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Table 2. Demonstrated high organophosphorus tolerance in larvae of *Aedes nigromaculis* or *A. melanimon;* and *Culex pipiens* subspp., *C. peus*, or *C. tarsalis*, through 1967.

Control Agency	MALATHION		PARATHION		METHYL PARATHION		FENTHION	
	Aedes	Culex	Aedes	Culex	Aedes	Culex	Aedes	Culex
Southeast		X						X
Orange County		X		X		X		X
Ballona Creek								X
Northwest								X
Carpinteria								X
Goleta Valley								X
Kern	X	X	X	X	X		X	X
Westside		X						
Delano			X					
Kings	X	X	X	X	X		X	X
Tulare	X	X	X		X		X	X
Delta	X		X		X			
Consolidated	X	X	X					X
Fresno	X	X		X				X
Fresno Westside			X		X			
Madera		X						
Merced	X	X	X					
Turlock		X	X		X			X
Eastside		X	X		X	X		X
San Joaquin			X				X	X
No. San Joaquin	X							
No. Salinas Valley		X		X		X		X
Solano		X	X					X
Sacramento-Yolo		X						
Sutter-Yuba		X	X		X	X		
Colusa			X					
Butte County		X	X		X			X
Corning			X					X
Los Molinos	X							
Tehama County			X					X
Pine Grove	X							

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OUTLOOK FOR THE CONTROL OF RESISTANT MOSQUITOES

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Since the advent and use of modern synthetic insecticides, several species of mosquitoes have acquired tolerance to some of these materials. Among the species notoriously known to acquire resistance to the organochlorine and organophosphate larvicides are our ubiquitous floodwater *Aedes* mosquitoes. No other species of mosquitoes in California have such a propensity for coping with the whole array of synthetic chemicals.

For the past twenty years, we have been noticing evolutionary trends and traits in our irrigated pasture mosquitoes. Due to the selection pressures applied through the use of various kinds of synthetic chemical larvicides, new resistant physiological strains of *Aedes nigromaculis* have been produced in the central valley. The worst areas where this phenomenon pops up every time a new organophosphate material is used are of course limited. But this is no cause for rejoicing to the rest of us who do not experience failures with the use of OP larvicides. It probably is only a matter of time until resistant strains of *Aedes nigromaculis* and related species encompass the whole state.

The fact that development of acquired resistance in *Aedes* manifests itself every time in the same areas may spell out certain underlying factors which invariably lead to the appearance of resistance to new materials. These factors have not been adequately studied and we, therefore, are at a complete loss when control failures with new materials are encountered.

Irrigated pasture *Aedes* have changed imperceptibly to such an extent that they hardly resemble their forerunners of mid-forties. However, we are still essentially using the same techniques of the mid-forties with some modifications here and there and switch to newer materials every now and then.

During the 1950's, a logical answer to the solution of resistance problem in *Aedes nigromaculis* was generally sought through the screening and development of new larvicides. Although this approach has been the mainstay of our larviciding programs up til now, we cannot totally rely on this approach in the future. Switch from one OP to another has been successful thus far, but the development of newer materials that would soon become obsolete due to the development of resistance in a short time is an expensive and time consuming research program. The time and expense involved in the development of new materials, and the needed toxicological and pharmacological data will definitely slow down the flow of suitable newer materials on the market. We can hardly afford obsolescence of any of our currently used larvicides due to resistance as we could in the early fifties. In this regard, times have changed. Every time there is an obsolescence of a control agent, it is accompanied by a simultaneous increase in budgets of affected districts.

As far as "OUTLOOK" for the future is concerned, it is certain that solution is not going to come from researchers alone. It will take all of us; researchers, industry, trustees, mosquito abatement personnel including foreman and control operators to solve the resistance and similar problems.

It is hard for me to look through the crystal ball and predict the future with certainty. But, I am confident if research efforts are channeled and coordinated properly, we will be in a position to cope with the resistance problem. The problem before us now is to embark on a crash research program for finding a long range solution to the *Aedes nigromaculis* problem. In order to expedite such a program, I am tentatively offering the following suggestions:

1. The CMCA Research Committee should formulate a plan to work toward establishment of an *A. nigromaculis* research group, composed of researchers and support personnel from the effected areas especially those in Kern, Kings and Tulare Counties. The smaller this group, the more effective would be the working relationships.

2. The research and cooperative personnel should be requested to formalize and expedite needed research studies on irrigated pasture mosquitoes.

3. CMCA and its Research Committee should lend support to such studies.

4. The program should be kept small and at manageable level.

5. All studies initiated and conducted should have relevance to solving the *Aedes nigromaculis* problem.

6. Information developed in these studies would be of great help in the suppression of other species of mosquitoes.

Some of the needed research areas are briefly enumerated below:

1. Surveillance of present and future resistance picture should be carried out more intensely and related to other research activities in this area.

2. Mechanism, scope and development of resistance in the laboratory should be studied. Development of resistance on exposure to sublethal dosages of candidate materials should be investigated.

3. Feasibility of adult control with respect to resistance development should be explored. Dusts and ULV treatments could be of value here.

4. The frequency and rate of development of resistance on exposure of eggs, larvae, pupae, and adults should be explored in the laboratory.

5. Study of the environmental factors contributing to the inactivation or breakdown of control agents. This is a rather complex aspect and emphasis should be placed on phases which are pertinent.

6. Residue Studies. In order to develop candidate materials rapidly, it will be necessary to have an established program for assessing residues in crops, water and other attributes of the environment.

7. Threshold level. This is a very important aspect of the whole problem. It should be investigated to find pest density levels which will require treatments. Factors such as expanse of infestation, weather conditions, proximity of residential areas and livestock will undoubtedly influence decision making.

8. Evaluation of newer materials should continue at the present pace with emphasis on groups of compounds which are structurally different from OP and have different mode of action.

9. Emphasis should be placed on finding compounds which will be both pre-imago and imagocides. Indeed the outlook here is promising, since numerous compounds are now becoming available which kill all ontogenetic stages of mosquitoes.

