PROCEEDINGS AND PAPERS

of the

Forty-sixth Annual Conference of the

California Mosquito and Vector Control Association, Inc.

January 29 - February 1, 1978

held at the

AHWAHNEE HOTEL
YOSEMITE, CALIFORNIA

Editor - C. Donald Grant
Co-Editor - Robert K. Washino
Co-Editor - Don J. Womeldorf

Business Office
CALIFORNIA MOSQUITO and VECTOR CONTROL ASSOCIATION, INC.
1737 West Houston Avenue
Visalia, California 93277

Published - July 25, 1978

CMVCA PRESS - Visalia, California 93277

1978 OFFICERS AND DIRECTORS OF THE CALIFORNIA MOSQUITO and VECTOR CONTROL ASSOCIATION, INC.

PRESIDENT . . . . Calvin J. Rogers
PRESIDENT ELECT . . . . Gilbert L. Challet
VICE PRESIDENT . . . . Eugene E. Kauffman
PAST PRESIDENT . . . . Douglas C. White

REGIONAL REPRESENTATIVES

COASTAL . . . . Bradley B. Anderson
SACRAMENTO VALLEY . . . . . . Peter B. Ghormley
N. SAN JOAQUIN VALLEY . . . . Jack V. Fiori
S. SAN JOAQUIN VALLEY . . . . David E. Reed
S. CALIFORNIA . . . . L. Lino Luna

TRUSTEE CORPORATE BOARD

CHAIRMAN . . J. Don Layson (N. San Joaquin Valley)
VICE CHAIRMAN Robert H. Brown (S. San Joaquin Valley)
PAST CHAIRMAN . . . . . W. Leo West (S. California)
COASTAL . . . . Eugene Sussli
SACRAMENTO VALLEY . . . . . . J. Don Womeldorf
N. SAN JOAQUIN VALLEY . . . . . . L. F. Christesen
S. SAN JOAQUIN VALLEY . . . . Frank Noli
S. CALIFORNIA . . . . John L. Smith

1978 CORPORATE MEMBERS OF THE CALIFORNIA MOSQUITO and VECTOR CONTROL ASSOCIATION, INC.

Alameda County MAD
Antelope Valley MAD
Burney Basin MAD
Butte County MAD
Carpinteria/Goleta Valley MAD
Coachella Valley MAD
Coalinga-Huron MAD
Colusa MAD
Compton Creek MAD
Consolidated MAD
Contra Costa MAD
Corning MAD
Delano MAD
Delta VCD
Diablo Valley MAD
Durham MAD
East Side MAD
El Dorado County Service Area III
Fresno MAD
Fresno Westside MAD
Glenn County MAD
Kern MAD
Kings MAD
Lake County MAD
Los Angeles County West MAD
Madera County MAD
Marin/Sonoma County MAD
Merced County MAD
Moorpark MAD
Napa County MAD
Northern Salinas Valley MAD
Northern San Joaquin County MAD
Northwest MAD
Orange County VCD
Sacramento County - Yolo County MAD
San Joaquin MAD
San Mateo County MAD
Santa Clara County Health Department
Shasta MAD
Solano County MAD
Southeast MAD
Sutter-Yuba MAD
Tulare MAD
Turlock MAD
Westside MAD

1978 SUSTAINING MEMBERS
CALIFORNIA MOSQUITO and VECTOR CONTROL ASSOCIATION, INC.

BIO QUIP PRODUCTS . . . . Richard P. Fall, General Manager
Post Office Box 61
Santa Monica, California 90406
Phone - 213/322-6636

CHEMAGRO AGRICULTURAL DIVISION . . . . Clay H. Hill, Regional Sales Manager
1900 North Gateway Boulevard
Fresno, California 93727
Phone - 415/944-2014

DOW CHEMICAL U.S.A. . . . . Harold W. Lembright, Ph.D.
Drawer H
Walnut Creek, California 94596
Phone - 415/944-2014

FENNIMORE CHEMICALS/MICRO-GEN . . . . H. B. Munns, President
Post Office Box 1116
Glendora, California 91740
Phone - 213/334-0116

H. D. HUDSON MANUFACTURING CO . . . . S. (Sid) L. Newell, Sales Representative
17514 Vacas Circle
Fountain Valley, California 92708
Phone - 714/962-9623

JACKSON & ASSOCIATES INSURANCE AGENCY . . . .
1348 Drpaer Street
Kingsburg, California 93631
Phone - 209/897-5831

L & J PRODUCTS COMPANY . . . . Joseph F. O'Brien
3529 Touriga Drive
Pleasanton, California 94566
Phone - 415/846-4043

MOYER CHEMICAL COMPANY . . . . Kenneth D. Gillies, Vice President
Post Office Box 945
San Jose, California 94108
Phone - 408/297-8088

OCCIDENTAL CHEMICAL COMPANY . . . . Roger Williams
Post Office Box 198
Lathrop, California 95330
Phone - 209/521-5149

SEQUOIA FISHERIES . . . . Steve Sanchez, Fisheries Biologist
10513 Road 236 - Post Office Box 928
Terra Bella, California 93270
Phone - 209/535-4764

TARGET CHEMICAL COMPANY . . . . Lon Records
17710 Studebaker Road
Cerritos, California 90701
Phone - 213/865-9541

THOMPSON-HAYWARD CHEMICAL COMPANY . . . . Hollis Campbell, Sales Dept.
James Wilkerson, R & D - Visalia
Post Office Box 7797
Fresno, California 93727
Phone - 109/251-7144

WILBUR-ELLIS COMPANY . . . . Darol Lloyd, Manager, Pesticides
Post Office Box 1286
Fresno, California 93715
Phone - 209/442-1220

WITCO CHEMICAL CORPORATION . . . . Carter Knowles, Product Manager
Golden Bear Division
Post Office Box 378
Oildale, California 93302
Phone - 805/399-9501

ZOECON CORPORATION . . . . Robert E. Lucas, Sales Manager
975 California Street
Palo Alto, California 94304
Phone - 415/855-6325

TABLE OF CONTENTS

CHEMICAL CONTROL

PUBLICATION POLICIES AND INFORMATION FOR CONTRIBUTORS

"THE PROCEEDINGS" is the Proceedings and Papers of the California Mosquito and Vector Control Association, Inc. One volume is published each year. Intended coverage by content includes papers and presentations of the Association's Annual Conference, contributions and meritorious reports submitted for the conference year, and a synopsis of actions and achievements by the Association at large during the preceding year.

CONTRIBUTIONS: Articles are original contributions in the field of mosquito and related vector control providing information and benefit to the diverse interests in technical development, operations and programs, and management documentation. Papers on controversial points of view are accepted only as constructive expositions and are otherwise generally dissuaded, as is the case with an excessive number of papers on one subject or by one author where imbalance might ensue. Although preference is given to papers of the conference program, acceptability for publication rests on merit determined on review by the editors and the Publications Committee.

MANUSCRIPTS: The diversity of interests and fields of endeavor represented by contributors and readership of the Proceedings precludes strict conformance as to style. Authors should refer to recent issues of Mosquito News for general guidance. Authors of technical papers should follow the basic recommendations as presented in the Council of Biology Editors Style Manual. Authors should submit an original on white bond paper, with one additional copy. All parts of manuscripts (text, tables, references and legends) must be typed, double-spaced with ample margins. Avoid footnotes in text. Author should indicate with pencil, in the margins, the approximate positions desired for illustrations and tables.

The complete scientific name of an organism must be given the first time it is used. Terms commonly abbreviated in specific fields should be given in full the first time used, followed with the abbreviation. The abbreviation alone is acceptable in further usage in the paper. Common latin abbreviations (et al., e.g., i.e., etc.) are not italicized. Use of the metric system is encouraged. The bi-letter system of generic abbreviations is used for Culicidae.

All manuscripts will be edited to improve communications, if needed. Editors are biased against verbosity or needless complexity or jargon. Grammar will be corrected if necessary. Articles needing extensive editing or not conforming to style and instructions will be returned to the author for correction.

Manuscripts should be submitted to the editor within 45 days after the Annual Conference to ensure publication. Mail all material to the CMVCA PRESS, 1737 West Houston Avenue, Visalia, California 93277.

ABSTRACTS: Only technical papers need be accompanied by an abstract, which should not exceed 3% of the length of the article. When an abstract is submitted for publication in lieu of a paper, the abstract length may be extended. If possible, the journal where the paper is to be published in full should be stated.

TABLES: Tables are typed on separate sheets placed in correct sequence in the text and should be limited to those strictly necessary. Tables made up by the author in the form of line drawings for photocopy are acceptable. Graphs and line drawings should be prepared with regard to the ultimate printed size of one column (3¼") or page width of 7 inches, as applies to columns of table data.

Submitted figures as maps and charts should not exceed 8½ X 11" (22 X 28 cm), with labels and line weight adapted to the published size. Total page space for tables and figures must necessarily be limited by the editors.

ILLUSTRATIONS: Illustrative material must be mailed flat. A copy for use of reviewers is desirable. Figures should be numbered consecutively. Illustrations prepared for printing as line drawings are preferred but those requiring half tones are acceptable. Titles, legends or other headings should be grouped according to the arrangement of the figures and are typed double-spaced, on a separate sheet at the end of the paper. As with tables, the illustrations should be planned to fit reasonably the width of one column (3¼") or one page (7"). Figure numbers, as well as author's name and paper title should be written in blue pencil on the back of each illustration.

PROOF AND REPRINTS: Authors will receive page proof, as well as an order blank for reprints with a schedule of charges. Authors should not make major revisions of their work at this stage. Proofs with corrections, if any, should be returned within 10 days to the printer (CMVCA PRESS, 1737 West Houston Avenue, Visalia, California 93277).

California Mosquito and Vector Control Association, Inc.

Volume 46 January 29 – February 1, 1978

THE STATE OF CALIFORNIA VECTOR AND WASTE MANAGEMENT PROGRAM -- AN OVERVIEW

Richard F. Peters

California Department of Health, Vector & Waste Management Section

714 "P" Street, Sacramento, CA 95814

INTRODUCTION.–Some 38 years ago, preceded by my emergence from the University of California and two years of local environmental health experience, I was appointed Mosquito Control Officer of the California Department of Public Health and assigned the entire State of California as my territory. The California Mosquito Control Association was then a decade old and utterly dependent for technical guidance upon its founders: William B. Herms and Harold F. Gray.

At that time, California had a total population of about seven million (less than one third of the present) and Southern California was then a pleasant place to visit or even live. About two dozen local mosquito control agencies were in existence. Collectively they covered only several thousand square miles and few had budgets in five figures. Harold Gray was the only college trained local administrator in the entire state. Records were slim or lacking. As an example the Delta Vector Control District, which today prides itself as a model of documentation, then used one orange crate for its complete office records!

Local control technology then was performed by the numbers: 1. the hand shovel; 2. diesel oil; and 3. *Gambusia affinis.* Yes, to those who think that the use of mosquito fish is a relatively recent technique, I well remember Harold Lilley, Superintendent of the then 14 square mile Merced MAD, back in 1940 distributing *Gambusia* by dipper from a ten gallon milk can into irrigated pasture potholes many miles outside his district. Ham Emerick of the Napa County MAD also used many *Gambusia* and even had a strain adapted to sewage ponds.

I'll never forget my first trip up the Sacramento Valley meeting Mack Holloway, then a Trustee and Ivan Mattoon, then Superintendent, now a Trustee, of the Los Molinos MAD. Mr. Holloway, mindful of the state financial assistance provided in the S.E.R.A. program during the early 1930 depression years, instructed Mr. Mattoon (to my considerable embarrassment): "Whatever this state man asks you to do, you do it - - if he asks you to stand on your head, you stand on your head!" Money has a unique way of making even a state man important.

Many changes have occurred in the past forty years. California today, in the event it were separated from the nation, has been said to possess the resources and economic wherewithall sufficient to become the sixth most capable nation in the world. Certainly, its ranking in vector problems and control program needs would be likewise close to the top. Our topography, climate, and population pattern, and our agricultural, industrial, conservational and recreational characteristics combine to present a promising long range employment prospect to the vector control worker. Outdoor living and suburban sprawl have brought the public into increasingly closer contact with a wide assortment of vectors. Approximately one thousand different species of invertebrate and vertebrate animals have been documented by the Vector and Waste Management Section to cause the public some form of discomfort or other concern. Around fifty different pathogens are acknowledged to be potentially transmissible to man by vectors in California.

The California Department of Health, as part of its overall responsibilities, is charged under the Health and Safety Code: with determining the causes of communicable disease in man and domestic animals occurring or likely to occur in the state; with enjoining and abating nuisances dangerous to health; with advising all local health authorities (on matters of health) and in the event the public health is menaced (by local negligence), to control and regulate local action; with conducting special investigations of the sources of morbidity and mortality and the effects of localities, employments, conditions and circumstances on the public health; with making studies and demonstrations needed to determine the areas of the state which have a high occurrence of mosquito borne disease; and with entering into cooperative agreements with local vector control agencies to accomplish mutually desirable objectives.

The Vector and Waste Management Section has a long history of emphasizing state-local program complementation as its basic policy. Certainly the state has no proper role in conducting routine vector control operations. Accordingly, our functions are largely qualitative, involving technical and administrative services which seek to enhance local vector control programs. Thus, surveys, surveillance, investigations, demonstrations, training, consultation, evaluation and emergency actions are our principal functions. We are part of a broad environmental health program which recognizes a close interface between health, safety, environmental protection, consumer protection, housing, agriculture, recreation and conservation and the assortment of federal, state and local agencies and private interests which interrelate, each seeking to serve its major objective.

We are dedicated to the belief that all of these interests have their respective places, but in the event any of these related programs creates vector problems which threaten the health and well-being of the public, then we contend that our state-local program needs must have top priority. Recent federal and state legislation and regulations in the environmental protection and resource arena, spurred by pseudo-environmentalists, have created conditions which require us to arch our collective backs in safeguarding our interests and capabilities within the state-local vector control program.

Some of this audience appear to have the impression that the Vector and Waste Management Section is largely, if not entirely, linked to the local agencies comprising the California Mosquito and Vector Control Association. To be sure, a substantial part of our program has such a warm and pleasant relationship.

During the past two years, however, because of the widespread manifestation of plague in the wild rodents of our mountain recreation areas, our ability to devote the desired amount of time to mosquito and other aquatic insect activities has been severely restricted. In other years, waste management, featuring domestic rats and flies, has required inordinate program effort. Urgent shorter term demands are periodically placed upon us to deal with a variety of vectors, including wasps, biting gnats, spiders, scorpions, rattlesnakes, skunks and even imaginary insect infestations of the body (referred to as delusory parasitosis).

Recognition must now be made of the significant role of our Vector Control Advisory Committee, which has provided broad technical assistance to the Section since it began in 1947. Dr. William C. Reeves remains as a charter member of this Committee, whose help over the years has been invaluable.

The balance of this presentation will feature our key Section staff furnishing an overview of the main segments of our program. As a result of their collective presentation, the field of vector control will largely come into view.

MOSQUITO AND MOSQUITO-BORNE DISEASE SUPPRESSION

Don J. Womeldorf

California Department of Health, Vector & Waste Management Section
714 "P" Street, Sacramento, CA 95814

The relationship of the California Department of Health with local governmental entities engaged in mosquito control is one of long standing. Beginning in 1933, the Bureau of Sanitary Engineering provided a staff member to serve the California Mosquito Control Association as its Secretary-Treasurer and to perform consultation as required to the mosquito abatement districts statewide.

In 1946 a Mosquito Control Section was created in response to a legislative charge assigning the Department "to determine the mosquito-borne disease hazard in California" and to administer a nearly matching state subvention to local mosquito control agencies.

Then, in 1947, the Mosquito Control Section and the Bureau of Sanitary Inspection (engaged largely in plague surveillance and suppression) were combined into the Bureau of Vector Control. It has since undergone some name changes, currently being called the Vector and Waste Management Section.

Administration of the $400,000 subvention fund provided by the legislature gave impetus to formation of mosquito control agencies in order to forestall epidemics of diseases brought into California by returning WWII veterans. One of the earliest jobs of the old BVC was to assist in formation of mosquito abatement districts, a job done to a large extent by Richard F. Peters. The standards and recommendations promulgated in 1948 did much to assure that local programs achieved the high levels of technical and administrative proficiency which exist today. The Section still provides assistance in establishing or enlarging a local mosquito control agency, the first step in meeting the public health needs of the population of a mosquito-infested area.

At the same time as the Legislature provided subvention funds, it charged the Department with surveillance of mosquito-borne diseases including malaria and encephalitis. The virtual disappearance of malaria as a locally transmitted disease allowed the efforts of the Section to be largely concentrated upon encephalitis surveillance. With support of the Department's Biomedical Laboratories, in coordination with research projects of the University of California, and with the aid of local agencies, the Section monitors the prevalence of virus in adult mosquitoes. An annual summary of the results of surveillance is usually included in the Proceedings of the California Mosquito and Vector Control Association. A second major encephalitis-related activity is compilation and distribution of the results of light trapping done by local agencies and reported weekly to the Section.

Rarely, as happened most recently in 1969, the Section is involved in direct control operations under emergency conditions. These actions are conducted in the parts of the state without local agency capability.

Most of the Section's activities in mosquito control are in direct support of local agency programs. Eight field offices deploy biologists and engineers throughout the state. They are backed by several staff specialists. Major support activities include:

- Technical assistance. The CMVCA was active several years ago in obtaining additional biologists, and in adding registered engineers, to the technical assistance capability of the Section. The field offices, with staff backup, can provide aid in solving problems related to all control technologies. As a result of ongoing contact with University of California and other researchers, the Section performs a quasi-extension role. Another important function is picking up ideas developed by the innovative ingenuity present in every local program, and aiding in adjusting these ideas to fit needs of other agencies. California Vector Views, a monthly publication of the Section, provides a means of disseminating technical information.
- Program review. At the request of a Board of Trustees, the Section provides in-depth administrative, technical and operational program reviews.
- Technical development. A technical development facility in Fresno complements research performed by the University of California and others in implementing new technologies into local control programs.
- Identification services. Although most local programs employ qualified entomologists, some mosquito specimens may be unfamiliar or especially difficult to identify. The Section maintains a medical entomology laboratory in Berkeley staffed with internationally recognized specialists in taxonomy of mosquitoes and other medically important arthropods.
- Training and certification. At the request of the CMVCA some years ago, the Section initiated a program designed to ascertain that technicians employed by local mosquito control agencies have been trained and are certified to be competent. During development of the program, federal certification requirements were imposed by the U. S. Environmental Protection Agency. California's program of training and certifying vector control technicians fully meets the federal standards.
- Insecticide resistance surveillance. For a decade and a half, the Section has maintained a formalized program to monitor susceptibility and developing resistance in all major mosquito species. Staff specialists operate from laboratories in Sacramento and Fresno, and coordinate the work of local agency entomologists.
- Oversight on pesticide use. Through the vehicle of a cooperative agreement, local agencies may align themselves with the Department of Health in the use of pesticides to protect the public health. The California Department of Food and Agriculture, which regulates pesticides through county agricultural commissioners, allows signatory agencies exemptions from regulations which would otherwise hamper local agency operations.
- Environmental actions. Planning documents, such as environmental impact reports, are reviewed by Section registered engineers to ascertain that mosquito problems will not be created by a new project. Oppositely, an exemption is currently being negotiated which would preclude local agencies from having to prepare environmental impact reports for their control programs. Finally, the Section acts as lead agency for general permits, issued by governmental regulators such as the U.S. Army Corps of Engineers, which

allow mosquito source reduction projects to be conducted with minimal paperwork.

The Section has enjoyed a long history of close cooperation not only with the CMVCA but with other associations which promote public health, such as the California Conference of Local Health Officers, the California Conference of Directors of Environmental Health, and others. The Section participates in conferences, symposia, and seminars; additionally, staff members serve as technical consultants to committees, and provide editorial and other support to publications.

PLAGUE SURVEILLANCE AND SUPPRESSION IN CALIFORNIA

Bernard C. Nelson

California Department of Health, Vector & Waste Management Section

2151 Berkeley Way, Berkeley, CA 94704

ABSTRACT

From 1975 through 1977 California experienced the most widespread evidence of plague (caused by *Yersinia pestis*) in wild rodents since the extensive epizootics of the 1930's and early 1940's. Laboratory confirmed evidence of plague was found in 30 of California's 58 counties, including for the first time Butte, Calaveras, and Humboldt counties. The presence of plague in sylvatic species from Humboldt County represents the first such evidence from north coastal California, a region heretofore thought to be plague free. Plague was confirmed from the following major recreational areas in both 1976 and 1977: Lassen Volcanic, Sequoia, and Yosemite national parks; Lava Beds National Monument; the greater Lake Tahoe Basin; the Mammoth Lakes Area of Mono County; the Lake Almanor and Plumas-Eureka State Park areas of Plumas County; and the San Bernardino Mountains. Six confirmed human cases with four fatalities occurred during this period (one in 1975 in Ventura County, two in 1976 from Kern and Plumas Counties, and three in 1977 from Kern, probably Monterey, and either Placer or Sierra Counties). Three cases were acquired during recreational activities; two were acquired about the home environment, with the site and source of the fatal case presumably acquired in Monterey County remaining unknown.

The plague program of the California Department of Health, in which the Vector and Waste Management Section (VWMS) is the field unit, consists of preventing human cases through education, epidemiological and epizootiological surveillance, and vector suppression. Plague is a disease of rodents, and occasionally rabbits, transmitted primarily by their fleas. Effort is directed towards keeping people out of the chain of infection by advising them how they can minimize contact with potentially infective rodents and their fleas. Information is disseminated through lectures, interviews, individual contacts either face-to-face or over the telephone, publications, press releases to the news media, brochures, pamphlets, and posters. Surveillance is undertaken by VWMS staff to determine current areas of enzootic and epizootic plague activity. Positive evidence leads first to a more intensified warning system. If the site is judged to have a high risk of exposure to people, the area is quarantined and suppressive measures are initiated by controlling fleas with insecticides.

The VWMS has the responsibility for supervising control operations against plague-infected fleas. Control measures are carried out by selectively dispensing an effective insecticide dust with hand dusters into rodent burrows, dens, and nests. Insecticide-bait stations, where rodents self-applicate themselves with insecticide, are used in some situations. Pretreatment and posttreatment flea indices are required to determine effectiveness of control.

The VWMS has the sole responsibility for plague surveillance in California. Also, when human cases do occur, the VWMS staff undertakes immediate epizootiological investigations. Surveillance consists of three primary areas of activity. First, an intelligence network is developed and maintained by recruiting persons (e.g., park rangers) engaged in out-of-doors activities throughout the State to report to us any significant abnormalities in animal health, behavior, or numbers. These trained observers may collect and hold (under refrigeration) suspected sick or dead rodents for subsequent laboratory testing. Second, a carnivore serology program has been implemented by the VWMS in coordination with the Plague Branch, USPHS Center for Disease Control, assisted by county and federal trappers. The carnivores that are most apt to ingest plague-infected rodents and rabbits are moderately, or in some cases highly, resistant to the plague organism. Through this avenue of exposure, antibodies are produced, following perhaps benign infections, that can be detected by serological methods. By sampling carnivores in winter and spring a sensitive and early indication of plague activity in a given area is available. Third, staff of the VWMS routinely conduct surveys of areas that have had a history of plague or have come to our attention through the intelligence network or the carnivore serology investigations. Evidence of plague activity can be obtained through visual assessment of rodent populations, followed by trapping rodents and testing of their sera and fleas. The performance of surveillance is time-consuming and demands continuity to ascertain the status of plague in any given area. This requires a highly competent staff well trained in the ethology, ecology, and taxonomy of rodents and their fleas. Because plague is a dynamic disease ecologically, the methods of surveillance must keep abreast with the changes in rodent and flea populations brought about by the selective forces of the disease agent, other natural phenomena, and the activities of man.

A REVIEW OF THE DOMESTIC RAT PROBLEM IN CALIFORNIA

Earl W. Mortenson

California Department of Health, Vector and Waste Management Section
2151 Berkeley Way, Berkeley, CA 94704

ABSTRACT

The Norway rat, *Rattus norvegicus*, and the roof rat, *Rattus rattus*, are the two major domestic rats of public health concern in California. The close association of people living in residential areas which also support high populations of domestic rodents poses a significant health threat from food contamination, disease transmission, and rat bite injuries.

The Norway rat is found primarily in the older central city areas, along waterfront locations, and in rice field habitats in the Sacramento Valley. The roof rat is distributed in surburban areas in Southern California, the Central Valley, and the San Francisco Bay Area.

The increase in both types of rat populations has been caused by the rapid changes which have taken place during the past 20 years in the development of the State. Migration of the human populations out of the major urban centers has caused some of the older central city residential areas to deteriorate, lowering property values, and to be occupied by a lower economic segment of the population. A major portion of this inner-city population has fewer financial resources and a lesser social commitment to keep the level of environmental sanitation at a point that would prevent the development of conditions favorable for support of Norway rat populations.

In contrast, the rapid growth of the suburbs, along with the subsequent maturing of lush growths of fruit and nut trees, ivy vines, and shrubs characteristic of single family residences has provided ideal conditions of food and shelter for roof rat populations to flourish.

As an indication of the expansion of roof rat problem, the number of complaints in San Mateo County increased from 100 to 3,000 over the period 1972 to 1977. Orange County experienced a rise in roof rat complaints from 375 in 1965 to 2,425 in 1977. In Santa Clara County, the complaints increased from 134 in 1966 to 3,762 in 1976. Records indicate that the major portion of these complaints came from middle to upper-middle class suburban areas that were 15 to 20 years old.

Long term control of both Norway and roof rat populations can be achieved only by the modification or elimination of environmental factors that sustain rats: food, water, and shelter. The need to develop community oriented rat control programs emphasizing environmental improvement is even more critical in light of recent evidence which indicates that both Norway and roof rat populations are developing resistance to commonly used anticoagulant rodenticides. Continued unilateral reliance upon rodenticides without concurrent efforts to manipulate environmental conditions causing rat infestations will continue to cause control failures in the future.

MEETING THE COMMUNITY NEED FOR THE SERVICES OF A VECTOR CONTROL SPECIALIST

Benjamin Keh

California Department of Health, Vector and Waste Management Section

2151 Berkeley Way, Berkeley, CA 94704

The great expanse of the State of California with its varied landscape is home to a wide variety of living things. On a statewide basis the vector control specialist performing the full range of services might easily see several hundred species of insects, mites, spiders and other arthropods. When one considers the two sexes and the immature stages as well, the number of forms to be recognized is increased. On the basis of this recognition, the life history and the importance of the species are known and the most appropriate response under a variety of circumstances can be proposed.

A vector control specialist working essentially alone in a new territory might easily feel overwhelmed by the prospects. It is possible to reduce the work to some manageable proportion by attempting to anticipate some of the most likely types of inquiries and also by developing and maintaining contacts with colleagues with whom one can consult.

There are a number of starting points -- some overlapping -- that one might consider.

•Common infestations. The common types of infestations are likely to generate the most inquiries. An example is the cockroach. The German cockroach is responsible for more complaints than the other species. It is also known to have developed resistance to some insecticides. The fact that it usually infests the kitchen or other areas where food is present tends to complicate the control problem. The most common food distribution pattern has been from the manufacturers or processors to distributors and then to homes. But with the increased trend to return bottles and other containers from homes to the distributors (e.g., grocery stores) it is probable that cockroaches may be transported into the stores. If the control of cockroaches there is not completely effective, the stores could then serve as a distributing point for cockroaches. Thus the solution to one problem, that of roadside litter, is potentially the aggravation of another, the spread of cockroaches.

The American, Oriental and brown-banded cockroaches are other important species in California. The brown-banded cockroach, originally introduced into the United States at the turn of the century was first noted in California in the early 1940's. It is now widespread in the State. Other species of cockroaches that could potentially become established in California are constantly being intercepted on incoming shipments.

One should not only be prepared with the existing body of information, but should be alert to new developments as they come into view. The cat flea is our number one nuisance flea species. A community with a large population of cats and dogs in some years may have a considerable outbreak of fleas.

Questions arise regarding the public health aspects of household pests. Will cockroaches carry diseases to man? What happens if stored food insects are accidentally ingested? The vector control specialist may wish to offer advice on the different methods of control. The individuals might be referred to a commercial pest control operator. Some people, wishing to avoid the use of insecticides in the home, want advice on alternative methods of control.

•Emergency information. There are certain questions for which the public naturally turns to the vector control specialist to answer. These relate to bites and stings of venomous arthropods. One should be prepared to answer questions about the effects of the bite of the black widow spider, be able to identify it with certainty and to supply authoritative information about treatment. The violin spider, native to California, is capable of causing a necrotic lesion in man. Other violin spiders or brown recluse spiders that are closely related to our species have been found to have invaded California. Since some bites produce extensive lesions and could cause death, a certain amount of sensationalism has been associated with these spiders.

Other inquiries can be expected on spider bites generally, scorpion stings, and bee and wasp stings.

•Flare-ups. Arthropod populations are subject to great increases in certain years. These flare-ups are great enough to attract media attention on occasion. In recent years the incidence of head lice has increased significantly. Pubic lice and scabies are also on the increase and are subjects of inquiries. Some years there is a great increase in the numbers of ticks, millipedes, crickets, or other arthropods. Representatives of radio, television and newspapers call for information.

•Seasonal occurrence. Many species reach their peak at certain times of the year. The valley black gnats (*Leptoconops*) - - whose full colloquial name is "no-see-um-bite-like-hell" - - appear around May and June. Yellowjackets become numerous later in the season.

•Geographic distribution. The tick, *Ixodes pacificus*, occurs mainly in the cooler coastal areas of California. Others are limited to the mountains. Scorpions, of which there are over 40 species in California, occur over much of the State but the one species (*Centruroides sculpturatus*) whose sting can be lethal to man occurs in very limited localities on the southern borders.

In establishing one's priorities, the species closest to home usually merits greater consideration.

•Diagnosis and referral. There are certain complaints that should be investigated and referred to others for further treatment. This may require a good understanding of the general field of medical entomology and often provide a stern test of one's knowledge. Some of the easier instances of diagnosis and referral are those that are obviously not of public health significance. For instance, people will bring in termites and a whole array of garden pests.

Delusions of parasitosis require a careful examination to avoid misdiagnosis. These cases, alleged to have an arthropod base but in fact primarily psychological, are not entomological problems but are a problem to entomologists. These cases, when fully and accurately diagnosed, should be referred to medical specialists who may or may not be able to manage them.

Another example of reported "bites" a vector control specialist may encounter is schistosome dermatitis. These are caused by the immature stage of blood flukes of birds. The immature stage, the cercaria, emerges from snails and by accident gets on the skin of swimmers. The cercariae burrow into the skin and cause an itching eruption. Swimmers who are not aware of these cercariae often report flea bites or ther causes.

●Ecologic reconnaisance. It is advisable to make an ecologic reconnaissance of a problem area to see what potential sources of arthropod pests could be anticipated. Parks and recreational areas generate inquiries about yellowjackets, ticks, and other nuisances. There is usually some bias against area-wide application in these places, and so insecticides in these cases must be applied more like a rifle instead of a machine gun. For instance, to control yellowjackets, bait prepared by adding a toxicant to catfood is carried by the wasps to their nests. This method confines the insecticide to a very small area and is often acceptable to park authorities. Here again it is important to distinguish the species of yellowjacket, since some are not readily attracted to meat baits.

The presence of a substantial number of wood rats is an indication that coenose bugs may be a recurrent nuisance. These bugs are a serious medical problem to those who are sensitive to their bites and there has been a documented death in California attributed to this insect.

It would be wise to assess one's own capabilities and resources realistically and to take early steps to find ways of covering any foreseeable needs. For example, acarology is a growing specialty. House dust mites have been the focus of considerable interest and the dimensions of their importance are still being studied. Another example is the increase in restrictions on the use of insecticides. These regulations are in a state of rapid and constant change.

There is much that one can do by forethought, planning, and organization. But, however one may prepare and however long one's experience may be, no one can be entirely self-sufficient. There is a lengthy list of infrequent or unusual occurrences that could be cited. Chiggers occur sporadically in parts of California. We have a few cases of myiasis - - the occurrence of live fly larvae - - in humans. These occurrences are opportunities to see the unusual. They are also occasions for some perplexities.

The resources of the Vector and Waste Management Section are available to local health agency vector control specialists through our District Representatives.

HEALTH RELATED ASPECTS OF SOLID WASTE MANAGEMENT

John H. Poorbaugh

California Department of Health, Vector and Waste Management Section

714 "P" Street, Sacramento, CA 95814

California's population and industry produce an increasing amount of solid wastes each year. The estimated production in 1978 will be about 90 million tons, a significant increase over the 1967 amounts of 71 million tons. Over 50% of this waste consists of putrescible organic materials, including manure and crop wastes, food processing wastes, and residential garbage and lawn clippings. The major impact upon public health and the environment of these organic wastes is that they provide food, harborage and breeding sites for vector insects and animals, such as flies, cockroaches and rodents. Odors and dusts are also important, especially in agricultural situations. It is evident that these large amounts of wastes have a significant impact on public health and the environment in many ways, and it is not surprising that state government is increasingly involved in how these wastes are handled, stored, disposed of, or recycled. Disposal of the wastes has received the most attention to date.

To prevent pollution of ground and surface waters from disposal sites, California Regional Water Quality Control Boards dictate the location and construction of sites and the kinds of wastes that a site may accept. The State Solid Waste Management Board requires the counties to issue permits to all disposal sites and solid waste transfer stations, and is coordinating enforcement of the state minimum standards for proper operation of these facilities.

Disposal of solid wastes at well-regulated sites is therefore substantially under control. The major problem which remains in regard to the health impact of solid wastes is the storage, collection and handling of the wastes before they reach the disposal site. Historically these have been the areas of major concern to local health agencies. Included are municipal garbage cans, composting plants and other resource recovery operations, and the bulk of agricultural wastes which are now recycled one way or another. Vectors, especially flies and rodents, thus assume the dubious honor of being the focus of attention in our program to provide California's citizens freedom from the negative health impact of solid organic wastes. I will emphasize our activities in regard to fly prevention and control.

Flies take a place alongside their near relatives, mosquitoes, as causers of nuisance affecting the public, and will be surely a major part of the control activities of a mosquito control agency that wishes to expand to include vectors other than mosquitoes. The relationship of flies to overt human disease is not as clear as, for example, that of mosquitoes to encephalitis, but their feeding habits make flies significant carriers of microorganisms associated with human disease, especially the enteric diseases. Recently in California certain species have been implicated as vectors of diseases affecting livestock and wildlife, especially exotic newcastle disease of poultry and botulism in waterfowl.

Fly problems became a major part of the activities of our Section in the 1950's as suburban populations encroached upon agricultural operations and with the advent of intensive livestock operations such as cattle feedlots and poultry in caged houses. The public made increasing demands to local health departments for relief, and our Section conducted over 22 fly surveys in counties throughout the state. As a result of these surveys, we ascertained the major species of importance and the relationship of different organic wastes to problems caused by different fly species. These are: the housefly, *Musca domestica*; green blowflies, *Phaenicia sericata* and *P. cuprina*; the little housefly, *Fannia canicularis*; the stable fly, *Stomoxys calcitrans*; the false stable fly, *Muscina stabulans*; the black blowfly, *Phormia regina*; the face fly, *Musca autumnalis*; and the vinegar fly, *Drosophila melanogaster*.

We have found that successful fly control depends upon the prevention of fly production by the elimination of habitats (sources) which breed flies rather than by trying to kill adult flies after they emerge. This strategy is similar to mosquito source reduction, and is necessary because flies, like mosquitoes, have generally become resistant to most available insecticides. In urban areas, garbage cans are usually the most important fly sources. Garbage cans and bins must be emptied at least twice a week during the warmer months to prevent prolific breeding by green blowflies. Public education to properly manage pet and small animal manures, compost piles and lawn clippings is necessary to prevent production of houseflies, stable flies, little houseflies and false stable flies.

Important agricultural sources are the manures from livestock production and crop wastes, especially from processing plants such as canneries. All operations, large or small, should have a specific plan for proper handling, storage and disposal of their organic wastes to prevent emergence of houseflies. Black blowflies and other blowflies are produced if dead animals are not quickly disposed of. Fruits and vegetables, both culls left in the field and food processing wastes, can produce enormous numbers of houseflies and vinegar gnats if not dried rapidly and plowed into the soil in three or four days. The long term goal for most animal and crop wastes is a program for immediately returning them to the fields as soil amendments and fertilizers, or a controlled composting method which stabilizes the material so as not to produce odors or flies.

What about the future, as Californians demand an increasing level of vector control in their environment? The local agencies designated to enforce the minimum standards for municipal and agricultural organic wastes will request increasing support from the Department of Health for educational programs in fly prevention and in enforcement actions. Support can also come from mosquito abatement districts which opt to use their existing authority to assume responsibility for vectors other than mosquitoes. The few abatement districts which have done this have been relatively successful, mainly because the vector abatement act is much stricter and more specific than most county ordinances, and because the requirements for abatement are specific and special tax monies are available. In successful programs, these vector control districts have worked in partnership with the local health departments as the operational arm to do the abatement work after the need and general approach has been determined by the local health department. A fly control program which has been in operation for many years and which I use as an example of a success is that of the Delta Vector Control District. Within this district, which includes municipalities as well as extensive agriculture, the residents enjoy a relatively fly-free environment as compared with most other similar areas in California. The taxpayers there are getting their money's worth through coordinated activities in fly prevention and control.

In closing, I would like to say that we believe that fly prevention and control is a viable program need in the majority of local agencies and can readily be put into operation. The Department of Health will be staffed within the very near future with expert technical consultants to assist local programs in planning, operational aspects, and enforcement actions.

SURVEILLANCE FOR ARTHROPOD-BORNE VIRUSES AND DISEASE BY THE CALIFORNIA STATE DEPARTMENT OF HEALTH, 1977

Richard W. Emmons[1], Gail Grodhaus[2], and Edmond V. Bayer[3]

California State Department of Health

2151 Berkeley Way, Berkeley, CA 94704

This is the eighth annual report we have prepared since 1969, on this aspect of the California Department of Health's efforts in preventive medicine. A brief review of recent human encephalitis cases, equine cases, and viruses detected in mosquito pools, is given in Table 1 and illustrates the scope of surveillance activities in the state. The fortunate trend we have seen in the past decade to having only rare or no cases of arboviral encephalitis was again seen in 1977 (Table 2), but the reservoirs of viral activity and the threat of possible recurrence of epidemics persist, requiring continued vigilance and control efforts.

During 1977, at least 316 patients in California were tested for western equine encephalomyelitis (WEE) and St. Louis encephalitis (SLE), as well as for more common causes of encephalitis, by the State Viral and Rickettsial Disease Laboratory (VRDL) and various County Health Department virus laboratories (Table 3). We include these data annually to show the extent of surveillance for human disease and to encourage greater efforts in this regard. As usual, the majority of these cases were found to be caused by viral or bacterial agents other than arboviruses, or the cause could not be determined. A sub sample of sera from 141 patients will be further tested in Dr. W. C. Reeves' laboratory (the 13th year for this special study), to see if any of a dozen other mosquito-born viruses, known to occur in the state besides WEE and SLE viruses, might be causing human disease. There were only 12 human brain samples from fatal cases of encephalitis which were submitted for inoculation into suckling mice, and none yielded arboviruses.

Only 1 case of SLE was found during 1977: a 42 year old woman residing in San Bernardino County, who most likely acquired infection while fishing and vacationing at the Salton Sea near Niland, Imperial County, on July 16-17. She had also spent the July 4 weekend near Lake Henshaw in the Cleveland National Forest area of San Diego County, where she was bitten by mosquitoes. She became ill July 23, and was hospitalized with lethargy, chills, fever, then disorientation and confusion. High fever and a coma persisting for a two-week period followed, but recovery was eventually complete and she was discharged from the hospital August 5, subsequently moving to Louisiana. Serologic tests confirmed the diagnosis of St. Louis encephalitis: 3 serum samples were available, taken August 1, August 12, and October 31. The complement-fixing (CF) antibody titers were 1:4, 1:16, and 1:32; hemagglutination-inhibition (HAI) titers were 1:160, 1:640, and 1:160; indirect fluorescent antibody (IFA) titers were 1:128, 1:512, and 1:512; and plaque-reduction neutralization (PRNT) titers were 1:2048, 1:4096, and 1:256 (repeat test results were 1:2048, 1:16,384, and 1:512). The fall in titer in the third serum, by both the HAI and PRNT tests, was unexpected, but was apparently due to the long interval between the two convalescent specimens. Five other persons (2 from Tehama County, 1 each from Butte, Sacramento and Santa Barbara Counties) were found to have stationary levels of SLE antibody, but no relationship to their current illnesses could be demonstrated. One 10 year old boy from Orange County, suspected clinically of having California encephalitis virus (CEV)

[1]Viral and Rickettsial Disease Lab. and Infectious Disease Section.

[2]Vector and Waste Management Section.

[3]Veterinary Public Health Unit, Infectious Disease Section.

Table 1. Arbovirus surveillance activities and results by the California State Department of Health.

	1971	1972	1973	1974	1975	1976	1977
Suspect human cases of encephalitis/meningitis tested serologically	620	729	1,037	643	583	455	316
SLE +	3	5	5	1*	2*	3	1
WEE+	3	3	0	0	0	0	0
VEE+	0	2*	0	0	0	0	0
Suspect equine cases of encephalitis tested serologically	145	68	56	61	40	35	31
WEE +	16	1	2	2	0	0	1
Number of mosquito pools tested	1,784	6,336	4,838	1,690	1,002	1,273	836
WEE +	16	42	97	4	0	0	19
SLE +	6	64	75	2	0	10	6
Other +	43	74	109	38	0	12	19
Total +	65	180	281	44	0	22	44

*Out-of-state contraction.

Table 2.–Human cases of arthropod-borne encephalitis - California, 1950-1977.

Year	Total	WEE	SLE	Deaths
1950	115	88	69	2 - (1 WEE, 1 SLE)
1951	55	22	33	-
1952	420	375	45	10 - (9 WEE, 1 SLE)
1953	36	14	22	1 - (SLE)
1954	121	22	99	2 - (SLE)
1955	9	6	3	-
1956	21	14	7	-
1957	26	3	23	1 - (SLE)
1958	53	37	16	-
1959	42	2	40	1 - (SLE)
1960	13	1	12	-
1961	10	2	8	1 - (WEE)
1962	21	5	16	1 - (SLE)
1963	15	3	12	-
1964	12	10	2	-
1965	10	9	1	-
1966	17	9	8	-
1967	15	7	8	-
1968	15	11	4	-
1969	5	-	5	-
1970	2	-	2	-
1971	5*	3	2	-
1972	8**	3	5	-
1973	5	-	5	-
1974	-***	-	-***	-
1975	-****	-	-****	-
1976	3	-	3	-
1977	1	-	1	-

*In addition, 1 case of VEE confirmed, in traveler to Mexico.