10. Techniques of application, for example, aerial, versus drip irrigation, pre-hatch versus post-hatch treatments.

Not all of these research phases have to be worked upon at the same time. It will be necessary to undertake these studies in sequence moving from one phase to the other. There undoubtedly are other important aspects which may merit priority.

We are at a stage to initiate such a specific program now. It is only through a team research effort that we might be able to have a successful mosquito control program now and in the future.

CROSS-TOLERANCE OF CALIFORNIA *AEDES NIGROMACULIS* (LUDLOW) LARVAE TO EPN, ABATE®, AND DURSBAN®

Patricia A. Gillies, Don J. Womeldorf
and Kathleen E. White
Bureau of Vector Control
California State Department of Public Health

A portion of this abstract was omitted from the 1967 *Proceedings and Papers, California Mosquito Control Association* 35:111. *Following is the article as it should have appeared.*

ABSTRACT

Insecticide resistance of the pasture mosquito, *Aedes nigromaculis* (Ludlow), has provided control problems for almost 20 years. The first control failures due to resistance in California were with DDT and were reported in 1949 by Smith (Mosquito Buzz 3:2). By 1951, the problem had extended to the other chlorinated hydrocarbon insecticides then in use (Gjullin and Peters, 1952, Mosquito News 12:1-7).

Substitution of the organophosphorus compounds was generally satisfactory until 1958, when resistance to parathion was verified by Lewallen and Brawley (California Vector Views 5:56). Since this time, resistance to both malathion and methyl parathion has been confirmed (Brown et al. 1963, Mosquito News 23:341-5). Presently, increasing reports of control failures using fenthion make a change to a new material imminent in certain areas where severe resistance problems have made obsolescent the previously effective materials.

In response to the needs of mosquito control agencies for early detection of resistance, routine laboratory testing of field-collected mosquito larvae was initiated in 1963 by the State Department of Public Health. A major portion of this program has been devoted to surveillance of susceptibility levels for populations of *A. nigromaculis*. In addition to determining relative susceptibility to the chemicals currently used, promising candidate materials have been evaluated. These materials have been tested against both resistant and susceptible populations from throughout the State in an effort to determine their relative effectiveness and the degree of cross-tolerance present. Three organophosphorus compounds which have been extensively tested as possible substitute materials are EPN, Abate® and Dursban®.

Brown et al. propounded a nonspecific cross-resistance in this species, extending equally to the four organophosphorus compounds commonly used in California: malathion, parathion, methyl parathion and fenthion. Resistance to any one of these materials induces resistance, or at least increased tolerance, to the others. The susceptibility of a population to any one of these compounds will therefore reflect the general organophosphorus resistance of that particular population.

Different larval populations, ranging from complete susceptibility to extreme organophosphorus resistance, were tested against the candidate material and fenthion. It was found that the resistant populations demonstrated cross-tolerance to all three test materials. An approximate 10-fold increase in tolerance to fenthion was accompanied by a six- to seven-fold increase in tolerance to EPN and Dursban. Abate was more seriously affected, demonstrating about a 12-fold increase, double that of the other two compounds. With extremely resistant populations, the tolerance to Abate exceeded that determined for fenthion.

While it is difficult to predict the potential usefulness of a given material on the basis of laboratory tests alone, some general observations can be made, based on previous experience with other larvicides applied at a given rate by aircraft or calibrated ground equipment. A failure threshold concept was developed by Womeldorf et al. (Proc. Calif. Mosquito Control Assoc. 33:77-79) relating laboratory-derived susceptibility levels to control in the field. Two failure thresholds were identified. Within the range of the lower failure threshold, varying degrees of control failure may occur. Unless coupled with adverse application conditions or unusually large populations, the failure may go unnoticed at the lower limits of the threshold. When the higher threshold is surpassed, field failures are readily recognized and the material is useless.

If a field application rate of 0.1 lb per acre is assumed, the failure threshold concept can be applied to the test material as follows: The highest levels determined for EPN and Dursban, while not exceeding the lower threshold limit, are approaching it. Indications are that the materials are still generally useful, but the possibility of partial control failure exists if the materials are applied against highly-resistant populations, particularly when application conditions are less than ideal. Abate levels for many organophosphorus-resistant populations are already within the lower failure threshold area. In a few cases, levels have exceeded the higher threshold, predisposing to failures with this material.

PRESIDENTIAL MESSAGE

JAMES W. BRISTOW, *President,* 1968
California Mosquito Control Association

I want to thank the members of the CMCA for electing me to the office of President for the year 1968. You have broken all precedents in so doing. My feeling is one that is difficult to describe. Rest assured that I shall do my best to uphold the traditions and customs of the CMCA. I have attended enough of the National meetings to see that what we have in California is much better than any other area or state. Our world-wide reputation is one in which we have reason to feel a great sense of pride. Your material gains from this organization have been beyond price to the taxpayers of your districts. Without it your sources of information would soon dry up. Your loss would be measured by rising tax rates and less effective work on your part.

During the coming year I want all of us to take a look at ourselves and make an evaluation. An evaluation of ourselves, as an organization, not as individuals.

Our primary goal is an exchange of information.

This ranges from the most complicated evaluation of insecticides and biological control research at the University level, to the exchange of ideas between drivers, operators, and mechanics, on how to get a better mount of an air compressor on a jeep engine.

Most of our benefits come from this one item. Therefore, our evaluation must be based on the means of exchange, or if you wish to put it another way, on a continuation of education for us all.

Today we have reached the point in time and excellence at which we now stand because many men have given of themselves unselfishly. They, and you, have acted nobly and he who acts nobly does God's work.

The CMCA started some 35 years ago with a few managers and entomologists gathering for a few days of talk at some central point. An organization was started and officers were elected. I doubt that any, or at best, very few here had anything to do with that original founding or have any memory of it. Committees were appointed. These committees now cover every phase of our work from aerial spraying to source reduction; from equipment manufacturer to legislative action on a local, state and national level. Reports are made and printed and circulated to not only our own membership, but to many other related and similar organizations. The same applies to the papers and reports submitted to this convention by researchers and others not members of the CMCA. This exchange of information is our "life blood" (so to speak) as an organization.