**In addition, 2 cases of VEE confirmed, in travelers to Mexico.

***1 case of SLE contracted in Texas.

****1 case of SLE contracted in Texas, 1 case in Illinois.

disease, was found to have CEV HAI antibody titers rising from<1:10 to 1:20, but IFA and CF titers were negative (<1:8), so the significance of this is uncertain. It is of interest, however, that a strain of CEV group virus was isolated this year from Inyo County (see following).

No human cases of WEE were detected during 1977. There were 31 suspect cases of encephalitis in equines which were reported to the Department, from 17 counties, but only one case could be proven due to WEE virus (Table 4). This was a 1½ year old unvaccinated colt from a ranch situated in both Riverside County, California, and Yuma County, Arizona. The colt was located on the Arizona side of the border at the time illness occurred. The WEE CF antibody titer rose from <1:16 to ≥1:64, and the WEE IFA antibody titer rose from <1:8 to 1:128. Of 16 equine brain samples submitted from fatal cases of encephalitis in various counties, and inoculated into suckling mice, none yielded arboviruses.

A total of 836 mosquito pools (including 33,649 mosquitoes) were collected and tested in suckling mice during the year (Tables 5 and 6). The greatest effort again was directed to Southern California counties, as has been usual in recent years, in large part due to the special interest of Harvey Magy and coworkers in developing a better understanding of arbovirus ecology in this previously little-studied region of the state. Diversion of other State Vector Control specialists to bubonic plague surveillance and control activities, plus the expectation that drought would help stop mosquito and virus activity in Central and Northern California, limited the effort elsewhere in the state.

The viruses isolated from mosquito pools (Table 7) included WEE (19), Turlock (13), SLE (6), Hart Park (5), and CEV-group (1). This is the first CEV-group virus we have isolated since 1973, and the first WEE virus since 1974. However, since collecting sites and intensity of effort vary from year to year, no firm interpretation or indication of trends can be made from results of our general surveillance.

A pilot study of one flock of 30 chickens (H. Magy and coworkers) near El Centro, Imperial County, showed SLE seroconversion for 1 chicken by May 5, and for a second chicken by August 8, but no seroconversions for WEE virus (PRNT method).

In addition to the State studies, the independent but collaborative investigations by Dr. W. C. Reeves and coworkers showed serologic evidence for avian infections by Turlock virus in Sacramento Valley and Kern County study areas, but no evidence for SLE or WEE virus activity. The studies by Dr. Telford Work and coworkers in Imperial County study sites confirmed both WEE and SLE activity, as has been usual in this different environment for some years. Details of these findings will be available in their annual progress reports or published papers.

There was special interest in dengue during 1977, because of large outbreaks in the Caribbean, Pacific, and South-East Asian regions. Eight cases of dengue in Californians exposed during travel were verified by serologic tests (IFA, CF and PRNT): 5 from Jamaica, 1 from Puerto Rico, 1 from Tahiti, and 1 from the Philippines. More cases undoubtedly occurred, but specimens were not submitted. Dengue type 1 appeared to be the infecting serotype in all 8 cases based on specific plague-reduction neutralization tests of the patients' serum samples. This is the first outbreak by dengue type 1 virus documented for the Western Hemisphere, although previous ones are suspected from serologic surveys. Outbreaks due to dengue types 2 and 3 have occurred previously. *Aedes aegypti* is not known to occur in California, but does occur in at least 10 Southeastern states, and the possibility of local transmission of dengue viruses there has been a concern.

The usual surveillance for Colorado tick fever (CTF) revealed 10 cases during 1977: 8 from exposure in known-endemic areas of Northeastern California, 1 from Idaho, and 1 apparently from Colorado.

Plans for surveillance for arbovirus disease during 1978 are similar as for previous years. The evidence for persistent reservoirs of at least 4 viruses of public health importance, and the unpredictability of climatic and other ecologic factors which influence their potential for causing epidemics, show the need for continuing such surveillance and maintaining control efforts.

Table 3.--Humans tested serologically for mosquito-borne arbovirus disease by the Viral and Rickettsial Disease Laboratory, California State Department of Health and by County Health Department laboratories, by county of residence and month of illness onset, California 1977.

County	Totals	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Unknown
Alameda	2		1						1					
Berkeley	9						3	1		2	1	1		1
Butte	5									2	1			2
Colusa	1													1
El Dorado	15			1	1	1	4	2	4	2				
Fresno	4					2		1				1		
Humboldt	25						1	7	11	4				2
Imperial	2												2	2
Inyo	1												1	1
Kern	3					1	2							
Kings	2							1						1
Lake	1							1						
Los Angeles*	16						3	3	5	1	2	1		1
Marin	10					1	3		2	1	1			2
Mendocino	4							1	1	1		1		
Merced	4								1					3
Modoc	1													1
Monterey	1						1							
Napa	2					1								1
Orange*	2						1		1					
Placer	5						1	2	1		1			
Riverside	4					2		1						1
Sacramento*	17					1	2	8	3	3				
San Bernardino	1							1						
San Diego*	81	1	1		3	8	5	10	17	18	11	1		6
San Francisco	12				3	1	1	2	1		1			3
San Joaquin	18					1	5	2	3	3	2			2
San Luis Obispo	9						4	1		2	1	1		
Santa Barbara	1						1							
Santa Clara	7					2	2	3						
Santa Cruz	11			1		1		1	4			1		3
Shasta	6	1						2	2	1				
Solano	1							1						
Sonoma	8						1	3	1	2				1
Stanislaus	3				1	1			1					
Sutter	2						1		1					
Tehama	7					1		1	2		3			
Ventura	5					1	1			2				1
Yolo	6					2	1				1			2
Yuba	1							1	1					
Unknown	1												1	1
TOTALS	316	2	2	2	8	27	43	55	63	44	25	7		38

*Some or all sera tested by county health department laboratory.

ACKNOWLEDGMENT.–The assistance and cooperation of many staff members of the Viral and Rickettsial Disease Laboratory, the Vector Control Section, and others in the California State Department of Health, as well as of local mosquito abatement districts, the California State Department of Food and Agriculture, and other local, county and state or federal agencies in carrying out the surveillance program are gratefully acknowledged.

Table 4.–Suspected clinical cases of arbovirus encephalitis in equines by county and month, for California 1977.

COUNTY	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Undetermined[a] or Not Tested	Totals[b]
Totals	2	-	2	1	5	6	6	1	1	3	2	-	2	31
Alameda	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Amador	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Fresno	-	-	-	-	2	-	-	-	-	1	-	-	-	3
Kern	1	-	1	-	-	1	1	-	-	-	-	-	1	5
Kings	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Lake	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Los Angeles	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Orange	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Placer	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Riverside	-	-	-	-	-	3	1[c]	-	-	1	1	-	-	6
San Joaquin	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Santa Barbara	1	-	-	-	-	1	-	-	-	-	-	-	-	2
Santa Clara	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Shasta	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Tehama	-	-	-	-	-	1	1	-	-	-	-	-	-	2
Tulare	-	-	-	-	-	-	-	-	-	-	1	-	1	2
Tuolumne	-	-	-	-	-	-	1	-	-	-	-	-	-	1

[a]Inadequate serum specimens available for testing.

[b]Complement fixation tests were performed on all serum specimens submitted and virus isolation techniques were attempted on all brain specimens by the Viral and Rickettsial Disease Laboratory, California Department of Health.

[c]A positive case of WEE in a 1½-year-old colt in Yuma County, Arizona; onset July 11, CF antibody on blood serum taken July 19 was $<$1:16, second blood sample taken November 1 was $\geq$1:64. No history of vaccination. The colt belongs to a ranch located in both Riverside County, California, and Yuma County, Arizona; it was on the Arizona side at the time infection was acquired.

Table 5.–Number of mosquitoes (pools) tested, by species and county, by the Viral and Rickettsial Disease Laboratory. California State Department of Health, 1977.

County	*Culex tarsalis*	*Culex erythrothorax*	*Culex pipiens* complex	*Culex peus*	*Culiseta inornata*	*Culiseta incidens*	*Aedes vexans*	*Aedes dorsalis*	*Aedes melanimon*	TOTALS
Butte	234(5)									234(5)
Colusa	1,648(33)									1,648(33)
Glenn	1,189(24)									1,189(24)
Humboldt	50(2)		58(3)		31(1)					139(6)
Imperial	707(23)	263(8)	132(7)							1,102(38)
Inyo	315(12)	519(15)			41(7)	3(1)		3(1)	305(11)	1,186(47)
Kern	565(12)		5(1)							570(13)
Kings			1,405(30)							1,405(30)
Los Angeles	7(2)									7(2)
Madera	130(3)									130(3)
Merced	95(3)									95(3)
Orange	63(2)	50(1)								113(3)
Riverside	7,806(194)	570(19)	134(10)	32(1)	424(14)			11(1)		8,977(239)
San Bernardino	4,078(93)	144(5)	21(1)		5(1)		435(13)			4,683(113)
San Diego	1,117(38)	3,084(64)	6(1)	10(1)				6(1)		4,223(105)
Shasta	50(1)									50(1)
Sutter	1,051(22)									1,051(22)
Tehama	150(3)									150(3)
Tulare	25(1)									25(1)
Yolo	672(14)									672(14)
Yuba	993(22)									993(22)
Mojave, AZ	2,862(61)						282(6)			3,144(67)
Yuma, AZ	979(23)	884(19)								1,863(42)
TOTALS	24,786(593)	5,514(131)	1,761(53)	42(2)	501(23)	3(1)	717(19)	20(3)	305(11)	33,649(836)

Table 6.–Number of mosquitoes (pools) tested, by species and month, by the Viral and Rickettsial Disease Laboratory, California State Department of Health, 1977.

Species	April	May	June	July	August	Sept.	Oct.	Nov.	TOTALS
Culex									
tarsalis	797(22)	4,829(112)	3,815(81)	4,624(111)	4,413(117)	2,788(68)	2,795(65)	725(17)	24,786(593)
erythrothorax	103(5)	1,404(30)	519(12)	1,083(26)	918(24)	1,037(23)	450(11)		5,514(131)
pipiens complex	5(2)	131(7)		93(7)	105(3)		1,427(34)		1,761(53)
peus		10(1)	32(1)						42(2)
Culiseta									
inornata				31(1)	5(2)	36(5)	72(6)	357(9)	501(23)
incidens					3(1)				3(1)
Aedes									
vexans		267(7)	32(1)	50(1)	275(6)	50(1)	43(3)		717(19)
dorsalis				6(1)	11(1)	3(1)			20(3)
melanimon					131(5)	174(6)			305(11)
TOTALS	905(29)	6,641(157)	4,398(95)	5,887(147)	5,861(159)	4,088(104)	4,787(119)	1,082(26)	33,649(836)

Table 7.–Viral isolates from mosquito pools during 1977, by the Viral and Rickettsial Disease Laboratory, California State Department of Health.

Mosquito pool no.	County	Place	Date Collected	Species	No. of Mosquitoes	Virus Isolated
RV-1233	Riverside	Blythe	May 11	*Culex tarsalis*	14	Turlock
SB-0461	San Bernardino	Needles	May 24	*Culex tarsalis*	50	WEE
SB-0472	San Bernardino	Needles	May 24	*Culex tarsalis*	50	Turlock
1306	Riverside	Norco	June 20	*Culex tarsalis*	50	Hart Park
V2-2726	Yuba	Wheatland	June 22	*Culex tarsalis*	50	Turlock
V2-2727	Yuba	Wheatland	June 22	*Culex tarsalis*	50	Hart Park
V2-2728	Yuba	Wheatland	June 22	*Culex tarsalis*	48	Hart Park
SB-0515	San Bernardino	Needles	June 30	*Culex tarsalis*	50	Turlock
SB-0529	Mojave, AZ	Bermuda City	June 30	*Culex tarsalis*	50	WEE
SB-0532	Mojave, AZ	Bermuda City	June 30	*Culex tarsalis*	50	WEE
SB-0534	Mojave, AZ	Bermuda City	June 30	*Culex tarsalis*	50	WEE
SB-0540	Mojave, AZ	Bermuda City	June 30	*Culex tarsalis*	50	WEE
SB-0545	Mojave, AZ	Bermuda City	June 30	*Culex tarsalis*	50	WEE
V2-2730	Sutter	Sutter	July 6	*Culex tarsalis*	50	Hart Park
V2-2733	Sutter	Sutter	July 6	*Culex tarsalis*	50	Turlock
V2-2734	Sutter	Sutter	July 6	*Culex tarsalis*	50	Turlock
V2-2735	Sutter	Sutter	July 6	*Culex tarsalis*	50	Turlock
V2-2749	Yuba	Marysville	July 6	*Culex tarsalis*	50	Hart Park
V2-2750	Yuba	Marysville	July 6	*Culex tarsalis*	50	Turlock
IV-0628	Imperial	Calexico	July 12	*Culex tarsalis*	50	WEE
IV-0629	Imperial	Calexico	July 12	*Culex tarsalis*	50	WEE
SB-0567	San Bernardino	Needles	July 27	*Culex tarsalis*	50	WEE
SB-0572	San Bernardino	Needles	July 27	*Culex tarsalis*	10	WEE
V1-1520	Tehama	Woodson Br.	August 15	*Culex tarsalis*	50	Turlock
IV-1026	Imperial	Bard	August 22	*Culex tarsalis*	35	SLE
IV-1027	Imperial	Bard	August 22	*Culex erythrothorax*	14	WEE
AZ-0151	Yuma, AZ	Yuma	August 22	*Culex tarsalis*	33	SLE
AZ-0156	Yuma, AZ	Yuma	August 22	*Culex erythrothorax*	50	SLE
AZ-0158	Yuma, AZ	Yuma	August 22	*Culex tarsalis*	28	SLE
IN-0005	Inyo	Bishop	August 24	*Aedes melanimon*	43	CEV group
SB-0577	Mojave, AZ	Bermuda City	August 29	*Culex tarsalis*	50	WEE
SB-0578	Mojave, AZ	Bermuda City	August 29	*Culex tarsalis*	18	WEE
SB-0580	Mojave, AZ	Bermuda City	August 29	*Aedes vexans*	50	WEE
SB-0581	Mojave, AZ	Bermuda City	August 29	*Aedes vexans*	50	WEE
SB-0584	San Bernardino	Needles	August 29	*Culex tarsalis*	50	WEE
SB-0586	San Bernardino	Needles	August 29	*Culex tarsalis*	50	WEE
SB-0587	San Bernardino	Needles	August 29	*Culex tarsalis*	50	WEE
SB-0591	San Bernardino	Needles	August 29	*Culex tarsalis*	26	SLE
SB-0597	San Bernardino	Needles	September 21	*Aedes vexans*	50	WEE
RV-1459	Riverside	Mecca	October 19	*Culex tarsalis*	50	SLE
RV-1465	Riverside	Mecca	November 16	*Culex tarsalis*	50	Turlock
RV-1466	Riverside	Mecca	November 16	*Culex tarsalis*	50	Turlock
RV-1467	Riverside	Mecca	November 16	*Culex tarsalis*	50	Turlock
RV-1483	Riverside	Mecca	November 16	*Culex tarsalis*	50	Turlock

THE SUDDEN RISE OF DOG HEARTWORM (*DIROFILARIA IMMITIS*) TO A SERIOUS PEST LEVEL IN SAN MATEO COUNTY

Charles P. Hansen

San Mateo County Mosquito Abatement District
1351 Rollins Road, Burlingame, California 94010

INTRODUCTION.–Dog heartworm (*Dirofilaria immitis*), a serious disease of canines, is common to the Atlantic and Gulf Coast states and is now considered to be common in the Great Lakes and New England areas. This filarial disease is a major veterinary problem which is vectored by mosquitoes and, therefore, should be of concern to all vector control agencies and their personnel. The disease is not new to California nor to San Mateo County, but the large number of cases reported from within our District during 1977 was unexpected. At a Dog Heartworm Workshop in October 1977, Dr. Clarence J. Weinmann, Associate Professor of Parasitology, University of California at Berkeley, stated that he felt the disease was definitely on the increase in California. However, Dr. Ronald F. Jackson, a veterinarian who is an internationally recognized authority on canine heartworm and President of the American Heartworm Society, stated in a July 1977 publication that the Far West is still free from the disease with the possible exception of the Sacramento Valley in California.

DISCUSSION.–The causative agent of dog heartworm is a nematode in the family Filariidae. The worm lives primarily in the heart and pulmonary circulatory system of the dog. The life cycle is mosquito-dog-mosquito. The microfilaria cannot complete its life cycle without first passing through the intermediate host, the mosquito. The microfilaria develops within the mosquito to become an infective larva which may become the source of a new infection in healthy dogs or possibly reinfection of animals that are currently inflicted with the disease. The infective stage larvae burrow into the dog's skin and go through a development process in the tissue, then penetrate blood vessels and move on to the heart where eventually microfilariae are produced. At this time, the dog may become a source for perpetuating the disease.

CASES.–Normally the San Mateo County Mosquito Abatement District receives confirmation of one or two cases of dog heartworm annually. However, the picture changed drastically during the summer of 1977. The disease reached an epizootic level according to a local veterinarian who examined more than two hundred animals from the Los Trancos Woods area of Southern San Mateo County. Because the vector is a mosquito, our agency became involved in the problem through the cooperation of the Portola Valley Animal Clinic. Meetings were held with one of the veterinarians to review the etiology of the disease in this area. It was determined that none of the "positive" animals had been out of the state nor had traveled far from their homes. Dr. John Schulte, a veterinarian who has practiced seven years in this community, was not able to document a prior history of this disease except for occasional cases introduced from out-of-state animals. Several other veterinarians in the area were contacted in regard to the incidence of the disease. Positive cases were reported only in animals from Los Trancos Woods. To obtain complete and accurate records is difficult, but I estimate conservatively that fifty positive cases were diagnosed in the area in 1977. The first case was diagnosed from an animal which was obviously clinically ill. Fortunately, Dr. Schulte had gained experience with dog heartworm in Hawaii and was well acquainted with its symptoms, frequently misidentified with cardiac or pulmonary problems. Through the cooperative effort of the Peninsula Veterinarian Medical Association, concerned dog owners, and our agency, the entire populace of Los Trancos Woods became informed of the importance of having their animals checked annually for heartworm. This mountainside community nestled in the woods is known to be an area of high incidence of the tree hole mosquito, ***Aedes sierrensis***, along with several *Culex* and *Culiseta* species. Although the vectors of this disease have not been determined in our area, at least twelve species have been implicated in the transmission of heartworm disease state-wide.

DISTRICT ROLE.–I believe that, as Vector Control Specialists, there are several facts with which we should acquaint ourselves. Dog heartworm disease rarely affects human beings directly, but indirectly causes significant emotional and financial problems. Since pets frequently receive a place of honor in their homes, I consider it our responsibility to acquaint ourselves with all aspects of this disease so we can deal intelligently, in some cases compassionately, with the public. I suggest the following procedural steps be adopted as ways to help arrest or stop the spread of this disease:

1. Develop a public education and awareness program as a community service for the concerned public seeking information. Veterinarians are frequently inadequately informed as to mosquito abatement practices; therefore, as responsible vector control agencies, we should be prepared to answer questions relating to the vector, such as mosquito behavior, biting habits, breeding sources and seasonal occurrence. If we are able to provide reliable information to pet owners, we do a valuable service to the community and enhance our own public image as a competent vector control agency.

2. Develop an active relationship with local Veterinarian Associations and promote an on-going dialog about a problem which concerns us all. This communication will keep both professions informed about the current status of the disease and mosquito populations.

3. Suppress mosquito populations in areas where the disease is prevalent. Field personnel may have to accelerate the surveillance program to insure a higher level of control in these endemic disease areas.

4. Delineate known boundary lines and map the spread of the disease. This information is important for the Certified Technicians to use in mounting a thorough surveillance and abatement program.

5. Encourage pet owners to have their dogs checked semi-annually for dog heartworm.

6. Determine vector(s) transmitting the disease. This is extremely difficult and will require professional assistance from the State Department of Health and/or local univer-

sities who have specialists able to make accurate determinations. A species composition survey should be conducted and seasonal occurrence recorded.

7. Design and set up a surveillance program to determine the incidence and population level of larval and adult mosquitoes. Ideally, control programs will reduce the mosquito incidence below a transmission level.

8. Advise pet owners on ways to protect their animal from unnecessary exposure to mosquitoes, such as screening outdoor sleeping quarters, not allowing animals to run loose, using repellents and eliminating mosquito breeding sources.

9. Together with other mosquito control agencies in California, develop acceptable standardized guidelines to insure that the problem is approached in a consistent manner, and that accurate information is disseminated to the public.

10. Request that grant money or research funds support further research on this disease.

CONCLUSION.—Dog heartworm disease is spreading and could potentially reach epizootic proportions. Veterinarians, dog trainers, kennel associations, and dog owners are naturally very concerned and want to prevent further spread of heartworm disease from endemic areas. As vector control agencies, we have an important role and a definite responsibility to address this very real and unfortunately growing problem in Califonria. An active involvement at this time could greatly enhance our public image.

VECTOR PREVENTION THROUGH THE PLANNING PROCESS

Dale Sanders

Contra Costa County Planning Department

Martinez, California 94553

We have entered an era of public concern over the governmental expenditure of tax monies. This concern has affected and will continue to affect mosquito and vector control programs. The public is taking a hard look at governmental efficiency. Regardless of the passage of the now famous Jarvis-Gann Initiative in June, agencies should face the reality that it will become harder to justify programs that do not make efficient use of tax generated monies.

When judged in this light, it has become obvious that mosquito and vector control agencies can no longer fight defensive battles generated by other governmental entitites. It has become too costly in terms of staff, materials and time. Mosquito and vector control agencies must take the offensive. Such agencies must now be prepared to apply pressure in areas where control problems can be prevented before they occur. This pressure should be brought to bear on the essentially political realm of the planning process – wherever the decisions are made on land use changes, subdivisions and public projects. Mosquito and vector control agencies must be prepared to make use of the existing avenues for input into this process (i.e., project review and environmental impact analysis). Some of these avenues have been successfully utilized by control agencies. The key to success in the planning process is understanding how a particular governmental system works and having impact at key points in the process. Generally, planning agencies are as underfunded and under staffed as mosquito and vector control agencies. Often the staffs are doing as much as they can. Obtaining recognition and the attention of the decision-makers (boards, councils and commissions) is essential in order to alter the planning agency's priorities to more adequately reflect the needs and responsibilities of the control agency. In short, mosquito and vector control agencies should take a position that citizens' groups have found useful – to make their presence known and felt.

Historically, control agencies have taken a "low profile" approach to doing business. If the decision-maker can be made to understand that tax dollars can be saved through a more efficient interaction between mosquito and vector control agencies and planning agencies you will get their attention. This can only be accomplished through a more vigorous and aggressive approach to mosquito and vector control prevention and less reliance on the historically defensive attempts to control problems after they have been created.

SOURCE EVOLUTION AND PREVENTIVE PLANNING IN AN URBAN VECTOR CONTROL DISTRICT

Charles H. Dill

San Mateo County Mosquito Abatement District
1351 Rollins Road, Burlingame, California 94010

When our District was formed sixty-two years ago, we had extensive salt marshes and the mosquitoes to go with them. The problems were so extreme as to severely limit any attempts to reside comfortably in the area. Today the acres of salt marsh remaining in the District can be counted on one hand, yet we are still confronted with year-round mosquito problems. Now when our Certified Technicians go into the field they don't seek out marsh vegetation but rather something more "concrete", and I mean that literally.

I'm talking about the developers' concrete and the multitude of new sources that have been created and to which mosquitoes and other aquatic insect pests have successfully adapted.

Before talking any further about these new problems, I would like to give you a brief background review concerning our District's mosquito control philosophy. Four years ago, two things brought about a rather extreme change in our control approach. One was the manifestation of high chemical resistance in our *Culex pipiens* population as well as evidence of levels approaching resistance in several other species. The other factor was the determination by the District staff that chemicals were not environmentally or economically practical and that alternative control measures should be utilized. We set an on-going objective of the progressive reduction of the amounts of chemicals used for control. We hoped to accomplish this through a reaffirmation and employment of the principals of integrated control or Integrated Pest Management (IPM) as it has become known. While we were able to drastically curtail our use of the organo-phosphates and at the same time not having to increase our use of larvicidal oils, it became readily apparent that the pace of our source reduction/elimination was far below that of the planner/developers source creation. The next logical step was to attempt to prevent these sources from being created and the best way to accomplish this was by early planning input to the permitting agencies in our area.

We entered the planning process through the local office of the United States Army, Corps of Engineers' public notice system. This turned out to be a mistake in that in many cases by the time a project went to public notice the planning process had been in motion for several years and developers were reluctant to amend their plans at that point.

At this time we went to the first agency a developer would contact in formulating his plans . . . . . the municipality where the project was to be built. Our high priority areas occur along the Bay, for reasons that will be evident from the slides shown at the end of my talk, and so we have concentrated our efforts in those cities which front the Bay. We made contact with their planning departments and departments of public works and requested notification of pending projects and the opportunity to provide input of a preventive nature. Our initial contacts produced mixed results. Our largest city has responded beyond expectations. In some instances this city's planning department has held an applicant's permit in abeyance until the San Mateo County Mosquito Abatement District's concerns had been addressed and steps adequately taken by the applicant to prevent the creation of potential sources. On the other hand some contacted cities have never acknowledged our requests or made any contact subsequent to our request. This is due, in part, to their not taking us seriously. Mosquito abatement has maintained such a low profile in recent years that most other governmental agencies consider us a non-entity. And another reason we've failed so far with some cities is that we have not put together a formal, co-hesive preventive planning program. We've been in the defensive position of trying to provide input to projects that are near the end of the planning/permitting process and this requires considerably more time than at the ideal, conceptual stage. We are in the process of designing an educational program to increase local municipal involvement and cooperation by outlining their role and responsibility in this valuable and essential process of source prevention.

Although the slides and projects just given should have shown why preventive planning is valuable, I have been asked to answer the question "Is your program effective?". This is hard to say as none of the projects we've commented on have, as yet, turned a shovelful of dirt. If effectiveness can be measured by the acceptance, on paper, of our proposed changes, then I would say we are very effective. In every instance where we have had input, either the final draft environmental document has our comments included together with appropriate assurances that correction will occur or the District is in receipt of a letter from the developer outlining the corrective actions they will take to prevent potential sources. Until actual work begins and we can carry out field inspections, we can only assume these paper changes are made in good faith. In any case, this program of preventive planning is a positive step and one that we feel could realize great economic and environmental benefits to the taxpayers in our District.

PLANNING FOR THE PREVENTION OF VECTORS AT THE LOCAL LEVEL

Roy E. Eastwood

Orange County Vector Control District

Post Office Box 87, Santa Ana, California 92702

The basic premise during the planning stages of community development is the conclusion that vector sources can be eliminated or reduced. This is accomplished through proper solid waste, water, and harborage management. It is most important that vector elimination at health or pest levels be distinguished from total elimination.

Goals and objectives need to be stated. The vector population size which, when exceeded, becomes either a nuisance or of public health significance must be clearly defined.

Environmental factors which affect the quantity of vectors produced from a source must be categorized and enumerated for all concerned. Qualities of physical construction making possible economic environmental management need to be clearly stated.

Failures will undoubtedly occur. However, these should be looked upon as opportunities from which to learn. They may present new approaches or the need for a restatement of our goals and objectives.

Planning for vector prevention is not new to CMVCA members. In 1955 John Ruddock of the Los Angeles Health Department stated his concern over the number of new housing tracts in the city causing new habitats due to grading and filling of certain areas. Jack H. Kimball, 1954 Highlights of the Orange County Mosquito Abatement District, stated "An important mosquito control problem has rapidly developed within the County by the construction of over 1,000 subdivisions within the County during 1954. Many small sources have been created by installation of open drainage channels in easements paralleling backyard property lines." In 1970 Howard Greenfield would have changed the title of his paper from "District Activities and Relationship to Various Jurisdictions" to the "Myth of Cooperative Relationship with Various Jurisdictions."

The Orange County Vector Control District has taken another stab at the problem of cooperation with various agencies for vector prevention. This has been undertaken by diversification of resources and approaches through the following functions.

The daily contact of persons requesting service by technicians trained in collecting information for use by the technical staff provides regular reminders of environmental change to the public. A comprehensive educational program conducted in grade schools by the use of District furnished training aids. The Educational Coordinator's program, involving all County High School F.F.A. Classes, training students in vector management as it pertains to agriculture. Assisting school districts in preparation of plans for new agriculture facilities and environmental recycling projects.

Soliciting the aid of county and city planning personnel. Presentations are made to these people which make them aware of environmental conditions creating vector problems. Solutions to these problems are presented. A request is made of each city and the county to forward Environmental Impact Reports, Use Permits, and Demolition Permits to this District for review and recommendations.

Accepting the task as solid waste enforcement agency concerning agricultural waste. This allows input into agricultural waste disposal planning as well as input into all other solid waste disposal and or utilization which may concern vector prevention.

Success of a preventive program is difficult to measure. When a new potential source of vectors does not create a problem, can we prove it is due to our efforts of preventing vector production?

Water Districts profess full cooperation in meetings and fail in practice. A problem common to other entities. Cities will send plans for review by the Vector Control District if all of their staff are informed of our needs which is usually not the case. Howard Greenfield's statement concerning the myth of cooperation is true all too often.

When the decision must be made to provide water, housing, solid waste disposal, etc. for a million or more people, the control of potential vectors is not so important to the planners of our communities, especially when the vectors are only pests.

REFERENCES CITED

Ruddock, John. 1955. Mosquito control activities of the Los Angeles Health Department for the year 1954. Proc. Calif. Mosq. Control Assoc. 23:132-33.

Kimball, Jack H. 1955. 1954 highlights of the Orange County Mosquito Abatement District. Proc. Calif. Mosq. Control Assoc. 23:133.

Greenfield, Howard R. 1970. District activities and relationship to various jurisdictions. Proc. Calif. Mosq. Control Assoc. 38:69.

MOSQUITO PREVENTION PLANNING WITH THE REGIONAL AGENCIES OF ALAMEDA COUNTY

Fred C. Roberts

Alameda County Mosquito Abatement District
3024 East 7th Street, Oakland, California 94601

It is a pleasure to be discussing methods to provide mosquito control through the planning process. I would like to provide a brief overall view of our source prevention program and then focus on the District's approach to planning with regional agencies.

Richard Husbands of the State Bureau of Vector and Waste Management made the following statement in a paper presented to this association eight years ago:

> "If source reduction principles are used to correct the problem before it occurs, then the time spent in man-hours that helps to prevent a mosquito problem can be balanced against average district costs normally associated with an uncorrected problem of this type"

The sentence successfully covers the elements of source prevention. Mr. Husbands is not satisfied with simply correcting a problem through preventive planning, but just as important, documenting the process is a manner that would prove or disprove its cost-effectiveness.

Alameda County is particularly fertile ground for a source prevention program. Many kinds of mosquito problems can be produced as an incidental by-product of man's activities. There are potential mosquito problems inherent in sewage treatment, underground water recharge systems, gravel harvesting operations, and irrigation. Land development can create storm drain systems, ornamental ponds, septic tanks, swimming pools - - all potential mosquito sources.

Most dramatic, perhaps, are the increased activities to create wetlands in the San Francisco Bay Area, including salt water, wastewater and freshwater marshes.

The kind of land and water-project development in Alameda County and the rate at which it is occurring, strongly suggests that an aggressive source reduction program would pay dividends. Fortunately, perhaps as never before, the legal environment is conducive to the District's involvement in the planning processes of development. The planning procedures established by the California Environmental Quality Act and the permit processes established by the regional regulatory agencies are relatively new and can be used effectively for mosquito source prevention purposes.

The Board of Trustees of the Alameda County Mosquito Abatement District developed a "Source Reduction Policy" that specifically states that source prevention is an integral part of our source reduction program. The policy reads in part: "Source reduction shall be accomplished through District review of governmental planning processes, ...". It may seem trivial to mention, but some governmental agencies have actually directed their staff to stay out of planning. We feel we shouldn't miss the opportunity to prevent a mosquito problem when it can be done most inexpensively, i.e., before it is created.

One of the keys to the effectiveness of our probram depends upon the local planners being aware that we are interested in "water-involved projects". One of our first steps in establishing contact with the planners was to modify and distribute the "Checklist for Reviewing Environmental Impact Reports for Potential Mosquito Problems", a document produced by the Source Reduction Committee of the California Mosquito Control Association. Although the document provided a good first step, constant effort by our staff is necessary to assure that planners remember that we exist. In spite of these efforts, occasional projects are not directed to the District for review.

Our source prevention program is triggered into action by a variety of inputs. We receive Environmental Impact Reports from agencies, permit notices from regulatory agencies, planning notices from planners and referrals from various sources. We are also alerted to projects by field observations of our staff, and by reviewing negative declarations.

Our first steps in the prevention process is to review the document and inspect the site of development. We have recently begun using an inspection form to be filled out for each project. The form is designed to help detect problems, make a permanent record, and be used as a basis to formulate solutions. The form asks the inspector three basic questions:

1) Are there mosquito problems at the development site?
2) Will the existing sources be eliminated by the project?
3) Will the project create new mosquito problems?

Finally, the form asks the inspector to make recommendations based upon his inspection and review of the proposed project. The recommendations are designed to eliminate existing sources or prevent new ones through the development.

The output of our source prevention program is our formal written recommendations to the planners or others. Because we find we are responding many times to the same kinds of problems, we have developed "Standard Recommendations" for the prevention of a number of types of sources including gravel harvesting operations, freshwater holding ponds, stream modifications, flood control channels, and catch basins.

REGIONAL GOVERNMENT.–Many of the kinds of problems we deal with are common to all the vector control agencies of the Bay Area. The Coastal Region of the California Mosquito Control Association has developed standard recommendations to prevent mosquito problems in the most important of those common problems: (1) salt marsh restoration projects, (2) dredge material disposal, and (3) fresh and wastewater marsh creation.

The Bay Area is blessed, or cursed, with a number of regional agencies. The San Francisco Bay Corps of Engineers now has jurisdiction not only of the navigable rivers and bay, but the tributaries. The San Francisco Bay Conservation and Development Commission regulates development along the shoreline. The association of Bay Area Government has been given the responsibility to administer the Environmental Management and the 208 Surface Runoff Program. Finally, more restricted, yet still with regional influence, are the East Bay Regional Park District, the East Bay Discharge Authority, and the South Bay Wildlife Refuge.

The vector control agencies of the Coastal Region of the California Mosquito and Vector Control Association and the SDH Section of Vector and Solid Waste Management have presented a united front to these agencies. The efforts, as you are probably already aware, have resulted in streamlined permit systems for source reduction and source prevention work that falls within the regulation of regional agencies.

The regional activities of the mosquito control agencies of the Coastal Region has provided some obvious advantages to the Alameda County Mosquito Abatement District.

1) We have avoided conflicts with other vector agencies by using standard recommendations that have been developed and approved by all the local vector agencies.
2) Our agency's status has been elevated to the regional level through the activities of the Coastal Region.
3) We have enjoyed the benefits of sharing the technical expertise and staff of the vector agencies of the Coastal Region.
4) Perhaps most surprising of all, we find the "Standard Recommendations" of the region are leading the way in wetland design criteria, an eventuality that puts our mosquito control District in a strong position in the planning stages of wetlands.

LESSONS LEARNED.–The staff of the District has learned a number of lessons while implementing our prevention program. Here are some of the most important.

Lesson I.–NO ONE DOES IT BETTER. We have studied plans done by experts in ornithology, wildlife, salt marshes, and on and on. Unequivocally, the lesson stands out that no one does preventive mosquito control planning unless we do it.

Lesson II.-HOW EASY THEY FORGET. Unless we constantly make efforts to keep key people aware of our concern, we are forgotten and mosquito problems are overlooked in planned developments.

Lesson III.–WE MUST NOT EQUIVOCATE – – BE SPECIFIC. We once commented on a Draft EIR that there was not enough information to predict whether a mosquito problem will be created. They responded by saying in essence, we were correct. We should have said the report was inadequate and asked for specific information.

Lesson IV.–BEWARE OF THOSE TOO EAGER TO ACCEPT OUR RECOMMENDATIONS. We have seen situations where the real or imagined influence of our agency has been used by developers. They use our recommendations, which happen to suit their purposes, to reject the conflicting recommendations of another agency. In actuality, our recommendations most often can be designed to be compatible with many objectives.

Lesson V.–WE MUST CONTINUE TO LEARN FROM OUR MISTAKES. We have made a number of mistakes, mostly of omission. We must document our effort and results precisely in order to learn from our past errors.

CONCLUSION.–If we are to determine whether or not we have an effective mosquito provention program in Alameda County, we should know the following (1) the quantity of sources currently existing in Alameda County, (2) the rate at which new sources are being created by natural processes and the activities of man, (3) the rate at which the sources are being eliminated, and (4) how effective the District is at preventing new mosquito sources by our preventive planning program.

The program is currently in its infancy. We know the answer to only two of the above four questions. We hope we have put the proper forces in motion to provide answers to all of the four questions.

VECTOR PREVENTION THROUGH LEGAL ACTION

Don J. Womeldorf[1] and David F. Keast[2]

California Department of Health

714 "P" Street, Sacramento, California 95814

This question has been raised: If, during the planning process for any given project a potential vector problem is identified, does a local vector control agency have the legal authority to force that potential problem not be be created?

Most vector control agencies in California are mosquito abatement districts, pest abatement districts, or local health entities. Mosquito abatement districts are empowered to abate nuisances. Health and Safety Code Section 2270(b) states that the district board may:

> 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.

A public nuisance is defined by Section 2271:

> Any breeding place for mosquitoes, flies, or other insects upon any land which exists by reason of any use made of the land on which it is found or any artificial change in its natural condition, is a public nuisance. The presence of mosquito, fly, or other insect larvae or pupae in any place shall constitute prima facie evidence that such place is a breeding place for mosquitoes, flies or other insects.

Pest abatement districts are also empowered to abate nuisances. Health and Safety Code Section 2856 states that:

> Any nuisance may be abated in any action or proceeding by any remedy provided by this article or any other law.

"Nuisance" is defined by Section 2800.5 in language similar to that of the mosquito abatement district act:

> As used in this chapter, "nuisance" means any breeding place for mosquitoes upon any land 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. The presence of mosquito larvae or pupae in any place shall constitute prima facie evidence that such place is a breeding place for mosquitoes.

Local health entities obtain power to abate nuisances by a more circuitous route. The State Department of Health is granted these general powers by the Health and Safety Code:

> 205. It may commence and maintain all proper and necessary actions and proceedings for any or all of the following purposes:
> (a) To enforce its rules and regulations.
> (b) To enjoin and abate nuisances dangerous to health.
> (c) To compel the performance of any act specifically enjoined upon any person, officer, or board, by any law of this state relating to the public health.
> (d) To protect and preserve the public health.
> It may defend all actions and proceedings involving its powers and duties. In all actions and proceedings it shall sue and be sued under the name of the State Department of Health.
>
> 206. It may abate public nuisances.

These powers are extended to the county health officer by Health and Safety Code Section 452:

> The county health officer shall enforce and observe in the unincorporated territory of his county, all of the following:
> (a) Orders and ordinances of the board of supervisors, pertaining to the public health and sanitary matters.
> (b) Orders, quarantine and other regulations, and rules prescribed by the State Department of Health.
> (c) Statutes relating to public health.

Other parts of the Health and Safety Code provide for incorporated areas. A city may contract with a county for health services (Sections 480, 481) or may have its own health officer whose powers are essentially the same as those of the county health officer (Section 504).

The basic definitions of "nuisance" and "public nuisance" are in the Civil Code:

> 3479. Anything which is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, or unlawfully obstructs the free passage or use, in the customary manner, of any navigable lake, or river, bay, stream, canal, or basin, or any public park, square, street, or highway is a nuisance.
>
> 3480. A public nuisance is one which affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal.

[1]Vector & Waste Management Section.

[2]Office of Legal Affairs.

In no instance or definition is it construable that the legislative intent was to deal with potential nuisances. In fact, both the mosquito abatement district act and the pest abatement district act use the word "exists". Further evidence that preventing nuisances was not the legislative intent is provided by the Health and Safety Code Section 458, which appears to limit preventive actions to emergency situations:

> The county health officer may take any preventive measure which may be necessary to protect and preserve the public health from any public health hazard during any "state of war emergency," "state of emergency," or "local emergency," as defined by Section 8558 of the Government Code, within his jurisdiction.
>
> "Preventive measure" means abatement, correction, removal or any other protective step which may be taken against any public health hazard that is caused by a disaster and affects the public health. Funds for these measures may be allowed pursuant to Sections 29127 to 29131, inclusive; and 5302 to 52023, inclusive, of the Government Code and from any other money appropriated by a board of supervisors of a county or governing body of a city to carry out the purposes of this section.
>
> The county health officer, upon consent of the board of supervisors of a county or the governing body of a city, may certify any public health hazard resulting from any disaster condition if such certification is required for any federal or state disaster relief program.

It is clear, then, that a vector control agency cannot utilize its powers to force nuisances not to be created. Equally clear are the powers to force existing nuisances to be abated.

We now turn to another statute. The California Environmental Quality Act (CEQA), Sections 21000 et seq., Public Resources Code, requires that documentation be provided of the significant environmental effects of a proposed project. There is to be time for concerned persons and agencies to comment. A vector control agency might review an environmental impact report and identify a potential vector problem. It should inform the agency responsible for the environmental impact report of this determination. If the vector problem is significant and there is a feasible way to modify the project to substantially reduce the severity of the problem, then the agency should not approve the project as proposed. Vector control agencies should focus their comments on the issues of whether there would be a significant problem and on whether there are feasible ways to modify the project to reduce the severity of the problem. CEQA, then, provides some remedies but does not empower a vector control agency to force a nuisance not to be created.

If a vector control agency is unable to force a nuisance not to be created, it must then either operate within existing law or seek legislative relief. The latter course is neither realistic nor necessary. It would go against the basic American concept of "innocent until proven guilty" to include legal sanctions against potential problems; it is highly unlikely that the legislature would provide such powers to vector control agencies.

Much more reasonable and palatable will be to continue, and if necessary expand, the current practice of informed professional review of planning documents, pointing out to the responsible individuals or agencies any foreseen problems. If such communication is met with recalcitrance, a brief educational session could point out the powers of the vector control agency to abate a nuisance should one be created. Any reasonable person will be convinced.

REVIEW OF 1977 LEGISLATIVE SESSION AND OUTLOOK FOR 1978

Robert Beckus

California Advocates

Sacramento, California

The firm "California Advocates" represents 21 firms on a contractual basis. Most of these firms are local governmental agencies such as the California Special Districts Association (CSDA), Southern California Association of Governments (SCAG), and the Association of Bay Area Governments (ABAG). I am President of California Advocates and I have a partner who is an attorney.

The only bill I recall ever being asked to carry for the mosquito control agencies was one requesting the addition of "vector control" to the Health and Safety Code. We had just introduced it when the Pest Control Association representative appeared to determine our motives. We calmed their fears by assuring them we were not imposing on their programs. A bill at the start of 1977 which would have affected mosquito abatement and other districts was introduced by Assemblyman Cullen of Long Beach. It would have eliminated all special districts and turned their programs over to the county boards of supervisors.

It has been my observation that mosquito abatement districts (MAD's) have been highly visible, and the costs are among the lesser charges of governmental programs as well as among the most effective.

The Jarvis-Gann Initiative, if approved by the people, will limit property tax assessments to 1% of the market value of property, and will limit any increase in appraisal value to 2% per year. I do not support this kind of measure but I prophesy the Jarvis-Gann Initiative will pass, because it received over 1,200,000 signatures, an unusually large number.

The Governor set up a special session for "tax relief". The ploy was to use the special session, in which a simple majority can pass a bill, rather than the regular session in which a 2/3rds vote is required to pass tax bills. The Legislature, however, became stubborn and refused to meet the Governor's deadline of January 27. The January 27 Bulletin of the League of California Cities stated "At this date the matter is at a virtual impasse. The purpose of the Governor calling the special session, aside from requiring fewer votes, was to try to get a bill to thwart the Jarvis initiative.

We lobbyists accept the Legislature as we find it. We have no problem finding authors for the bills of our clients. On the other hand, we are careful not to get a Legislator into a conflict with his constituency. One of our jobs is to develop a report on all bills which may have importance for special districts, identifying them and noting their status. Once a month we compile these bills in advance of the meeting of the Board of Directors of the CSDA and distribute them to this Board. The CSDA should have a representative sit with the CMVCA Board of Directors, and he should obtain information of importance to this Association.

Question: How can CMVCA work with CSDA and you for legislative matters?

Beckus: I started with CSDA 8 or 9 years ago. CSDA started with a crisis, and we came up with a reasonable solution. Since then we have carried a number of bills for various types of districts in the CSDA. There have been problems for CSDA, one of which being that so many districts would not participate. There are about 2,000 independent special districts in California, but most of them will get benefits yet will not have shared in the costs. Not long ago the organization diluted its efforts and funds into other programs, and some statewide Associations such as CMVCA refused to participate as Associations. It was hoped that CMVCA would contribute to CSDA, sit on the Board and have input. Problems in 1977 now seem to be resolved, and today I believe CSDA is stronger than it has ever been. For me, CSDA, with the various districts and associations, is a good account. I would note that 100% of the counties belong to the County Supervisors Association of California (CSAC), and 492 cities (100%) belong to the League of Cities. There are about 2,000 special districts but only about 350 belong to CSDA. Thus the districts do not have the same unanimity to approach the Legislature as do the counties and cities.

Question: One of the major issues for CMVCA has been "which way to go." We have tried to encourage the districts to participate in CSDA as individual districts, and many of them do. Another way is for CMVCA to participate with CSDA as an Association. A third way would be for CMVCA to work directly with your agency, the California Advocates. The CMVCA started in 1930 as an educational and professional association. For many reasons it has been desirable for us to be classified thus, as a non-profit corporation, with the Internal Revenue Service. How can we best be legal under IRS and still get the legislative information and assistance we need?

Beckus: The IRS test has always been whether a substantial amount of money goes to the legislative process - if so, you cannot get around the IRS tax requirements. I have worked with many organizations and they have not been challenged. I recommend that your Association, along with the Public Cemetary and the Park and Recreation Associations, contribute to the CSDA, which in turn will provide for my firm the appropriate amount. The goal was to have all the individual districts join CSDA, thus providing sufficient funds for operational expenses. I prefer to represent CMVCA through CSDA. If 100% of the mosquito abatement districts would participate in CSDA, the CMVCA contribution could be dropped. Your kind of agencies are my favorite level of government - you are the people in the neighborhood.

Question: Do you lobby the Governor's office - the administrative areas.

Beckus: Some of the time. However, to me the two houses of the Legislature are more important than the Governor's office. We are more interested in doing something positive for our clients than in just killing bills.

Question: What do you see as the legislative aftermath if the Jarvis initiative passes in June?

Beckus: I believe that before the Jarvis proposition passes there will be some kind of tax bill which makes more sense.

The Governor has much support from the business community. If the Jarvis initiative turns out to be an impossible act, the Legislature may be called into a special session this fall. Almost surely something will be worked out.

Question: Are there provisions in the Jarvis initiative to allocate the funds that are available?

Beckus: This is one of the unknowns. There are estimates that about $7 billion will have to be obtained from other sources. Some have suggested significant raises in the sales tax, but labor objects to this. The League of California Cities and CSAC are very much opposed to the Jarvis initiative. However, people are very concerned about the great increases in taxes on their homes and property and may take drastic, even unwise steps to get attention and relief.

BOARD OF TRUSTEES RESPONSIBILITY IN LABOR RELATIONS NEGOTIATIONS

Robert Dalton

San Joaquin Mosquito Abatement District

District Counsel

Post Office Box 1835, Stockton, California 95201

Typical meetings of governing boards of schools, mosquito abatement districts, or even county boards of supervisors were relatively simple in reviewing labor negotiations only a few years ago. For example, the boards might determine that the employees wanted more money, and would then decide whether to give it and if so how much. Those relatively simple days are over. Two years ago all labor negotiations in the public sector were covered by two new laws. All educational employees came under the Winton Act, which was called "meet and confer." All special districts, counties and cities came under the Myers, Milias, Brown Act, also called "meet and confer." The only obligations the trustees had was to meet and confer in good faith. Discussions covered wages, health benefits and working conditions.

In July, 1976, the Educational Employees' Relations Board and a new act, then SB160, came into law. All of the educational employees came under the EERB law. A three person Board appointed by the Governor was created to oversee what was called the replacement of the Winton Act. Activities were no longer "meet and confer," but were "collective bargaining." In 1978 EERB will be replaced by PERB (i.e., Public Employees Relations Board) which will cover all State employees. I believe the districts, the counties and the cities will soon be operating under the PERB and under the terms of collective bargaining.

There will be major differences. There will no longer be a simple memorandum of agreement; rather, there will be greater sophistication. Further, the people who represent the employees will be moving towards collective bargaining. It is no longer a question of salaries and how much, but of fringe benefits, of health and welfare, of working condition, and of whatever may be negotiable. There are many school districts which got along fine under the Winton Act. Their leaders believed they would have no trouble under collective bargaining, but that is a pipe dream! Many small districts failed to designate what was negotiable and even began negotiating wages under grievance procedures. The boards of trustees must not give up their rights through collective bargaining.

I was the legal representative of the San Joaquin Mosquito Abatement District for a number of years. The district manager did the negotiating, and that was effective until recently. At the present time more and more governmental agencies are hiring legal counsels for the negotiations, and the reason is simple. A long negotiating period in which the manager is involved can create animosity, making it difficult for the employees to work closely with him the rest of the year. A negotiator comes in, deals with the board and gets to know and understand its wishes, and then can deal effectively with the employees.

Two years ago I urged the San Joaquin MAD to establish an agreement with the bargaining agent. It is easier for a small district to deal with a single employees' organization. Trustees are finding that what used to be a simple process of dealing with employees is becoming very complicated. For example, they may come to a trustees' meeting and find 6 or 7 dissatisfied employees. The key is to have one group, association or union organize the employees, establish an employee's representative, and then have the manager get an understanding with that representative. This does two things - it makes the employee representative feel it is not the employees versus the board, and it makes the employees feel that management is listening to their concerns.

What are the important things in negotiations? Trustees can get hung up on negotiations quickly by not understanding what the employees think is important. They know that a discussion on wages will be included. There may be a couple of other items which the employees consider important, but other items are just there; if they are approved, fine, if not, they were not of much concern. The board and the negotiator decide what items are important to the district.

When I negotiate, I go to the employees and say: "My Board is concerned about health care." I expect the board to back me up. As a result, in part, of malpractice and insurance problems, health care benefits have skyrocketed rather drastically. The Board needs insight into how important this item is to the employees. What will they give up for health care for themselves and their families?

Boards should be careful when they draw up a contract. If they put into a contract that they will give health care for the employee and his dependents, that is set in concrete. The board will not be able to take it away unless it is in the contract that the matter may be renegotiated if costs become excessive. There is a push for multi-year contracts. This may have advantages because it may be written in the contract that wages will not be negotiated again for another two years.

The threat of a strike should not concern too many mosquito abatement district boards, because they may be able to get an injunction to stop it. For California public employees to strike has been said to be illegal, but that is not the way the courts have handled it. They have simply stated that there was no provision to strike. If a district had a strike and fired everyone, it could possibly get away with it, but I do not know what would happen to the district. The key is for the district labor negotiator to build up enough rapport with the employees' representative and union or group so that issues will be discussed in a productive manner.

There are many boards which take the position that they are the guardian of the taxpayers' money and therefore will not spend any of it on the employees. It would be much better if they took the position that they are the representatives to more effectively and efficiently provide mosquito control services to the citizens of their respective districts. The San Joaquin County Board of Supervisors got itself into a difficult position several years ago by saying: "We are not going to give any more money because we do not have it." A fact finder was brought in and he found money and the Supervisors were chagrinned. Trustees should be certain they understand their budget before they make challengeable statements. For one thing, they should understand the need for contingency planning.

If collective bargaining comes to our districts, "good faith" may fade away, to be replaced by "unfair labor practice." Thus unfair labor practice may be filed for each little item. Today the employees can say that the trustees are not bargaining in good faith. Good faith is simply a willingness to proceed with negotiations. If the employees put a package on the table and the trustees start with "no" and end with "no," that would be very hard faith. The trustees simply cannot start at 0 and end at 0 all through the negotiations.

When trustees get involved in areas of collective bargaining, they will be involved in deciding what is negotiable. A typical collective bargaining bill such as EERB states that there are many things beyond just wages (e.g., working conditions, health care, safety matters, hours). The Superintendents of schools in California today have the greatest experience in collective bargaining in the public sector, and I recommend that district managers get information on problems and procedures from them.

If a district does not have an impasse procedure, I recommend that it start working on one. It will need to know what it will do in the event that negotiations come to a halt. Districts also will need to know more about processing grievances. The only way a district can assure success in discharging an employee is by having a good employee evaluation system.

State Personnel Board cases have verified that it is difficult to get rid of public employees, and if a district fails to handle a case right procedurally, it will fail to get rid of the employee.

District trustees should review past memoranda of understanding and verify that they represent current board policies. More and more areas of society will be encroaching on what the boards may have considered their fundamental rights (i.e., affirmative action, civil service policies, personnel policies, etc.)

Question: Should a district board hire an outside negotiator?

Dalton: That depends on the board and its relations with its employees. If negotiations used to take 3 to 6 weeks and now are taking 6 months, the board should seriously consider hiring an outside negotiator, otherwise the manager may be spending too much time negotiating.

Question: Is there a trend for hiring a full time person as a negotiator rather than a part time person for just that portion of the year when negotiations actually occur?

Dalton: I believe a district can get someone on a retainer basis to handle the hard core aspects of negotiations without having a full time person. He should not be an employee of the district, as he may become too unpopular to be effective.

Statement: Contra Costa MAD two years ago hired an outside negotiator on a retainer basis and we believe this is one of the best things we have done. It is a more sophisticated, professional approach. Trustees are part time persons who want questions about negotiations answered properly and timely.

Question: How comprehensive should a memorandum of agreement be?

Dalton: I am for simple contracts, but with collective bargaining many items may need to be set down in writing There will be possible errors in interpretations by lawyers. Many school district contracts are now up before the EERB Board saying: "This is not what we meant."

Statement: Our manager knows every one of his men. When we get too sophisticated we will not even know our men except by their names. We should try to do these things by ourselves to prevent the strifes from happening. We need to ask ourselves how we can avoid some of these troubles.

Statement: Conditions today are changing. Despite the fact that we may have excellent rapport with our staffs, one day an employee will say he is dissatisfied and will go to a union representative. Also, a lot of our problems will come from the outside rather than from the inside.

Dalton: The larger the district, the more likelihood of people coming in from other areas who have different ideas about what labor negotiations mean. When collective bargaining comes, district boards will be regulated by a state board and that board will make the decisions. That is coming! A big point in collective bargaining is who will run the agency - the Board of Trustees or the employees.

MOSQUITOES' RIGHT TO PRIVACY

Robin L. Rivett

Pacific Legal Foundation

455 Capitol Mall, Suite 465, Sacramento, California 95814

I am here today to discuss with you the application of the Fourth Amendment to the United States Constitution and what it means in regard to the successful enforcement of the rules and regulations and responsibilities of mosquito abatement and vector control districts in this state.

Of course, to obtain a thorough understanding of the Fourth Amendment would take a scholar many hours of study but we will attempt to discuss the foundations of the amendment and the development of its application in such a manner as to give you a certain sense of understanding as to its crucial content. The Fourth Amendment reads as follows:

> "The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized."

In order to determine what proceedings were intended by the Fourth Amendment to be classified "unreasonable searches and seizures," a brief historical reference is appropriate. Let me refer to a case entitled, **Boyd v. United States**, 116 U.S. 616 (1885). This case presents concisely the historical background of the Fourth Amendment referred to above.

Boyd states in reference to unreasonable searches and seizures: "it is only necessary to recall contemporary or then recent history of the controversies on the subject both in this country and in England. The practice had obtained in the colonies, of issuing writs of assistance to the revenue officers empowering them in their discretion, to search suspected places for smuggled goods, which James Otis pronounced, "the worst instrument of arbitrary power, the most destructive of English liberty and the fundamental principles of law, that ever was found in an English law book;" since they placed "the liberty of every man in the hands of every petty officer." This comment was made in February, 1761, in Boston and the famous debate in which it occurred was perhaps the most prominent event which inaugurated the resistance of the colonies to the oppressions of the mother country. "Then and there" said John Adams, "then and there was the first scene of the first act of opposition to the arbitrary claims of Great Britain. Then and there the child Independence was born."

"Events which occurred in England immediately following the argument about writs of assistance in Boston were very fresh in the memories of those who achieved their independence and established our form of government." **Boyd v. United States**, 116 U.S. at 626. In England warrants had been issued for the purpose of locating the publishers of articles critical of the throne. Warrants specific as to the items sought but indiscriminate as to the persons and places subjected to it were struck down for creating a "discretionary power given to messengers to search wherever their suspicions may chance to fall." In the case of **Entick v. Carrington and 3 other Kings Messengers**, a warrant specific as to the person but general as to the papers to be seized was also held unlawful. **Entick**, 19 Howell, St. Tr. 1029. The **Entick** decision was later termed by the Supreme Court of the United States as "one of the landmarks of English liberty." These historical antecedents are quite simply the underpinnings of the Fourth Amendment.

Since the formative years and in most recent years, the interpretation of the Fourth Amendment by federal judicial decisions has been in a dynamic transformation. It appears that in recent years the government's efforts in promoting health, safety and welfare have necessitated an increased number of administrative inspections of commercial and noncommercial premises. It is this trend and the court decisions dealing with them on which focus will be placed herein.

Beginning in 1869 the lower federal courts consistently held that the Fourth Amendment applied only to criminal investigations and refused to bring persons subjected to administrative searches within the ambit of its protection. Similarly at the state level, the attacks on the constitutionality of warrantless administrative inspections were rejected. Finally, in 1949, in the case **District of Columbia v. Little**, 178 F. 2d 13 (D.C. Cir. 1949), the warrantless administrative inspection was seriously considered by the court. In that case a homeowner refused to allow a health inspector to enter his home without a warrant. The homeowner was convicted of having hindered, obstructed and interfered with an inspector of the Health Department in performance of his duties. The conviction was reversed and Judge Prettyman emphasized the right of privacy which must be accorded the home:

> "The basic premise of the prohibition against searches was not protection against selfincrimination; it was the common law right of a man to privacy in his home, a right which is one of the . . . essentials of our concept of civilization . . . it was not related to crime or to suspicion of crime. It belonged to all men not merely to criminals, real or suspected . . . to say that a man suspected of a crime has a right to protection against search of his home without a warrant but that a man not suspected of crime has no such protection is a fantastic absurdity."

Essentially, this was the first time that the protections of the Fourth Amendment were applied to administrative searches.

This certainly was not the final or permanent ruling from the judiciary, but is was not until 1959 that the United States Supreme Court definitively decided **whether** the Fourth Amendment's warrant requirements encompassed administrative inspections. In **Frank v. Maryland**, 359 U.S. 360 (1959), in a five-to-four decision, the court found that a search warrant was not necessary to enter a residence to investigate sanitary conditions. In that case, an inspector from the Baltimore City Health Department requested permission to inspect Mr. Frank's basement area because the Department had evidence of a rodent infestation in the home. The time and extent of the search were reasonable but Mr. Frank refused entry without a warrant. Mr. Frank was fined and the court upheld both the fine and the clearly established rule that the Fourth Amendment did not apply, where the search was pursuant to an administrative inspection of premises where health and safety considerations were involved.

This doctrine was well established and was not overturned until 1967 in the Supreme Court decisions of **Camara v. Municipal Court**, 387 U.S. 523 (1967), and **See** v. **City of Seattle**, 387 U.S. 541 (1967). It is important to note that by 1967 the composition of the Supreme Court had changed. The court had two new members. The two members lost were among the majority in the **Frank** decision. The two new members sided with the four dissenting members in the **Frank** decision and formed a six-to-three majority in these two new cases.

In **Camara** and **See**, the Supreme Court held that administrative inspections of commerical and non-commercial premises are generally subject to warrant requirements of the Fourth Amendment. In **Camara**, an inspector of the Division of Housing Inspection of the San Francisco Department of Public Health entered an apartment building to make a routine annual inspection. The building's manager informed the inspector that Mr. Camara, lessee of the ground floor, was using the rear of the premises as his personal residence. This apparently was not permitted in the building's occupancy permit and the inspector demanded access. Mr. Camara refused because there was no search warrant. Mr. Camara was convicted of violating Section 507 of the San Francisco Municipal Code for refusal to comply with the order of the Director of Public Health. The Supreme Court reversed this ruling and stressed the following:

> "The Fourth Amendment's prohibition against unreasonable searches and seizures is to safeguard the privacy and security of individuals against arbitrary invasions by governmental officials."

No distinction was made for the inspection purposes, whether it be to gather evidence pursuant to criminal or civil matters.

The opinion emphasized four fundamental principles:

1. The Court stated that except in certain narrowly defined situations, any search of a private property without proper consent is unreasonable unless authorized by a valid search warrant. Essentially, the court stated that citizens subjected to administrative inspections are entitled to the same protections as individuals subjected to searches directed at criminal behavior.
2. The degree of probable cause needed for the issuance of an administrative inspection warrant is considerably less than that required for a criminal search warrant. The court found that the individual's right to privacy must be balanced against the reasonable and valid purpose of inspections to insure public health and safety. In view of this the court stated that probable cause to issue a warrant to inspect exists "if reasonable legislative or administrative standards for conducting an area inspection are satisfied with respect to a particular dwelling." **Camara**, 387 U.S. at 538.
3. Area code enforcement inspections are on their face reasonable (with warrant). The permissibility of these inspections was founded upon these facts: 1) area code enforcement inspections have a long history of judicial and public acceptance; 2) the public interest demands that all dangerous conditions be prevented or abated; and 3) these inspections constitute a limited invasion of the "urban citizens" privacy because they are neither personal nor criminal in nature.
4. The court stated that prompt warrantless inspections in response to an emergency are not proscribed. The court also indicated to avoid the administrative nightmare of always having to procure a warrant, it was permissible to seek a warrant only after entry had been refused by the occupant.

In the companion case to **Camara**, that of **See v. City of Seattle**, 387 U.S. 541, the Supreme Court applied the Fourth Amendment warrant requirements to commercial structures. Therein a representative of the City of Seattle Fire Department sought to enter and inspect a locked commercial warehouse as part of a routine citywide program to obtain compliance with the City's fire code. The inspector did not have a warrant or reasonable cause to believe that any fire code violations existed. Mr. See, who refused entry, was convicted of violating the Seattle Fire Code and received a suspended fine. In reversing the conviction, the Supreme Court relied heavily on the rationale of **Camara**. The court stated:

> "The businessman, like the occupant of a residence, has a constitutional right to go about his business free from unreasonable official entries upon his private commercial property. The businessman, too, has that right placed in jeopardy if the decision to enter and inspect for violation of regulatory laws can be made and enforced by the inspector in the field without official authority evidenced by a warrant."

The court further stated that administrative entry, without consent, upon the portions of commercial premises which are not open to the public may only be compelled through prosecution or physical force within the framework of a warrant procedure. "We do not in any way imply that business premises may not reasonably be inspected in many more situations than private homes, nor do we question such accepted regulatory techniques operating a business or marketing a product." **See**, 387 U.S. at 543-46.

By the decision the court apparently established three additional exceptions to the warrant requirement:

1. Where there is consent;
2. Where there is an inspection conducted pursuant to a valid licensing program; and
3. Where the workplace is open to the public view.

A quick review of these exceptions to the **Camara** and **See** rules requiring warrants before administrative searches may proceed, may be helpful.

The first exception is emergency. The court in **Camara** stated:

> "Nothing we say today is intended to foreclose prompt inspections, even without a warrant, that the law has traditionally upheld in emergency situations." **Camara**, 387 U. S. at 539.

According to this traditional view, exigent circumstances eliminate the warrant requirement because the urgency of an immediate search outweighs the right to privacy. But, this emergency exception is invoked only in the most extreme cases. The court in **Camara** cited the following situations as constituting genuine emergency:

1. Seizures of unwholesome food;
2. Compulsory smallpox vacination;
3. Health quarantine; and
4. Summary destruction of tubercular cattle.

The courts have also justified warrantless searches under the following emergency exceptions:

A man, later determined to be diabetic, was unconscious in a hospital. The police, attempting to obtain identification and information related to the cause of his condition, opened his briefcase and found stolen money.

Another case dealt with a firearms dealer known to possess large quantities of firearms, whose home was located near a hotel where President Lyndon Johnson was staying. The finding that the Secret Service had the right to make warrantless inspections in protecting the President from physical harm was upheld on appeal.

And finally, in another case, it was held that evidence of the commission of arson was properly admitted into court because it was initially discovered during a fireman's emergency entry into the arsonist's home in order to extinguish a fire and rescue victims.

As indicated, therefore, only truly extreme exigent circumstances justify this exception. Attempting to claim emergency circumstances to the routine area inspection of the mosquito abatement districts would be improvident and unsuccessful.

The second exception to the warrant requirement is consent. As was quoted from **See** previously, the court concluded that administrative entry without consent may be compelled only through the warrant procedure. The implication, obviously, is that with consent the warrant is not required. Of course, the most immediate question is what standards of consent are we dealing with.

The leading case on consent, **United States** v. **Thrifty Mart, Inc.**, 429 F.2d 1006 (9th Cir. 1970), adopted a standard less stringent than that required for determining consent in criminal cases. It is clear from that case that casual consent, which would be insufficient by the criminal law standard, would be sufficient by the administrative inspection standard. The reason is as the court stated:

> "The consent to an 'administrative' inspection is not only not suspect but is to be expected. The inspection itself is inevitable. Nothing is to be gained by demanding a warrant except that the inspectors have been put to trouble - - an unlike aim for the businessman anxious for administrative good will." 429 F.2d at 1009.

Thus, the prevailing rule seems to be that consent to an administrative inspection need not be expressed, but where there is evidence of intimidation, coercion, or misrepresentation, courts will find consent to be invalid.

The third exception is based upon an implied consent or licensing exception. This exception has been applied in a number of cases since the **See** decision, the most noteworthy being **Colonnade Catering Corporation** v. **United States**, 397 U.S. 72 (1970), and the **United States** v. **Biswell**, 406 U. S. 311 (1972).

In **Colonnade**, a federal agent, who was a member of the Alcohol and Tobacco Division of the IRS, was a guest at a party in the catering facility of Colonnade. The agent noticed a possible violation of federal excise law and when federal agents revisited the establishment another party was in progress during which liquor was being served. Without consent, an inspection was made of the cellar, and the manager was asked to open a locked liquor storeroom. When refused, the agents broke into the storeroom and seized bottles of liquor suspected of being illegally refilled. The Supreme Court held that the bottles had been illegally seized but nevertheless concluded that the federal statute which authorized such a search was constitutional.

The Supreme Court found that in light of a long history of governmental control that Congress was vested with authority to fashion reasonable standards for inspections, incident to liquor industry regulations. **Colonnade** relied heavily upon the unique historical origins of governmental liquor regulations to find a reasonable search.

Biswell extended **Colonnade**. Biswell, a pawnshop operator, was a federally licensed dealer of sporting weapons - - guns. A federal treasury agent asked to inspect Biswell's locked gun storeroom but was denied absent a warrant. Biswell acquiesced after being informed that the agent had the authority, whereupon two sawed-off rifles were found in Biswell's storeroom. The Supreme Court, avoiding any question of consent, stated:

> "In the context of a regulatory inspection system of business premises which is carefully limited in time, place, and scope, the legality of the search depends not upon consent but on the authority of a valid statute." 406 U.S. 315.

It appears that Biswell negated the consent requirement for a warrantless search when it is specifically authorized by statute. The statute in **Biswell** was the Gun Control Act of 1968 and the court in reference to this further stated:

> "Federal regulation of the interstate traffic and firearms is not as deeply rooted in history as is governmental control of the liquor industry, but close scrutiny of this traffic is undeniable of central importance to federal efforts to prevent violent crimes and to assist the states in regulating the firearms traffic within their borders."

Therefore, the court relied only in part upon the historical origins of governmental control of firearms. The court also relied upon the reasoning that to not require search warrants was justified in order to insure the most effective enforcement of the law. In other words, a warrant requirement may have frustrated the congressional purpose in regulating the specified activity. The second reason suggested by the court was that by engaging in a "pervasively regulated business" the individual has waived Fourth Amendment rights and implicitly consented to warrantless administration inspections. **Biswell**, 406 U.S. at 316.

Since these decisions, federal court appeals have upheld the validity of warrantless inspection and seizure of a pharmacist's records when conducted in accordance with state law, even where the statute permitting such administrative search failed to limit the inspection to business hours or to confer authority on agents to use force. The court indicated that the scope of the search was sufficiently limited by the statute to orders, prescriptions or records relating to narcotic, depressant and stimulant drugs. Therefore, the court found a warrant unnecessary. The court stated:

> "The warrant which would be issued for the asking, would simply track the statute and would give the person who was the object of the search nothing more than he already had." **See United States ex. rel Terraciano v. Montanye**, 493 F.2d 682, 685 (2d Cir. 1974).

The licensing exception was further extended **in Youghiogheny and Ohio Coal Company v. Morton**, to include an unlicensed but regulated industry. It can be seen that the decisions in **Colonnade** and **Biswell** have been significantly extended and have expanded the licensing exception delineated in the **See** decisions.

The fourth exception would apply to areas open to public view. The court stated that administrative inspection without consent upon the portions of commercial premises which are **not open to the public**, may only be compelled through prosecution or physical force within the framework of a warrant procedure. This language has been interpreted to mean that a warrant is not required where the premises are open to the public, and is consistent with the well settled rule that merely observing what is open to public view does not constitute a search. The most important factor in applying this doctrine is to consider whether an individual or business has a reasonable expectation of privacy even though the individual or business is in an area open to the public.

Open view searches may generally be divided into two classes: 1) plain view searches; and 2) open field searches. The plain view doctrine holds that an officer or other official may lawfully obtain any evidence that is within plain view if the officer or official had a legal right to be in the location from which the observations were made. The open fields doctrine is explained in **McDowell v. United States**, 383 F. 2d 599, 603 (8th Cir. 1967):

> "Although the Supreme Court has recently expanded the Fourth Amendment protection of the business enterprise . . . it has not expanded such protection beyond that which a private dwelling can obtain; the privilege thereof is likewise entitled. Therefore, a search of open fields, without a search warrant, even if such fields are construed as part of the commercial enterprise, is not constitutionally unreasonable."

The trend in open fields cases has been to uphold the seizure of any evidence either on or in the ground even if concealed or hidden unless the particular area in question is intimately related to a protected area.

The most important case involving an administrative inspection under this doctrine is **Air pollution Control Variance Board v. Western Alfalfa Corporation**, 416 U.S. 861 (1974). There an inspector of a division of the Colorado Department of Health entered the outdoor premises of the company without its knowledge or consent in order to take readings of smoke coming from the plant's chimneys. In subsequent proceedings the company argued that the inspection violated the Fourth Amendment. The Supreme Court unanimously disagreed emphasizing that the inspector did not enter the plant or offices; the inspector cited what anyone in the city who was near the plant could see; and it was not shown that the inspector was in an area from which the public was excluded.

Among the other circumstances which permit warrantless administrative inspections are airport security searches, border searches (both by way of immigration checks and customs inspections), and inspections made as a result of receiving government gratuities. The concept of government gratuities has the most potential for being a widely applied exception to the general rule requiring warrants.

The leading case is **Wyman v. James**, 400 U.S. 309 (1971). It involved the home visitation requirement of New York's Aid to Families with Dependent Children program. There the welfare worker was denied entry and in response the aid to the family was curtailed. The court focused on the basis of the inspection statute which was that: 1) the inspection furthered the paramount needs of the dependent child; 2) it was only reasonable that the public should be permitted to determine if its funds are being used in the proper manner; and 3) the visitation was not an unnecessary intrustion of the beneficiary's rights in her home because the visitation was made by appointment, at a reasonable hour, and with no forcible entry and no snooping; 4) that the search provided essential information not obtainable from secondary sources; and most crucially 5) the visit was not oriented towards criminal investigation. Failure to permit the inspection could not result in a criminal sanction.

This last reason indicates that were a mosquito abatement district employee to make a warrantless inspection of someone's backyard and were there no potentials for criminal sanctions, this would be entirely legal especially in view of the public interest and need for the inspection, it of course being for the protection of publich health and safety.

It is apparent that the state of the law for administrative investigations may be in flux, but in relation to mosquito abatement investigations is fairly well settled. Presently proceedings through the courts is the case entitled **Marshal v. Barlow's**, which deals with the question of warrantless inspection of a business by agents of the Occupational Safety and Health Administration. There have been federal decisions extending the finding that Fourth Amendment protections are not required but **Barlow**'s found just the opposite. It is now before the United States Supreme Court. Without question, this Supreme Court decision on the application of the Fourth Amendment will go a long way towards defining the limitations of Fourth Amendment protections as applied to administrative investigations.

Let me summarize briefly for you the status of Fourth Amendment protections in the administrative area. Since 1967 and the **Camara** decision, the limitation of administrative searches of private residences has had vitality. The decision found that even in administrative investigations a warrant was required but that it was much easier under the circumstances to satisfy probable cause for requiring a warrant than in a criminal matter. The court also found that area code enforcement inspections were *prima facie* reasonable and that prompt warrantless inspections in response to an emergency situation were permissible.

See dealt with the administrative inspection of a business. It extended to the business area the protections of the Fourth Amendment as outlined in **Camara**, but found explicitly three exceptions in addition to the emergency exception articulated in **Camara**. These were: 1) consent; 2) workplace open to public view, which can be divided into the two subareas of the plain view doctrine and the open field doctrine; and 3) an inspection conducted pursuant to a valid licensing program or implied consent. There are other areas permitting administrative search without warrant and these are: airport security searches, border searches, and situations involving government gratuities. Of significance in the area of government gratuities is the rationale that an inspection made where there is no potential for criminal liability needs no warrant.

With requirements of **Camara** and **See**, and the exceptions thereto in mind, the important question is what is sufficient for probable cause to require a warrant. In **Camara**, the court held that the probable cause standard for the issuance of a warrant was demonstrably less stringent in administrative inspections than in criminal investigations. "Where reasonable legislative or administrative standards have been adopted, the probable cause requirement imposed by the Fourth Amendment will, without more, be satisfied," 387 U.S. at 538.

In other words, an administrative inspection warrant may issue despite the absence of probable cause to believe that a specific violation has occurred so long as the inspection is made pursuant to valid statutory authorization. In one case challenging the sufficiency of the warrant, the First Circuit noted that the application for the warrant disclosed: 1) that an agent's personal examination indicated that there was a possible violation of the law; and 2) that the defendant's premises had not been inspected within the last year. The court stated that a warrant issuing upon either of these two operative facts would easily comport with existing administrative and legislative inspection criteria, and would thus be reasonable under the Fourth Amendment. So, an administrative inspection warrant may be issued upon a mere showing that the inspection is authorized by statute and is subject to reasonable legislative or administrative regulations.

Referring back to **Camara**, it is essential to recognize that the court realized a valid governmental interest in preventing conditions hazardous to health and public safety. The court **balanced the need** for the inspection against reasonable goals of code enforcement and found area inspections the only effective way of assuring compliance. The court recognized probable cause as the constitutional measure of reasonableness and because of the nature of code violations determined that an inspector's decision to search must be based upon the area's condition and the passage of time, not upon knowledge of each building's particular condition. Arguably, the court's analysis requires that first the court must make a general determination of the inspection's reasonableness and then specifically determine whether the requested inspection is part of an authorized inspection program.

It thus appears a magistrate who is issuing the warrant must decide only 1) whether there is an established area inspection policy and 2) whether the requested inspection is consistent with that policy. If so, a warrant should issue.

In summary, application of the case law cited to above as applied to general inspections by mosquito abatement districts would appear to require warrants for areawide inspections which are not subject to the plain view or open field doctrines, or no warrants if the areas to be investigated are subject to these doctrines or other exceptions. Attention must also be paid, though, to California statutes. California has codified the requirements of **Camara** and **See** in the Code of Civil Procedure SS 1822.50, *et seq.* This administrative warrant statute must be read in conjunction with all statutes authorizing agency inspections. Case law has found that without a warrant requirement the statute authorizing inspection would be unconstitutional. See **Vidaurri** v. **Superior Court**, 13 Cal. App. 3d 550 (1970). There a state agricultural inspector went to a residence to inspect citrus trees for pests. He found no one home but entered the yard through an unlocked gate. There he found a stand of marijuana, which he turned over to the police. The court found:

> "One who surrounds his backyard with a fence and limits with a gate, locked or unlocked, has shown a reasonable expectation of privacy for that area and it is protected from unreasonable government intrusion or a search without warrant, unless the circumstances excuse the warrant." 13 Cal. App. 3d at 553.

The agricultural inspector was acting pursuant to the authority of Agricultural Code Section 5023 which stated that the Commissioner whenever necessary may enter and make an inspection of any premises, plant or thing in his jurisdiction. But the court ruled that this statute is subject to the overriding mandate of Code of Civil Procedure Sections 1822.50 through 1822.56 which permits inspection by a health officer only upon issuance of a warrant. The court cited **Camara**, stating that without a warrant requirement the statute authorizing inspection would be unconstitutional. Inasmuch as the analysis in **Vidaurri** was based on **Camara**, the exceptions to **Camara** would still have vitality and would apply in a state case such as **Vidaurri**.

The case **Currier** v. **City of Pasadena**, 48 Cal. App. 3d 810 (1975), also addressed this issue of administrative inspections and spoke of a possible exception to the warrant requirement, that of great public necessity. The standard to justify this exception would be a showing that a warrant requirement would frustrate the governmental purpose behind the search. As applied to inspections for vector infestations, there would have to be a showing that the warrant requirement would make it impossible to carry out abatement responsibilities. If it would only cause administrative inconvenience, there would not be justification to relax the warrant requirements.

If an exception cannot be found, a warrant will be mandatory for inspection by the district. The procedure that must be followed for obtaining the warrant appears to be codified in Code of Civil Procedure Sections 1822.50 *et seq.*

In conclusion, it appears that the mosquito abatement districts are not authorized warrantless searches, pursuant to Health and Safety Code Section 2270(f), without a valid exception such as consent.

Compliance with the warrant procedures of Code of Civil Procedure Sections 1822.50 *et seq.*, is required absent an exception. As the court has said, as of this date administrative convenience does not justify intrusion into a person's privacy.

SELF INSURANCE FOR DISTRICTS

Roy Wolfe

Madera County -- County Counsel
%Madera County Mosquito Abatement District
900 North Gateway Drive, Madera, California 93637

A year ago I recommended that the mosquito abatement districts, through the California Mosquito and Vector Control Association (CMVCA), consider a course of action relative to self insurance. In April a seminar was held in Monterey to discuss the needs, problems and procedures, and a committee was formed. The committee sent a questionnaire to the districts and received a reply from 18 of them. On the basis of the returns, I estimate that all districts in California in the past 7 years paid about $1,600,000 in liability insurance premiums and that claims paid were about $71,000. Simple 5% interest on the premium payments is $80,000 which alone would have paid for the claims without ever using the principle. This would indicate that a joint effort by all or a good portion of the districts could have accomplished a very substantial saving.

Unemployment insurance was adopted into law on January 19, 1977 and February 27 was designated as the date when a choice of one of four options had to be made. Mosquito abatement districts typically employ workers for 6 or so summer months and then lay them off for the winter. These workers are now entitled to unemployment insurance. Therefore the districts will have to pay into a fund that will be lumped together with private industry. It will be very expensive. You can take one of the options, but be able to change it to another option sometime in the future. The districts can try to reduce the costs by working together to change the method of payment, changing the options, or perhaps even changing the legislation.

The most attractive field for self insurance is workman's compensation. This is probably the most predictable insurance relative to long run expenses and reserves because the industrial accident commission has a specific amount that is paid for specific injuries. There are specific records of how many employees are hurt on the average, and of course each district has its own individual records. I do not think hazards in mosquito abatement programs are as great as in many other work situations. The only area in which you might have had particular difficulty in the past is with insecticides, and today with closed systems that hazard has been reduced. The reduction of sources also makes the mosquito control program safer. Therefore the districts have now reached a point where they should consider a whole plan for insurance.

One or two districts alone could not develop a self-insurance plan, but a majority of the districts could very easily accomplish this in a joint action -- joint powers. For instance, the Madera MAD has a budget of about $270,000. That district could not afford self-insurance because one claim or accident could paralyze it. I will note again that the districts do not have to make immediate payments -- they would have up to 10 years to pay a judgment. The biggest problem is in the negotiating, administering, and the incidental costs. If these can be pooled, self-insurance can be accomplished. The program would provide that:

1) each district would be liable for its own losses;
2) one district would not be carrying the liability of another district;
3) each district would contribute in proportion to its budget;
4) the only thing that would be shared would be the investment of the money and the use of the pool as needed.

Local insurance agents have usually been friends of the districts in the past. They will want to continue selling insurance so they may try to discourage the districts from going into self-insurance. However, they do not have the legal background to put together a self-insurance program for all the districts.

Question: The city of Stockton together with the county of San Joaquin have an insurance agent. He has tried to get the best policy at the lowest price. We asked him to help us. Last year our district paid over $3,000 for airplane liability insurance, but this year the cost will be about $8,000. Further, only one company will provide this coverage, and in fact is not even interested in us. What can we do?

Wolfe: This is typical of the problems which we can solve by working together. For example, the county of Madera could not buy any liability insurance and was forced to become self-insured. I wish we could join with other counties so that we could help each other, but to date there has been no interest among the counties. While the county of Madera is small, it has done well to date. Most MAD's, however, are much too small individually.

Question: 18 out of 45 districts responded to your survey. Would these 18 be able to afford joining together? If so, how can we implement it?

Wolfe: The 18 districts paid $587,000 in premiums and $26,000 in claims. I believe that about one third of the districts could carry self-insurance under joint powers.

I am about to retire and am interested in starting a consulting service for self-insurance. I will be glad to help put together a plan, if you wish me to.

Question: At this time will we consider liability insurance alone, or also workman's compensation?

Wolfe: It is logical to consider them both at the same time. The districts will be building a reserve for the first several years, and the one reserve pool can be used for both types of insurance.

Question: Can we include unemployment insurance?

Wolfe: There are many unresolved issues in the unemployment insurance program. It may be several years before we receive answers from the courts. It might be best to work this into the self-insurance plan. At the same time, I believe it would be wise to contest issues you do not like every inch of the way.

Question: Would your plan call for an educational program in risk management to control claims?

Wolfe: More than that! You would have to agree not only to an educational program but in some cases to compulsory requirements, particularly in workman's compensation.

Question: Would we in self-insurance have an excess limits or umbrella coverage?

Wolfe: Counties and cities are being forced to self-insurance, but they cannot now get umbrella coverage. Insurance companies have been losing business and may be willing in the future to provide this coverage, but at present their premiums are too high. It would seem reasonable to build into our plan an excess limit insurance for workman's compensation because it is available and resonable. In liability insurance I do not believe we are ready for the excess limits but may be so soon.

Question: In event an accident results in a big loss and the district cannot make the payment under self-insurance, what liability falls on management or trustees?

Wolfe: If the management and trustees are performing their duty within the scope of their authority, there is no personal liability, even if a lawsuit names them as individuals. The district would pay to defend, and would pay any judgement. The scope of authority is wide, and only if it were very clear that the matter was not district business would they be personally liable.

Question: Would the districts in self-insurance have to have contiguous borders?

Wolfe: No.

There are many details which will need to be worked out. The districts should start developing plans now. After the plans are in rough draft form, I could take them to the CMVCA Regions where we could have an all day session to develop a suitable method of coordination of the districts.

Question: Is there adequate legislation presently for self-insurance by our districts?

Wolfe: Yes, there is no question that Ken Maddy has been of tremendous help in the field of self-insurance for districts and other public agencies. He obtained some of the very best legislation we could get. We now have statutes which state specifically that districts can join together for liability, for workman's compensation, and for unemployment insurance.

Question: What would be the time factor before we could be in operation on self-insurance?

Wolfe: We cannot decide this until we review the program with each Region. I would hope that by July 1 we can be moving into the program.

Question: How would you envision the administrative setup?

Wolfe: The best procedure would be for all the districts in the State to adopt one plan. One Board of Directors would handle the calculations, determine how much money each district will contribute, what funds are borrowed, and how to invest the funds. There will be a lot of bookkeeping and some legal management on claim handling. Every district should have a representative on the Board of Directors. A small Executive Board of 5 members perhaps could run the day to day business. They could hire one adviser to help them operate the plan, and a part-time administrator.

Question: Could we establish this as subsidiary of the CMV-CA and still preserve the independent rights of the districts to join or stay out as they see fit?

Wolfe: I think so. The organization would be on a joint powers relationship, or it could be handled on a contractual basis with the Association.

Question: What are the risks of self-insurance?