One thing I am certain of is that anything which dilutes our efforts or changes the focus of our vision will result in a divided effort and a loss of not only quality but quantity of the education we so much desire. We must always be alert to improve on this phase of our work.

One item that has been discussed, studied and pondered, is the desire for a permanent central office for the headquarters of the CMCA. Properly founded and staffed, it would not for one moment lessen the effort each of us must put forth, but it would offer each of us a better means of access to the information needed to solve our problems.

Last, but not least, I would like to touch upon a subject which is in all our minds, a problem we must all, both Trustee and Manager, keep foremost in our minds. This is the slow, but almost certain tightening of the laws, rules and regulations governing our work. We have not yet found among our small but dedicated membership, a Rachel Carson. The story of our work will probably never make a national best seller list. The average legislator is not an entomologist but more likely a lawyer—a lawyer whose thinking has been shaped, or at least shaded by the "best seller". We can only hope that none of us will add to the misleading publicity by our efforts. We must work towards the further education of our own group to prevent and/or minimize the many inherent dangers of our occupation.

The legislative process is one that is at times, slow and cumbersome in our democracy, as well it should be. However, I cannot help knowing that once those wheels are started they will continue. We will, in the foreseeable future, see more and tighter regulation of our work from every angle—working conditions for ourselves and our employees —the amounts and kinds of chemicals that we use—we may even see a limit set on the permissible level of control we can place upon insects. This does not mean the end of our jobs but that we must constantly seek better ways of accomplishing the control of man's environment. The need for the CMCA will be greater than ever. It can and will maintain its reputation for excellence, integrity, and good, down-to-earth thinking. Let us here and now pledge ourselves to continue working together for the betterment of all mankind.

RELEASE OF NEW MOSQUITO LARVICIDES INTO WATER FROM GRANULAR FORMULATIONS

MIR S. MULLA AND M. F. B. CHAUDHURY
University of California
Department of Entomology, Riverside

The use of granular formulations for treating breeding sources of mosquitoes has some advantages over other types of formulations (Chapman 1955, Mulla, *et al* 1963, Mulla 1965). A study of the various factors influencing the release of toxicants from granular formulations is important. It is necessary to gather information on the extent and magnitude of release of a toxicant, rate of degradation and the level of residual activity after application.

The present study was undertaken for the purpose of investigating the release into water and assessing the effectiveness of new organic phosphate insecticides formulated as granular material. The influence of some additives on the efficacy of certain granular formulations was also studied.

METHODS AND MATERIALS: Some samples of granular formulations of Dursban® (an organophosphate larvicide) were prepared in the laboratory. Different sizes of various types of granules were impregnated with the toxicant using various solvents. For each sample, a 40-gram quantity of carrier was used. The toxicant solution was prepared as discussed elsewhere (Mulla and Axelrod 1960). Other formulations of Dursban and the formulations of parathion, Abate®, Geigy GS-13005 and General Chemicals GC-9160 were obtained from the manufacturers.

Tests were performed in the laboratory. Samples of 0.70 g. of 1 percent, 0.35 g. of 2 percent or 1.75 of 10 percent formulation were added to 3,500 ml of tap water in a gallon mayonnaise jar kept at a constant temperature of 82° F. Water pH ranged from 7.8 to 8.1 and the height of the water in the jar was 8.25 inches. Two jars were set for each of the 1 percent Dursban granules and a single jar for the rest of the formulations. The calculated amount of the material added to each jar would give a theoretical concentration of 2 ppm for 1 and 2 percent formulations and 50 ppm for the 10 percent formulation if all the toxicant were released in the water.

At different intervals after addition of granules, 2.5 to 5 ml of water was aspirated each from the top and an inch from the bottom of the jar. These samples were composited to yield a sample of 5 to 10 ml of treated water. One half ml aliquot of this sample was added to 100 ml of water in a 6-oz treated paper cup containing 25 4th-instar larvae of *Culex p. quinquefasciatus* Say. The cups were placed at a temperature of 78° F. and the mortality was recorded 24 hours after treatment. Average percent mortality from this bioassay was calculated. The amount of the toxicant corresponding to a certain level of mortality was determined by reading it off a dosage-mortality-line of the insecticide already established against the larvae of this species. The following equation was used to obtain the percent release of the toxicant at each interval from the amount of actual toxicant present in the water and the initial theoretical concentration of the insecticide added to the water assuming all of it were released into the water:

$$\% \text{ Release} = \frac{A}{B} \times 100$$

Where, A is ppm of toxicant found and B is ppm of toxicant required for 100% mortality.

Results and Discussion

The magnitude of release of Dursban formulated on various carriers is presented in Figure 1 (A, B) where acetone was used as a solvent for impregnating the granules. The information indicates that corn cob and the finer mesh (30/60) granules of California Absorbent and Frianite yield complete release within ten days after application. The coarser mesh granules of California Absorbent and Frianite granules yielded lower release of Dursban than the finer mesh granules of the same material. Perlite gave very little release during the test period.

Dursban release from Bentonite, Celite, Pyrex and Perlite granules was generally inadequate when acetone was employed as solvent for impregnation. An inverse relationship between release and the particle size is obvious from the data