Wolfe: In regular insurance from a company, the company determines how much to charge based on what it believes the liability is and thereafter the district has few if any worries. If a claim occurs, the case is turned over to the insurance company and the district forgets it. This is a serious fault of district managers and trustees. In self-insurance, on the other hand, the districts must be aware of risks and take steps to reduce them. They must operate carefully and precisely. The advantage of self-insurance is destroyed if the districts do not pay close attention to safety procedures. If a claim occurs, the district may pay, may refuse to pay, or may fight the case. In self-insurance, the Executive Board would contact the Board of Trustees of an affected district, offer advice, and determine what action the Trustees prefer. The key which the districts do not now have with insurance companies is the direct participation in what if any money may be paid and on what basis.

Statement by James W. Bristow: The Contract Cities Association of California, which consists of some 35 cities, started on this problem two years ago. We hope to have over 30 cities insured under a joint powers agreement. We employed an insurance consultant and set up a fee schedule. The date of the start of insurance will be July 1, 1978. We had over 50 cities that were interested, and over 30 have accepted the program and are paying. The pool of money is developing, and we will have an umbrella over it, I believe for $1,000,000 or perhaps more. The self-insurance will be for anything under the umbrella. The Cities Association has employed counsel and consultants who have developed the program and who are still working for the Association. I sincerely advise the CMVCA to pursue this program. The seed money, which will be paid back, was furnished by the Contract Cities Association.

Wolfe: I have followed that program, along with one in northern California. The cities have a little different problem than MAD's, but what they have done could be helpful to the CMVCA program. They could share their information on the background in this field.

If you want to proceed in self-insurance, the districts should start now. It may be a year or so before we could be in full operation.

INEFFECTIVE EFFICIENCY AND OTHER PROBLEMS IN PUBLIC COMMUNICATION

Fred Christensen

Madison/Marcus

Post Office Box 2086, Oceanside, California 92054

In glancing over your program, it appears to me that you have included me as a single generalist among a host of highly technical specialists. I take it as a high compliment both to myself and to the art I represent that your program committee felt I could share with you something of value to your professional lives. I will do my best to live up to their expectations. But in an age where expectations are great and results too often puny, I must caution you that there are limits to what I can do. So let me tell you at the outset what it is I propose to do and how I believe this can be a beneficial exercise for us both.

First, I propose to expose you to a particular perspective. It is a perspective that approaches communication not from the direction of the sender or the means he chooses to send his message - - but that of the receiver. In other words - - my viewpoint will not be that of the government agency nor of the medium used . . . but of the citizen to whom the information, directive, instruction, or other message is intended.

Second, I propose to share with you a regular rogue's gallery of poor communication practices . . . practices so common each of you will have little trouble identifying yourself as the unintentional practitioner . . . or the innocent citizen victimized by the practice . . . or both.

Third, I propose to share some concepts which, I believe, can be used universally to improve communication between the public sector and its constituents. Although specific application will differ from case to case, I believe you will be able to put these concepts to use in dealing with your own unique audiences.

Communication - - and particularly public communication - - in the context in which I am speaking this morning - - involves the art of passing intelligent information from one brain to another . . . specifically, the collective brain of a public agency to the collective brain of its constituents. But even though I speak of "collective brains" - - in practice, the information emanates from a single source . . . or a whole group of single sources and flows to a whole group of individual recipients. It's important to realize this, because we are tempted to think in terms of "mass audiences" and "mass media" . . . forgetting that our target is really each individual within that "mass".

Next, let's briefly examine the process . . . I might suggest to you that one of your prime targets - - the mosquito - - characterizes the main elements of successful communication. First, she gains your attention - - often to the point of being downright frustrating. Then, she implants her message - - forcefully. And finally, she sees to it that the message stimulates a continuing and attention-getting response.

Seriously though, the process of communication is highly complex and impacts the life of each and every one of us. Further, it is going to increase in its impact and its complexity. We are living through a veritable communications revolution, and the speed of change is accelerating. Most historians place the start of this revolution with the invention of the printing press and movable type in the 15th century. It took 400 years for the next major development to occur. That was in 1836 when the telegraph was invented. The next step took only 40 years. That was the invention of the telephone, and the beginning of long-range communication by voice. Then, some 30 years later, the electronic information era was born with the advent of the electron tube.

We are still experiencing this remarkable stage in the communications revolution. First radio . . . then, television . . . then the transistor . . . next the laser . . . and so on. There seems to be no end to it. All of this technology is applied to the process whereby one human brain transfers intelligence to another. And, as remarkable as our current communication systems may be, it serves us well to pause for a moment and consider the most remarkable element of the entire process - - the brain itself. The brain has a memory capacity of about one billion bits of information. In size, it weighs about three pounds . . . and it operates on one watt of power. Its productive time from inception to failure is approximately 70 years. It is one of the few complex objects on Earth today readily reproducible by comparatively unskilled labor. Yet, if we attempted to make an equivalent human brain in the tube technology of only twenty years ago, it would probably require a computer the size of a block-square building twenty stories high . . . the generators operating at full capacity at Oroville to power it . . . and the American River at peak flow to cool it. Why am I sharing this "Believe It or Not?" type of information with you? Because I think we are rapidly becoming overwhelmed by the communications revolution - - so fascinated by it that we often use it simply because it is there . . . whether it helps us to really communicate or not.

At Madison/Marcus, there are three fundamentals we consider crucial to effective public communication. First - technology is both a blessing and a curse. Second - effective communication depends primarily on the wise use of the human brain. And third - most failures in public communication involve either over-dependence on technology . . . under-utilization of the brain . . . or both.

Let me illustrate those three fundamentals. First - technology is both a blessing and a curse. On the surface, the telephone would seem to be an effective means of communication. One need only pick up a telephone and dial a number to transfer intelligence directly to another human being. But let me give you two examples of how the telephone can become a curse - - or at the least a nagging discomfort. These are examples of what we term telephone trauma.

The first involves the forced marriage of the telephone and the tape cassette: A citizen in a southern California city awoke one day to find that a dog had been struck by a car during the night, and the impact had thrown the carcass onto his driveway. There was no way he could drive his car out of the garage without removing the dog's remains. Seeking help, he checked his telephone directory under the City's listings, but found nothing under "dog." He did find "animal control" which seemed about the most appropriate heading. Instead of a number, the listing referred him to the County listings under the same heading . . . "animal control."

He looked up that number in the directory and dialed it. He was answered by a three-minute recording. The voice advised him of the operating hours of the animal shelter . . . how he could get the carcass spayed or neutered . . . how much it would cost him to license it . . . and what it would cost the citizen if the carcass were found wandering the streets unlicensed. Then, acknowledging it might not have all the answers . . . the recording gave him another number to call.

The citizen hung up immediately . . . repeating the number to himself in mounting frustration . . . and dialed it quickly - - before he forgot and had to listen to the whole tape again. This time . . . he was answered by a live voice. He described his problem, and the animal control officer at the other end of the line told him, "Oh, you want to contact dead animal removal, over at the City."

I checked out this story and learned, by the way, that "dead animal removal" is in the City listings. Under "P". That's because dead animal removal is a section of the sanitation division of the public works department. And, obviously, public works department begins with the letter P.

As for my second example: this one involves technology in the hands of an incompetent. I had occasion recently to call a department head in a major public agency. The receptionist transferred me to his secretary, and our conversation went like this:

"Mr. Jones' office."

"I'd like to speak with Mr. Jones."

"Who's callin'?"

"My name is Fred Christensen."

"Does he know ya?"

"Yes."

"Hold on, I'll see if he wants to talk to ya."

One of our services involves a workshop in public communication techniques for public contact personnel and supervisory staff . . . but I'm afraid this young lady is quite beyond hope.

Let's explore our fascination with technology a little further. Most of us know that the Battle of New Orleans was fought after the British and Americans had agreed to terms in the Treaty of Ghent. But no instant communication was available to disseminate this information in time to prevent one final battle.

Today, people are instantly informed. The innermost thoughts of Sadat and Begin are speculated upon (often before the leaders have a chance to articulate them) . . . the potential nuclear disaster of a fallen Russian satellite is widely disseminated . . . and the rare closing of O'Hare in Chicago by a violent blizzard is brought vividly into our living rooms during the six o'clock news.

The mass media, and its nightly panoply of spectacles, cannot help but impress us as the answer to our public communication problems. In fact, public officials are addicted to what we call media mania. This disorder is caused by an almost compulsive belief that the press is the prime carrier of their information. A corollary to this notion is the idea that a good public communication effort need only be built around that euphemism: press relations. But having relations with the press is something like having relations with a Bengal tiger. We stand in awe of its power and are obsessed with an urge to domesticate it. We believe we've captured it and are pleased when it takes what we feed it and accepts our housing. But sooner or later, it hauls off and claws us. That's because the tiger, like the press, is well aware of its role, even if we're not.

First, in its relationship to government, the press is a guardian . . . not a town crier. It is an adversary; hopefully a friendly adversary, but adversary nonetheless. Second, the press is in business to attract readership, viewership and listenership. And that means disseminating those things which will cause people to read, to watch and to listen.

A rather common example of media mania occurred during the recent series of storms. The day the third storm hit, I happened to be driving to Riverside. Somewhere between Sun City and Perris, a particularly violent squall hit . . . the water literally cascaded across the highway and my windshield wipers frantically beat back and forth in an unsuccessful attempt to clear my windshield. At that precise moment, a voice from my car radio advised me that the drought was not over.

For several more days, while people were evacuating their homes, merchants sandbagging their doors and display windows, roads washing out, and cars stalling dangerously in flooded roads and underpasses, the Metropolitan Water District of Southern California continued to insist, in radio, TV, and newspapers . . . that the drought wasn't over. Ironically, it probably wasn't - - and may not be over yet - - for all I know. My point is the District management - - as well as its spokesperson - - couldn't have chosen a more literally incredible time to try to make us believe that! I suspect an enterprising reporter called the District, asked what effect the rains would have, and started a convulsive move on the part of the District to protect the drought psychology in case we received no more rain this year. But if so, District spokesmen could easily have played down the question of effect simply by suggesting it was too early to tell and injecting a little harmless optimism - - "If the rains continue, our situation will be much improved." A soaked and discomfitted audience would have been much readier to accept that approach.

But this rather typical example serves to underscore yet another problem with over-dependence on the press. Government officials get a reassuring feeling that they've disseminated information when they answer a reporter's questions or file a news release. They assume that having "released" the information, it is now up to the press to "disseminate" it. When, in the opinion of the public official, the release is mishandled, they see the failure to communicate as the fault of the press.

I could go on with examples of over-dependence on our wonderful communications technology and its practitioners. The two-color news-letters that are read by practically no one . . . the slick annual reports that really do little more than make money for a lot of my colleagues in the public relations business . . . the colorful brochures that tell a disinterested audience about an agency's budget and structure.

But let me move on to the second fundamental - - effective public communication depends primarily on the wise use of the human brain. Failure to adhere to this principle can be illustrated by a couple of practices which I have discovered while providing public communication consultation to government agencies.

The first of these I refer to as language inflation. Now, I have nothing against the growth of the English language. Language should be a developing and growing art. The problem is that bureaucracies - - both public and private - - continually make a massive and confusing contribution to this growth without ever stopping to realize that its new creations are quite meaningless to the general public. While city and county fathers debate the purchase of land for a "sanitary disposal site" to handle "solid wastes", most of us continue to take our trash to the dump.

The other day I came across an article that advised me that our local school district had hired an "intersession coordinator." Having been raised in a Catholic environment, this conjur-

PUBLIC EDUCATION IN ORANGE COUNTY

B. Fred Beams

Orange County Vector Control District
Post Office Box 87, Santa Ana, California 92702

In 1975, the function of vector control was transferred from the Orange County Health Department to the Orange County Mosquito Abatement District. With this increase in duties, expansion of the District's public education program was undertaken and today is an important element within the District's total control operation.

The District uses several approaches to information dissemination. They include public school programs, various media forms, public educational displays, individual contact and other special projects.

PUBLIC SCHOOL PROGRAMS.–There are over four hundred elementary schools within the twenty-six separate school districts in Orange County. We carry out an elementary school presentation program in as many schools as can be scheduled during the school year. The program begins in September when a notice is sent to each elementary school principal advising him of the availability of and the scheduling procedure for the program. One hour presentations are made on Mondays and Tuesdays of each week to the schools scheduled. We can usually make up to six presentations a day depending on the distance between schools scheduled. A District study kit is left with the school, along with reference material and take-home pamphlets for the students. The study kit is picked up Friday afternoon giving the students at least four days to observe the live mosquito and fly material contained in the study kit.

In 1977, 9,109 elementary school students heard the District's educational presentation. These students were in grades third through sixth. In addition, study kits alone were made available to grades kindergarten through second and were used by 9,543 students in these grade levels in 1977. Every school visited receives a certificate of appreciation for their participation in the program. In 1977, a little over 10 percent of the total number of elementary school students in Orange County were exposed to vector control information.

Presentations to other grade levels (intermediate, high school and community college) are scheduled as requested. A total of 374 students in the upper grade levels were given presentations in 1977. All presentations are made by the District Educational Coordinator.

The Farm Sanitation Award Program is another important part of the District's public education effort. This program is described in detail in a paper given at the Forty-fifth Annual Conference of the California Mosquito and Vector Control Association in February, 1977. The total number of high school students who were involved in this program last year was 230.

DISTRICT FACILITIES TOURS.–The District conducts frequent tours of the laboratory, operational, and mosquitofish rearing facilities for any group interested. Boy and girl scout troops, special class projects, and handicapped children groups have toured the District Headquarters. The visitors are provided with informational material which they are encouraged to take home with them after the hour long tour.

MEDIA PROGRAMS.–The District takes advantage of the several media forms which serve Orange County. Press releases are sent, along with cartoons provided by the San Joaquin Valley Public Information Committee, to nineteen of the daily and weekly newspapers on a regular basis. Radio spot announcements by local radio stations have also been used with some success. We stay in contact with Dr. George Fishbeck, Weather Reporter for KABC Television News. Dr. George, as he is known, has mentioned such problems as standing water in backyard containers after rain storms to his large television audience. We also send him a copy of all press releases issued.

Two magazine articles were written and published by an Orange County magazine in 1977, and other magazines in the area have expressed interest in similar articles. We feel that this is an excellent way to provide vector control information to specialized groups of people such as gardeners, landscapers, livestock owners, and agriculturalists.

Included in the District's monthly agenda is a vector of the month report, in which a vector organism common to Orange County is discussed. A copy of the agenda is mailed to several newspapers each month and the information is often used for public interest articles by the press.

DISTRICT EXHIBITS.–In 1975, the District purchased a portable exhibit display unit which is used at the annual Orange County Fair during its ten day run. The display is composed of color photographs, aquaria with mosquitofish, live mosquito material, a fly display and informational pamphlets available to the fair-going public. The display is manned at all times in order that specific questions can be answered. A record 260,000 people attended the Fair in 1977.

We are working with the Orange County Public Library System and have used a number of its twenty-five branch locations as sites for the display exhibit. We conclude each week long display with a Saturday afternoon presentation to library patrons on the subject of vector control. Bookmarks serve to announce the dates which the exhibit will be at the branch. Other facilities which can be used for the exhibit are city halls, museums, and public school fairs. Because the display is portable, it can be set up by one person in less than one hour.

OTHER PROGRAMS.–Several Orange County cities participate in federally funded neighborhood revitalization programs. We have made contact with key workers within various city governments and have been invited to participate in programs sponsored by the city.

These presentations are usually in the evening and are perfect for emphasizing residential vector prevention because the program theme is cleanup in general. We participated in programs involving 275 homeowners in 1977 by this means.

Service clubs have traditionally been a good vehicle for public information and we accept all invitations to speak to these groups. Other more specialized groups to whom presentations have been given are garden clubs, women groups, corporate staff meetings and safety meetings, teacher's groups, and homeowner's associations.

DIRECT CONTACT.–One of the most important elements of a sound and successful public education program is the day to day public contacts made by District operational and office staff. The first contact most people have with our agency is our telephone receptionist. We feel it is most important that the initial contact be a pleasant one for the public we serve. We make every attempt to provide **all** information desired by proposed development projects. In a few cities we have had tremendous success where we have requested that, prior to site plan approval, the developer was required to meet with our district to show that he had designed mosquito prevention into his project. Generally, we have found most developers to be very cooperative and willing to work closely with us. Comments and recommendations from our staff are now being incorporated into Draft Environmental Impact Reports (EIR) early in the planning phase.

JOINT MEETINGS WITH OTHER GOVERNMENTAL AGENCIES AND ORGANIZATIONS.–This approach has great promise but requires someone to take the initiative and do the necessary contacting and coordinating. These meetings can be very productive when they are organized with predetermined and well defined objectives.

For example, we have been working closely with the City Engineer of Foster City in a cooperative effort to minimize mosquito problems in the catch basin-storm drain system. Joint meetings generally reveal that other agencies are also faced with problems. Personal contact helps all concerned to more clearly understand all the ramifications of any one problem.

STANFORD UNIVERSITY.–Our agency has worked closely with Stanford University for two years. Basically we conduct field research and evaluate the effect this has on breeding sources at Searsville Lake. The positive response to public relations in this situation has continued to improve with time. Public relations does not always generate public support. However, we consider that the development of a working relationship with another agency may be enhanced through an understanding of district functions and obligations.

INTER-AGENCY WORKSHOPS.–Alameda County MAD and our District have cooperated to put together several workshops on salt marsh restoration. We invited all the concerned agencies and requested their input. The purpose was to outline agency objectives, detect areas of conflict, discuss design objectives, cost estimates and management proposals for such projects. The promotion of public support from other public agencies cannot be overlooked or over emphasized.

PUBLIC COMMITTEE MEETINGS.–Our District has representation on the Steering Committee of the "208" Environmental Management Program for our County. This program has several problem areas that are of direct concern to the District. Therefore, to best meet the District's needs and objectives, our continued participation will allow for planning input of a preventative nature. This is another good way to increase one's profile.

WHERE TO GO FROM HERE.–Our experience in this area is still growing. Certainly there are organizations, clubs and associations that we have not contacted but with time we hope to reach most of them. I believe we have a solid base from which to work and in the future we will find that experience will surely become an important part in the future direction of the program. In order to be an efficient and effective agency, it is vital that we continue to evaluate and incorporate changes as they occur. If we elect to rely on public support, and we do, I believe an active and inspired public relations program is a must. In closing, because I support this statement completely, I would like to quote from a paper given by Mr. Glenn M. Stokes, Director, Jefferson Parish Mosquito Control District, Metairie, Louisiana. "I firmly feel that the results of knowledge is better than the risk of ignorance."

ed up some very interesting visions - - heaven knows our schools need all the help they can get - - until I learned the post was intended merely to coordinate activities between school sessions.

Until recently, the office responsible for flood control in a major California county was known as the "hydrology section." Now, when "Punkin' Creek" jumps it banks, and the water is lapping at your front door . . . are you going to look up "hydrology" in the phone book?

But language inflation even creeps into everyday conversation. I know an administrator that calls his staff together to "dialogue" problems. The participants are expected to "input" in order to "maximize" "output" so that problems can be "prioritized" "at this point in time" - - "solution-wise" of course. And, by the way, have you ever thought of the reaction from our everyday housewife when she discovers that the rat that has invaded her garage may be infested with vectors?

Another technique we often employ as a means of avoiding communication while at the same time appearing to communicate is one I refer to as circling. A perfect example of this method of non-communicating occurred some time ago in a Los Angeles County suburb. Residents had begun a concerted letter-writing campaign demanding that their County Supervisor take action to solve a road problem. It seems they had complained and negotiated with the staff of the Road Commissioner's office for months without results. The Supervisor arranged for a conference in his office, inviting the Road Commissioner and his staff, as well as representatives of the homeowners' association.

The meeting took place as scheduled. On one side of the office, the Road Commissioner sat with his staff, armed with maps and reports. Opposite them, four association representatives took their place, prepared to plead their case.

The Supervisor sat behind his desk, separating the two warring factions. He first addressed the association people:

"What seems to be the problem?"

"We live in a cul-de-sac. About two-thirds of the way up the street, there is a large hole in the pavement. It's several feet wide and deep enough so that during heavy rains it fills with water. A child could drown in it. We've been after the County for months now, but we can't get anything done."

The Supervisor turned to the Road Commissioner: "Is the hole really that bad?"

"Yes, sir. It is."

"Why can't we fix it?"

"Because it's a private street."

"If it were a public street, could we fix it?"

"Yes."

"What needs to be done to make it a public street?"

"The property owners have to dedicate it to the County."

Turning to the homeowner group: "Would you be willing to dedicate the street?"

"Certainly. In fact, we've already offered to do that, but the County won't accept it."

Back to the Road Commissioner: "Why the hell won't we accept it?"

"Because it has a hole in it."

Circling, as you may have already noted, hinges on the ability of the circler to let loose of only one fact at a time. The underlying assumption is that the victim will give up in frustration, or assume he has been answered until he gets home and realizes he's no closer to a solution than he was when it all started.

Finally, our tendency to ignore common sense in communicating with each other can sometimes lead to what we call ineffective efficiency. Some time ago, I noticed a photo of a traffic signal in the Los Angeles Times. On a single pole, the creator of that sign had placed four separate messages. The passing motorist, driving in city traffic and looking for a parking place, was supposed to read and absorb - -

One - his vehicle would be towed away if he stopped in the posted area between seven a.m. and nine a.m. except Saturdays and Sundays . . .

Two - he could, however, park there between nine a.m. and six p.m. for two hours except Saturdays and Sundays . . . except that . . .

Three - if he parked just south of the sign, he could begin parking at eight a.m. . . . but . . .

Four - he'd better not park on Thursdays between ten a.m. and noon when the street is being cleaned.

Surely the public servant responsible for this sign had a totally unrealistic notion of the message-absorbing capacity of a driver in city traffic.

I'm confident that by now you realize that the messages I'm describing to you - - the public communication I'm talking about - - has nothing to do with crisis . . . with political controversy . . . with taxpayer revolts . . . or with a hostile press. It has to do with the routine, day-to-day business that represents the on-going interaction between your agency and its citizens. I can hardly over-emphasize that a citizen's feeling about his government is pre-conditioned by his experiences in hundreds of routine exposures . . . incidents precisely like the ones I've described to you.

Why is it that government - - whose entire reason for existence is public service - - often gives its citizens precisely the opposite impression . . . one of disinterest or even arrogant disregard? One of the fundamental reasons - - perhaps the most critical one - - is the fact that both parties to the process often operate under conflicting perceptions.

Let me explain what I mean . . .

Government seems desperately to want to be understood.

People, on the other hand, simply want to be served.

Government wants to reduce all problems into orderly groups and categories, with equally organized solutions.

People want to be dealt with as individuals and resist being placed into categories.

Government wants people to attend to its messages.

People don't want to be bothered with messages that don't apply to specific needs, wants or interests.

Government agencies are deeply concerned that the citizens they serve are aware of their role in the provision of services.

People don't particularly care who provides a service . . . so long as it is delivered when and as needed . . . and the price is right.

Beyond that - - the public generally evaluates the price by gut feeling and not by any rational process. In fact, if it doesn't cost any more today than it did yesterday, then the price if probably right!

Remember another critical factor in the process of communication. There is no way you can pass information to the guy at the other end of the telephone line if he isn't holding the receiver to his ear. In other words, nobody can be forced to listen to a message . . . even if the message is for his own good. At the risk of revealing my true age, I can still remember the year the State Legislature passed a bill providing for a tax rebate. The bill provided that rebates would be sent to taxpayers - - if they sent in their tax returns by a certain deadline. Now, this message appeared in all the major newspapers in the Sacramento area where I was living at the time. It was given front page attention in weekly newspapers. All radio and television stations carried stories about it. About a week before the deadline, I had occasion to hold a public communication workshop with a group of supervisory employees in Sacramento County government. I asked for a show of hands of those who were aware of the deadline . . . and that it was a week away. Out of some 30 persons attending, less than half were aware of either the rebate or the condition applied to it. But the problem doesn't stop there. Have you any idea the number of messages that all the government agencies having some jurisdiction over you or the community in which you live generate each day? And how many competing, conflicting, or even outright contradicting messages we receive?

If we really believe all the health messages that are engulfing our communications conduits today, we would either die of anxiety or alcoholism. I suppose the only thing that doesn't cause cancer is marital relations . . . and I'm waiting for the Surgeon General to give me his conclusions about that! In fact, I'm sure you're well aware that drinking water has now been found to be dangerous to our health! It shouldn't take a Gallup poll to alert our health communicators to the growing disenchantment among people with the overkill in health messages. My guess is that most of us are beginning to do one of two things - - ignoring more and more of the messages . . . or becoming highly susceptible to the simplistic answers manifested by miracle diets, health food fads, and commercial "stop-smoking" plans.

At about this point, I wouldn't blame you if you threw up your hands in despair and decided that the best course of action is to button up and not say anything to anybody at any time. Let me offer an alternative. Let me suggest that what is really needed in the public sector is a different perspective.

Suppose government agencies decided - - for one year - - not to try to tell their constituents who their board members are . . . how they are structured . . . where their funds come from . . . what services they provide . . . how the tax dollars they collect are spent.

Suppose, instead, they decided to adopt a "customer service" attitude - - and set about to do this by first determining the information needs of their constituents, and then committing resources to meet those needs.

What do I mean when I speak of information needs? Let me use your own area of concern to illustrate my point. I live in San Diego County, in the city of Oceanside. Assume that I don't know any more about government structure than any typical citizen. Assume further that mosquitoes have become a serious irritant around my home. I want to contact somebody to see what I should do about it. So, I do what any reasonably intelligent person would do. I go to my phone book. And experience a mild case of telephone trauma. I find no listing for "mosquito control" in the white pages. Nor is there a listing in the yellow pages under "pest control." I even look in the yellow pages under the section headed "government services", with no success. It is first necessary for me to know that in San Diego County mosquito control is a county function - - because the only listing is under "San Diego, County of . . ." in the white pages.

Now, let's suppose mosquitoes were in the same category as termites . . . and getting rid of them was the responsibility of the private sector rather than the public sector. Your success would be determined not by your annual report but by your annual profit and loss statement. Would you list your firm in the white section under "Business Services - Property Protection - Organic Structural Damage Control"?

What I'm trying to tell you is that government insists on forcing me to understand its structure and organization in order to use its services . . . while the private sector first forces itself to understand my perception of its services to persuade me to use them.

The first - - and crucial decision facing you - - is to be convinced that public communication means meeting the information needs of your citizens . . . not persuading your citizens to respond to the informational or political needs of your agency. Your first action - - after you've reached that conclusion - - is to adopt a set of public communication policies based on public communication goals and objectives. These, in turn, can serve as guidelines for your agency's administrators, supervisors, and public contact personnel. Making this policy decision has an important side effect. It provides you with a justifiable and logical rationale to commit resources - - money and personnel - - to this crucial activity.

What are some of the specific elements that make up a "customer service" public communication program?

First - - directories. If you have a large organization and operate through a switchboard . . . your switchboard operators must have a functionally-organized internal directory. All public contact personnel should also have access to an internal directory. But - - most importantly - - whether it is an internal or general public directory - - it must be organized functionally . . . not structurally.

Second - - public contact personnel. Ironically, the person assigned to answer the office phone, or man the public counter, is frequently the youngest, the newest, and the least experienced staff member. Yet, he or she may be the key point of contact between your constituents and you. Further, that contact is a service contact. The individual on the phone or at the counter is there because he has a need he believes you can supply.

It is imperative that your public contact person . . . along with every other staff member who has occasion to deal regularly with the public . . . maintain a "customer service" attitude. Too often, citizens are met with the "public servant" attitude. This is characterized by a defensive reaction that leaves the citizen feeling that he is an interruption rather than an important part of the staff members' job. The customer service attitude calls for a "problem solving" approach in which the citizen is viewed as a client. As an example of its effectiveness, how often have you gone back to the merchant who took the time to solve your problem, even if it meant sending you to a competitor?

A third element in a "customer service" oriented public communication program involves supervisory and management personnel. The public communication process is a manageable process. It can be analyzed . . . its elements can be isolated . . . a program can be designed to meet specific public communication needs effectively . . . and management personnel can oversee the function. This means that potential trouble spots can be identified and mitigated or eliminated entirely.

Take a look at your own process and see if you can isolate potential trouble points. Generally speaking, these fall into four categories. The first I've already emphasized enough - - the telephone. The second involves direct contact with your "customers." Building directories are common offenders.

Many of them are ambiguous, misleading, or filled with organizational jargon difficult for the citizen to understand.

Check out the forms you use. A client water district of ours used a computerized billing form. Under district policy, no delinquency fee was charged if the account was in arrears. But the computer firm that handled the billing standardized the form to meet the needs of several customers . . . some of these did charge a delinquency fee. Consequently, the form had three headings to tell the customer what he owed - - the first simply read "amount due" . . . the second "delinquent" - - meaning delinquency fee . . . and the third "total due". Customers of our client district who fell behind in their monthly bill received dunning notices warning them their water would be turned off . . . warning notices that showed their past due amount under the heading "amount due" - - but no total entered under the heading "delinquent." Needless to add, a considerable amount of staff time was spent explaining this anomaly to customers.

Another potential trouble point involves meetings. Check the language in your meeting notice and agenda. We all realize that in some instances certain legal terminology must be used. But there is nothing to prevent you from translating that into English with a simple following sentence in the agenda. Are your constituents treated as "customers" whose good will is important to you at your meetings? I'm aware of a situation where the citizen-taxpayer is given three minutes to address the Board, regardless of the complexity of his problem. At the end of two minutes, a yellow light on the podium starts flashing. Sixty seconds later the red light goes on and the Chairman gavels him to silence. Arbitrarily limiting the time of citizens before a public body is - - in mind - - an inexcusable affront. Meetings can be conducted in a businesslike fashion by a strong, but fair, chairman. In fact, his assertive silencing of an obstreporous citizen will meet complete approval by others in the audience awaiting their turn.

And what about the typical trappings of a "PR" program - - the newsletters, annual reports, press conferences, audio-visual presentations? Well, they, too can be a supplementary part of an effective public communication program. Our production subsidiary - - Creative Communication - - provides those services . . . but we try to advise our clients to use them prudently and with specific objectives in mind.

For example, a tersely-written one-page monthly newsletter. I first used this technique in Sacramento County. The newsletter went to a selected list of opinion leaders. It would have been infeasible to try to contact all 700,000 residents, but a carefully drawn list of community, organization and professional leaders permitted us to mail out just 1,000 newsletters. We used the newsletter to give those leaders information about the county's goals, its problems, and the trends we could foresee that would affect their lives and those of their constituencies. We organized the list by zip code, so that it was possible to send out limited mailings affecting only certain geographical areas of the County. The newsletter had no pictures . . . no graphs and charts . . . only narrative with key words and phrases underlined. A busy professional or businessman could scan the newsletter in two or three minutes and absorb whatever material interested him.

After we had been publishing the newsletter for about 18 months, the County decided to change the funding process for their sewer systems, going from total dependence on ad valorem taxes to a combination of taxes and service changes. Normally, such a change would have created widespread citizen concern and opposition. For several months before the change, we conducted meetings in the three most affected communities. We also sent special mailings to the community leadership - - first carefully explaining the purpose behind the change, then openly seeking their help in informing citizens in their communities. When the change occurred, our Public Works people told us that inquiries increased less than 10% after the first direct billing, and returned to normal by the third.

We try to provide a functional purpose behind any publications that are generated by a public agency. In analyzing the goals and objectives of one of our clients, we learned that its long-term goal was to assume additional service responsibilities that were either not being provided at all, or were being provided minimally by a remote county government. We learned further that the agency was little-known by the community since its billing had for some years been handled by another agency. Additional analysis indicated that citizens in the community - - the district served a population of some 4,000 - - had no effective directory for a wide variety of services . . . including emergency services. A privately-produced telephone directory which originated in an adjacent county actually listed the wrong numbers for both police and fire emergencies.

From this analysis, we devised a standardized directory listing key emergency, utilities and amenities available to the community, together with the correct telephone numbers. The directory has space for a brief message from the originating agency. And it can be modified for use in just about any community in the nation. But - - to repeat - - the key consideration in devising this publication was its functional purpose to the recipient. The originating district gains name identification in a totally positive context and accompanying good will.

The process of communication is complex and vexing. It has been said that we can send a message around the world in less time than it takes to penetrate the quarter-inch that separates the skull from the brain. But it can be done. If - -

We perceive the needs of our intended audience . . .

We realize that our needs are really secondary to them . . .

We use today's amazing communications technology with purpose, keeping always alert to avoid becoming infatuated with it . . .

We use common sense at all times . . .

And we constantly bear in mind that nobody remembers yesterday's headline.

COMMUNITY EDUCATION IN THE SAN MATEO COUNTY MOSQUITO ABATEMENT DISTRICT

Charles P. Hansen

San Mateo County Mosquito Abatement District

1351 Rollins Road, Burlingame, California 94010

INTRODUCTION.—I view community education as a "public relations" program that instills an awareness of the subject, increases the interest of the people and most important, seeks to maintain public support from the communities we serve. Although it is difficult to totally separate "education" from "public relations" in a well designed program, it is important that we do not lose sight of our objective: that of providing a public service and not an education center. Careful resolution of one's goals and a knowledge of the importance that public relations can play in mosquito control programs is essential.

PUBLIC RELATIONS: WHY!—Over the years, we have lost several effective insecticides because of resistance, economics and governmental restraints, but a well organized public relations program continues to function in an efficiently managed mosquito control operation. A very important goal of the program is that the public understands, appreciates, cooperates and supports the need for mosquito control. To accomplish this task we must communicate with the public so they can develop a basic understanding of mosquito control activities such as biology, habitats, disease potential, prevention, and control techniques. The various means that we use to reach the public will be discussed later in this paper. The degree that public relations is utilized will vary considerably from district-to-district, but the mere fact that we exist is proof that each and every district has some type of community relations program in operation.

HOW! . . . . .TO ESTABLISH A PUBLIC RELATIONS PROGRAM.—How a program is started could be the key to success or failure. The staff must be motivated and stimulated about using this approach. They have to be dedicated and committed to the continuous development and improvement of the program. Equally important is an enthusiastic continuous development and improvement of the program. Equally important is an enthusiastic and fully informed Board of Trustees. Without their support, it is likely that your program will fail. Board members, in their daily role, frequently reinforce public relations through contact with other public officials thus adding to the external resources working on behalf of our agency. On-going communications with the Board of Trustees is a must if the program is to be successful.

WHERE! . . . . TO START.—There is no one particular way to accomplish your goals, but instead, ultimate achievement may require the use of all the available resources. The key to success is a direct reflection of the degree you are organized. The development of a plan could be the critical factor if you wish to evaluate program effectiveness at a later date. Therefore, each district may approach public relations in a slightly different manner, but as a basis for a starting point, briefly I would like to mention those segments of the community we work with and how we reach them.

WHERE! . . . . WE ARE.—The following is a partial list of groups that we talk with about our role in mosquito abatement. Each group makes up a part of the whole public we serve and aids in reaching people in other specialized fields and occupations, thus becoming arms of the district. Each of these groups serves a different purpose and/or function in the community, so it is important that we talk to our audience where they are, not necessarily where we would like them to be. A good communicator realizes that his methods and manner of presentation must coincide with the needs and temperament of his audience. We are aware that this program, like any other program, may have its disappointments. We recognize them, challenge them, and then move forward with the power of positive thinking. The list that follows has many groups that are common to all districts. The needs and limitations of a district may determine the priorities of emphasis given to these groups.

Board of Trustees
County Board of Supervisors
Local Agency Formation Commission
County Health Department
City and Town Councils
County, City and Town Planning Commissions
Public Works Department

Civic Groups:	Kiwanis, Lions, Rotary, Welcome Wagon, Sons-in-Retirement, American Association for Retired People and Senior Activity Centers
Schools:	elementary through college
General Public:	personal communication

This information should provide sufficient leads to "assist" in developing a public relations program. However, we try to be selective and work in areas that can best serve the needs of our district.

METHODS WE USE TO RELATE WITH PEOPLE.—Groups, organizations and the people these groups comprise, have particular needs and individual desires. Therefore, our methods of approach may vary from group-to-group. With this in mind, let me touch on some of the ways we sell our program.

1) Have a well trained field and office staff
2) The use of effective personal verbal communication
3) Written communication - letters
4) Newspaper articles
5) Staffed County Fair Booth, using both employees and Board members
6) Distribute literature: mosquito and fish brochures, CMVCA Mosquito Notes, bookmarks and educational bulletins
7) Presentations: the use of slides, charts, displays and live material followed by a question/answer period
8) Certified Technicians with uniforms and proper identification
9) Vehicles and equipment clearly marked
10) Advisory role to various planning commissions where professional biological input is needed

Some of these items have had a high priority in our program, but in the end, all serve an important role in achieving our goals. Let me touch now on those areas I feel should be exploited in order to attain the ultimate reward for our program.

PLANNING DEPARTMENTS.—This is one area where early district input can help to build mosquito prevention into

Table 2.

Tray	Liver Powder Added (mg)	% Pupation	Average Weight of Pupae (mg)	Total Biomass of Pupae (mg)	Day Completed
1	50	72	0.386	12.8	29
2	20	42	0.213	4.4	60
3	8	14	0.203	1.5	56
4	0	24	0.160	2.0	56

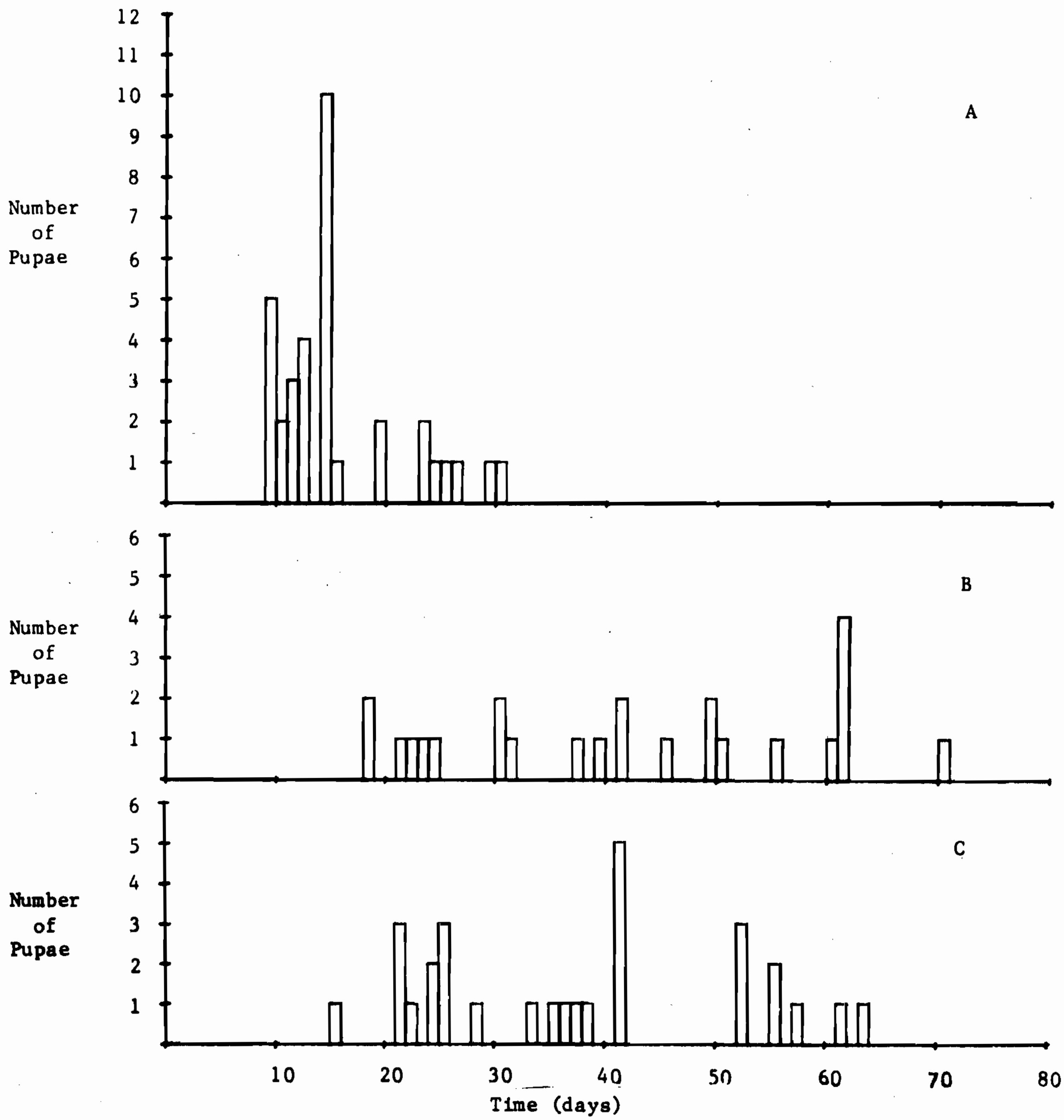

Figure 1.–Daily pupation rate as a function of day from start of experiment. A) Tray to which 35 mg of liver powder was added. C) Tray whose treehole water was filtered to remove particulate matter.

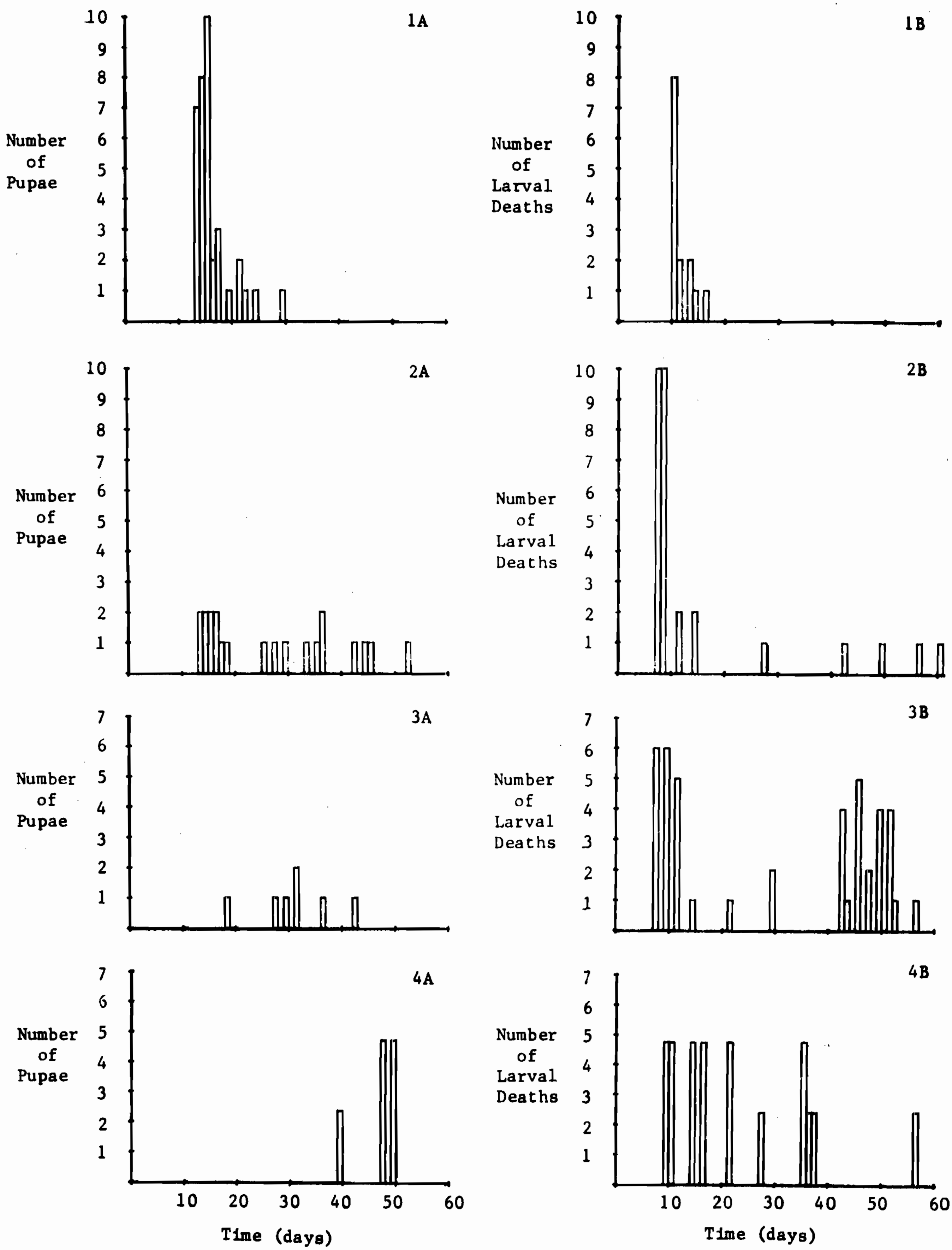

Figure 2.–Daily pupation rate (column A) and larval death rate (column B) as a function of day from start of experiment. Rows 1, 2, 3 and 4 represent, respectively, trays to which 50, 20, 8, and 0 mg of liver was added.

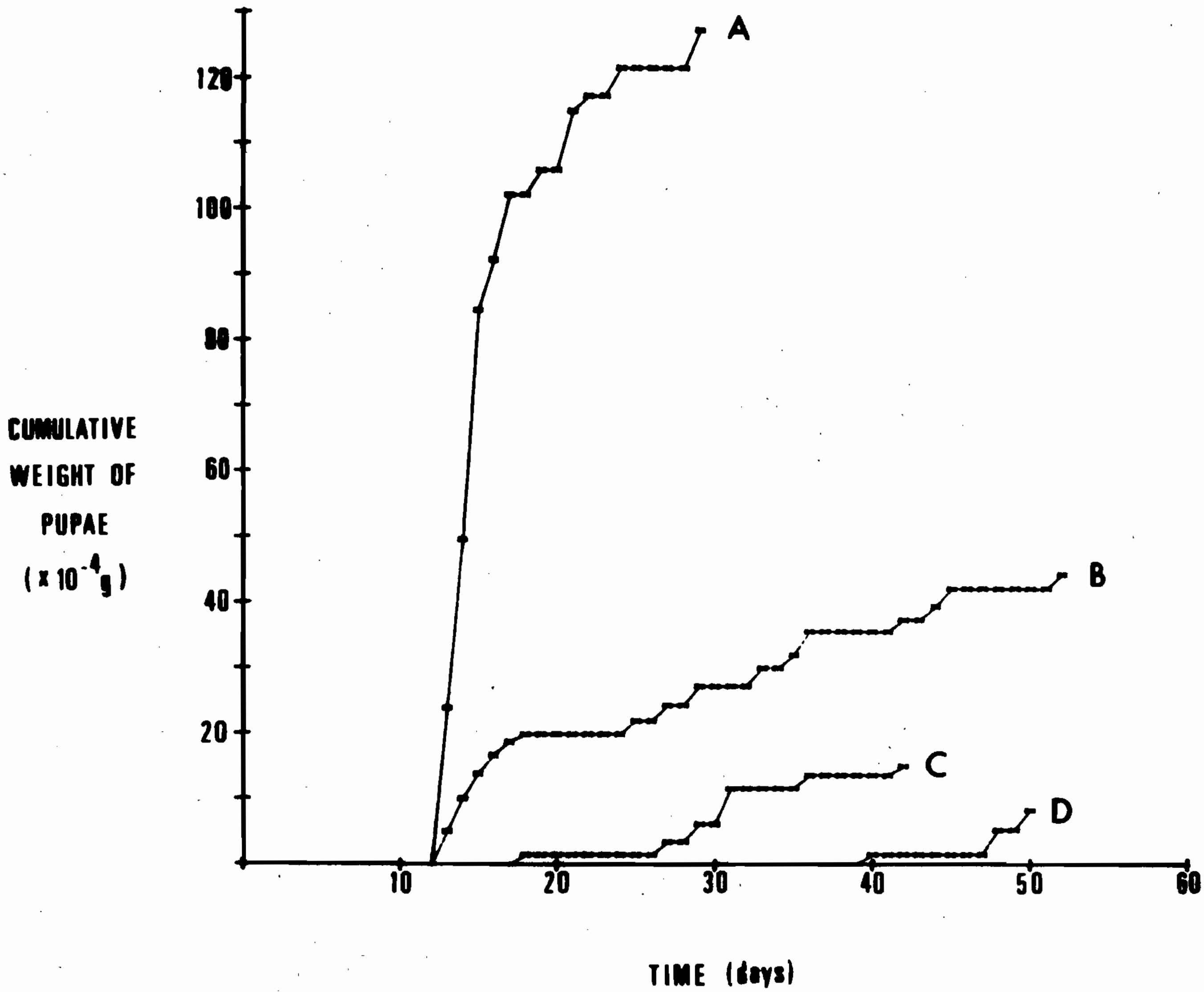

Figure 3.–Cumulative total weight of pupae as a function of time. Lines A, B, C and D represent, respectively, trays to which 50, 20, 8 and 0 mg of liver powder was added.

A SURVEY FOR TREEHOLE BREEDING MOSQUITOES IN CENTRAL CALIFORNIA WITH FABRICATED TREEHOLES

Leyburn F. Lewis[1] and Takeshi Miura[2]

ABSTRACT

In 1977, artificial treeholes were used to survey for the western treehole mosquito, *Aedes sierrensis* (Ludlow), in the Sierra Nevada mountains and foothills in Central California. Eggs were obtained at sites which ranged from an area where all the trees were hardwoods (elevation ca. 168 m) to an area where all the trees were conifers (elevation ca. 2570 m).

[1]USDA, ARS, Western Insects Affecting Man and Animals Laboratory, 5544 Air Terminal Drive, Fresno, CA 93727.

[2]University of California Mosquito Control Research Laboratory, 5544 Air Terminal Drive, Fresno, CA 93727.

USE OF THERMAL SUMMATIONS TO PREDICT HOST-FEEDING RATES OF *AEDES SIERRENSIS* FEMALES IN NORTHERN CALIFORNIA

Steven R. Bennett

University of California

Department of Entomology, 303 Briggs Hall, Davis, California 95616

ABSTRACT

Thermal development thresholds and day-degree thermal summations were used in a study of temperature requirements of the western tree hole mosquito, *Aedes sierrensis*, to infer female host-feeding rates and gonotrophic activity from temperature records of climatically-diverse areas in Northern California where the species is known to breed.

Two periods of female development, (1) emergence to first bloodmeal, and (2) bloodmeal to oviposition, were observed in the laboratory at temperatures from 10° - 27°C. Development times for (1) and (2) varied with temperature as expected, but respective thermal summations for these periods (day-degrees above 7°C) were relatively stable, allowing thermal constants for each period to be calculated. Weather records from four communities where *Ae. sierrensis* populations were known to occur (Petaluma, Davis, Placerville, Tahoe City) were also converted into daily thermal summations and used with thermal constants of (1) and (2) to predict mean durations of gonotrophic cycles in each area from March through July.

Predictions of this study indicate that:

1) Time intervals between female emergence and onset of host-feeding behavior may vary from 4 to 14 days or more, depending on season and location of the population;
2) A female's first gonotrophic cycle is likely to last at least two times longer than subsequent cycles;
3) Seasonal onset of host-feeding activity will be similar in *Ae. sierrensis* populations of coastal and valley areas but will tend to be delayed at higher elevations, and above 2,000 meters blood-feeding activity would not be expected before late June.

SAMPLING LARVAL MOSQUITOES IN A RICE FIELD: A COMPARISON OF THREE TECHNIQUES

J. B. Christensen and R. K. Washino

University of California

Department of Entomology, Davis, California 95616

ABSTRACT

To sample mosquito larval population in a rice field habitat, the standard dipper was compared with a 50-square-inch plastic tub and a standard aquatic dip net. In a field estimated to have abundant mosquito larvae, the highest mean number of *Culex tarsalis* and *Anopheles freeborni* per unit sample were taken by the dip net, the plastic tub, and dipper, in that order. The tub, however, showed the least variation in percent standard error about the sample mean. From these data, sampling curves (i.e., number of samples needed to precisely predict various population levels) were estimated for both species of mosquito per sampling device.

AN EMPIRICAL METHOD FOR PREDICTING THE HATCHING DATE OF *CULEX TARSALIS* EGGS IN THE EARLY SPRING IN FRESNO COUNTY, CALIFORNIA

Takeshi Miura[1], R. M. Takahashi[1], D. E. Reed[2] and D. G. Farley[2]

ABSTRACT

It was shown over a 7-year period that the first larval collection of *Culex tarsalis* Coquillett in the early spring was made between 22 to 26 days after a mean daily soil temperature at a 2-inch depth reached 50°F or more. However, if the required thermal constant (50.9 degree days) had accumulated during January this duration became 42 to 53 days. The accuracy of the method to predict egg hatching in the early spring is adequate for mosquito control agencies to prepare control operations.

Culex tarsalis is one of the most intensively studied mosquitoes in California, not only because it is a known vector of viral encephalitis, but also because of its extreme resistance to all commercially available larvicides in some areas.

In the Central Valley of California *Cx. tarsalis* females have been found to overwinter chiefly in the foothills (Bellamy and Reeves 1963, Burdick and Kardos 1963, Bailey et al. 1965, Kliewer et al. 1969) and along river bed areas (Mortenson 1953); it is therefore hypothesized that early spring populations in the foothills and river bed areas could serve as nuclei from which later season populations in the valley originate.

Since the establishment of the Fresno Westside Mosquito Abatement District (MAD), considerable *Cx. tarsalis* larval collection records have been accumulated. In order to develop a method for predicting the time of egg hatch in the early spring, the larval collection data have been examined in conjunction with local weather data.

METHODS AND MATERIALS.–In order to find the first appearance of *Cx. tarsalis* larvae in the district, larval surveillance was started in early February each year. Each operator inspected potential breeding sites in his responsible zone and sampled water with a long-handled dipper (450 ml capacity). Then the water was gently poured into a larval concentrator (Husbands 1969). Ten dips were taken from a site when the first dip contained larvae. At the end of a day, all inspections were recorded on a daily report sheet which contained weather data, field conditions, time of inspection, location and name of property owner. In the laboratory the collections were examined under a stereoscopic microscope for identification of species, number of specimens and developmental stages.

To determine the minimum effective temperature (developmental zero) for hatch, eggs of uniform age were obtained by the technique described by Miura et al. (1976). Forty egg rafts were placed individually in a plastic container (34 mm dia, 27 mm high) containing ca. 10 ml of water each and they were placed in the water baths maintained at constant temperatures of 55, 60, 70 and 80°F. The total number of larvae hatched was examined twice a day. The test was duplicated.

Developmental zero point was determined by the analysis of the linear regression method. The thermal constant (the number of degree days required for the eggs to hatch) was calculated using the following equation:

$$K = \frac{1}{N} \sum_{i=1}^{N} Y_i \ (t_i - a)$$

where Y_i is the days required to hatch at a constant temperature (t_i), "a" is developmental zero of hatching, and "N" is the number of constant temperatures tested.

Daily mean soil temperatures were obtained from daily max and min soil temperature at a 2-inch depth, published in "Climatological Data" by the U.S. Dept. of Commerce at Fresno Air Terminal, California.

RESULTS AND DISCUSSION.–Developmental zero point and thermal constant for hatch are 49.75°F (Figure 1) and 50.9 degree days (Table 1) respectively. Developmental zero and thermal constant for immature stages (1st instar larvae to pupal stage) were also calculated from the data reported by Bailey and Gieke (1968) as 44°F (Y = 0.0028X - 0.1223) and 370 degree days.

Table 2 shows expected dates of hatch based upon thermal constant calculation (50.9 degree days) and dates of hatch estimated from larval collection data. The result was disappointing, as there was a great discrepancy between the dates estimated by the thermal constant method and those actually calculated from the larval collection data.

The discrepancy in our estimation (Table 2) is probably caused by an insufficient number of sampling sites and areas because the larval surveillance made by the MAD was concerned primarily with analysis of species composition, density and distribution within the district, but not for estimation for thermal constant.

In order to investigate the possible interpretation of relationship between the date of the first larval collection in the spring and soil temperature, daily mean temperature was plotted against chronological date. The date on which the first larvae were collected is indicated each year (Figure 2 and 3). Almost consistently the figures show that the interval between the date when daily mean temperature reached 50°F and the date of the first larval collection ranged from 22 to 26 days. However, in 1970 the first collection was made on the 53rd day and in 1974 on the 42nd day.

This delayed phenomenon cannot be fully understood but this might be partially explained by examining the reproductive physiology of this mosquito. For example, in Fresno Co., California, the gonotrophic activity of *Cx. tarsalis* begins at almost the same time each year soon after the winter solstice (Kliewer et al. 1969), and the first gravid females appear during the last week of January (Mortenson 1953, Loomis and Green 1959, Schaefer and Miura 1971). In 1970 and 1974, we had extremely warm temperatures in January (Table 2 and Figure 3), even the required thermal constant for hatch was already accumulated by the middle of January in 1970 and at the end of January in 1974, while females were not quite ready to deposit eggs.

[1]University of California Mosquito Control Research Laboratory, 5544 Air Terminal Drive, Fresno, CA 93727.

[2]Fresno Westside Mosquito Abatement District, Post Office Box 124, Firebaugh, CA 93622.

Table 1.—Number of days and thermal constants for *Cx. tarsalis* egg hatch at constant temperatures.

Temperature (°F)	Days Required (Range)	Hatch (in %)	Thermal constant (in Degree Days)
55	8.8 (8.2 - 9.9)	87	46.2
60	5 (4.2 - 6.3)	92.9	51.2
70	2.7 (2.2 - 3.3)	91.4	54.7
80	1.7 (1.3 - 2)	83.6	51.4
mean			50.9

Table 2.- Comparison of *Cx. tarsalis* egg hatch-days estimated by the thermal constant method and larval collection dates in Fresno, California during1970 to 1976.

	Expected day of hatch by		Deviation	First larval collection	
Year	Thermal constant	Larval collection	(days)	Date	Stage[1]
1970	Jan. 22	Jan. 20	- 2	Feb. 19	II-IV, P.
1971	Feb. 12	Feb. 1	- 11	Feb. 24	IV
1972	Feb. 13	Feb. 21	- 18	Mar. 1	I-IV
1973	Feb. 16	Feb. 7	- 9	Feb. 21	II
1974	Jan. 29	Feb. 21	+23	Mar. 5	III
1975	Feb. 23	Feb. 17	- 6	Feb. 27	II
1976	Feb. 22	Feb. 13	- 9	Mar. 4	III

[1] I-IV = 1st to 4th instar larvae. P = Pupae.

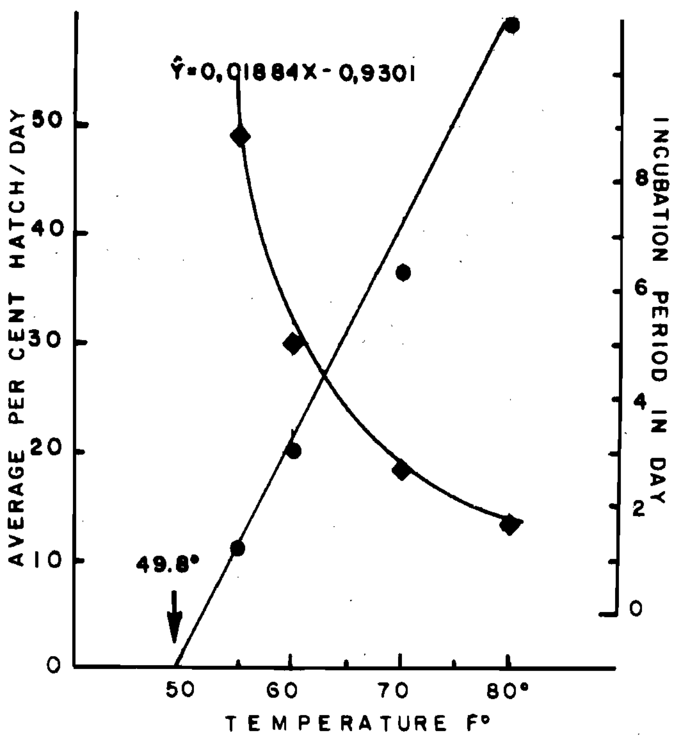

Figure 1.—Determination of the developmental zero point for *Cx. tarsalis* egg hatch.

The thermal constant concept is useful in predicting an approximate date of the first egg hatch in the spring. It does not pinpoint the date but it does give precaution to the mosquito control agencies to intensify larval surveillance activity. The method proposed here is calculated by the interval between the date when soil temperature hits 50°F and the date of the first larval collection and it gives a better prediction than that of the thermal constant method. Therefore, it has more operational value to the mosquito control agencies as a guide in timing control operations. Furthermore, it is simple and possible to make a prediction by using local climatological data published by the U.S. government.

REFERENCES CITED

Bailey, S. F., D. A. Eliason and B. L. Hoffmann. 1965. Flight and dispersal of the mosquito *Culex tarsalis* Coquillett in the Sacramento Valley of California. Hilgardia 37:73-113.

Bailey, S. F. and P. A. Gieke. 1968. A study of the effect of water temperatures on rice field mosquito development. Proc. Calif. Mosq. Control Assoc. 36:53-61.

Bellamy, R. E. and W. C. Reeves. 1963. The winter biology of *Culex tarsalis* (Diptera: Culicidae) in Kern County, California. Ann. Entomol. Soc. Amer. 56:314-23.

Burdick, D. J. and E. H. Kardos. 1963. The age stru ture of fall, winter and spring populations of *Culex tarsalis* in Kern County, California. Ann. Entomol. Soc. Amer. 56:527-35.

Husbands, R. C. 1969. An improved technique of collecting mosquito larvae for control operations. Calif. Vector Views 16:67-9, 72.

Kliewer, J. W., T. Miura, and H. C. Chapman. 1969. Seasonal occurrance and physiology of *Culex tarsalis* in foothills of Fresno County, California. Ann. Entomol. Soc. Amer. 62:13-8.

Loomis, E. C. and D. H. Green. 1959. Ecological observations on *Culex tarsalis* Coquillett and other mosquitoes in the Delta region of the Central Valley of California, 1953-1956 (Diptera:Culicidae). Ann. Entomol. Soc. Amer. 52:524-33.

Miura, T., C. H. Schaefer, R. M. Takahashi, and F. S. Mulligan, III. 1973. Effects of the insect growth inhibitor, Dimilin ®on hatching of mosquito eggs. J. Econ. Entomol. 69: 655-658.

Mortenson, E. W. 1953. Observations on the overwintering habits of *Culex tarsalis* Coquillett in nature. Proc. Calif. Mosq. Control Assoc. 21:59-60.

Schaefer, C. H. and T. Miura. 1971. Sources of energy utilized by natural populations of the mosquito, *Culex tarsalis*, for overwintering. J. Insect Physiol. 18:797-05.

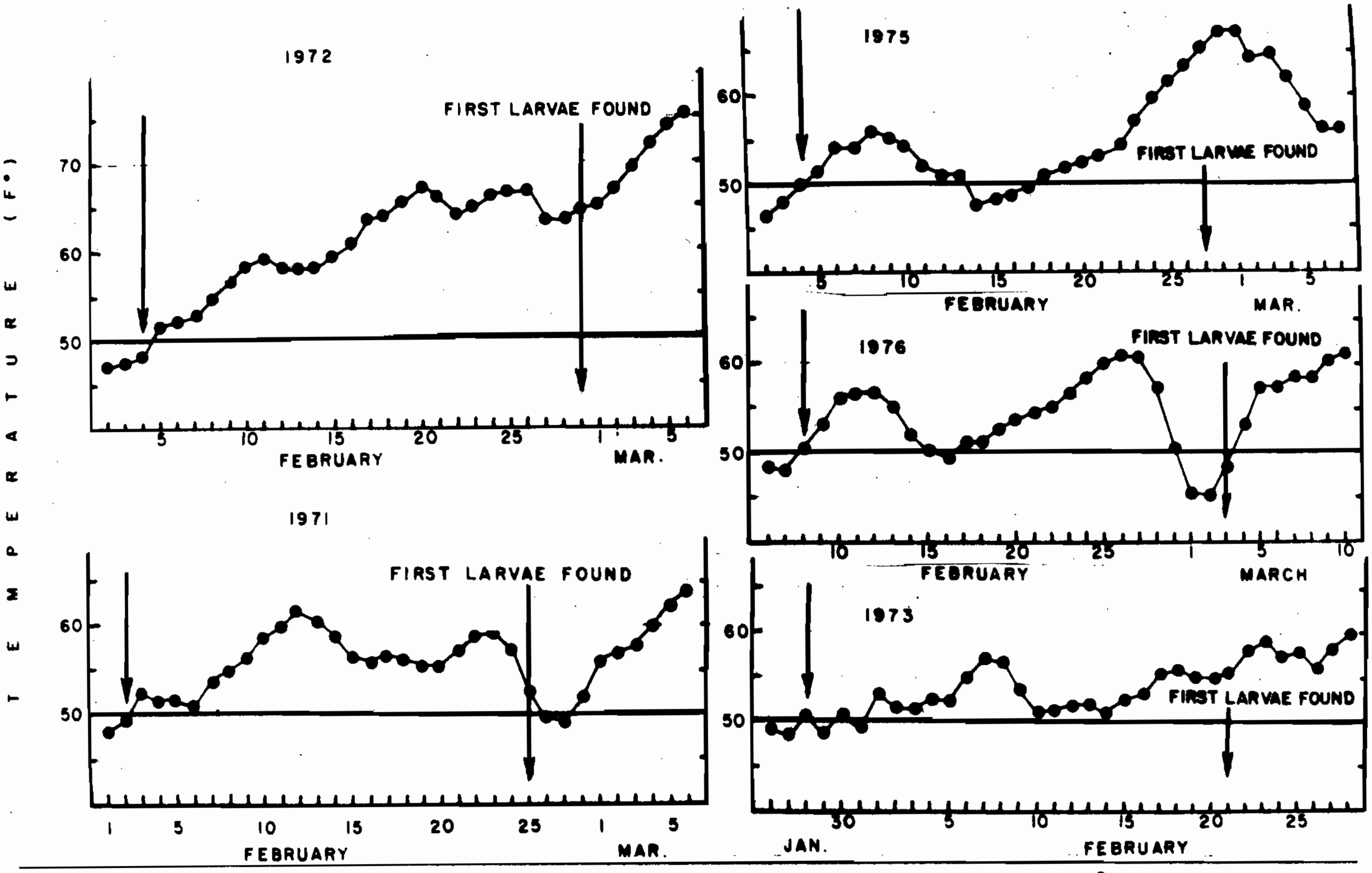

Figure 2.--Relationship between date of the first larval collection in 1971-3, 1975 and 1976 (a 50°F level and arrows have been shown to accentuate the duration, see text).

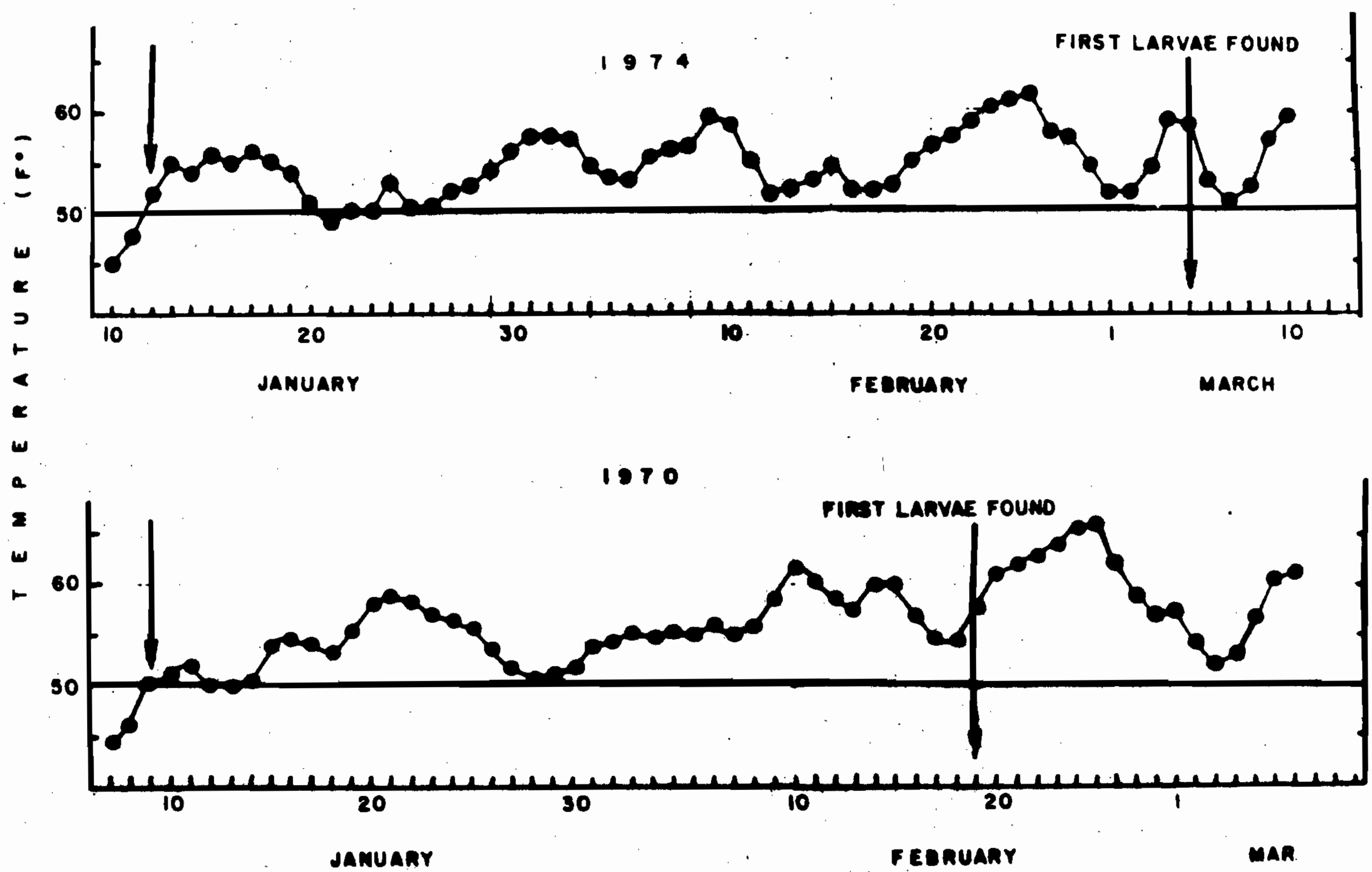

Figure 3.–Relationship between date of the first larval collection in the early spring and soil temperature, Fresno, California 1970 and 1974. (A 50°F level and arrows have been shown to accentuate the duration, see text.)

DISTRIBUTION OF *CULEX TARSALIS* IN AN ISOLATED FIELD AREA IN CALIFORNIA[1]

R. L. Nelson and M. M. Milby
University of California
Department of Biomedical and Environmental Health Sciences
Berkeley, California 94720

ABSTRACT

Mark-release-recapture studies of adult *Culex tarsalis* Coquillett in Kern County, California, provided information on the distribution of marked and unmarked mosquitoes within an isolated study site. In total, 8,400 females were marked and released, of which 452 were recaptured. Marked and unmarked specimens had similar patterns of distribution and mixed thoroughly within 24 hr of release of marked individuals. The latter dispersed throughout the study site within the first 24 hr and some remained for at least 10 days.

A series of monthly mark-release-recapture studies of adult *Culex tarsalis* Coquillett were made in the summer of 1976 in Kern County, California. The main purpose was to obtain background data on an isolated population that has been selected as a target for experimental genetic control trials. From data obtained, estimates were made of survival, population size, and emergence (Nelson et al. 1978). The purpose of this paper is to give further information that was obtained on the distribution of marked and unmarked *Cx. tarsalis* within the study site. This information may be useful in planning and assessing the results of introductions of genetically modified mosquitoes.

MATERIALS AND METHODS.–The study site (Poso West) is in the dry foothills 16 km north of Bakersfield, and is fully described elsewhere (Nelson et al. 1978). The site is a ravine that runs from south to north for about 1 km and is fed by waste water from nearby oil fields. The ravine banks rise from 20 to 25 m to the east and west and enclose the site on 2 sides. Figure 1 is a diagrammatic map of the site which, for convenience, was divided into zones A, B, and C. Mosquito larval breeding was heaviest in zones A and B where cattails and other emergent plants were abundant. The map shows the distribution of 24 trap sites. Sites 1 through 15 were at 55-m intervals on alternate sides of the stream. Each peripheral site, except number 16, was 135 m from the nearest water. Site 16 was 135 m south of zone A next to the narrow channel in the upper end of the ravine and was blocked from view from any other site. The sites along the east and west margins were behind the crests of the banks and were not directly visible from the stream bed.

Adult females were marked and released 1 morning each month from June through September. They were reared in the laboratory from pupae collected at the study site and were from 18 to 66 hr old when marked and released shortly after sunrise. They were marked with fluorescent dusts essentially as described by Dow et al. (1965). Three dusts were used. One of them (yellow) was a Helecon pigment from U. S. Radium Corp., and the other 2 (red and blue) were Radiant® pigments from Hercules Inc. Equal numbers of marked females were released near the center of each zone, at sites 3, 8, and 13 (Figure 1). Those at site 3 were marked with yellow dust, those at site 8 with red dust, and those at site 13 with blue dust. In all 8,460 females were marked and released in 4 monthly trials.

For 10 successive nights after each release, a CDC light trap (Sudia and Chamberlain 1962) supplemented with a 1.8-kg block of dry ice (CO_2) was operated at each of the 24 trap sites. All collections were examined under a dissecting microscope and ultraviolet light for marked specimens, and all mosquitoes were identified to sex and species.

RESULTS AND DISCUSSION.–The results that follow represent combined data from 10 nights of collection after each of the 4 monthly releases. Collection patterns were similar each month. Figure 2 shows the baseline distribution of 118,226 unmarked *Cx. tarsalis* from 960 trap nights. Collections were relatively small along the reservoir near the north end of the ravine and on the east and west margins. The ratio of males to females also was relatively small in these marginal traps. Collections were largest at trap site 16, although site 16 was well removed from the major breeding area in zones A and B.

A total of 452 marked females was recovered, and the overall recapture rate was 5.3%. Figure 3 compares the percentage distributions of unmarked and marked females. The data are from the 18 trap sites within the ravine (Figure 1), although marked females were taken at each of the 24 sites. Although equal numbers of marked females were released in each zone, the distribution of recoveries was similar to that of unmarked females. This suggested that marked and unmarked females were well mixed. Again, the largest numbers were collected at trap site 16.

A basic requirement for mark-release-recapture analysis is that released and field specimens become thoroughly mixed. Zone by zone examination of the distribution of marked versus unmarked females (Table 1) indicated that marked females of each color did thoroughly mix with the field population. A preference of mosquitoes for zones A and B over zone

Table 1.–Zone by zone distribution of marked and unmarked female *Culex tarsalis* at Poso West.[a]

		% of total in indicated status		
Mark status	No. females	Zone A	Zone B	Zone C
Yellow	144	44.4	39.6	16.0
Red	139	50.4	40.3	9.4
Blue	88	42.0	42.0	15.9
All colors	371	46.1	40.4	13.5
Unmarked	82,027	45.4	39.3	15.3

[a]From CO_2/light-trap collections in zones A, B, and C (Figure 1) on 10 nights after each of 4 monthly releases of marked females.

[1]This research was supported in part by Research Grant AI-03038 from the National Institute of Allergy and Infectious Diseases, and by General Research Support Grant I-S01-FR-05441 from the National Institutes of Health, U. S. Department of Health, Education, and Welfare.

C was evident. Also note that blue-marked females, released in zone C, were recovered least often.

Recapture data were further analyzed to determine how quickly mixing occurred, or whether the distribution of marked females on night 1 differed from that on nights 2 through 10 (Table 2). The data indicated that thorough mixing occurred within the 1st 24 hr, since the distribution was similar for each time period. For each color, there was a greater percent in zone C on night 1 than on nights 2 through 10. Apparently mosquitoes that first dispersed into zone C later gravitated toward more preferred habitats.

The data also were examined for evidence of movement up or down the ravine, to the south or to the north. Table 3 shows the number, direction, and mean distance from release points of recoveries on night 1 versus nights 2 through 10.

Table 2.–Zone by zone distribution of marked female *Culex tarsalis* on night 1 versus nights 2 through 10.[a]

Mark status	Collection night(s)	No. females	% of total in indicated status: Zone A	Zone B	Zone C
Yellow	1	59	42.4	39.0	18.6
	2-10	85	45.9	40.0	14.1
Red	1	53	52.8	34.0	13.2
	2-10	86	48.8	44.2	7.0
Blue	1	32	43.8	37.5	18.8
	2-10	56	41.1	44.6	14.3

[a]From CO_2/light-trap collections in zones A, B, and C (Figure 1) on 10 nights after each of 4 monthly releases of marked females.

Table 3.–Movement of marked female *Culex tarsalis* north and south from release points on night 1 versus nights 2 thru 10.[a]

Mark status	Release point (trap site)	Night 1: Number females recovered	Night 1: Mean distance of recoveries (m) North	Night 1: Mean distance of recoveries (m) South	Nights 2-10: Number females recovered	Nights 2-10: Mean distance of recoveries (m) North	Nights 2-10: Mean distance of recoveries (m) South
Yellow	3	43	306		45	284	
		9		92	14		79
Red	8	14	173		11	95	
		31		239	58		197
Blue	13	2	83		0	-	
		28		371	51		362

[a]From CO_2/light-trap collections at trap sites 1 through 15 (Figure 1) on 10 nights after each of 4 monthly releases of marked females.

Data were limited to trap sites 1 through 15, which were aligned from south to north at near-equal intervals. Red-marked females, released at site 8, showed greater movement to the south than to the north, both in terms of numbers and distance. Sites 3 and 13 were near opposite ends of the row of traps, so movement of yellow-marked females to the north was compared with that of blue-marked females to the south, and the latter showed a greater mean distance of movement. These limited observations suggest that movement depended largely upon the position of the release point relative to the preferred habitats, identified in Figure 2.

Significantly, the mean distance from release points of recoveries always was greater on night 1 than on nights 2 through 10. Thus, marked females apparently dispersed throughout the study site within the first 24 hr. Further evidence of rapid dispersal was that marked females of each color were trapped at both ends of the ravine (sites 16 and 20 or 21) on the first night after their release. Also, marked females of 1 color were taken at up to 16 trap sites on the first night.

Excessive emigration of *Cx. tarsalis* from the study site argues against use of the site for introduction of genetically modified mosquitoes. Table 4 indicates that marked females of each color remained within the study site throughout the 10-day trapping periods. Also, females that took blood meals at a chicken house on the crest of the west bank of the ravine (near trap site 18) later were collected along the ravine bottom (unpublished data). However, the rapid dispersal of marked females and the collections in peripheral traps, particularly at site 16, suggested some loss from emigration.

Table 4.–Recoveries of marked female *Culex tarsalis* at Poso West on 10 successive nights after releases of marked speciemens.[a]

Collection night	No. female recoveries of indicated color: Yellow	Red	Blue	All colors
1	69	65	40	174
2	17	17	12	46
3	16	22	13	51
4	28	22	20	70
5	17	16	7	40
6	9	13	3	25
7	6	7	3	16
8	6	2	2	10
9	2	4	3	9
10	5	3	3	11

[a]From CO_2/light-trap collections at trap sites 1 through 24 (Figure 1) after each of 4 monthly releases.

Data from the studies referred to earlier (Nelson et al. 1978) bear upon the question of emigration. Estimates of daily survival from recapture of marked females averaged about 70%. These estimates probably reflected loss from emigration as well as from mortality. However, estimates of daily

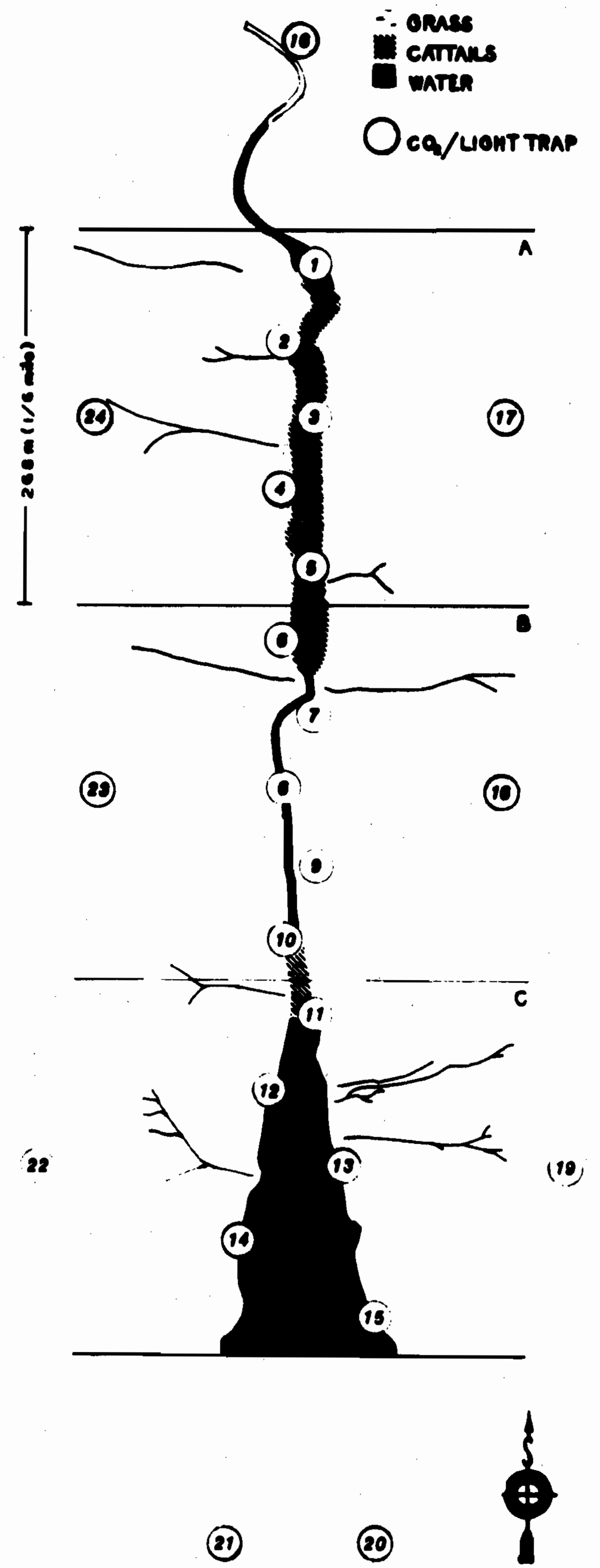

Figure 1.—Map of Poso West study site, showing distribution of 24 trap sites.

survival based upon parous rates of females were near 85%. If the 15% difference in the 2 estimates was due to emigration, losses from emigration and from mortality may have been about equal.

In summary, marked and unmarked female *Cx. tarsalis* had similar patterns of distribution within the Poso West study site, and the 2 types mixed thoroughly within 24 hr of release of marked females. The latter dispersed throughout the study site within the first 24 hr, and some remained for at least 10 days. Similar behavior by mosquitoes released for genetic control, at or between trap sites 3 and 8, should favor the chances for successful control at Poso West.

ACKNOWLEDGMENTS.—We gratefully acknowledge the contributions to these studies of Dr. W. C. Reeves, University of California at Berkeley, and of staff members of the U. C. Arbovirus Field Station, Bakersfield.

REFERENCES CITED

Dow R. P., W. C. Reeves and R. E. Bellamy. 1965. Dispersal of female *Culex tarsalis* into a larvicided area. Amer. J. Trop. Med. Hyg. 14: 656-670.

Nelson, R. L., M. M. Milby, W. C. Reeves and P. E. M. Fine. 1978. Estimates of survival, population size, and emergence of *Culex tarsalis* at an isolated site. Ann. Entomol. Soc. Amer. (In press).

Sudia, W. D. and R. W. Chamberlain. 1962. Battery-operated light trap, an improved model. Mosq. News 22:126-129.