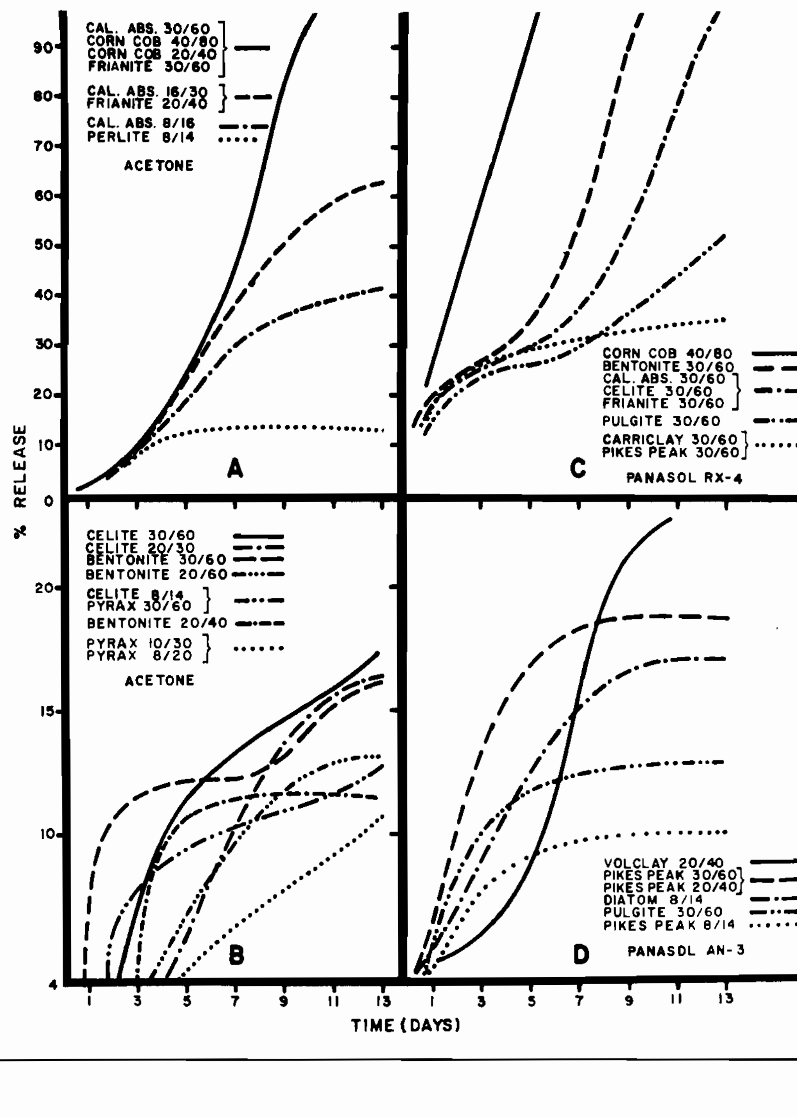

Figure 1. Release of Dursban (1%) into water from various carriers impregnated with various solvents.

in Figure 1A, B. This finding agrees with the results reported earlier where such a relationship between particle size of the carriers and extent of release of parathion was shown (Mulla and Axelrod 1962).

Bentonite and Celite, however, released Dursban effectively when Panasol RX-4 was used for impregnation (Fig. 1C). No marked difference was observed in the release of the toxicant impregnated with acetone or Panasol RX-4 onto the smaller mesh sizes of California Absorbent and Frianite granules (Fig. 1A,C). Several granules exhibited exceptionally poor release of the toxicant with Panasol AN-3 as the solvent (Fig. 1D). Results indicate that the solvent used in impregnating the granules influences the rate of release of the toxicant considerably. The influence of solvent on the release of insecticides from granular formulation has been discussed in other papers (Mulla and Axelrod 1960, Weidhaas 1957). Mulla and Axelrod (1960) reported that the rate and magnitude of release from some petroleum solvents is affected by the flash point, minimum and maximum boiling points, distillation range and evaporation rate of the solvents. They showed an inverse relationship between the rate and extent of release and some of the physical characteristics of the solvents. The extent of release in the present set of experiments agrees with that observed by Mulla and Axelrod (1960). Panasol AN-3, having a higher flash point, and high minimum and maximum boiling points, high distillation range and greater evaporation time (Mulla and Axelrod 1960) resulted in decreased release of the toxicant from the formulations.

Figure 2 shows the percent release of Dursban from several granular formulations supplied by the manufacturer (Dow Chemical Company, Midland, Michigan). Dicalite and two of the Vermiculite granules yielded good release within two weeks after application (Fig. 2A). When additives like 2% Nonylphenol and 4% castor oil were used, none of the formulations attained more than 29% release level (Figure 2B). Formation of plateau by the curves for most of the formulations indicates that the rate of release being very slow, may not attain an effective level for short term control. The addition of high boiling additives plays the same role as a high boiling solvent, depressing the extent of release.

Figure 3 shows the release of parathion, Abate, Geigy GS-13005, General Chemicals GC-9160 and Dursban from granular formulations supplied by the manufacturers. Formulations of parathion and Abate yielded almost 100% release within two days. The release of Geigy GS-13005 was found to be slightly less than the disappearance rate. A less effective larvicide, General Chemicals GC-9160 was released very slowly showing almost no effectiveness after 72 hours. This is primarily due to the high level of concentration at which this compound was added to the water. The rate of parathion release from granular formulations has been investigated in detail (Mulla and Axelrod 1960, 1962) and has been shown that the release of this toxicant is regulated by the type of carriers or solvents used for impregnating the granules. Release of Dursban was very slow and essentially the same as observed in Fig. 1A.

It is evident from the present study that Dursban and other toxicant granular formulations have a property of releasing the toxicant into water slowly and gradually. It is also evident that the rate of release of Dursban and other mosquito larvicides can be regulated by using different kinds of granular carriers, various mesh sizes of these and employing different types of solvents used in impregnating the granules. As a whole Dursban is released much slower