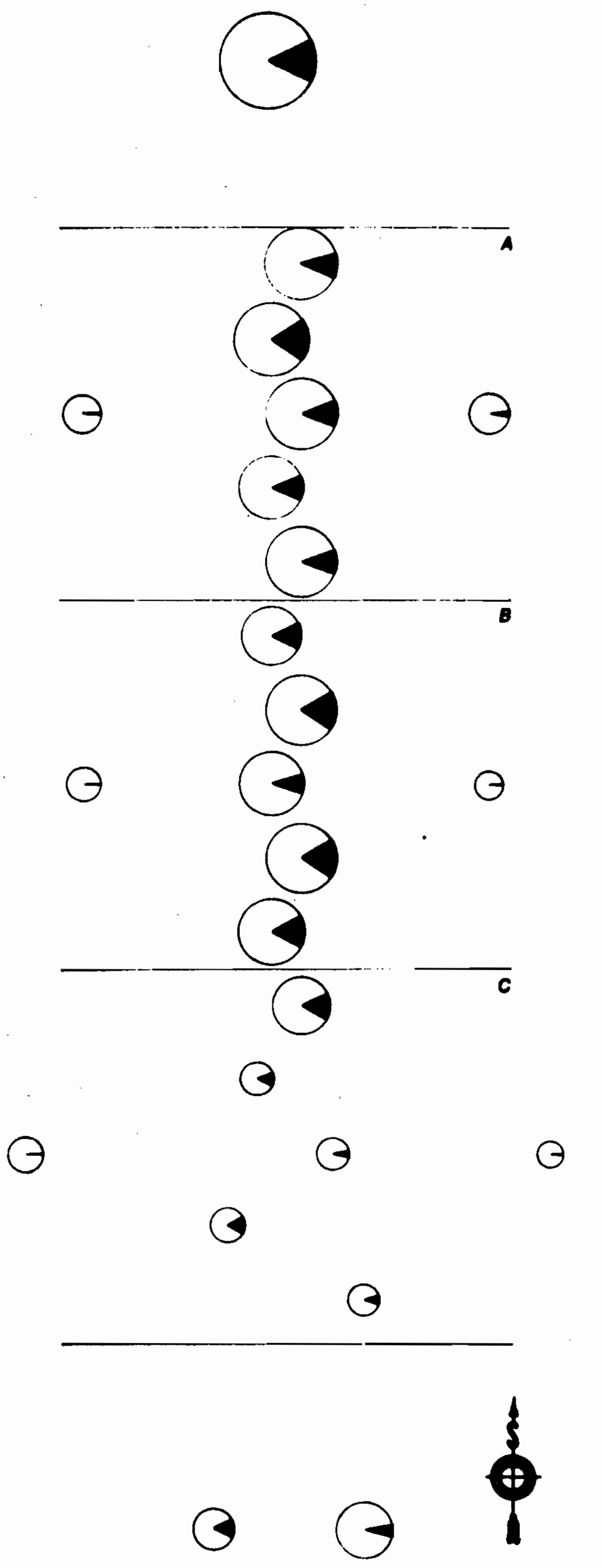

Figure 2.—Baseline distribution of 118,226 unmarked *Culex tarsalis* at Poso West, from CO_2/light-trap collections. Each circle represents a trap site, and its size the relative number of mosquitoes collected. Shaded areas indicate males, and open areas females.

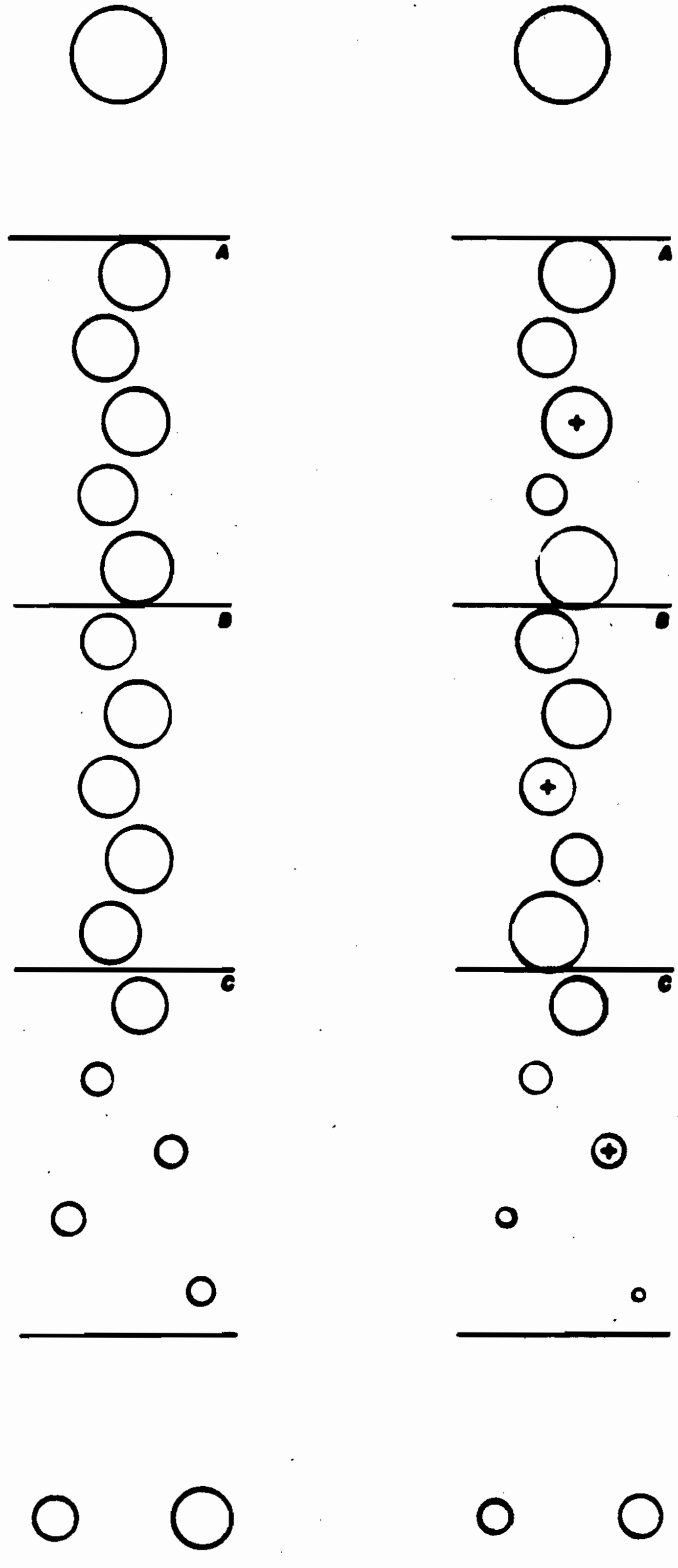

Figure 3.—Distribution of 92,938 unmarked (left) and 409 marked (right) female *Culex tarsalis* at Poso West, from CO_2/light-trap collections. Each circle represents a trap site, and its size the relative number of mosquitoes collected. Equal numbers of marked females were released at each of the 3 sites marked with a cross.

SEASONAL ACTIVITY, RELATIVE ABUNDANCE, AUTOGENY, AND PHYSIOLOGICAL-AGE IN CENTRAL CALIFORNIA POPULATIONS OF *CULISETA INORNATA* (WILLISTON)

R. P. Meyer and R. K. Washino

University of California

Department of Entomology, Davis, California 95616

From October to late May of 1975-76 and 1976-77, the seasonal activity, relative abundance, autogeny, and physiological-age were investigated in populations of *Culiseta inornata* (Williston) associated with coastal saltmarsh, valley, and Sierra foothill regions of central California (Meyer and Washino 1976). Within each region larvae of *Cs. inornata* develop primarily in the following aquatic habitats: (1) Suisun Marsh (marsh) – fall-winter flooded water fowl refuge and duck club ponds (water salinity <2.0%); (2) Sacramento Valley (valley) – irrigation flood water, vernal ponds in lowland areas, drainage ditches, and oxidation ponds; and (3) Sierra Nevada foothills (foothill) – vernal ponds that form in dredger tailings and lowland areas.

Drought conditions which persisted during both seasons of sampling limited mosquito production to localized source areas in the Sacramento Valley and Sierra Nevada foothills. Also, most duck clubs and holding ponds on Suisun Marsh were drained by late February to further limit production sources.

SEASONAL ACTIVITY AND RELATIVE ABUNDANCE.--Both seasonal activity and relative abundance were determined by operating CDC miniature light traps baited with 2.25 kgm of dry ice for one night at 14 day intervals. Adult populations were sampled at three locations, 2 rural and 1 urban, within each region. Climatological data were obtained through monthly reports (NOAA) from weather stations located within 15 km of all adult trapping sites.

Collection size was used to correlate the effect of various climatological factors, primarily minimal temperature, on adult activity. Traps were operated on nights that were calm and occasionally overcast, and under wind or fog conditions when these weather factors were predominant for that sampling interval.

Results indicate that both activity and abundance were significantly higher at all rural locations and least in urban areas for each region. The largest collections were consistently taken on Suisun Marsh in October and November of both seasons and were 10-fold above those from either valley or foothill locations. During both seasons periods of peak activity occurred in the fall and mid-winter at marsh and valley locations. Collection sizes from foothill traps were typically smaller than either valley or foothill collections and only minor peaks were observed during the same sampling period. Samples from traps operated on nights when conditions were characterized by fog, wind with gusts above 16 km/hr., and air temperatures near or below freezing were usually negative or contained only a low number of females. The average collection site for each location was higher in 1976-77 than in 1975-76 and probably related to increased habitat availability and/or favorable climatic conditions. On warm evenings (>15°C) in the marsh during October and November females were persistant biters, and would readily take a blood meal.

AUTOGENY.--Rates of autogeny in field populations were obtained from inseminated 10 day old females fed on 10% sucrose and reared from late 4th instar larvae and pupae collected from routinely sampled (biweekly) larval habitats in the Suisun Marsh and Sierra foothills. Females were held for 10 days at 21.0°C and exposed to 14 hours of light per 24 hour period. At the end of the holding period females, at least 50 per sample, were dissected and the stage of follicular development (Christophers Stage) was recorded.

In three of four cases autogeny was negatively correlated to temperature. When the observed rate of autogeny determined on each sampling date was compared with the mean ambient air temperature calculated for the preceeding 14 day interval, correlation coefficients of $r=-.72$ were obtained both seasons for Suisun Marsh correlates; and $r=-.42$ (1975-76) and $r=-.89$ (1976-77) for Sierra Nevada foothill correlates.

By late December and early January observed activity in both Marsh and foothill regions had declined significantly at daily mean temperatures between 0-5°C. A corresponding increase was observed in the rates of autogeny in females reared from field collected larvae and pupae during the same period for both seasons. In early January the rate of autogeny in 10 day old females from Suisun Marsh reached a maximum of 42.0% in 1975-76 and 35.0% in 1976-77; and in females from the Sierra foothills, 40.0% in 1976-77.

This pattern suggests that increased autogeny observed during early winter functioned as a homeostatic mechanism for maintaining egg production when flight activity in anautogenous (blood-feeding) females was limited by low ambient air temperatures and indicated by either small or negative collections of females.

PHYSIOLOGICAL-AGE.--Physiological-age was determined by the Polovodova method (Detinova 1962) in live-trapped females. When collection size precluded aging the entire sample, a subsample consisting of 50 females was selected at random. Parous rates determined from subsamples were considered as an estimate of the parity in the remaining undissected portion.

The number of parous females collected was generally proportional to the sample size. Observed parous rates were not significantly different between regions, particularly rural locations, but were higher in rural versus urban locations. Although the number of parous females recovered in urban traps was low, seasonal patterns in parity conformed to those observed in rural collections. Multiparous females (2-parous and above) were more frequently present in samples containing a higher proportion of parous than nulliparous females. Of the females age-graded, none showed evidence (serial dilatations), of having completed more than four gonotrophic cycles (4-parous). The oldest females collected were from traps operated on Suisun Marsh in November of 1975 and during mid-winter of 1977.

The seasonal patterns of parity in females collected from rural locations in each region is summarized as follows: (1) at Suisun Marsh, most parous females were collected in November of 1975 and from mid- to late January of 1977; (2) at Sacramento Valley, highest parous rates were recorded from collections taken between late November and mid-January of 1975 and from March to early April of 1977; and (3) at Sierra foothill, parity was highest in October of 1975 and from mid-October to mid-November of 1976, and from mid-February to mid-March of 1977.

REFERENCES CITED

Detinova, T. S. 1962. Age-groups methods in Diptera of medical importance; with special reference to some vectors of malaria. WHO, Genera. 216 p.

Meyer, R. P. and R. K. Washino. 1976. A comparison of northern California populations of *Culiseta inornata* (Williston): A progress report. Proc. Calif. Mosq. Control Assoc. 44:116-119.

THE EFFECTS OF TROPICAL STORM "DOREEN" ON MOSQUITO POPULATIONS IN IMPERIAL VALLEY

Eric W. Gordon[1], Theodore A. Smith[2], Janet Ortiz[2] and Elise Moisse[2]

On August 15, 1977, tropical storm "Doreen" lashed across Imperial County causing wide spread flooding and power outages. When the storm dropped 3.5 inches of water, major damage was done to roads, breaks occurred in the irrigation canal systems, and serious damage was done to alfalfa and cotton crops estimated in the area of 14 to 20 million dollars.

The wind driven rain storm was the result of a circular storm system which had been building up about 275 miles southwest of San Diego and moved northwest.

The question of whether or not heavy rainfall in the summer season has a direct correlation to the mosquito population in the Imperial Valley is often a matter of dispute. During these periods of heavy precipitation we have tremendous amounts of standing water in the form of flooded agricultural fields, roadside ditches and temporary lakes. Certainly the additional water would seem to enhance the mosquito population in terms of available breeding sources, but does this necessarily mean increased mosquito breeding?

Tropical storm "Doreen" afforded us the unique opportunity of comparing mosquito populations during two different summer storm years; tropical storm "Kathleen" in 1976 and tropical storm "Doreen" in 1977.

A comparison of the female *Culex tarsalis* population graphs of 1976 and 1977 (Figure 3) yields some interesting information. First of all, both graphs display a bimodal characteristic which has been found to be typical of Imperial Valley with population peaks in the fall and late spring. However, in 1977 the "spring" peak occurred in June, while in 1976 it occurred in May. At first we were at a loss to explain the shifting of the spring population peak. There was no appreciable difference in rainfall or mean temperatures during the months of May and June, 1976 and 1977. However, a closer inspection of the weather data (Figure 2) showed us that the temperature maximums during May, 1976 were 5° to 20°F warmer then those in May, 1977. These months also proved to be significantly different (statistically, test distribution (t) = 4.58 at 5%, degrees of freedom (df) = 60.)

The warmer month of May, 1976 with temperatures in excess of 100°F could have facilitated breeding in female *Culex tarsalis* in terms of day-degree development. The cooler temperatures in May, 1977 may have delayed the *tarsalis* spring peak until June and July when temperatures were optimum for breeding. A comparison of the fall *tarsalis* peaks of 1976 and 1977 shows both peaks occurring in Mid-October. However, the 1976 peak is greater. Again, we looked at a comparison of temperature maximums. In September, 1976 we had temperatures that appeared to be warmer than those in September, 1977 (Figure 2) but the differences between the two months were not statistically significant (t = 1.699 at 10%, df = 14). Here it should be noted that tropical storm "Kathleen" occurred on September 10, 1976, dropping three inches of rain on the Imperial Valley, as compared to the 3.5 inches of rain from tropical storm "Doreen" on August 15, 1977. The additional water did seem to facilitate *tarsalis* breeding in October, 1976 but the peak still occurred around the same time in October as in 1977 when there wasn't a storm.

An inspection of the overall female mosquito population charts of 1976 and 1977 again shows us the bimodal tendencies with prominent peaks on both graphs in late July and early August. The high summer peaks are attributed mainly to *Psorophora confinnis* and *Aedes vexans*, which go through a complete life cycle in three to four days in flooded pastures during the hot summer months.

On the 1977 chart of total species trapped (Figure 1) we can see that the mosquito population peaked out in 3 to 4 days after tropical storm "Doreen" hit Imperial Valley. This is explicable in terms of the favorable breeding sources created when the agricultural fields were flooded. *Psorophora* eggs in diapause from the previous year required only a few days to go through a complete cycle with the temperatures in excess of 100°F. However, in 1976 we have a similar peak, but this time the peak (116 per light trap night) occurs before the summer tropical storm. "Kathleen" occurred on September 10, 1976. In this case there were not any additional breeding sources created. In addition, the sets of data proved to be statistically similar (t = 1.37 at 5%, df = 25).

This information, along with the data on population cycles of female *Culex tarsalis* leads us to believe that many of these breeding cycles are obligatory in nature, and modified primarily by temperature rather than precipitation. This is especially observed in the *tarsalis* spring peaks. Certainly increased precipitation will enhance breeding, but it appears so only if it coincides with the designated peak periods of breeding. In the case of *Culex tarsalis* breeding peaks occur in the spring and the fall, while *Psorophora* and *Aedes* peaks are in midsummer.

As an additional note it should be mentioned that most of the heavy rainfall and flooding by "Doreen" did not seem to create favorable breeding habitats. The great majority of water sources extensively surveyed were devoid of vegetation and

[1]Imperial County Health Department, 935 Broadway, El Centro, California 92243.

[2]California State Department of Health, Vector and Waste Management Section, 1350 Front Street, Room 146, San Diego, Califonria 92101.

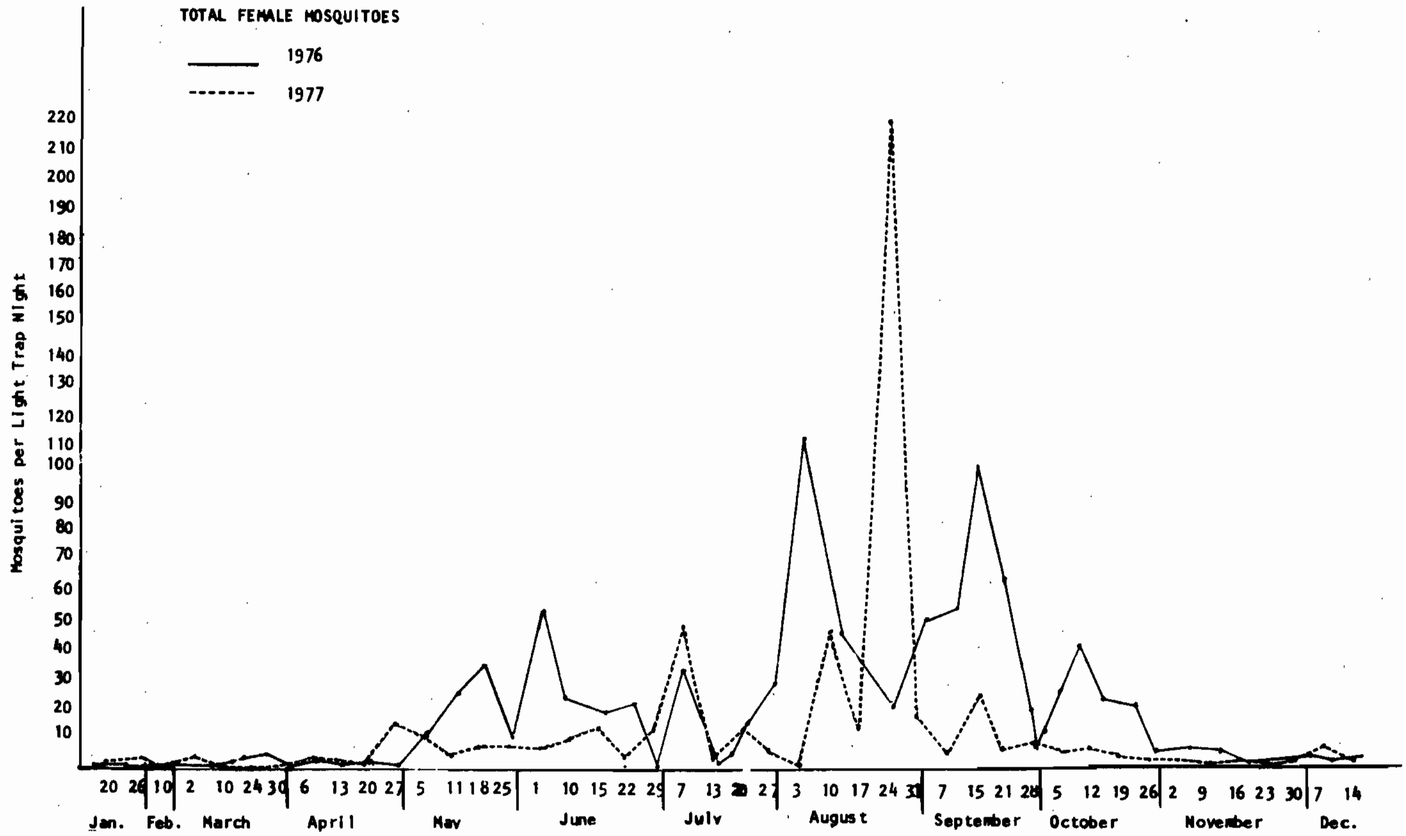

Figure 1.–Total females of all species trapped and plotted by week for the years 1976 and 1977 for the Imperial Valley, California, showing population peaks at significantly different time periods from those of *Culex tarsalis*.

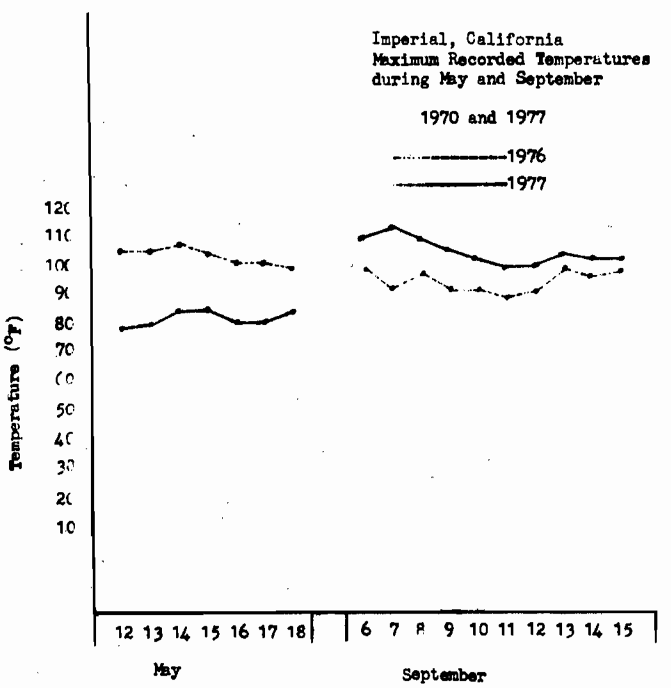

Figure 2.–Temperature data for the years 1976 and 1977 for the Imperial Valley, California.

larval activity. It seems to follow that there is probably a nutrient or shelter requirement necessary for breeding by the incident species.

These are only preliminary observations on the problem. More work will be required to ascertain the problem for implementation of effective mosquito control and encephalitis research, especially in the New River area.

It would appear that Imperial County can bank on additional storms in the future. The National Weather Service has said that the phenomena of tropical storms moving up from the South Pacific via trough systems is not at all unusual. Contrary to popular opinion, the storms are not 50 year or 100 year occurrences, but could happen any given year. Certainly, this is a factor that we must keep in mind for future operations.

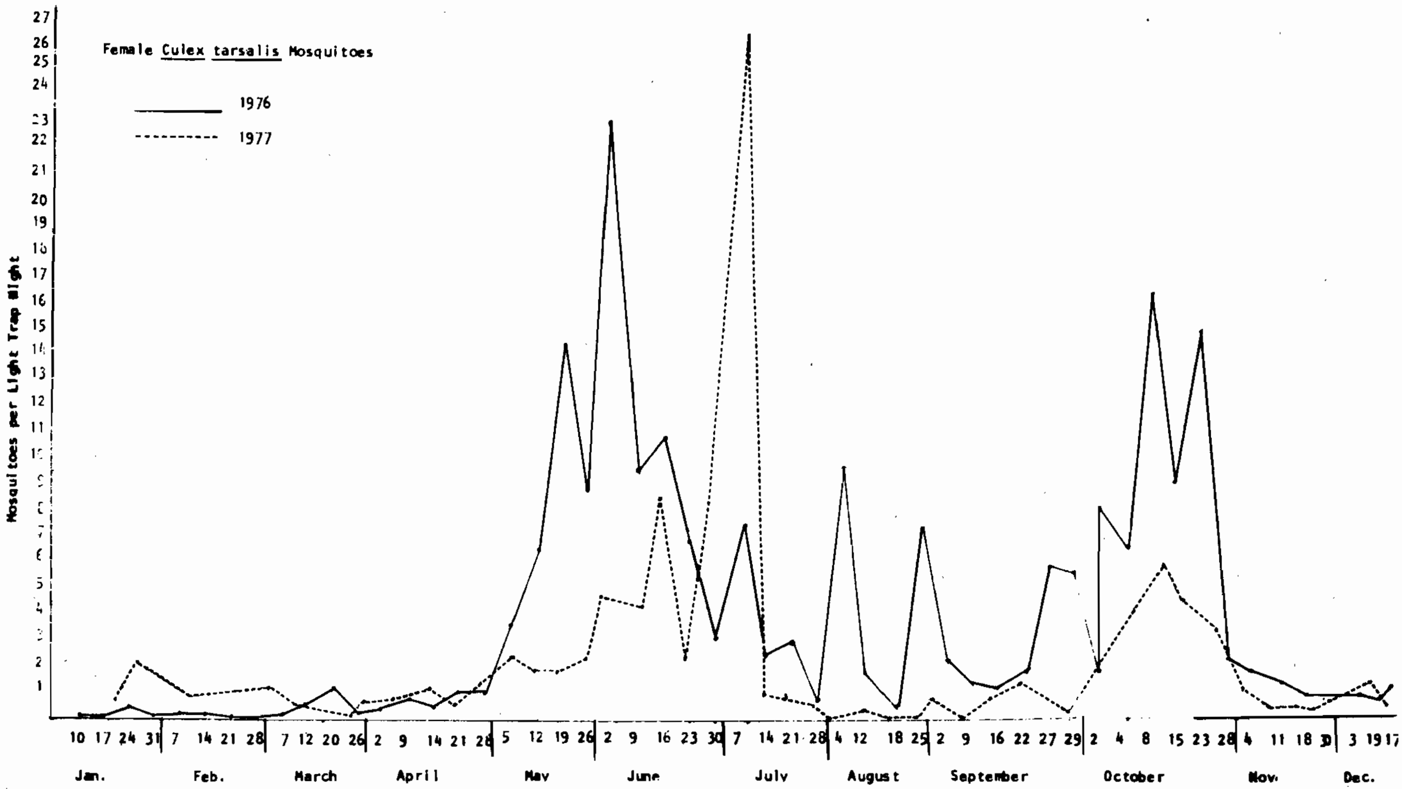

Figure 3.—Total female *Culex tarsalis* trapped and plotted by week for the years 1976 and 1977 for the Imperial Valley, California, following tropical storms with bimodal (1976) and single peak in 1977.

CONVERSION OF CDC LIGHT TRAP INDICES TO NEW JERSEY LIGHT TRAP INDICES FOR SEVERAL SPECIES OF CALIFORNIA MOSQUITOES[1]

Marilyn M. Milby[2], Eugene E. Kauffman[3] and Jerald F. Harvey[3]

In mosquito control programs, it is sometimes desirable to establish a surveillance of adult vector or pest populations in areas where standard New Jersey light traps are not routinely operated. A difficulty arises when no power supply is available so that a standard New Jersey trap can be installed. An obvious solution is to use a small battery-operated CDC trap. However, you're then faced with the problem of interpreting the results in comparison to collections from the standard New Jersey traps. A number of papers have reported studies of various types of traps (Acuff 1976; Meyer et al. 1975). Unfortunately, they rarely provide more than a listing of the variety of species caught by each kind of trap and the total numbers of each species collected over a period of time. Such data are of limited value if you wish to analyze seasonal or environmental differences.

Last summer, the Sutter-Yuba Mosquito Abatement District and the Arbovirus Research Unit of the University of California at Berkeley cooperated in a study in the Sacramento Valley to compare CDC traps baited with CO_2 with New Jersey traps. Collections were analyzed as to: 1) species, 2) sex, 3) variations at differing population densities, 4) differences in environments and 5) distances from known or potential sources of mosquito breeding. A secondary goal was to compare standard New Jersey trap collections with collections from aluminum light traps, obtained as military surplus and normally used by the District at a number of their regular light trapping stations.

MATERIALS AND METHODS.—Eight locations were utilized: 3 were in residential areas, 2 were in orchards, 1 was in a permanent pasture area and 2 were in rice field areas. Six locations represented regular Sutter-Yuba District light trap stations where aluminum traps were in use.

At each location, 2 trap sites were selected and metal posts with crossarms were installed to provide a place to hang the traps. The 2 sites at each location were at least 110 feet apart, but not more than 200 feet, and were separated by a visual barrier such as a building or foliage. Whenever possible, the sites were placed in the open where they were unrestricted by adjacent foliage or structures. Each of the 2 sites had a power supply so that either type of trap (New Jersey or CDC) could be operated. CDC traps (Sudia and Chamberlain 1962) were baited with 4-pound blocks of dry ice wrapped in brown paper bags, and were powered by 6-volt batteries. New Jersey traps were all of the American type (Mulhern 1953), with a 25-watt light source.

Comparison runs were made 2 nights every other week for 8 weeks, beginning June 6th and ending the week of September 12th. Traps at each location were randomly allocated to sites on the 1st night, and were placed at alternate sites on the 2nd night. Aluminum traps operated normally both nights at their regular sites.

Ratios of collections from CDC and New Jersey traps were analyzed separately for each trap run. There were differences in density between the 2 sites at several locations; hence for each week, we summed the 2 nights' collections at the east and west sites for each kind of trap. We added 1 to each summed collection before calculating ratios; this eliminated ratios of zero or infinity for negative collections. This procedure provided a weekly ratio for each species and sex at each location. Finally, we calculated the average of the 8 weekly ratios to obtain a mean ratio for each species and sex at each location.

RESULTS AND DISCUSSION.—A total of 134,485 mosquitoes were collected (Table 1). The 3 most abundant species in all 3 trap types were ***Culex tarsalis***, ***Aedes melanimon*** and ***Anopheles freeborni***. CDC traps collected more females than New Jersey traps for all species except ***An. freeborni***. New Jersey traps collected more males of all species than CDC traps.

Analysis of weekly data (not shown) revealed that weekly ratios at each location were consistent throughout the summer despite fluctuations in population density. The principal source of variation in ratios was the difference between the types of environment in which the traps were operated, but apparently influenced by their distance from breeding areas.

For *Cx. tarsalis* females, the CDC-to-NJ mean ratios ranged from about 3-to-1 in the rice field and pasture areas to roughly 12-to-1 elsewhere. The highest ratio came from a residential location in Sutter. The NJ-to-CDC mean ratios for male *Cx. tarsalis* were about 10-to-1 in the rice field areas, but were much lower at other locations where very few specimens were collected.

The CDC-to-NJ mean ratios for *Ae. melanimon* females were also about 3-to-1, and showed less variation by location than did those for *Cx. tarsalis* females. Male *Ae. melanimon* were essentially absent from collections except in 2 rural locations, where their NJ-to-CDC mean ratios were just over 4-to-1.

For *An. freeborni*, the brighter light of the New Jersey traps appeared to be a more effective attractant for both sexes than were the smaller light and CO_2 bait used with the CDC traps. Thus, for females the trap ratios were reversed. The NJ-to-CDC mean ratios in the rural areas were more than 3-to-1 for females, and even higher for males. Differences between the 2 types of traps were not so great in other areas where *An. freeborni* collections were small, and the presence of trees and shrubs may have reduced the effective range of the light.

The same mean ratio technique was used to compare New Jersey and aluminum trap collections at 6 of the 8 locations. Although we did find several NJ-to-aluminum mean ratios which were significantly different from 1.0, we feel con-

[1]This research was supported in part by Research Grant AI-03028 from the National Institute of Allergy and Infectious Diseases, and General Research Support Grant I-S01-FR-05441 from the National Institutes of Health, U.S. Department of Health, Education and Welfare.

[2]Department of Biomedical and Environmental Health Sciences, University of California, Berkeley, California 94720.

[3]Sutter-Yuba Mosquito Abatement District, Post Office Box 726, Yuba City, California 95991.

Table 1.--Mosquitoes collected during 1977 Sutter-Yuba trap comparison study.

Species	New Jersey (60 trap nights) Males	New Jersey (60 trap nights) Females	CDC/CO_2 (61 trap nights) Males	CDC/CO_2 (61 trap nights) Females	Aluminum* (40 trap nights) Males	Aluminum* (40 trap nights) Females	Total (161 trap nights) Males	Total (161 trap nights) Females
Aedes melanimon	444	9,029	246	24,036	494	3,514	1,184	36,579
Aedes nigromaculis	73	304	6	467	42	193	121	964
Aedes sierrensis	0	1	0	2	0	0	0	3
Aedes vexans	13	50	1	352	5	34	19	436
Anopheles franciscanus	0	0	0	5	0	0	0	5
Anopheles freeborni	2,419	8,993	216	3,511	2,644	6,295	5,279	18,799
Anopheles punctipennis	0	1	0	0	0	0	0	1
Culex erythrothorax	1	33	1	136	1	13	3	182
Culex peus	2	5	1	4	9	4	12	13
Culex pipiens	73	22	3	54	13	18	89	94
Culex tarsalis	6,928	11,947	1,095	33,866	7,162	9,645	15,185	55,458
Culiseta incidens	0	0	0	1	0	1	0	2
Culiseta inornata	6	15	1	25	7	3	14	43

*Aluminum traps not operated at 2 of 8 locations.

Table 2.–Average number of mosquitoes collected per week and mean ratios, 1977 Sutter-Yuba trap comparison study.

Location	Females: Mean weekly collection, New Jersey	Females: Mean weekly collection, CDC/CO_2	Females: Mean ratio (CDC+1)/(NJ+1)	Males: Mean weekly collection, New Jersey	Males: Mean weekly collection, CDC/CO_2	Males: Mean ratio (NJ+1)/(CDC+1)
Culex tarsalis						
Rice field	995	1769	2.93	508	88	9.38
	386	1034	3.27	287	34	10.50
Pasture	91	494	5.25	65	17	4.98
Orchard	24	346	9.40	3	<1	2.44
	56	650	15.45	14	2	5.81
Residential	4	38	9.11	2	<1	2.71
	7	68	10.95	1	3	2.02
	5	180	27.83	5	1	2.45
Aedes melanimon						
Rice Field	4	6	2.97*	<1	10	0.86*
	924	2405	6.91	12	2	4.93
Pasture	275	620	2.47	49	24	4.19
Orchard	1	13	3.48*	0	0	1.00*
	1	14	4.25	0	0	1.00*
Residential	2	<1	1.08*	<1	0	1.14*
	0	3	3.71	<1	0	1.14*
	3	35	5.62	0	0	1.00*
Anopheles freeborni			(NJ+1)/(CDC+1)			
Rice field	551	182	3.23	217	14	17.07
	334	107	3.78	83	9	6.02
Pasture	51	16	3.14	18	5	3.33
Orchard	136	61	1.64*	3	<1	2.00
	131	75	1.33*	3	<1	2.94
Residential	5	1	1.93	3	<1	2.57*
	3	8	1.06*	2	0	2.86
	3	2	1.50*	<1	<1	1.50*

*Mean ratio not significantly greater than 1.00.

fident that these differences primarily reflected trap placement, and not an inherent difference in the efficiency of the 2 traps.

In summary, we believe this study confirms that collections from any kind of light trap will always be subject to a great deal of variation. Trap placement is very important, but the most attractive trap site will produce widely fluctuating collections. Despite this, we feel the present study has shown that CDC light traps with dry ice can be used effectively to monitor the populations of at least 3 mosquito species in the Lower Sacramento Valley, and that the data can be converted for comparison with data from the standard trapping procedure. The conversion factors vary for each species and sex, and must take into account the type of environment in which the trap is operated.

ACKNOWLEDGMENT. The authors wish to thank Dr. William C. Reeves for his advice in the design and operation of the study and his critical review of the analysis and interpretation of the results.

REFERENCES CITED

Acuff, Virgil R. 1976. Trap biases influencing mosquito collecting. Mosq. News 36(2):173-176.

Meyer, R. P., T. McKenzie, C. K. Fukushima and R. K. Washino. 1975. Comparison of three sampling methods for measurement of adult mosquito populations. (Abstract) Proc. Calif. Mosq. Control Assoc. 43:154.

Mulhern, Thomas D. 1953. Better results with mosquito light traps through standardizing mechanical performance. Mosq. News 13(2): 130-133.

Sudia, W. D. and R. W. Chamberlain. 1962. Battery-operated light trap, an improved model. Mosq. News 22(2):126-129.

OCCURRENCE OF MOSQUITO LARVAE IN IRRIGATED PASTURES IN WESTERN FRESNO COUNTY, CALIFORNIA

David E. Reed

Fresno Westside Mosquito Abatement District
Post Office Box 125, Firebaugh, California 93622

Routine sampling of all major mosquito sources was instituted at the Fresno Westside Mosquito Abatement District as an integral part of its control program in 1968 and was described by Reed and Husbands in 1969. This practice had made possible a review of mosquito species occurrence in major sources within the District on a seasonal and year to year basis. Such a review has been reported on for rice sources for the eight year period 1969-76 (Reed 1976).

Species composition and distribution have been reported for a single pasture (Thurman et al. 1951), for stations within a field (Husband and Rosay 1952) and for multiple pastures during one season (Reed and Husbands 1969). This paper summarizes the results of sampling over the eight year period 1969-76.

METHODS & MATERIALS.–The procedures used for sampling pastures were similar to those used in rice (Reed 1976). Operators were instructed, however, to begin the inspections from the most recently flooded areas and work towards the older waters when checking for larvae in irrigated pastures. District control operators carry a sampling kit (Reed 1970) which includes a mosquito larvae hand concentrator (Husbands 1969).

Inspection of mosquito sources usually commences about mid-February. Often the first larvae found in irrigated pastures are due to ponding as the result of rain. Irrigation normally does not begin in pastures until March and rarely before mid-February. Mosquito control in pastures is geared to *Aedes* production therefore inspections and sampling of these sources will reflect this emphasis.

Samples were identified by species and instar and the number of each was recorded. Extremely high numbers in the samples were estimated and species composition prorated on the basis of an aliquot of the total sample taken from the source.

Samples of sources were taken to insure a positive sample for identification in the laboratory. Larval sample densities as used in this paper do not necessarily reflect actual field densities but are close to parallel to the field densities.

RESULTS AND DISCUSSION.–The results of eight years (1969-76) of larval surveillance in irrigated pastures is summarized in Table 1. In total, 59,600 inspections were made of which 42.27% had standing water. Of these wet fields only 27.23% contained mosquito larvae; 94.11% of these positive fields were sampled and larvae identified. There were 10 mosquito species collected in irrigated pastures over this 8 year period as summarized in Table 2. There were three species of *Aedes*, four *Culex* species, two *Anopheles* species and one *Culiseta* species. The species collected in most significant numbers and incidence were ***Ae. nigromaculis***, ***Ae. melanimon***, ***Cx. tarsalis*** and ***Cs. inornata***, representing 99.7% of the specimens identified. As expected ***Ae. nigromaculis*** was identified in 62.33% of the samples collected and was closely followed by ***Ae. melanimon*** at 46.64% of the total samples.

Cx. tarsalis was found in 22.35% of the samples. This low percentage may be an artifact of the personnel's operating procedures in that inspections and spraying of pastures has been generally directed to *Aedes* control. A large percent of the *Culex*, *Culiseta* and *Anopheles* samples were from areas of pastures which remained ponded from irrigation to irrigation. It is felt, however, that incidence of these species in pastures which have no ponding from one irrigation to another is of little significance in total adult mosquito production.

There were definite seasonal distribution differences in the appearance of most species collected. ***Cs. inornata*** was found mainly during the first four months (February-May). About 91% of the samples containing this species were collected during this period. ***An. freeborni***, on the other hand, was collected primarily (74% of the samples) in September and October. ***Culex pipiens quinquefasciatus***, ***Culex peus*** and ***Anopheles franciscanus*** were also late appearing species in pastures. The August-October incidence represents 77% of the ***Cx. pipiens quinquefasciatus*** seasonal total, 62% of the ***Cx. peus*** and 100% of the ***An. franciscanus*** (1 appearance only).

Cx. tarsalis was not collected in irrigated pastures until the second week in March and was collected at about the same rate from that point on until October with the exception of April (Figure 2). Larval densities, based upon 10 dip samples, gradually increased until August at which time they gradually dropped (Figure 1).

Incidences of larval ***Ae. nigromaculis*** and ***Ae. melanimon*** were expected to show highly contrasting results. The contrast occurred but not to the degree expected during summer and fall. Both species appeared early in pastures. ***Ae. melanimon***, however, was significantly the most dominant species in February and March. April, a transitional month for these species, saw both species collected equally. During the balance of the year, ***Ae. nigromaculis*** dominated. The differences in incidence of these species are considered to be of low to moderate significance.

Incidence of these major *Aedes* species was compared for the northern and southern divisions of the District the results of which are shown in Figures 3-6. ***Ae. nigromaculis*** was collected with greater frequency in the southern area of the District while ***Ae. melanimon*** dominated in the northern area. ***Ae. nigromaculis*** incidence in the southern division was significantly different from that of ***Ae. melanimon***, but in the northern areas differences in incidence of these two species was only moderate. The high incidence of ***Ae. melanimon*** in the northern division had a moderating effect on the District-wide results.

Larval concentrations of ***Ae. melanimon*** and ***Ae. nigromaculis*** as collected in 10 dip samples followed similar patterns to the larval incidence. The densities of ***Ae. melanimon*** were higher in the northern areas of the District and ***Ae. nigromaculis*** densities were significantly higher in the south (Figure 3 and 4). The overall District effect was one of little difference in density between these species except during August and September.

These results confirm what was reported in 1968 (Reed and Husbands 1969) giving greater credence to effects of soil types to the mosquito composition in pastures. Soils in the pasture area of the southern division are sandy clay loam of the Fresno, Traver, Pond and Waukena series, but the northern division pastures are located on Merced Clay. Also, irrigation is from cold surface waters in the northern division and warmer well water is used in the south.

In conclusion, all mosquito species in the valley portion of the District (except the tree hole species *Aedes sierrensis* and *Orthopodomyia signifera*) were found in irrigated pastures. Seasonal distribution and occurrence of each species were as expected except for *Ae. melanimon*, where heavy, cold soils maintained a high incidence and density of this species throughout the season thus affecting the District-wide seasonal distribution of this species.

Table 1.–Summary of results of mosquito larvae collections in irrigated pastures from 1969 to 1976.

	Total Pastures				*Aedes nigromaculis*		*melanimon*		other		*Culex tarsalis*		other*		*Culiseta inornata*		*Anopheles* Species	
Month	Inspection	Wet	W/larvae	Sample	No. sources	No. larvae	No. sources	No. larvae	No. S	No. L	No. sources	No. larvae	No. S	No. L.	No. S	No. lar.	No. S	No. L
Feb.	143	81	23	23	1	6	17	10					1	1	7	96	1	1
Mar.	2,889	1,922	431	406	89	1,638	245	3,315	2	6	89	494			90	687	2	3
Apr.	6,524	2,739	569	545	322	6,741	309	3,408			53	349	2	5	50	852	1	1
May	7,910	3,243	920	881	525	6,100	406	4,223	2	5	194	2,049	3	10	52	457	1	1
June	10,343	4,284	1,340	1,231	739	11,802	592	12,736			307	3,387	3	20	13	52	3	4
July	8,866	3,747	1,135	1,034	639	15,231	508	13,711			288	3,392	1	1	2	7		
Aug.	9,437	4,013	1,191	1,133	784	30,610	460	7,771	3	14	246	3,765	7	88	2	6	1	1
Sept.	10,250	4,360	1,221	1,177	884	43,494	448	10,150			274	3,759	7	223			20	61
Oct.	3,238	1,975	349	326	208	8,556	166	4,753			61	634	13	144	3	7	6	12
Total	59,600	26,364	7,179	6,756	4,191	124,178	3,151	60,177	7	25	1,510	17,829	37	492	219	2,096	35	84

**Culex pipiens quinquefasciatus*, 26 samples, 419 specimen.

Table 2.—Summary and evaluation of 8 years of sampling for larvae in irrigated pastures.