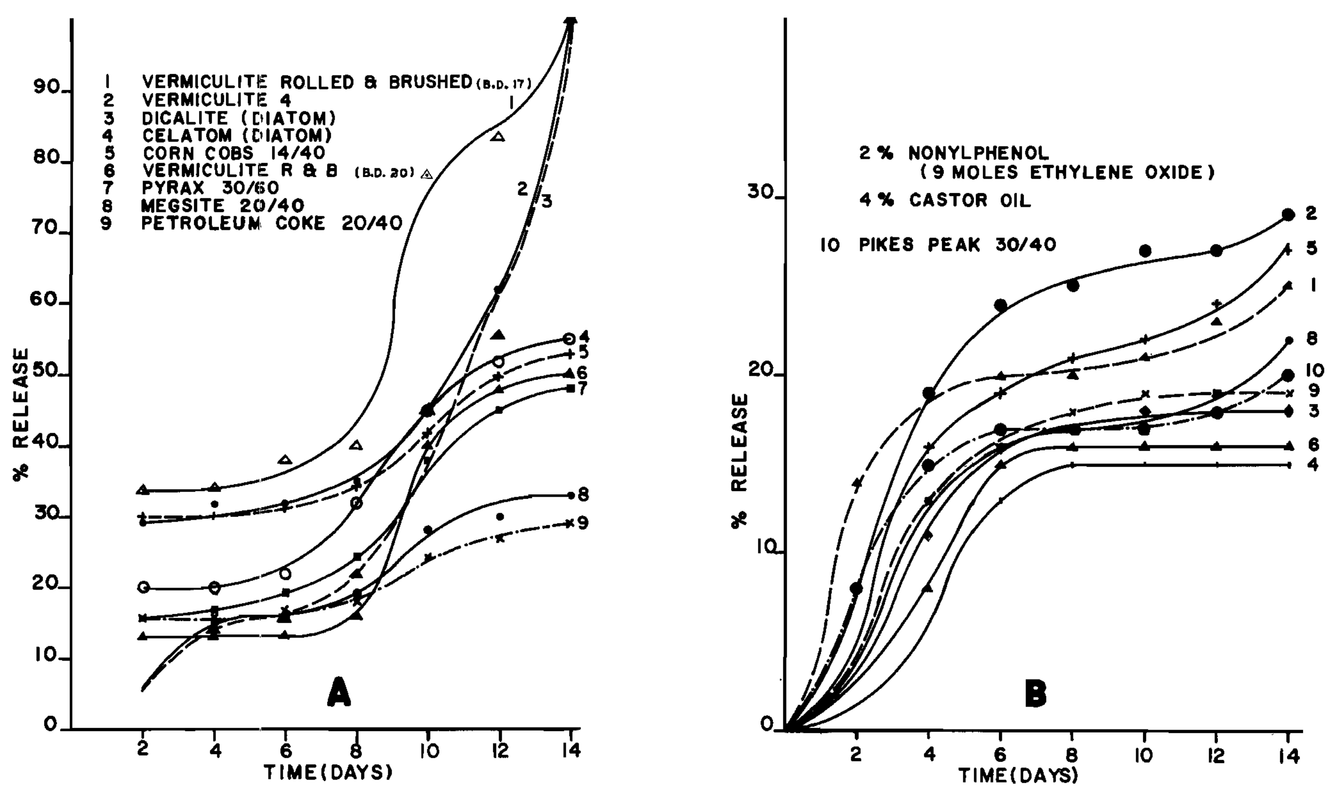

Figure 2. Release of Dursban (1%) into water from various granular carriers with and without additives.

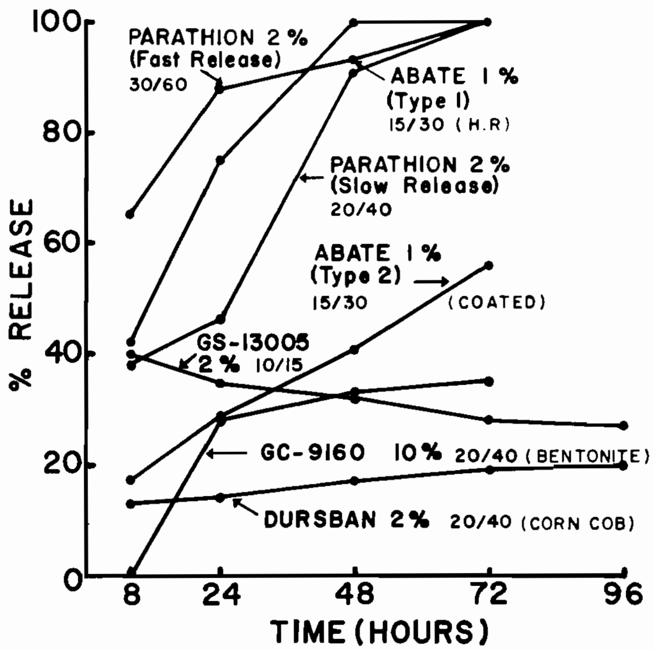

Figure 3. Release of various mosquito larvicides into water from various granular formulations.

than some of the other organophosphate mosquito larvicides. This feature of this compound can be utilized to a better advantage where long term larval control is desired.

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THE EFFECTS OF INSECTICIDE RESISTANCE ON KINGS MOSQUITO ABATEMENT DISTRICT

Richard F. Frolli

Kings Mosquito Abatement District, Hanford

The Kings Mosquito Abatement District has engaged insecticide resistance problems of one sort or another for many years. For this reason we felt a record of our experiences might be of value to other districts lacking the range and maturity for dealing with resistance problems. The record is submitted in the hope that the vantage point gained at Kings can be used to meet resistance problems elsewhere with calculated confidence. The point of view in this paper is confined to the impact of resistance upon man, materials and money during the past decade.

Resistance Versus Man

Fortunately, the Kings district has operators with a rare knack for discovering operational misses and subsequently, chemical failures in the making. This requires diligent post-treatment inspection of fields. It requires a lot of initiative and is a real challenge when the momentum of the season is rapid. Learning fruitful post-treatment inspection techniques cannot be left to chance. They are vital measures of a control program and must be taught and learned.

Continuous in-service training and field experience are essential elements for catching resistance in its infancy and staving off higher operational costs with understanding. Most operators have a hunger for knowledge, as they must deal with a vastly greater accumulation of scientific facts when recording operational misses. They refer to the species, the insecticide and the location with the utmost precision when resistance strikes.

They are able to analyze the control failures in light of pseudo-resistance conditions, such as, poor timing, penetration problems, physical barriers, etc. They must reject or confirm the causes for the operational misses in the quickest and cheapest manner. They will generally respray the field with the same chemical to do this.

Application failures are not uncommon in a large spray program yet they amount to less than 1% of the fields treated. Considering that between 100 to 140 sources are treated daily, failures are apt to occur. The unrelenting chemical pressure on the mosquito population undoubtedly hastens the resistance phenomena, adding chemical failures to the total operational failures.

We respond to the application and potential chemical failures by respraying the field with the same chemical. It is the simplest test for resistance that can be made. Failures of the chemical to perform a second time, perhaps a third, rules out pseudo-resistant phenomena. Subsequent successful treatment of the field with another chemical, confirms resistance to the first chemical. Frequently, laboratory analysis confirms the chemical resistance, but not always. Larval densities drop following application of a successful material and collection of sufficient numbers of larvae to lab test on successive irrigations is usually difficult.

Between the personnel dealing with applicational misses or chemical failures, there cannot be any psychological barriers which would inhibit passing of information. Communications must be near perfect to avoid confusion. Among those necessary to be informed are the foreman, the pilot, the girl posting records and ultimately the manager and the source reductionist. All district personnel eventually will have an interest in the reason for a requested respray.

The operator interprets field observations and abstracts facts to district personnel, and outside technical agents, as well as landowners. To be successful, the operator must have a sense of inquiry, for he collects larvae for laboratory analysis when he recognizes the opportunity. This is done in a random fashion depending upon larval densities. The densities are generally greatest just prior to the discovery of resistance; apparently, partial kills have gone unnoticed to this time. Clean larval collecting equipment is carried at all times to accomplish this task in the most efficient and subtle manner. Unnecessary worry to the landowner is avoided by limiting the number of entries upon his land. The toxicology has been performed by the California State Health Department. Attempts by the district to establish its own laboratory have been of little value and the funds are of better use elsewhere in the program. It goes without saying that the operators in a district experiencing resistance must be extremely capable, knowlegeable and on steady employment.

Resistance Versus Materials

When resistance is first engaged it generally occurs on a single field or ranch. It is a mere provocation and has only slight impact on the general control program. It's little more than a curiosity requiring special handling, i.e., a special plane load of a special material. Since the occurrence is generally toward the latter part of the season, the district has time during the winter to program materials which will meet anticipated problems if more toxic mosquitocides are available.

From the nature of organic evolution we know that chemical resistance is limited in its geographical distribution and spreads relatively slowly through the mosquito population. For m-parathion, EPN, and fenthion resistance, it required 4 or 5 seasons to spread a radius of 20 miles from its point of origin. It was possible, therefore, to retain m-parathion as an effective and inexpensive chemical in most areas during the immediate years following the discovery of resistance to it. This amounted to a considerable dollar savings each year.

Minor operational problems occur when employing two or three different chemicals during the daily operation, however. There are slight purchasing problems, slight dispatching problems, slight inventory problems, slight public relations problems and slight record keeping problems. The impact of resistance upon the general operation is not great, but it necessitates a little more effort throughout the line of operations. Newly-spawned resistance cases are occurring on three toxicological levels and keeping track of just which chemical works where and which doesn't requires a lot of mental bookkeeping.

Greater demand for a particular chemical invites competition in sales and this competition tends to lower the price of the product. Kings MAD, unfortunately, being one of the leaders in resistance, must pay a premium price for chemicals until other districts create a demand. The scarcity of new chemicals is also a problem. Purchasing new types of chemicals on three occasions inadvertently cornered all the special formulations in the western United States. To run out of a new material when it promised success was very disconcerting. On another occasion, a promising material proved to be ineffective on resistant populations and was a costly error.

Resistance Versus Money

There is no question that the impact of resistant mosquito populations is felt mostly in the area of fiscal budgeting. At this point in control programing, the problem transcends the prerogatives of management and proficiency of equipment to the realm of public financing and priorities. That is to say that the resistance problem becomes ultimately a problem to be reckoned by trustees, county supervisors, and the tax paying public. In a district which operates a large chemical control program, resistance cannot be shielded for long in professional jargon or academic secrecy, but becomes quickly measurable in hard public dollars.

The balancing of tax dollars and expenditures for prudent governmental services is celebrated annually with much public deliberation and some passion. A tax rate increase to balance increasing pesticide allocations brought on by resistant mosquito populations must be understood by the tax conscious public. Increased tax levying is inevitable, for the resistant mosquitoes are enjoying a higher standard of living. Pesticide costs may increase three-to four-fold, depending upon the sophistication of the chemical control program. Resistance is chronic; it persists, demanding ever-increasing amounts of funds annually. If the district tax rate doesn't reflect the accellerated expenditures realistically, a substantial deficit may occur or other basic district programs may suffer.

That is the case at Kings MAD. The district had maintained a maximum tax rate of $0.15 per $100 assessed valuation for nearly twenty years. To increase the rate beyond 15c requires the approval of the Board of Supervisors in two counties in which the district operates. This is a wise statute as it requires a review of justifications and tax money flow by unrelated boards. But it creates a psychological barrier. The District Board is reluctant to tax above a maximum 15c rate; this being only natural because the public hearings bring out not only the supporters of the program, but those with grievances as well. There is no need to invite trouble.

When resistance struck, the pesticide costs doubled from $25,000 in 1963 to $50,000 in 1967, cutting deep into the fiber of a tightly-knit budget. Prices of everything have seen an inflationary spiral, but when the per cent growth was more rapid than the general trend of other categories, it was difficult to absorb. At Kings the reserve accounts suffered first; when measures to hold the line on reserves were established, capital expenditures for equipment suffered. Salary and wage adjustments are continually lagging; increases are always uncertain and morle becomes low.

The tax rates have been increased at Kings at approximately 1c per year for the past 3 years. Increases connot continue indefinitely; we feel that there is a "maximum consensus" tax rate for mosquito control allowable by the community and it is approaching rapidly.

A tight budget has good effects, however. The district cannot overextend its original intended services to the public, that is, provide services that are unwarranted. All efforts by district personnel must be directly related to mosquito control. Other activities must wait.

Both the concept of chemical resistance and the intensity of mosquito infestations are well understood by people of the San Joaquin Valley. The benefits of modern control technology have been reaped, if only on a season to season basis. There is no tolerance for general relaxing of control efforts nor second thoughts to dilute the quality of the local program to maintenance of a mere buffering system. The public is desirous of "complete" control, but the effects probably contribute to the resistance phenomena.