Mosquito species	Total Samples	Total Specimen	Larvae Density	Percent of Total Specimen	Percent of Sources Sampled
Aedes nigromaculis	4,191	124,178	2.96	60.61	62.33
Aedes melanimon	3,151	60,177	1.91	29.37	46.64
Culex tarsalis	1,510	17,829	1.18	9,70	22.35
Culiseta inornata	219	2,096	0.96	1.02	3.24
Anopheles freeborni	34	82	0.24	0.04	0.50
Culex p. quinquefasciatus	26	419	1.61	0.20	0.38
Culex peus	8	68	0.85	0.03	0.12
Aedes vexans	7	25	0.36	0.01	0.10
Culex erythrothorax	3	5	0.17	0.00	0.04
Anopheles franciscanus	1	2	0.20	0.00	0.01
Other species	2	2	0.10	0.00	0.03
Total	6,756	204,883			

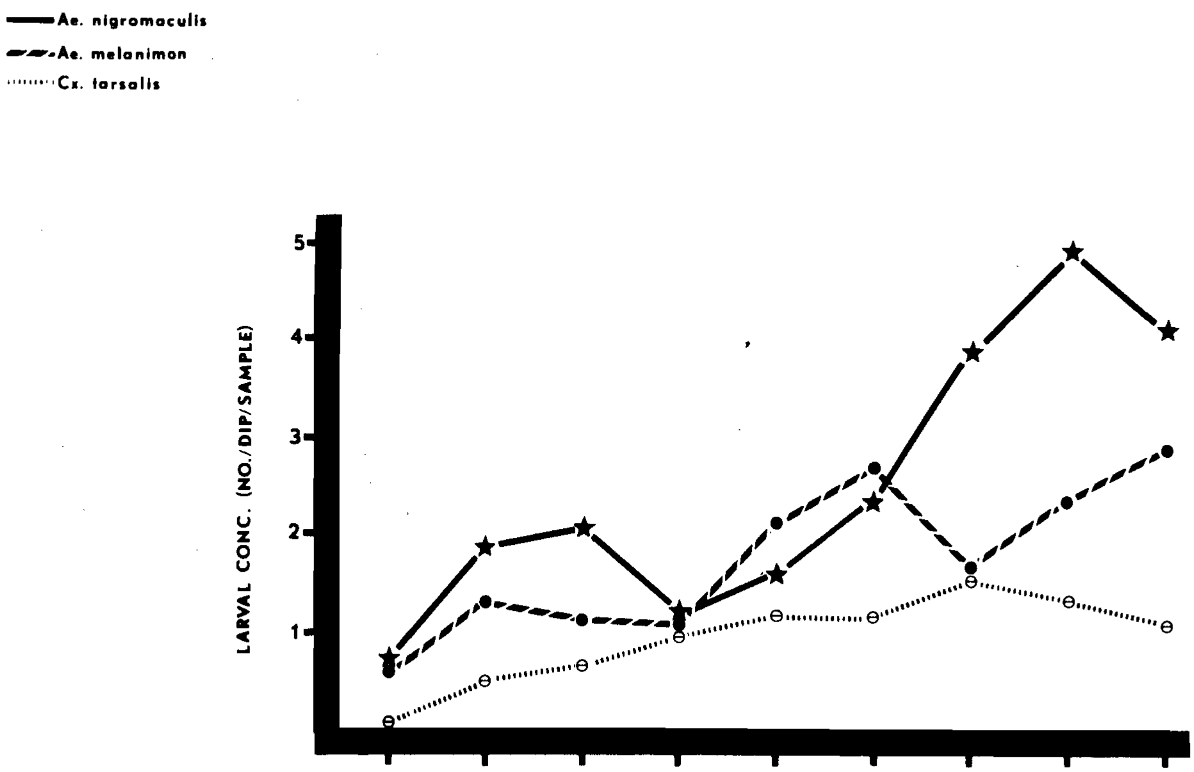

Figure 1.—Monthly larval densities of three mosquito species found in irrigated pastures from 1969 to 1976.

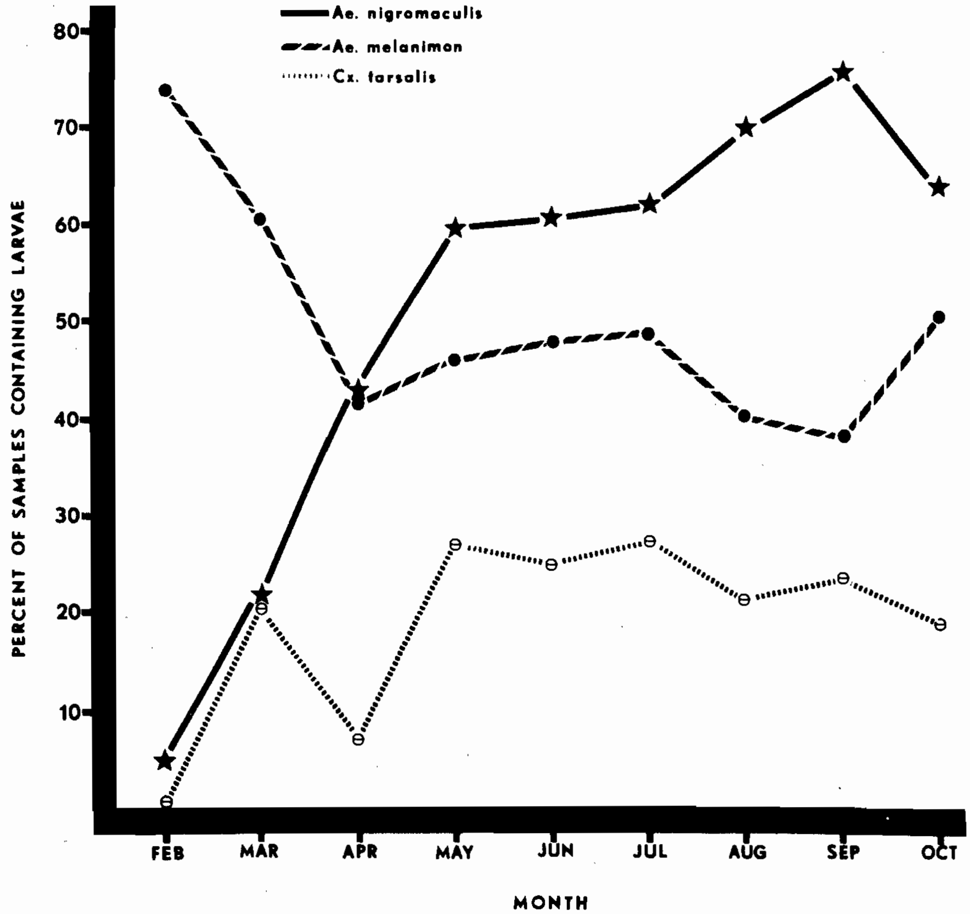

Figure 2.–Frequency of appearance of three mosquito species in irrigated pastures over an eight year period expressed in percent of positive samples.

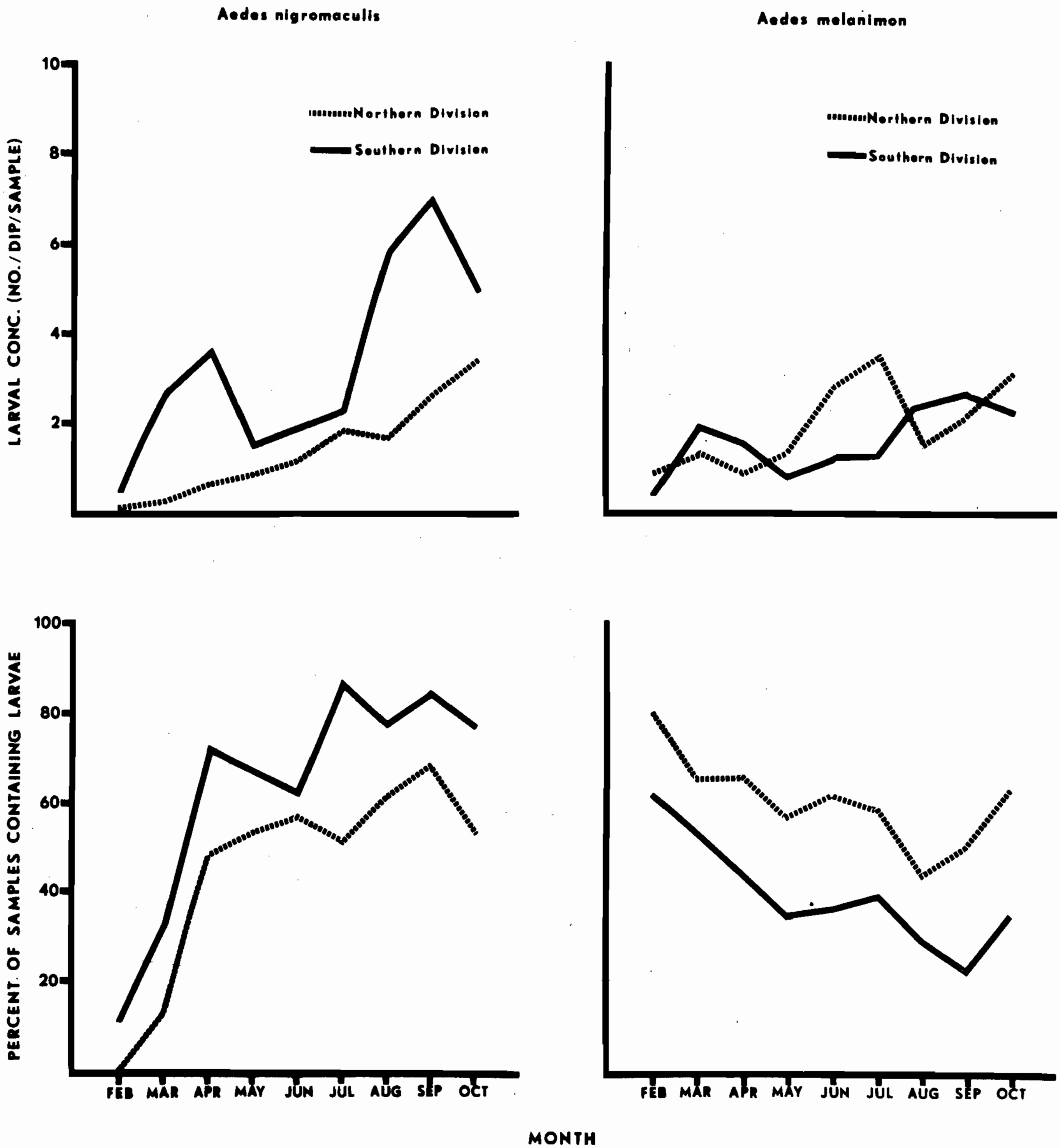

Figure 3-6.—A comparison of larval concentrations and incidence of *Aedes nigromaculis*, *Aedes melanimon* in the Northern and and Southern Divisions of the Fresno Westside Mosquito Abatement District.

A LABORATORY TEMPERATURE-CONTROLLED RECIRCULATING WATER SYSTEM FOR INVESTIGATING AQUATIC ORGANISMS

Jack Hazelrigg
Southeast Mosquito Abatement District
9510 South Garfield Avenue, South Gate, California 90280

INTRODUCTION.--A basic laboratory recirculating water system (closed) for handling many separate aquaria and studying aquatic organisms can be constructed easily and inexpensively. Adding auxillary features to regulate water temperature and supply compressed air increases the cost of such a system, but the expense is worth the gain in experimental flexibility and use. The basic system can be any size that fits the available space and needs of the researcher. The system described in this paper was modified from features of two existing systems designed by Ernest C. Bay (unpubl. data) and is now operational at the Southeast Mosquito Abatement District.

The District's system is shown in the schematic in Figure 1. Water is circulated by a pump from a reservoir at ground level to two horizontally supported plastic standpipes. Aquaria receive water from these pipes by gravity through Tygon tubing. Gravity also returns water from the aquaria into a series of horizontal and vertical drains of plastic pipes to the reservoir for recirculation. Water temperature can be maintained constant or fluctuated to simulate thermoperiodicity and compressed air can be supplied to aquaria. The system can support approximately 40 to 50 five-gallon aquaria.

DESCRIPTION OF THE BASIC SYSTEM.--As shown in Figure 1, the basic system is comprised of three levels. A larger lower table forms the main support and working area of the system, measures 4 ft x 8 ft x 1 inch and stands 37.5 inches (ours is discarded aircraft workbench). Atop this, a smaller table of 3/4-inch plywood forms additional working area and support for the system. It is 3 ft x 8 inches, 20 inches above the lower table and supported by 3 braced boards (1 x 12 inches), each cut with a hole to accommodate the horizontal 4-inch PVC standpipe. A platform of 3/4-inch plywood measuring 1 x 8 ft forms the third level of the system and a base for 3 wooden supports (2 x 12 inches) 5½ inches high and cut U-shaped to support the other 4-inch PVC standpipe. The platform is supported 12 inches above the upper table by 3 segments of galvanized pipe.

The plumbing of the system is entirely of Schedule 40 PVC. PVC is inexpensive, easily fitted, lightweight, and biologically inert. No attempt is given to describe pipe lengths and fittings used, since design criteria for plumbing can vary for similar systems.

As illustrated in Figure 1, water flows from the pump (March, orbital magnetic drive pump, Model AC-3C-MD) into the top end of the upper 4-inch standpipe through ¾-inch pipe; rate of flow is regulated with a ¾-inch globe valve fitted to the delivery pipe. A 3-inch length of 2-inch pipe sets vertically into the standpipe nearly opposite the fill (Figure 2). This permits the upper standpipe to fill with water at a fixed level and delivers the excess spill water into a vertical drain of 2-inch pipe opening into the top of the lower 4-inch standpipe. Fill design of the opposite end of lower standpipe is identical to the upper standpipe. Spill water flows down a vertical section of 2-inch pipe into a common horizontal drain of 2-inch pipe.

The standpipes are capped at each end and their lower 1½ inches drilled with opposing rows of ¼-inch holes spaced 6 inches apart. The holes are fitted with Tygon tubing which supplies water to the aquaria. The tubing is held in non-service position by 1 x 6-inch planks as shown in Figure 1.

Water from the aquaria delivered through the tubing drains into the slotted 2-inch pipes which are supported horizontally along each edge of the tables. The tops of these drains fit evenly with the top surface of the tables. Slotting facilitates cleaning and aquaria placement. These drains unite with the horizontal common drain (Figure 1) that forks, returning water either to the reservoir for recirculation or a nearby sink trap for flushing. Direction of water flow is determined through the use of two 2-inch valves at these end points (Figure 1). Since there is a capped hose fitting common to the point of inflow (Figure 1) and sink-drainage available, the entire system can be flushed and cleaned periodically. Also, the accessible ends of the standpipes have ¼-inch capped nipples which serve as drains (Figure 1). Unions are installed at critical sites in the plumbing, making possible the disassembly and relocation of the system.

The reservoir is an approximately 70-gallon capacity ¾-inch plywood box made watertight with fiberglass and resin. Components of the reservoir and filtration system are shown in Figure 3. The inner 4 inches of the reservoir are braced with 1 x 4-inch joists to support the water intake and biological filter.

The intake leading to the pump is Y-shaped, ¾-inch PVC, and positioned as shown in Figure 3. Holes ¼-inch in diameter and 1 inch apart are drilled along the bottom length of the intake. It is connected to an outlet fitted into the wall of the reservoir. A ball valve occurs between the reservoir and pump to prevent backflow into the reservoir should the pump fail.

The biological filter is comprised of a fiberglass plate or subgravel filter and two layers of gravel (Figure 3). The plate is two sheets of corrugated fiberglass glued together and perforated with slots according to Spotte (1970). The plate a 2-inch layer of pea gravel topped by a 1-inch of coarse aquarium gravel.

AUXILLARY FEATURES.–The basic system shown in Figure 1 is also equipped for maintaining constant water temperature or providing varying thermoperiods. Constant temperature is maintained within ± 1°C by bucking two 750-watt heaters (Hotwatt, item 1SH377 80 OW120 V SF2-6) against a refrigeration unit (Neslab, Model PBC-75 Portable Bath Cooler) integrated into the reservoir. Switching of the heating-cooling systems is accomplished by a thermoregulator (Cole-Parmer, Stock No. 2149-71 0-50°C) coupled to 2 electronic relays. The thermoregulator is enclosed within a plexiglass aquarium. Thermoperiodicity is achieved by coupling 2 thermoregulators (one for cooling, the other for heating) into the relays whose on and off positions are coupled to a 7-day interval timer (Dayton, Model 2E214). If desired, the timer can be set to simulate an extreme 3:21 hour thermoperiod for any diel.

Compressed air is also available to the system from a shop air compressor. Half-inch PVC pipes leading from a main delivery line parallel the length of the upper standpipe as shown in Figure 1. Along each, ¼-inch holes are drilled and fitted

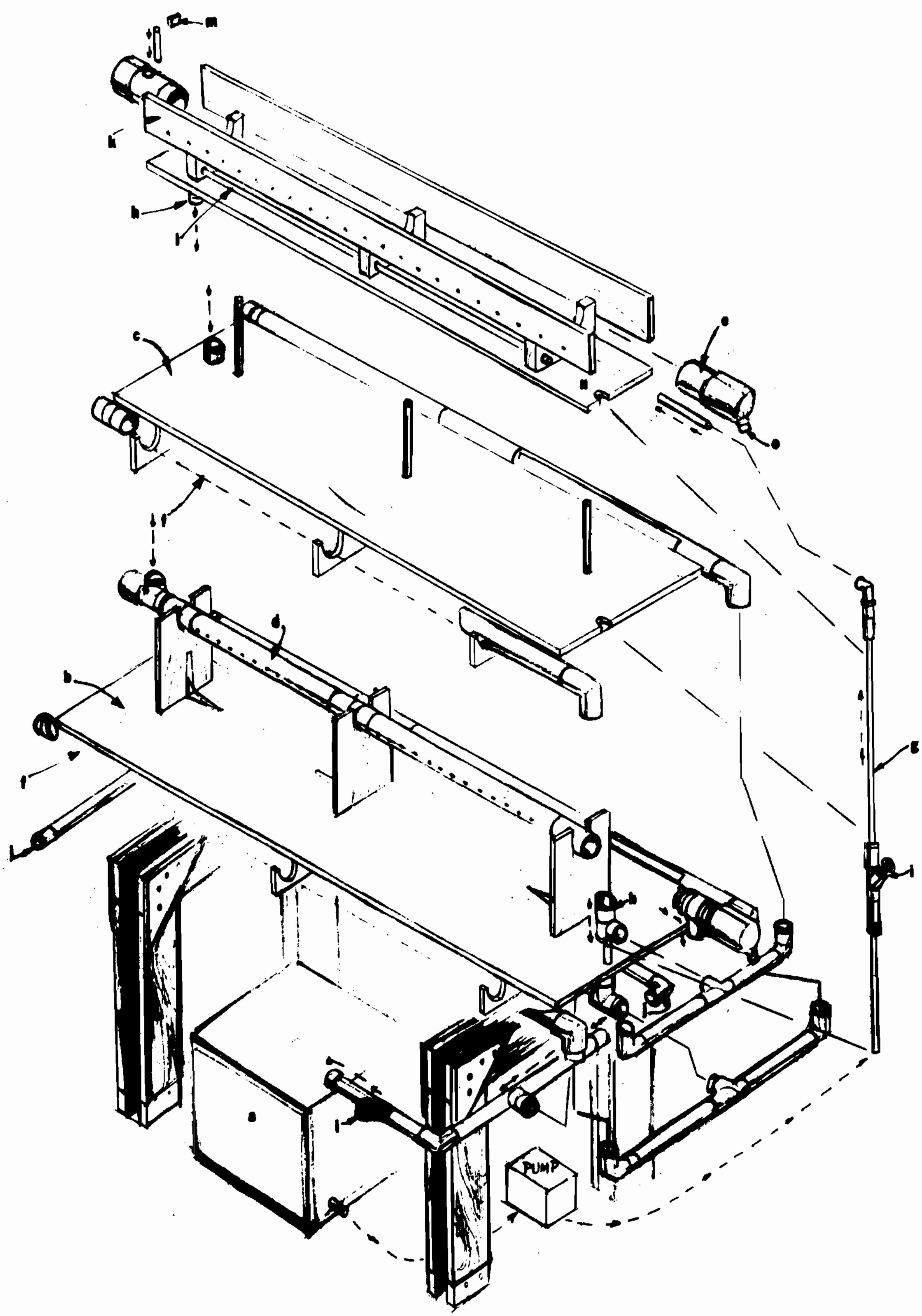

Figure 1.–Schematic of the system indicating major components: a. reservoir; b. lower table; c. upper table; d. lower horizontal standpipe; f. horizontal drains; g. fillpipe; h. vertical drains; i. globe valves; j. flush drain to sink (globe valve not shown); k. upper plank to support tygon tubing in nonuse position; l. PVC air line; m. garden hose adapter and fittings for flushing; n. platform, supporting upper standpipe; o. flush plug. Broken line with arrows indicates direction of water flow.

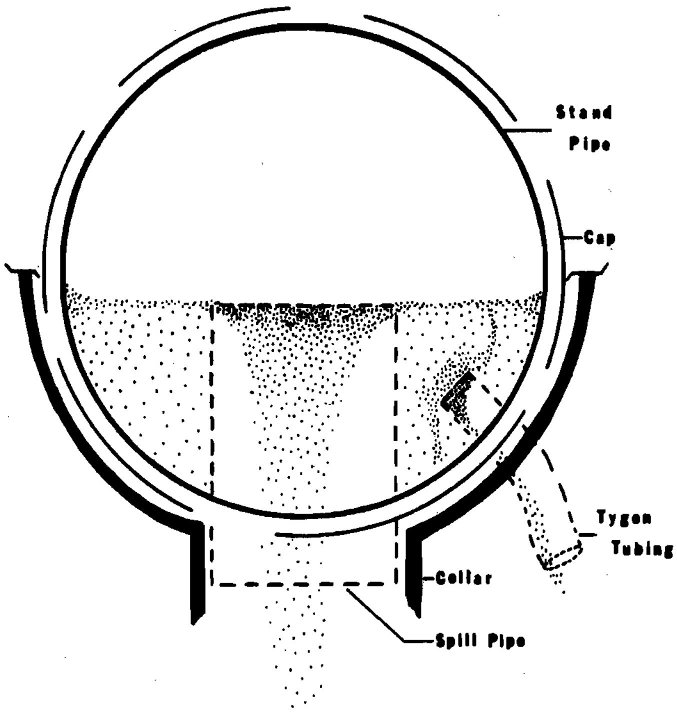

Figure 2.--Illustration showing position of 2-inch PVC pipe (spill pipe) within 4-inch PVC standpipe.

with segments of 5/16-inch Tygon tubing and connected to tri-nozzle air gangs attached to the edge of the smaller table. An air filter and regulator are connected to the main delivery line.

REFERENCES CITED

Spotte, Spephen H. 1970. Fish and invertebrate culture. Water management in closed systems. John Wiley and Sons, Inc., New York. 145 p.

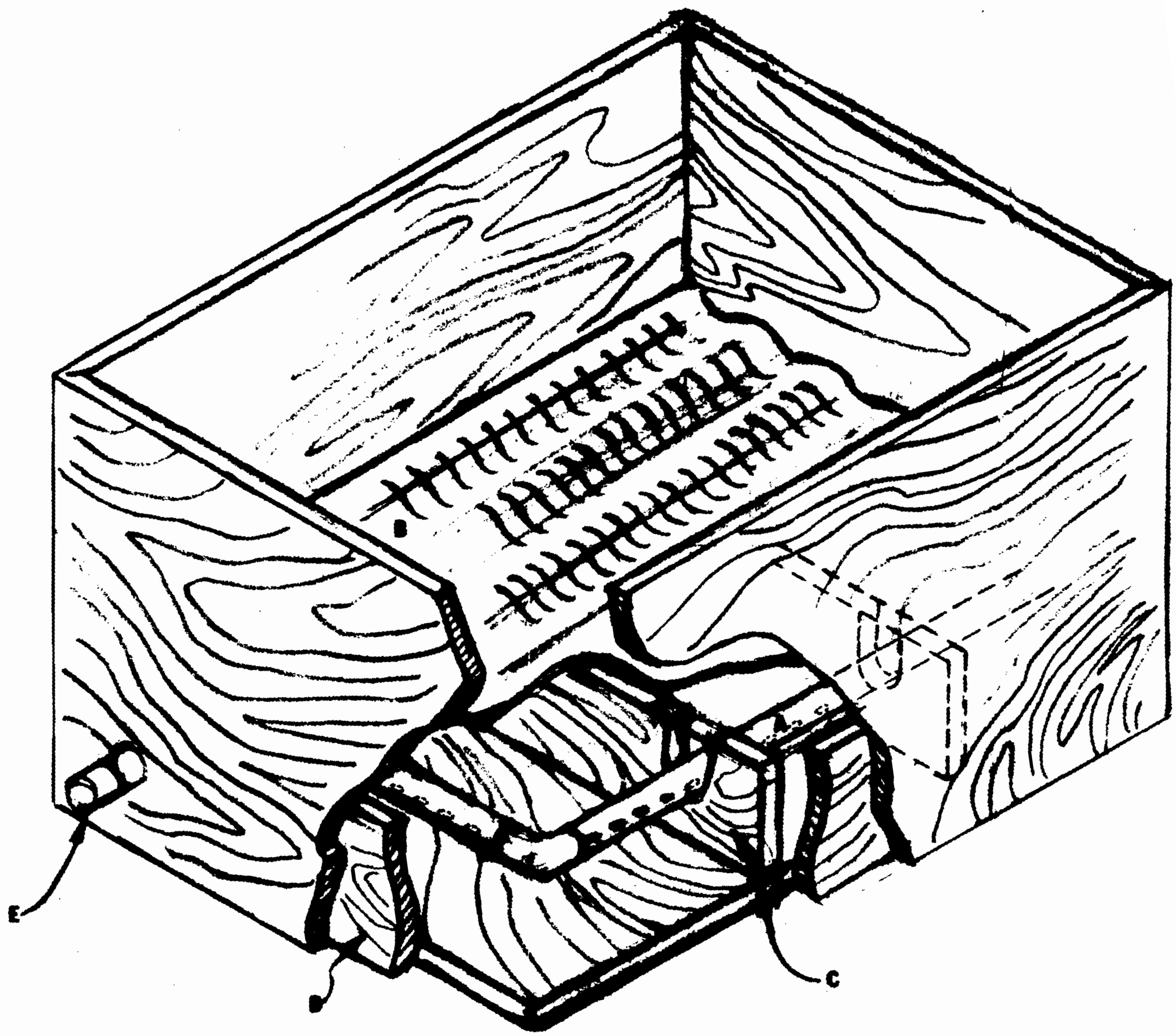

Figure 3.–Illustration showing components of the reservoir. A. PVC intake tubing or manifold; B. Fiberglass baffles with slits; C. One of two main joists; D. Trimming joist; E. PVC outlet to pump.

PRODUCTS OF PUTREFACTION AND BREWING ODORS THAT ATTRACT SYNANTHROPIC FLIES[1]

Mir S. Mulla[2], Yih-Shen Hwang[2], Edmond C. Loomis[3] and Harold Axelrod[2]

ABSTRACT

Volatile kairomones produced on putrefaction and fermentation of complex organic materials such as whole egg and molasses and sugar solutions with yeast have been chemically identified. The attractancy of the various emanated products against a number of synanthropic flies is investigated and reported.

Five volatile kairomones produced on rotting aqueous suspension of whole egg powder were found as attractants or coattractants against the eye gnat *Hippelates collusor* and other pestiferous species of this genus. Of these attractants, only 2 showed activity against *Musca domestica* and *Muscina stabulans*. None of these putrefying kairomones were attrative to *Fannia* species. Ethyl alcohol as the main component (>99%) of brewing was the only attractant against *Fannia*. It was attractive against *M. stabulans* and increased the potency of putrefying kairomones against this species and *M. domestica*.

INTRODUCTION.--Both vector and pestiferous species of Synanthropic flies are attracted to their vertebrate hosts and other sources of food by means of a variety of volatile chemicals. These chemicals are produced either in the process of catabolism in the hosts or by the resident microorganisms on the skin surface or inside the host body. Free-living microorganisms also play an important role in the production of chemical stimuli which provide cues for certain insects to locate a source of food and oviposition or breeding sites. Such chemical substances produced by one organism which induce response in another are known as kairomones or transspecific chemical stimuli.

It has been known for a long time that decaying meat, fish, and putrefying complex proteins liberate volatile chemicals which attract a number of species of eye flies, blowflies, fleshflies and muscid flies to the sources from where such chemicals are liberated (Burgess 1951, Dow 1959, Mulla and Axelrod 1977). Similarly, fermentation and infusion of plant products and animal wastes by ferments and infusoria produce volatile chemicals which serve as cues for a number of functional responses in the receiver organisms. These chemicals in general act as a stimulus for feeding, oviposition, aggregation or a combination of these.

Recent developments in the isolation and identification of volatile chemicals produced on putrefaction, fermentation and infusion of a variety of substances of plant and animal origin, made during the course of our research endeavors will be discussed here. The possible potential of these behavior modifying substances in population control and sampling techniques will be made the subject of this paper. To approach this subject matter in a systematic manner, products of putrefaction and fermentation or brewing which modify the behavior of pest and vector synanthropic flies will be discussed here. Products of infusions in so far as they influence oviposition behavior of mosquitoes will be discussed by other researchers from the University of California at Riverside.

KAIROMONES OF PUTREFACTION-SYNANTHROPIC FLIES.--Meat and fish liberate volatile chemicals even when fresh, but as putrefaction ensues the nature and quantity of the volatile chemicals change. Subsequently, the responses of the receiving organisms also change. A fresh putrescent preparation attractive to certain species may become repellent as the aging progresses. Species which did not respond initially may respond at the advanced stages of putrefaction.

In the case of the eye gnats, rotten egg in water aged for 4-12 days is highly attractant, with peak attractancy manifested at 4-8 days of putrefaction (Table 1). The attractancy of the rotting egg decreases beyond that time. The attractancy of putrefying materials is quite variable, since the production of the volatile chemicals is regulated by microorganisms whose species constituency and growth are also variable. Therefore the use of putrefying proteins or protein hydrolysates for monitoring insect populations is not desirable. Similarly, these preparations, due to inconsistencies in their attractancy, can not be utilized in insect control programs. Additionally, many of the volatile compounds produced in putrefying, fermenting, and infusing preparations are not responsible for inducing an attractancy response in insects and most of the odors are undesirable.

Table 1.--Putrefaction of 2% aqueous suspension of chicken whole egg powder, facilitated by microorganisms, producing volatile attractants against the eye gnat *Hippelates collusor*.

Treatment	Condition	Avg days	Avg no gnats/vial	% attractancy
Autoclaved Unplugged	Septic	6	2	2
		4	217	271
		8	116	145
		12	37	46
Autoclaved Plugged	Aseptic	0	2	2
		4	0	0
		8	0	0
		12	0	0
Not Autoclaved	Septic	0	1	1
		4	126	158
		8	6	8
		12	10	12
Standard	Septic	-	80	-

[1]Studies partially supported and conducted in cooperation with the Coachella Valley Mosquito Abatement District.

[2]Department of Entomology, University of California, Riverside, California 92521.

[3]Cooperative Extension Service, University of California, Davis, California 95616.

To overcome these problems, we initiated studies on the chemical nature of volatile substances produced upon putrefaction of aqueous suspensions of chicken whole egg powder (Hwang et al. 1975, 1976, Mulla et al. 1976). The rotting preparations were fractionated and the attractancy of each fraction tested against eye gnats in field (Mulla et al. 1976). Although many volatile compounds are produced in putrefied preparations of egg, only 5 compounds of these tested were found to constitute the main attractants or coattractants against eye gnats, *Hippelates* species (Hwang et al. 1976). These compounds in a combined form showed the highest level of attractancy.

The chemicals produced in putrefying egg, which act as attractants and coattractants are:

Trimethylamine	attractant
Ammonia	attractant
Indole (or Skatole)	coattractant
Linoleic (or Oleic acid)	coattractant
n-Butyric acid	coattractant

Trimethylamine and ammonia are gaseous under normal conditions. However, both are highly soluble in water. It is therefore easy to obtain aqueous solutions containing all 5 attractants and coattractants. Aqueous solutions, however, can not be readily employed in operational control programs of pest flies. The need for slow-release formulations is quite obvious and therefore we placed emphasis on the development of solid formulations. These were developed by incorporating the ingredients into a solid carrier. The constituents of the current formulation known as Synthetic Fly Attractants (SFA) are as follows:

Fishmeal (carrier)	54.25%	Solid
Trimethylamine hydrochloride	2.5%	Solid
Ammonium Sulfate (fetilizer)	40%	Solid
Indole	0.25%	Solid
Linoleic acid	1.0%	Liquid
n-Butyric acid	2.0%	Liquid

The solid ingredients are mixed with the carrier and then the liquid components are sprayed over the dry mix.

The attractants trimethylamine and ammonia can be released from their salts in the presence of water. Without moisture in the substrate on which the solid formulation is placed, there is little or no release of these 2 materials and therefore the attractant formulation shows very low activity when placed on a dry substrate (Table 2). This has been found to be the case with both house flies and the eye gnats. In treating with these attractant formulations, it is essential that the formulation be placed on damp ground or other substrates that are moist.

The synthetic fly attractant formulation (SFA) when compared to sugar baits containing the attractant muscalure, showed much higher activity against the house fly *Musca domestica*. In electrocuting zap traps, 8-12 times more flies were attracted to traps baited with SFA than those with sugar-muscalure bait (Table 3). In every case SFA attracted more flies than the standard commercial bait. The latter did not attract many more flies than an empty trap.

Since the SFA formulation developed for eye gnats was found to be highly attractive against house flies (Mulla et al. 1977), it became necessary to determine the chemicals responsible for inducing response in this insect. Several formulations containing 4 ingredients or minus one of the ingredients were evaluated in gallon jar and electrocuting zap traps against flies on a poultry ranch. The formulation containing 4 ingredients (trimethylamine HCl, ammonium sulfate, indole and linoleic acid) was more attractive than those missing one of these compounds. However, deletion of trimethylamine or indole significantly reduced the number of flies attracted to the formulation containing both of these compounds. The presence of linoleic acid in some tests increased catches while not in others. Deletion of the ammonia source, however, did not decrease the catch of flies. It is thus concluded that trimethylamine and indole are the main attractants against house flies, and that the addition of linoleic acid increased the catches. There are probably other attractive substances which regulate the behavior of domestic flies.

Since acetic and n-butyric acids were found to be the breakdown products in the putrefaction of whole egg powder and the latter acid was found to enhance attractancy of the other components to eye gnats, these 2 acids were evaluated against pest flies. The addition of n-butyric acid to the initial SFA formulation (containing trimethylamine HCl, ammonium sulfate, indole and linoleic acid increased attractancy to *M. domestic* (Table 4). This formulation had no attractancy to *F. canicularis*. However, addition of n-butyric acid significantly increased catch of *M. stabulans* over the addition acetic acid

Table 2.–Influence of soil moisture on the attractancy of SFA (placed on the surface) to the eye gnat *Hippelates collusor*[a].

Water added (ml)	Avg. no/cup
0	0
10	15
20	38
30	23
40	128
50	170

[a]Solid formulation of SFA plus Golden Malrin (for the killing agent) placed on the surface of soil placed in papers cups.

Table 3.–Attractancy of solid SFA formulation to house flies when evaluated in an electrocuting zap trap on a poultry ranch in Riverside County, California.

Attractant formulation	No. flies per trap
SFA	17,000
Lursect	4,500
SFA	18,000
Empty	1,170
SFA	17,500
Diluent (fish meal)	1,900
SFA	10,500
Super Golden Malrin[a]	810
SFA	28,300
Golden Malrin[b]	3,150

[a]Containing propoxur (0.025%), dichlorvos (0.04%) and muscalure (0.025%).

[b]Containing propoxur (0.125%) and muscalure (0.125%).

Table 4.–Attractancy of initial SFA as influenced by the addition of 2% acetic or n-butyric acid to pest flies on poultry ranch.

Species	Avg. no. flies/jar trap	
	Acetic	n-Butyric
	Liquid/Water	
Musca domestica	25	38
Fannia canicularis	0	0
Muscina stabulans	35	135***
	Solid on Alphacel	
Musca domestica	98	193**
Fannia canicularis	1	0
Muscina stabulans	22	92***

**Significantly different at 0.05 level between acids.
***Significantly different at 0.01 level between acids.

Table 5.–Distillation fractionation of fermentation attractants in a brew of 10% sucrose plus Brewer's yeast as tested against pest flies on a poultry ranch.

Fraction	Avg. no. flies[1]/jar trap		
	MD	FC	MS
Sugar + yeast brew	14***	237	46
Distillate of above	7	256	44
Sugar + yeast brew	14***	87***	30***
Residue of above	1	1	1

***Significant at 0.01 level from the distillate or residue.

1 MD - *Musca domestica*
FC - *Fannia canicularis*
MS - *Muscina stabulans*

Table 6.–Ethyl alcohol (brewing attractant) enhancing the attractancy of solid SFA (putrefaction attractants) against pest flies on a poultry ranch[a].

Species	Avg. no. flies/jar trap after			
	2 days		4 days	
	SFA	SFA+Alc	SFA	SFA+Alc
		10%Eth OH		
M. domestica	13	33	9	18
F. canicularis	1	24***	0	4
M. stabulans	23	134***	25	57***
		25% Eth OH		
M. domestica	2	6	1	2
F. canicularis	2	49***	1	37***
M. stabulans	41	216***	18	85***

***Significance at 0.01 level between formulatins with and without alcohol.

[a]Ethyl alcohol impregnated onto the solid fishmeal formulation of SFA.

in both liquid and solid formulations. From these studies it is concluded that SFA formulatin containing the above 5 ingredients is more attractive (than the initial one without this acid) to *M. domestica* and *M. stabulans* but not to *F. canicularis*.

KAIROMONES OF FERMENTATION-SYNANTHROPIC FLIES.–Fermentation of fruits, starches and sugars also produce volatile chemicals which induce responses in pest flies. Among these, brewing of solutions of molasses (25%) in water with the addition of Brewer's yeast has been utilized in baiting traps for flies on poultry ranches in San Bernardino County, California (personal communications with W. D. McKean and W. F. Rooney, University of California Farm Advisors, San Bernardino County). Molasses brews contained in gallon jars placed in a screen cone trap where the screen is treated with dichlorvos sugar bait slurry, has been shown to kill large numbers of pest flies. The brew becomes active in 2-3 days and continues to lure flies for about 3-4 weeks after which it is exhausted.

To determine the exact nature of the volatile attractants, we initiated studies on the fractionation of sugar + yeast brew which was equally attractive as molasses + yeast brew (Hwang et al. 1978). Both brews were found to be highly attractive to *Fannia canicularis* and *femoralis*.

On distillation of the sugar + yeast brew, the attractant components went into the distillate (Table 5). The original brew was equally attractive against *F. canicularis* and *M. stabulans* as was its distillate, but the latter was less attractive against *M. domestica* indicating that some component is missing in the distillate. The residue of the distillation, however, was completely inactive against all 3 species.

Chemical analysis of the molasses, sugar and yeast brews showed that ethyl alcohol was the major component, constituting 12.2% and 6.3% by weight in the molasses and sugar brews respectively. For detailed chemical analysis, distillate of a sugar + yeast brew aged for 8-10 days at 25.5°C (80°F) was subjected to investigation. Ethyl alcohol (6% by wt.) comprised over 99% of the chemicals present (Hwang et al. 1978). This material was then field tested at various concentrations and was found to be highly attractive to *Fannia* species.

To develop an attractant formulation against all pest flies, it became necessary to incorporate attractants of putrefaction and fermentation together. Ethyl alcohol (95%) was impregnated in 10 and 25% concentration onto the solid SFA-fishmeal formulation (Table 6). Addition of EtOH increased attractancy of the formulation against house flies. A highly significant increase was noted for both *F. canicularis* and *M. stabulans* by the addition of EtOH. SFA alone was not attractive to *F. canicularis* as expected. Housefly population during this test was low and therefore no conclusions can be derived from it.

CONCLUSIONS.–From these studies it is concluded that volatile attractants are produced on putrefaction and fermentation of complex and simple organic materials. The volatile products from putrefaction and fermentation providing stimuli to pest flies are:

Hippelates eye gnats: Trimethylamine, ammonia, indole, n-butyric acid and linoleic acid.

Musca domestica: Trimethylamine, indole, linoleic acid and possibly n-butyric acid and ethyl alcohol.

Muscina stabulans: Trimethylamine, indole, linoleic acid, n-butyric acid and ethyl alcohol.

Fannia canicularis: Ethyl alcohol.

Solid slow-release formulations of the putrefaction kairomones have been developed, but one that includes ethyl alcohol still remains to be developed.

REFERENCES CITED

Burgess, R. W. 1951. The life history and breeding habits of the eye gnat *Hippelates pusio* Loew in the Coachella Valley, Riverside County, California. Amer. J. Hyg. 53:164-77.

Dow, R. P. 1959. A method of testing insect traps and attractants and its application to studies of *Hippelates pusio* and *Culex tarsalis*. Ann. Ent. Soc. Amer. 52:496-503.

Hwang, Y.-S., M. S. Mulla and H. Axelrod. 1975. Attractants for synanthropic flies: evaluation of chemical attractants and coattractants against the eye gnat *Hippelates collusor* (Diptera:Chloropidae). Environ. Entomol. 4:769-73.

Hwang, Y.-S., M. S. Mulla and H. Axelrod. 1976 Attractants for synanthropic flies. Identification of attractants and coattractants for *Hippelates* eye gnats (Diptera:Chloropidae). J. Agric. Food Chem. 24:164-9.

Hwang, Y.-S., M. S. Mulla and H. Axelrod. 1978. Attractants for synanthropic flies: ethanol as attractant for *Fannia canicularis* and other pest flies in poultry ranches. J. Chem. Ecol. 4:463-70.

Mulla, M. S.,Y.-S. Hwang and H. Axelrod. 1976. Attractants for synanthropic flies: chemical attractants against the eye gnat *Hippelates collusor*. Bull. Soc. Vector Ecol. 3:47-51.

Mulla, M. S. and H. Axelrod. 1977. Attractancy of putrefied animal and plant proteins to the eye gnat *Hippelates collusor* (Diptera:Chloropidae). J. Med. Ent. 13:497-500.