THE EFFECTS OF INSECTICIDE RESISTANCE ON SUTTER-YUBA MOSQUITO ABATEMENT DISTRICT

Eugene E. Kauffman

Sutter-Yuba Mosquito Abatement District, Yuba City

The effect of insecticide resistance on our District has been displayed in three ways: (1) insecticides; (2) personnel; and (3) the public.

1. Insecticide changes have gone from ethyl parathion, which we started using about 1955, to an ethyl-methyl parathion combination. We were aided by Kenneth Gillies of Moyer Chemical Company in this change. When that failed we went to methyl parathion and finally to Baytex. We used the greatest amount of ethyl parathion, about 18,000 lbs., in 1961. In 1966, our last year of effective use, this had dropped to 4,400 lbs. Methyl parathion use increased: in 1965 it was 5,000 lbs, and in 1967 it was 9,600 lbs. Matching this slow increase was the fact that in 1965 we started to use fenthion, so we actually were using 3 chemicals at one time on the *Aedes* mosquitoes.

The mosquitoes have not yet shown any appreciable resistance to fenthion. The added cost has been from 11c to 12c per acre at .1 lb. per acre for ethyl and methyl to about .28c per acre for fenthion applied at .075 lb. per acre. In 1961 ethyl parathion cost the district $19,575. If in 1968 we use fenthion at .075 lb. on 105,000 acres, which we treated in 1967, the cost will be approximately $31,313. This is an increase of about $12,000 over this 7-year period, and it will be at least a $5,000 increase over 1967. This is quite a large jump, considering that it has not been budgeted, and we may try to use methyl parathion in places where we can get away with it. Our problems have been mainly with larvae. When a chemical failed on the larvae, we continued to use it on the adults. Eventually it would fail on the adults.

2. Personnel have not been discharged, as such, but our changes have been in attitude. Some temporary personnel who resisted change were not encouraged to return. Even though fenthion was less dangerous than parathion, the need for safety was reemphasized because laxity may have occurred and an accident ensued. Most of the handling was done by commercial air spray operators. We did not have much trouble with them, even though at times they used poor procedures. The need for new chemicals and under what conditions one chemical was preferred over another was explained to the personnel.

Most employees were not aware of the factors causing resistance, nor did they understand readily that resistance was not just a "yes" or "no" proposition. The thing that was hardest to explain was that the manager did not know all the factors either and had to seek a lot of advice. A considerable amount of time was spent in explaining all known factors that could result in a poor spraying job. Some of these were:

a. Wind. We tried to get all our work done in winds of less than 10-mile-per-hour.

b. Temperature. We preferred that all flying be done at a range not to exceed 90 to 95°F.

c. Flight height. Too low a flight resulted in narrow swaths, while too high a flight could result in a drift problem.

d. Complete field coverage. Gaps between swaths, and perhaps a complete failure to find a field, could result in poor control.

e. Pilot and aircraft variablities. These may cause difference in control.

f. Stage of the mosquito. Pupae are difficult or impossible to kill, and sometimes the 4th-instar larvae may also be uncontrollable at reasonable dosage levels.

g. Resistance of the species, and stage of the life cycle. Species differ in different fields, and sometimes in the same field. We had some fields in which we had *A. melanimon* in the early spring and fall, and in the middle of the year we had *A. nigromaculis*. If the personnel are not smart enough to know the difference between the species, they can get very excited over the populations. In our District one may be resistant while the other may not be. Resistance may be in the pupae and 4th-instar larvae but not in the younger larvae or adults.

h. Geographic location. Some areas have features which affect the analysis of a job. For example, some fields north of the Sutter Buttes area discharge their adults very quickly, in less than 24 hours after they hatch. If our operator is slow in returning to the field, the mosquitoes may have left and he may assume there had been a good control job, or that none was needed. Neighbors, however, might receive the full effect of the migrating adults.

3. The public. The public has to be aware of the changes that are going on. Two techniques have been used—news releases and personal contacts. News releases were the District's monthly newsletter, followed up for several months if additional information became available or necessary.

Visits have been made to cooperating farmers close to problem areas. Whenever the office received a telephone call and the situation was opportune, the program was explained and at times followed by a visit to the individual. Explanations in the newsletter were not as lengthy or detailed as those given by phone and in personal discussion. The more lengthy discussions were often along lines similar to those with our employees. Because of continuing changes in the status of our resistance problem, our program of educating the public and our employees is continuous. The public who will take the time to call, and who will allow you to come out and explain the program to them, usually turn out to be the best educators you have. I feel it is much more effective in our area than group meetings. These people may become better educators than you yourself, because they normally will be talking to people of their own class.

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

PANEL:

FLIT® MOSQUITO LARVICIDAL OIL (MLO)

W. Donald Murray, *Moderator*

FIELD EXPERIENCE WITH LARVICIDE OILS AND FLIT (MLO) BY THE SOUTHEAST MOSQUITO ABATEMENT DISTRICT

Gardner C. McFarland

Southeast Mosquito Abatement District, South Gate

The Southeast Mosquito Abatement District has been using larvicide oils since the start of the District in 1952. Several larvicide oils have been satisfactory and include Phillips Petroleum Company Annalos 11 and Atlantic-Richfield Company Larvicide A. Other larvicide oils have been used with erratic results. Erratic results have been due to lack of uniformity from one lot to the next. In addition, nonsuitability has occurred due to noxious odors and poor to extremely poor spreadability.

Specifications used for a suitable larvicide oil and made a part of bid invitations include:

1. Aromatics, Kattwinkel

Gravity, °API	approximately 50%
Viscosity at 100°F	23-33
Flash PM, °F	35-40
Distillation, °F	130°F or Higher
10%	430°-480°F
50%	508°-550°F
90%	630° or Higher
Odor	Nonoffensive

2. A one (1) gallon sample for testing by the District shall be provided by the successful bidder.
3. All shipments must meet the specifications and be equivalent to the sample originally tested and approved. Any change in the material (such as raw material source, method of manufacture, or plant of manufacture) requires notification, resubmitting sample and approval by the District. All shipments must be covered by the supplier's affidavit, certifying that the material meets specifications. Shipments not meeting specifications will be returned at supplier's expense.

Adequate larvicide oils are good larvicides and pupicides and are used at rates of 5, 10, or 15 gallons per acre depending on the characteristics of the mosquito breeding sources. Disadvantages of these larvicide oils include phyto-toxicity, burn hazards to skin, odors, short residual, and stain problems.

Recently the District has been conducting field trials with the new larvicide oil, Flit (MLO), which is supplied by the Humble Oil Company. Preliminary results show considerable promise for this material as both a larvicide and pupicide. Application rates of 5 to 6 gallons per acre have given 100% kill of both larvae and pupae. Rates of 1.5 to 2 gallons per acre have shown some survival of 2nd, 3rd, and 4th instar larvae. This may be due to application methods or perhaps wind conditions on relatively open water.

Control of larvae and pupae in poorly maintained swimming pools has been uniformly successful with the use of Flit. The material is applied by means of a Shure Shot pressurized quart container with an 8001 nozzle. Approximately one pint of material is uniformly spread over the swimming pool surface which gives a rate of approximately 10 gallons per acre. Water troughs for livestock can also be treated at this rate without danger to livestock. Trials for control of mosquito breeding in residential gutters are in progress and will be reported on at a later date.

Advantages of Flit (MLO) include, nonphyto-toxicity in dosages used, noncorrosiveness to skin, safety to vertebrates and nonvertebrates, slight odor and light to no stain problem. Possible disadvantages include reported noncompatibility with emulsion residues in spray tanks and cost in drum lots.

In our opinion, Flit (MLO) is another material in the mosquito control insecticide arsenal that shows great promise.

FIELD TESTS OF FLIT® M.L.O. ON LARVAE OF THE PASTURE MOSQUITO *AEDES NIGROMACULIS*

P. A. Gillies and D. J. Womeldorf

California State Department of Public Health
Bureau of Vector Control

ABSTRACT

In August 1967, Flit® Mosquito Larvicidal Oil was applied to three pastures in the Delta, Kings, and Tulare Mosquito Abatement Districts. The tests were conducted as a preliminary attempt to establish an effective application rate for control of OP-resistant *Aedes nigromaculis* larvae in California.

The material was applied both by hand-can and by aircraft. Hand applications were made at two, four and six gallons per acre. Aircraft application was at one-half, one and three gallons per acre. Post-treatment larval counts were made at twenty four hours.

The lowest rates giving acceptable control when applied by hand and by aircraft were two and three gallons, respectively.

FIELD TEST OF FLIT® ON ORGANOPHOSPHORUS-RESISTANT *AEDES NIGROMACULIS* IN THE DELTA MOSQUITO ABATEMENT DISTRICT

W. Donald Murray

Delta Mosquito Abatement District

The Delta Mosquito Abatement District ran one test on Flit® covering a sizeable field of 34 acres. This field was about 1 mile northwest of Goshen, in the heart of the area where *Aedes nigromaculis* has become resistant to all available chlorinated hydrocarbon and organophosphorus insecticides. Larvae were in the first through fourth stages, with a density of 0 to 20 per dip.

Sept. 29, 1967, 10:15 a.m.—air sprayed with Flit at 2 gallons per acre.

Sept. 29, 1967, 11:30 a.m.—0 to 10% kill of 3rd & 4th stage larvae.

0 to 30% agitation of pupae.

0% effect on old adults already present

1:00 p.m.—0 to 30% kill of 3rd and 4th stage larvae

40 to 60% agitation of pupae

questionable effect on old adults

2:00 p.m.—no significant change

3:30 p.m.—adults starting to emerge from pupae, thus the oil did not prevent the pupae from maturing to adults.

Sept. 30, 1967, 9:00 a.m.—all larvae dead. Some pupae still alive. Newly emerged adults in grass, in concentrations approximately equivalent to 25 per leg. Older, biting adults still active.

Observations and analysis:

1. There was no harm whatsoever to vegetation.
2. There was unquestionably good kill of larvae. The most efficient rate, and the interpretation of certain inconsistencies, need further study.
3. Two gallons per acre was the lowest rate that produced effective kill. Better application procedures may enable this rate to be reduced.
4. Using the airplane equipment set up for delivery of 1 gallon of water mix per acre, the Flit was atomized too much, resulting in the material floating in the air and coating the plane, especially the windshield, on subsequent passes. Adjustments of nozzles and pressure may solve this problem.
5. Kill of pupae and adults was not apparent in this test. Further studies are needed.
6. Cost. At present it is estimated to be about double that of Baytex at .1 lb. per acre. Better techniques of application may improve this appreciably.

FACTORS TO CONSIDER IN FIELD EVALUATIONS OF FLIT® MLO, A NEW CONTROL MEASURE FOR RESISTANT STRAINS

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ABSTRACT

Recent laboratory and field findings with FLIT® MLO® at rates as low as one gallon per acre have pointed out the importance of the following factors in field evaluations: (1) Life history stage, (2) species, (3) length of time after application before measuring performance, and (4) effects on adults. Consideration of these factors will allow the maximum control with a minimum amount of material.

Specifically, one should evaluate performance of FLIT MLO at no less than 24 hours after treatment. Further, it appears desirable to observe effects for up to 72 hours after treatment in order to measure the maximum benefits accrued. Also, measurements of the production of living adults are highly desirable in view of the "spectrum of activity" of FLIT MLO against a mosquito population. This material has a detrimental effect upon the eggs, all four larval instars, and the pupae, as well as some rather interesting benefits against adults.

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This index has been compiled as a supplement to the one developed by John R. Walker and printed in the Proceedings and Papers of the Twenty-Fifth Annual Conference of the California Mosquito Control Association, 1957. Mr. Walker concerned himself with the first twenty-four volumes of the Proceedings. This index extends that effort to include the next ten years (up to and including Volume 34, 1966).

Since the primary purpose of this work is to aid persons in finding technical information presented at the Conferences, much material, such as business meetings, committee reports and welcoming addresses, has been omitted. In addition, since there has been a wide variety of ways in which panel presentations have been made, a slight liberty has been taken with the wording of a few titles to help readers make a more precise association between the titles and the subjects under discussion.

Complete sets of Proceeding are to be found in the libraries of the following agencies:

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