Mulla, M. S., Y.-S. Hwang and H. Axelrod. 1977. Attractants for synanthropic flies: chemical attractants for domestic flies. Jour. Econ. Entomol. 70:644-58.

ISOLATION AND IDENTIFICATION OF CHEMICAL ATTRACTANTS FOR THE LITTLE HOUSE FLY *FANNIA CANICULARIS*

Yih-Shen Hwang, Mir S. Mulla and Harold Axelrod

University of California

Department of Entomology, Riverside, California 92521

ABSTRACT

Fermented molasses or sucrose solutions are known to attract the little house fly *Fannia canicularis* (L.) and other species of synanthropic flies. To isolate and identify the attractant, a fermented sucrose solution was distilled, and the distillate showing good attractancy was analyzed by gas chromatography. With a column packed with 15% Carbowax 600 on 60-80 mesh Chromosorb G., the distillate was shown to contain acetaldehyde, ethyl acetate, ethanol, 1-propanol, 2-methyl-1-propanol, and 3-methyl-1-butanol. Ethanol constituted the largest proportion of the compounds present in the distillate. An aqueous solution of ethanol showed the same level of attractancy as the distillate, the fermented sucrose solution, and a reconstituted distillate containing all the compounds identified. From these chemical and biological studies, ethanol was thus unequivocally identified as the sole attractant emanated from fermented carbohydrate solutions that elicited positive responses in pest flies, especially in *F. canicularis.*

CHEMICAL CHARACTERIZATION OF MOSQUITO OVIPOSITION ATTRACTANTS AND REPELLENTS

Yih-Shen Hwang, Wayne L. Kramer and Mir S. Mulla

University of California
Department of Entomology, Riverside, California 92521

Many species of gravid female mosquitoes show a high degree of preference in selecting oviposition sites. Starratt and Osgood (1972) investigated an egg-associated oviposition pheromone of *Culex tarsalis* Coquillett and found that the active fraction consisted of a mixture of 1,3-diglycerides. Bentley et al. (1976) found that holding waters of 4th instar larvae of both *Aedes triseriatus* (Say) and *Ae. atropalpus* (Coquillett) contained a volatile oviposition attractant for *Ae. triseriatus*.

The presence of decayed organic matter in oviposition sites was shown to increase oviposition of *Ae. triseriatus* (Wilton 1968). Gjullin et al. (1965) reported that grass infusions and log pond water increased oviposition of *Ae. aegypti* (L.) and *Culex pipiens quinquefasciatus* Say and that methane and furfural stimulated oviposition of these mosquitoes.

Recently, we found that 1% chicken manure infusions aged for 7-15 days were highly attractive to gravid *Cx. p. quinquefasciatus*, repellent to *Cx. tarsalis*, but attractive to the latter species at lower concentrations. At the same time, we also discovered that 1% Purina® Laboratory Chow infusions were repellent in the broad sense to both species of mosquitoes (unpublished data of the authors). These findings conclusively prove that volatile chemicals produced by the infusions of organic substances in mosquito breeding sources regulate the oviposition behavior of many species of mosquitoes.

These findings prompted us to initiate investigations on the chemical nature of the attractants and repellents produced by infusions of organic materials. The biological activity of various fractions obtained from active starting materials was monitored by bioassay test methods, developed in this laboratory, which will be published elsewhere. In this communication, we report the chemical characterizations of oviposition attractants and repellents, produced by microbial fermentation of organic materials, for the mosquitoes *Cx. p. quinquefasciatus* and *Cx. tarsalis*. In the case of the oviposition repellents, the active compounds were identified.

INFUSION.–Chicken manure, obtained from local chicken ranches in southern California, was suspended in water in a glass container to make a 1% infusion. The infusion of chicken manure was aged at room temperature without any covering for 12 days. Microbial fermentation was proven to be involved in this aging process (unpublished data of the authors). The fermented infusion of chicken manure induced a high degree of ovipositional responses in both species of mosquitoes, being attractive to *Cx. p. quinquefasciatus* and repellent to *Cx. tarsalis*.

To prepare an oviposition-repellent infusion, Purina® Laboratory Chow (Ralston Purina Co., St. Louis, Missouri) was suspended in water in a glass container to make 1% suspension. The Lab Chow infusion was fermented for 10 days at room temperature, and the fermented infusion was bioassayed against distilled water as a standard. Gravid mosquitoes of both species laid all of their eggs in the standard, indicating that the Lab Chow infusion induced a complete negative response.

FRACTIONATION.–For fractionation, the fermented infusion of chicken manure was distilled under atmospheric pressure until 80% of the infusion was distilled. The distillation gave a distillate and a residue, and both fractions were diluted with distilled water to the original concentration. When bioassayed against distilled water as standard, gravid *Cx. p. quinquefasciatus* and *Cx. tarsalis* laid 60 and 41% of egg rafts, respectively, on the distillate liquid solution, whereas 85 and 67.5% of those by *Cx. p. quinquefasciatus* and *Cx. tarsalis*, respectively, were laid in the residue liquid solution. It seems that the oviposition attractants which attract *Cx. p. quinquefasciatus* are not distilled off from the infusion under the experimental conditions, and that the repellents which repel *Cx. tarsalis* might be destroyed or disintegrated during the separation procedure. However, these studies are not conclusive, and further investigations are under way now.

Upon distillation under atmospheric pressure until 80% completion, the fermented Lab Chow infusion yielded a distillate and a residue which were both diluted with distilled water to the original concentration. Being tested against distilled water, the distillate showed 100% repellency against both species of mosquitoes, which laid their eggs exclusively in the standard. Meanwhile *Cx. p. quinquefasciatus* and *Cx. tarsalis* laid 63 and 26% of their egg rafts, respectively, in the residue. The results clearly indicated that the repellent chemicals, emanated from the fermented Lab Chow infusion, were volatile and could be removed from the infusion by distillation.

The distillate, being highly repellent, was extracted 3 times with ether. The ether extracts were combined and dried over anhydrous sodium sulfate. Evaporation of the organic solvent gave an ether extract which was diluted with distilled water to the original concentration. The resulting aqueous suspension was designated as the ether fraction. After the ether extraction, the remaining water layer was warmed to remove the dissolved ether and designated as the water fraction. When distilled water was used as standard, the ether fraction showed 93 and 97.5% repellency against *Cx. p. quinquefasciatus* and *Cx. tarsalis*, respectively, while repellency to the water fraction showed 80% against the former species and 84% against the latter species. When both fractions were compared against each other, both species of mosquitoes laid their eggs entirely in the water fraction, indicating that the ether fraction exhibited 100% repellency. The results implied that the repellents were more soluble in ether than in water. It appeared that if the distillate had been exhaustively extracted with ether, the repellents would have been completely extractable with the solvent.

CHEMICAL IDENTIFICATION OF OVIPOSITION REPELLENTS.–The ether extract was redissolved in ether, and the ethereal solution was extracted 3 times with 5% aqueous sodium hydroxide solution. The remaining ethereal solution was dried over sodium sulfate and evaporated to dryness to give an oily residue which was diluted to the original concentration and designated as non-acidic fraction. This fraction, containing basic and neutral compounds, if any, induced 19.5

and 20% repellency in *Cx. p. quinquefasciatus* and *Cx. tarsalis*, respectively, against distilled water as standard. The aqueous sodium hydroxide extracts were combined, washed once with ether, and acidified with hydrochloric acid. The acidified mixture was extracted 3 times with ether. The combined ether extracts were dried over sodium sulfate and evaporated to give a mixture of acidic compounds, which was reconstituted with distilled water to the original concentration and designated as the acidic fraction. The acidic fraction induced 100 and 90% repellent response in *Cx. p. quinquefasciatus* and *Cx. tarsalis*, respectively. The acidic fraction was bioassayed against the non-acidic fraction in both species. With *Cx. p. quinquefasciatus*, 100% of egg rafts were laid in the non-acidic fraction, and, with *Cx. tarsalis*, 83% laid in the same fraction. These results indicated the presence of repellent chemicals in the acidic fraction of the Purina Laboratory Chow infusions.

The mixture of acidic compounds, which showed characteristic absorptions of lower aliphatic carboxylic acids in its infrared spectrum, was subjected to gas chromatographic analyses for chemical identification. On a Porapak® R column at 270°C, the mixture of acidic compounds repeatedly showed 6 peaks. By comparing the retension data of the peaks with those of authentic compounds, they were identified as acetic, propionic, isobutyric, butyric, isovaleric and caproic acids. The acidic fraction also gave 6 peaks on a column packed with 10% AT-1200 and 1% phosphoric acid on Chromosorb®W at 110°C, and the presence of the 6 lower aliphatic carboxylic acids was reconfirmed. Among these acids, butyric acid was the most abundant component, occupying about 88% of the total weight of the acidic fraction.

The carboxylic acids thus identified were bioassayed for their ovipositional repellency against *Cx. p. quinquefasciatus* and *Cx. tarsalis* at various concentrations in distilled water using distilled water as control. At 0.6% concentration, all acids except isobutyric acid and caproic acid exhibited 100% repellency against both species of mosquitoes. Although isobutyric acid showed 85% repellency against *Cx. p. quinquefasciatus* at this concentration, it completely repelled the oviposition response in *Cx. tarsalis*. Caproic acid, which is rather insoluble in water, showed 87% repellency at the same concentration against *Cx. tarsalis* but completely repelled the oviposition of the other species.

When the concentration of these carboxylic acids was decreased 10 fold to 0.06%, the oviposition activity of all acids tested was significantly repellent for *Cx. p. quinquefasciatus*. For *Cx. tarsalis*, only butyric and caproic acids at this concentration were significantly repellent. The concentration of butyric acid in the fermented Lab Chow infusion was about 0.06%.

At 0.006% concentration, only isobutryic and acetic acids were significantly repellent for *Cx. p. quinquefasciatus*, and only caproic acid was significantly repellent against *Cx. tarsalis*.

Accordingly, the repellent activity of these carboxylic acids were concentration-dependent. The activity decreased as the concentration decreased in most cases.

We have therefore documented that infusions of some organic materials such as Lab Chow, through the action of unidentified microorganisms, produce chemical compounds which modify the ovipositional behavior of gravid mosquitoes. We have identified 6 lower aliphatic carboxylic acids which possess oviposition repellency against the 2 *Culex* mosquitoes.

Lower aliphatic carboxylic acids have been shown to play an important role in modifying the behavior of insects and some higher animals. For example, several carboxylic acids, such as acetic, propionic, isobutyric, butyric, isovaleric, and isocapric acids released in the vaginal region of rhesus monkeys serve as sex pheromones (Michael et al. 1971). Human females also produce sex pheromones which consist of the same carboxylic acids (Michael et al. 1974). Acetic, propionic, and butyric acids are also common products of putrefying proteins and have been found as coattractant for *Hippelates collusor* (Townsend) and *Musca domestica* L. (Hwang et al. 1976, Mulla et al. 1977). It is very interesting to note that these ubiquitous natural products play a variety of roles in modifying behavior in insects and higher animals.

REFERENCES CITED

Bentley, M. D., I. N. McDaniel, Y.-P. Lee, B. Stiehl, and M. Yatagai. 1976. Studies of *Aedes triseriatus* oviposition attractants produced by larvae of *Aedes triseriatus* and *Aedes atropalpus* (Diptera: Culicidae). J. Med. Entomol. 13:112-5.

Gjullin, C. M., J. O. Johnson and T. W. Plapp, Jr. 1965. The effect of odors released by various waters on the oviposition sites selected by the two species of *Culex*. Mosq. News 25:268-71.

Hwang, Y.-S., M. S. Mulla and H. Axelrod. 1976. Attractants for synanthropic flies. Identification of attractants and coattractants for *Hippelates* eye gnats (Diptera:Chloropidae). J. Agric. Food Chem. 24:164-9.

Michael, R. P., E. B. Keverne and R. W. Bonsall. 1971. Pheromones: Isolation of male sex attractants from a female primate. Science 172:964-6.

Michael, R. P., R. W. Bonsall and P. Warner. 1974. Human vaginal secretion: Volatile fatty acid content. Science 186:1217-9.

Mulla, M. S., Y.-S. Hwang and H. Axelrod. 1977. Attractants for synanthropic flies: Chemical attractants for domestic flies. J. Econ. Entomol. 70:644-8.

Starratt, A. N. and C. E. Osgood. 1972. An oviposition pheromone of the mosquito *Culex tarsalis*: Diglyceride composition of the active fraction. Biochem. Biophys. Acta 280:187-93.

Wilton, D. P. 1968. Oviposition site selection by the treehole mosquito, *Aedes triseriatus* (Say). J. Med. Entomol. 5:189-94.

NATURAL ENEMIES IMPORTED IN CALIFORNIA FOR THE BIOLOGICAL CONTROL OF FACE FLY, *MUSCA AUTUMNALIS* DE GEER, AND HORN FLY, *HAEMATOBIA IRRITANS* (L.)

E. F. Legner

University of California

Division of Biological Control, Riverside, California 92521

ABSTRACT

Recent efforts to control pasture flies with biological control have largely ignored fly predators, although past successes point to their importance. A possible endemic region in central Asia should be considered in the quest for effective predators of two principal North American fly pests, *Haematobia irritans* and *Musca autumnalis*. Further emphasis on scarab beetles alone is not apt to produce the desired decrease in fly densities.

The main emphasis for biological control of pasture breeding flies since Albert Koebele first imported dung scavengers and fly predators from Europe to Hawaii in 1909 (Swezey 1911, 1912) has been on scavenger scarab beetles to reduce breeding habitats (Anderson and Loomis 1978, Bornemissza 1976, Ferrar 1975b, Waterhouse 1974). The greatest effort in Australia, where a goal of equal or greater importance was pasture improvement (Ferrar 1975a), will probably not yield the expected benefits (see McKinney and Morley 1975). Although laboratory studies both in Australia and North America gave indications that pasture flies could be reduced through the removal of field dung (Blume et al. 1973, Bornemissza 1970), positive significant field reductions have yet to be reported. Macqueen (1975) reviewed the few cases in the field where fly reductions may have resulted from the activities of scarab beetles, but conclusive field data is still unreported, and the estimated degree of control was very low. The only documented drops of any magnitude in density of pasture flies as a result of biological control were in Hawaii, which involved both scarabs and predatory beetles (see Legner et al. 1974), and in Fiji involving a predator (Bornemissza 1968).

The lack of interest, and consequent effort, to import dung fly natural enemies seems to stem from a concern that such predators might not remove sufficient eggs and larvae from a breeding site so that surviving adult flies would be stronger, larger and more fecund as a result of the eased intraspecific competition (Macqueen 1975). This concern seems to be principally academic so far, as the capabilities of predatory species have been heretofore largely unknown. It is interesting to note that one of the principal effects of dung removing beetles as shown by laboratory studies has been to increase fly larval competition for food resulting in a stunted adult fly population. However, dispersal of fly larvae into surrounding moist soil before intense competition is realized has not been studied.

My studies of one histerid predator, *Sandalus parallelus* (Redtenbacher) from northwest Pakistan, show that areas in the soil below and surrounding the dung at 10-13 cm are occupied over 95% of the time. In addition, feeding can be both on eggs and young larvae within the dung pad and on emigrating older larvae, regardless of soil moisture. Egg laying is density dependent, occurring ca. 2-3 days after feeding on fly eggs or larvae. Predator movement into the pad is stimulated by the presence of fly eggs and larvae. In the field considerable dispersal away from the dung pad and into the surrounding soil could be expected of crowded fly larvae as observed with certain chloropid flies (Legner 1966, Legner and Olton 1969). An effective predator at this point would not "compete" with the intraspecific mechanisms but rather add to the total natural reduction of the fly population.

The most comprehensive appraisal of the capabilities of dung fly predators to effectively reduce their dung fly hosts was given by G. F. Bornemissza (1968) with *Hister chinensis* Quensel in tropical regions of the South Pacific. This species was originally introduced there from Java for *Musca domestica* L. control (Simmonds 1958). Subsequently, Bornemissza became interested in similar introductions in Australia for the biological control of buffalo fly, *Haematobia irritans exigua* (DeMeijere), bush fly, *Musca vetustissima* Walker, and a ceratopogonid, *Culicoides boevitarsis* Kieffer, using other species of climatically adapted predators as well. Although later emphasis turned to scarab beetles and fly habitat reduction, his earlier work involved the importation of two southern African beetles, *Hister caffer* Erichson and *Hister nomas* Erichson, from Hawaii. After demonstrating a great voracity for fly eggs and young larvae in laboratory trials, both species were field-released. However, only *H. nomas* established in northern Queensland at elevations up to 1,000 m. (G. F. Bornemissza, pers. commun.). A fly attacking nematode, *Heterotylenchus* sp., was also introduced (Nicholas and Hughes 1970), but favorable results have not been reported.

Workers from the Division of Biological Control, University of California, Riverside, considered natural enemies in 1968 for the control of California's two principal pasture-breeding fly pests, *Haematobia irritans* (L.) and the then newly-invaded *Musca autumnalis* DeGeer. In a joint effort with State investigators from the Department of Agriculture and U. S. Department of Agriculture, a search for promising fly predators was initiated. Only tropical species of scarab beetles which were being mass-produced in Australia were then available. We did not feel that it would be worth the effort to attempt their introduction as detailed reports from Australia showed that establishment was confined to regions with a minimum of frost in winter. The principal livestock areas in California where pasture fly problems exist are subject to considerably prolonged frost periods. Marginally acceptable climates in Australia sustained very low densities of these scarabs; and high densities, probably exceeding 50 beetles per dung pad, are required for field fly control to result (Macqueen 1975). There was also some threat that scarab beetles might aggravate the problem with intestinal helminth worm larvae of cattle, which since has, however, been largely discredited (Duric 1975). Pasture improvement benefits from scarab beetles would be minimal at maximum densities of 2-3 cattle per acre that are normally found in commercial grazing operations; and a problem of tieing up certain essential nutrients such as phosphorous has been associated with scarab activity (McKinney and Morley 1975). In any case, adequate dung degregation apparently exists in Australia where rainfall is adequate through fungal and abiotic processes contrary to what has been suggested by Waterhouse (1974). Scarab activity is minimal during dry periods and could not be expected to contribute significantly to the existing processes (McKinney and Morley 1975).

There was more encouragement for the adaptation of the two predatory histerids, *H. caffer* and *H. nomas*, however, as the latter had already adapted to frosty portions of the Atherton plateau in northeastern Australia. At the same time, U. S. D. A. researchers had focused their attention on a predatory-parasitic staphylinid beetle, *Aleochara tristis* Gravenhorst from northern France, and a nematode *Heterotylenchus autumnalis* Nickle, that infected adult face flies both in Europe and eastern North America.

While these predatory species were being introduced in California (Table 1), I became particularly interested in the point of origin of both *H. irritans* and *M. autumnalis*, which were generally considered invaders from the Palearctic Region. Several study trips to central and eastern Europe convinced me that effective natural enemy activity was very low. Comparable infestations as those that I have seen in North America are widespread in Europe; and it is possible that these flies may have originated elsewhere.

One isolated region in Central Asia that has been generally ignored as a source for natural enemies of *M. autumnalis* and *H. irritans* lies in northwestern Pakistan and in the southern U.S.S.R. Here exists a fly fauna with some species characteristic of two or three geographic regions: Palearctic, Ethiopian and Oriental. Some pasture breeding species, including a close relative of the Australian bushfly, *Musca sorbens* Wiedemann, apparently occur there at comparatively low densities (Commonwealth Institute of Biological Control 1970-72; Sytshevskaya 1963, 1970, 1972; Sytshevskaya and Vtorov 1969; M. A. Ghani, pers. commun.). Furthermore, studies in Pakistan suggested that the activities of certain predatory Histeridae may account for considerable natural control of these flies. We obtained cultures of 6 Histeridae that ranged up to 2,000 m elevations in northwestern Pakistan as follows: *Atholus coelestis* (Marseul), *Hister pullatus* Erichson, *Hister pullatus* var. *scissifrons* Marseul, *Peranus maindroni* (Lewis), *Santalus orientalis* (Paykull) and *Santalus parallelus* (Redtenbacher). Another species, *Hister chinensis*, was obtained at 150 m elevations. Three species, *H. chinensis*, *P. maindroni* and *S. parallelus*, were propagated with difficulty, and limited releases were made in Imperial Valley flood irrigated pastures (Table 1).

Post introduction surveys where predatory beetles were released revealed the presence of *Aleochara tristis* in stockpiled dairy cattle manure one year later in northern California. How-

Table 1.--Natural enemies introduced in California for the control of *Musca autumnalis* and *Haematobia irritans* during 1968-74.

Species	Origin	County in which released	Approx. No. released
COLEOPTERA			
Histeridae			
Hister caffer Erichson[1]	southern Africa	Humboldt	25
		Shasta	30
Hister chinensis Quensel[1]	Java	Imperial	25
Hister nomas Erichson[1]	southern Africa	Del Norte	27
		Humboldt	150
		Modoc	50
		Shasta	108
		Siskiyou	100
		Tehama	50
Peranus maindroni (Lewis)[1]	NW Pakistan	Imperial	550
Sandalus parallelus (Redtenbacher)[1]	NW Pakistan	Imperial	425
Staphylinidae			
Aleochara tristis Gravenhorst[2]	France	Del Norte	6,500
		Humboldt	5,500
		Modoc	5,500
		Shasta	6,500
		Siskiyou	2,300
		Tehama	10,000
NEMATODA			
Heterotylenchus autumnalis Nickle[2] --infected adult flies	eastern U.S.A. & Europe	Del Norte	10,100
		Humboldt	22,000
		Modoc	8,250
		Shasta	6,500
		Siskiyou	1,500
		Tehama	12,000

[1]Reared in the Division of Biological Control, University of California, Riverside.

[2]Reared by U. S. Department of Agriculture, Lincoln, Nebraska.

ever, it is doubtful that this species will range effectively in field dung pads as it is not strongly attracted there. On the other hand, cattle in Imperial Valley pastures that from 1973-1976 regularly sustained average adult fly counts exceeding 5,000 *H. irritans* per head, by autumn of 1977, three years after releases of predators, averaged only 10% or less of the original high densities. The establishment of predatory beetles was verified following releases, but their persistence into the 3rd year has not been established. This can probably be attributed to the small sample size that we were able to take, as the work entails considerable labor due to beetle dispersal in pasture soil, especially when beetles are disturbed. However, fly density reductions could have admittedly been due to other causes.

Future successes in the control of pasture breeding flies may depend on the introduction of predatory natural enemies as well as scarab habitat reducers. Recently research in the C.S.I.R.O. program in Australia has begun to emphasize mites and other predators for bush fly control (Ridsdill Smith et al. 1977), and this approach should certainly be examined further in North America as well. Particularly for our pest flies of northern hemispheric origins, further attention ought to be given to natural enemies from similar climatic areas of Central Asia. An over emphasis on cold hardy species of scarab beetles for temperate zones doesn't seem logical especially since few benefits can be claimed for introductions of their tropical counterparts in the lower latitudes.

REFERENCES CITED

Anderson, J. R. and E. C. Loomis. 1978. Exotic dung beetles in pasture and range land ecosystems. Calif. Agric. 32(2):31-32.

Blume, R. R., J. J. Matter and J. L. Eschle. 1973. *Onthophagus gazella*: effect on survival of horn flies in the laboratory. Environ. Entomol. 2:811-3.

Bornemissza, G. F. 1968. Studies on the histerid beetle *Pachylister chinensis* in Fiji, and its possible value in the control of buffalo-fly in Australia. Aust. J. Zool. 16:673-88.

Bornemissza, G. F. 1970. Insectary studies on the control of dung breeding flies by the activity of the dung beetle, *Onthophagus gazella* F. (Coleoptera:Scarabaeinae). J. Aust. Entomol. Soc. 9:31-41.

Bornemissza, G. F. 1976. The Australian dung beetle project 1965-1975. Aust. Meat Res. Committee Rev. 30:1-30.

Commonwealth Institute of Biological Control. 1970-72. Investigation on natural enemies of some flies that breed in dung and vegetable refuse. Ann. Repts. 1970-72, Pakistan Station, C.I.B.C.

Durie, P. 1975. Some possible effects of dung beetle activity on the infestation of pastures by intestinal worm larvae of cattle. J. Appl. Ecol. 12(3):827-31.

Ferrar, P. 1975a. Disintegration of dung pads in North Queensland before the introduction of exotic dung beetles. Aust. J. Exptal. Agric. Anim. Husb. 15:325-29.

Ferrar, P. 1975b. Preamble for symposium on effects of dung beetles. J. Appl. Ecol. 12(3):819-21.

Legner, E. F. 1966. Competition among larvae of *Hippelates collusor* (Diptera:Chloropidae) as a natural control factor. J. Econ. Entomol. 59(6):1315-21.

Legner, E. F. and G. S. Olton. 1969. Migrations of *Hippelates collusor* larvae from moisture and trophic stimuli and their encounter by *Trybliographa* parasites. Ann. Entomol. Soc. Amer. 62(1):136-41.

Legner, E. F., R. D. Sjogren and I. M. Hall. 1974. The biological control of medically important arthropods. Crit. Rev. Environ. Control 4(1):85-113.

Macqueen, A. 1975. Dung as an insect food source: Dung beetles as competitors of other coprophagous fauna and as targets for predators. J. Appl. Ecol. 12(3):821-27.

McKinney, G. T. and F. H. W. Morley. 1975. The agronomic role of introduced dung beetles in grazing systems. J. Appl. Ecol. 12(3):831-37.

Nicholas, W. L. and R. D. Hughes. 1970. *Heterotylenchus* sp. (Nematoda:Sphaerulariidae), a parasite of the Australian bush fly, *Musca vetustissima*. J. Parasitol. 56:116-22.

Ridsdill Smith, T. J., J. N. Matthiessen and J. A. Mahon. 1977. New approaches to dung beetle and bushfly research in south-western Australia. Proc. Western Australia Entomology Workshop, Dec. 2, 1977. pp. 16-19.

Simmonds, H. W. 1958. The housefly problem in Fiji and Samoa. South Pacific Comm. Quart. Bull. 8(2):29, 47.

Swezey, O. H. 1911. Professor Koebele's work on the horn fly for 1909. Rept. Bd. Comm. Agric. For., Div. Entomol., Hawaii. p. 116.

Swezey, O. H. 1912. Record of the hornfly parasite material received from Mr. A. Koebele in Europe during 1911 and 1912. Rept. Bd. Comm. Agric. For., Div. Entomol., Hawaii. p. 145.

Sytshevskaya, V. I. 1963. Some Chalcidoidea reared from puparia of synanthropic flies in the Uzbekistan. ((in Russian)). Zool. J. 42(6): 858-64.

Sytshevskaya, V. I. 1970. Zonal distribution of coprophilous and schizophilous flies (Diptera) in Middle Asia. ((in Russian)). Rev. U.S.S.R. Entomol. 49(4):819-31.

Sytshevskaya, V. I. 1972. Synanthropic flies (Diptera) from the lower Amu-Darya. ((in Russian)). Rev. U.S.S.R. Entomol. 51(3):534-53.

Sytshevskaya, V. I. and P. P. Vtorov. 1969. Synanthropic flies (Diptera) from mountain Kirghizia. ((in Russian)). Rev. U.S.S.R. Entomol. 48(4):816-30.

Waterhouse, D. F. 1974. The biological control of dung. Scien. Amer. 230(4):100-109.

FIELD EVALUATION OF THE EFFECTIVENESS OF PREDACIOUS INSECTS AS A MOSQUITO CONTROL AGENT

Takeshi Miura, R. M. Takahashi and F. S. Mulligan, III

University of California
Mosquito Control Research Laboratory
5544 Air Terminal Drive, Fresno, California 93727

ABSTRACT

An insecticidal check method was used to evaluate the efficacy of natural enemies as mosquito control agents. In the insecticide treated pond, larval population densities of *Culex tarsalis* Coquillett fluctuated between 0 and 15/dip, while in the untreated pond population densities remained low; density never approached a 1/dip level. The most abundant and effective natural enemies were *Notonecta unifasciata* Guerin and *Buenoa scimitra* Bare in the vicinity of Buttonwillow, California.

Mosquito control operations in California are predominantly dependent on chemical means even though various approaches of control measures are practiced.

In the past decade, however, increasing attention has been focused on the use of biological agents (Bay 1974), because mosquito resistance to chemicals has become so severe and widespread (Schaefer and Wilder 1970, Womeldorf et al. 1972, Gutierrez et al. 1976).

There are many laboratory studies concerning natural enemies of mosquito larvae (Bay 1974, Chapman 1974), but studies showing their efficacy as mosquito control agents in the field are limited (James 1965, 1967, Hoy and Reed 1970, Hoy et al. 1972).

This report presents the results of an experiment conducted to evaluate the effectiveness of some indigenous natural enemies of *Culex tarsalis* Coquillett larvae in the breeding habitats.

STUDY AREA.–The study was conducted at the Tracy Experimental Plot. It is located near the south end of Jerry slough, about 4 miles northeast of Buttonwillow, California. The surrounding area comprises recently reclaimed, irrigated farmland where cotton, alfalfa, rice and cattle are raised, but also contains undeveloped wasteland used by private gun clubs. Mosquito producing habitats in the area are reservoirs, sloughs, irrigation waste water, rice fields and other impounded waters.

MATERIALS AND METHODS.–Two small ponds (ca. 0.024 acre) in the plot were used for this study. Water for each pond was supplied twice a week from adjacent reservoirs fed by a well, the ponds were connected to the reservoirs by 6 inch diameter pipes, screened on one end to prevent movement of natural enemies into the test pond or vice versa.

Vegetation in the plot area was scant, but saltgrass (*Distichlis spicata* (L.) Greene) and tumbleweed (*Amaranthus* sp.) were common on dry land. The wet area (around water-line) of the ponds was occupied by barnyardgrass (*Echinochla crusgalli* (L.) Beauv.), bearded spangle-top (*Leptochloa fascicculis* (Lam) Gray), and bermudagrass (*Cynodon dactylon* (L.) Pers.). In the early season, vegetation was scarce in the basin, but as the season advanced stone wort (*Chara* sp.) and water net algae (*Hydrodictyon reticulatum* (L.) Lagertheim) became abundant in no. 1 pond, and in addition no. 2 pond was densely covered with patches of bermudagrass and spike rush (*Eleocharis* sp.).

To measure the efficacy of natural enemies for mosquito control, the insecticidal check method described by DeBach (1946) was used. It is the exact inverse of the method used for insecticide evaluation tests in the field, i.e., the effectiveness of natural enemies is measured by comparing the differences of pest population density between untreated (with natural enemies) and treated (without natural enemies) ponds.

The insecticide used for this study was a synthetic pyrethroid (Pydrin) because it has activity against a wide spectrum of insects and relatively short ecological impact (Miura and Takahashi 1976). The required amount of the chemical to make the rate of 0.1 lb AI/acre was mixed with 2 gal of water and applied with a 3 gal hand sprayer to no. 2 pond. Number 1 pond was left untreated to evaluate the effect of natural enemies.

Common natural enemies in the area are 3 species of Odonata, *Enallagma civile* (Hagen), *Anax walsinghami* MacLachlan, and *Pantala hymenaea* (Say); 3 species of Hemiptera, *Buenoa scimitra* Bare, *Notonecta unifasciata* Guerin and *Belostoma* sp.; and 9 species of Coleoptera, *Copelatus chevrolati renovatus* Guignot, *Eretes sticticus* (L.), *Laccophilus maculosus decipiens* LeConte, *Laccophilus mexicanus atristernalis* Crotch, *Laccophilus mexicanus mexicanus* Aube, *Thermonectus basillaris* (Harris), *Berosus* sp., *Tropisternus lateralis* (Fabricius) and *Hydrophilus triangularis* Say.

Population densities of natural enemies were estimated by trapping. The trap used consisted of a 1-ft^3 woodframe box with a solid bottom and removable screen top. Each side of the trap was covered with a window screen which was gradually indented into the trap interior and terminated in a funnel with a 15 mm opening. The traps were set out in the late afternoon and retrieved the next morning.

Mosquito population density was determined by dipping with a long-handled dipper (450 ml capacity) from 10 fixed collecting sites and transported to the laboratory where collections were examined under a stereomicroscope. Mosquito and natural enemy censuses were started in August. The pond was treated 3 times during the study period.

RESULTS AND DISCUSSION.–Results are shown in Figure 1. The data indicate a high correlation between natural enemy populations and destruction of large numbers of *Cx. tarsalis* larvae; in the untreated pond population density never exceeded 1 larva/dip, while in the treated pond the larval density fluctuated between 0 and 15/dip. It is apparent that chemical treatment did control *Cx. tarsalis* populations temporarily but then they recovered in a short period of time after application. This increase in numbers apparently resulted from the elimination of natural enemies by chemical treatment.

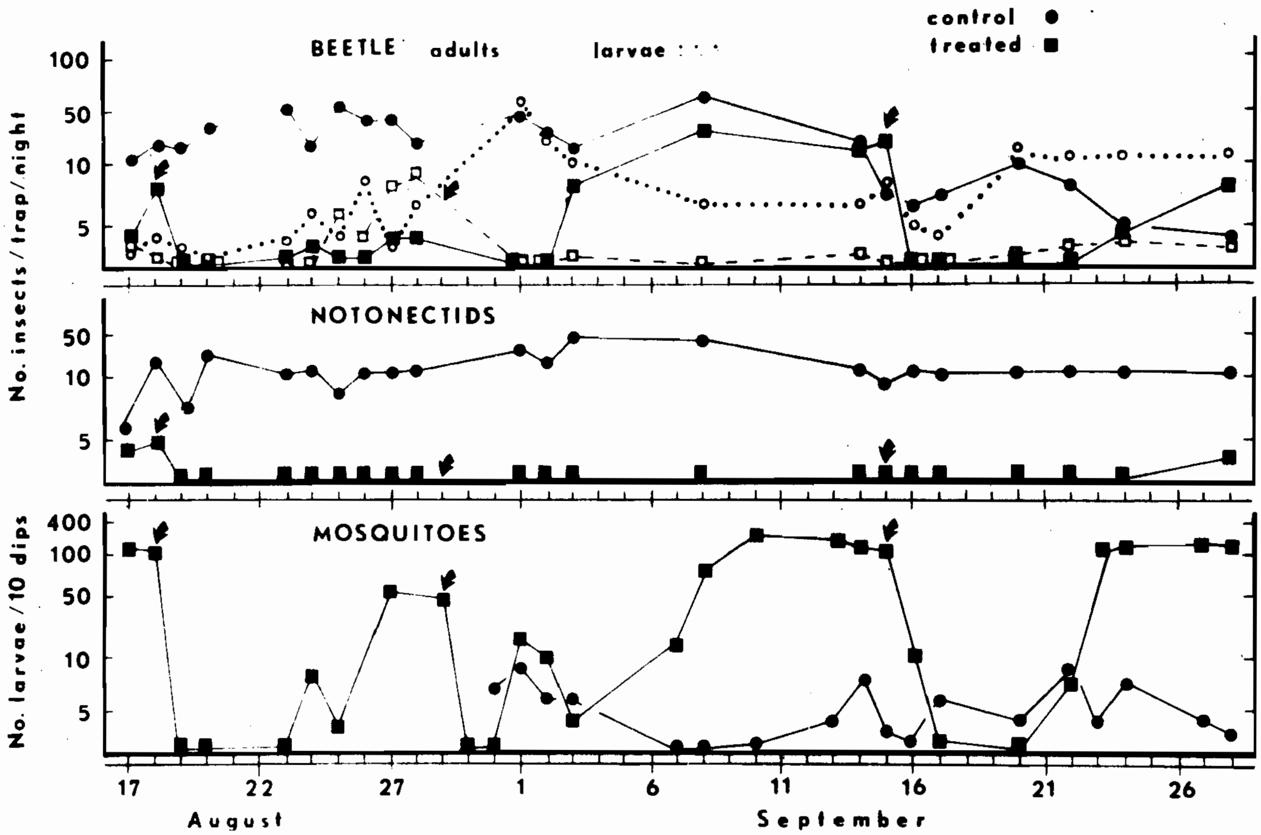

Figure 1.- Effects of mosquito larvicide treatment on the aquatic beetles, notonectids, and *Culex tarsalis* larval populations. Arrows indicate application days.

Abundant natural enemies in the ponds were *N. unifasciata*, *B. scimitra*, *T. lateralis* and *Laccophilus* spp. *H. triangularis* was conspicuous but low in number. Among all the natural enemies, notonectids were assessed as the most effective. Beetle larvae probably could play an important role, however, populations were low by our sampling methods. *T. lateralis* adults were the most abundant aquatic beetles but their effectiveness as a mosquito control agent was low (see Figure 1, 2nd treatment). This finding is in agreement with the results previously reported (Bay 1972). The 2nd treatment was an operational failure, i.e., vegetation became so dense as to cover almost 2/3 of the basin, hence the chemical applied was interrupted by the canopy and did not reach the water where mosquitoes breed.

The data obtained from the study provide indications to show a successful case for natural control of mosquito larvae by indigenous natural enemies. This kind of naturally occurring control without man's manipulation probably plays an important role in suppressing mosquito populations in certain ecosystems such as duck clubs, wasteland, and rice fields. For this reason, personnel of mosquito control agencies should carefully examine mosquito producing habitats for biological and ecological information before applying any pesticide. Furthermore, they should provide suitable ecological niches for these natural enemies by altering topographical conditions or clearing vegetation. The most effective and economical control of mosquitoes can be attained by well-planned procedures integrating biological, chemical and ecological control.

REFERENCES CITED

Bay, E. C. 1972. An observatory built in a pond provides a good view of aquatic animals and plants. The amateur scientist. Sci. Am. 227: 114-18.

Bay, E. C. 1974. Predatory-prey relationship among aquatic insects. Ann. Rev. Entomol. 19:441-53.

Chapman, H. C. 1974. Biological control of mosquito larvae. Ann. Rev. Entomol. 19:33-59.

DeBach, P. 1946. An insecticidal check method for measuring the efficacy of entomophagous insects. J. Econ. Entomol. 39:695-97.

Gutierrez, M. C., E. P. Zboray and P. A. Gillies. 1976. Insecticides susceptibility of mosquitoes in California: Status of Organophosphorus resistance in larval *Aedes nigromaculis*, *Culex tarsalis* and *Culex pipiens* subspp. Calif. Vector Views 23:27-33.

Hoy, J. B. and D. E. Reed. 1970. Biological control of *Culex tarsalis* in a California rice field. Mosq. News 30:222-30.

Hoy, J. B., E. E. Kauffman and A. G. O'Berg. 1972. A large-scale field test of *Gambusia affinis* and chlorpyrifos for mosquito control. Mosq. News 32:161-71.

James, H. G. 1965. Predators of *Aedes atropalpus* (Coq.) and of other mosquitoes breeding in rock pools in Ontario. Can. J. Zool. 43:155-59.

James, H. G. 1967. Seasonal activity of mosquito predators in woodland pools in Ontario. Mosq. News 27:453-57.

Miura, T. and R. M. Takahashi. 1976. Effects of a synthetic pyrethroid, SD43775, on nontarget organisms when utilized as a mosquito larvicide. Mosq. News 36:322-26.

Schaefer, C. H. and W. H. Wilder. 1970. Insecticide resistance and cross-resistance in *Aedes nigromaculis*. J. Econ. Entomol. 63:1224-26.

Womeldorf, D. J., P. A. Gilles and K. E. White. 1972. Insecticide susceptibility of mosquitoes in California: Illustrated distribution of organophosphorus resistance in larval *Aedes nigromaculis* and *Culex tarsalis*. Calif Proc. Calif. Mosq. Control Assoc. 40:17-21.

PREDATION BY THE LARVAE OF *TROPISTERNUS LATERALIS* (FABRICIUS) IN CALIFORNIA RICE FIELDS – A PRELIMINARY REPORT

F. G. Zalom, A. A. Grigarick and M. O. Way

University of California

Department of Entomology, Davis, California 95616

Water scavenger beetles (Coleoptera:Hydrophilidae) are abundant in the rice fields of California's Sacramento Valley, and are commonly collected in aquatic light traps (Washino 1969). The adults are generally herbivorous, while the larvae are largely predaceous. James (1964) wrote that aquatic Coleoptera could be effective agents of mosquito control. As hydrophilid larvae ingest entire prey or parts of prey following mandibular crushing, sclerotized structures can be identified

Table 1.–Number of prey items counted per hydrophilid larva.

PREY TYPE	*H. triangularis*			*T. lateralis*	
	3rd	2nd	1st	3rd	2nd
CRUSTACEA					
Copepoda					
Cyclops sp.	0.017	0.000	0.017	0.058	0.047
Ostracoda					
Stenocypris sp.	1.353	0.210	0.018	0.013	0.000
Candona sp.	0.580	0.090	0.128	0.097	0.016
Cladocera					
Ilyocryptus spinifer	0.300	0.117	0.075	0.126	0.053
INSECTA					
Hemiptera					
Corixidae					
Corisella decolor (adult)	0.117	0.017	0.000	0.000	0.000
C. decolor (nymph)	0.300	0.233	0.075	0.045	0.011
Belostomatidae					
Belostoma sp.	0.042	0.000	0.000	0.000	0.000
Coleoptera					
Dytiscidae					
Laccophilus decipiens (adult)	0.300	0.000	0.000	0.000	0.000
L. decipiens (larva)	0.283	0.100	0.025	0.013	0.000
Thermonectus basilaris (larva)	0.067	0.000	0.000	0.000	0.000
Hygrotus sp. (adult)	0.175	0.017	0.000	0.000	0.000
Hydrophilidae					
Tropisternus lateralis (3rd)	0.225	0.000	0.000	0.000	0.000
T. lateralis (2nd)	0.133	0.083	0.025	0.006	0.000
T. lateralis (1st)	1.275	0.183	0.050	0.013	0.000
Hydrophilus triangularis (1st)	0.033	0.000	0.000	0.000	0.000
Berosus styliferus (larva)	0.000	0.000	0.025	0.000	0.000
Curculionidae					
Lissorhoptrus oryzophilus (adult)	0.017	0.000	0.000	0.000	0.000
Diptera					
Chironomidae					
Cricotopus sylvestris (larva)	0.433	0.350	0.075	0.006	0.000
Tendipes attenuatus (larva)	0.075	0.017	0.000	0.006	0.000
Procladius culiciformis (larva)	0.008	0.000	0.000	0.000	0.000
Chironomus sp. (larva)	0.033	0.000	0.000	0.000	0.000
Paralauterborniella sp. (larva)	0.667	0.500	0.350	0.039	0.011
Tanytarsus spp. (adult)	0.033	0.000	0.000	0.000	0.000
Tanytarsus spp. (larva)	4.317	4.167	1.150	0.206	0.052
Ceratopogonidae					
Culicoides sp. (larva)	0.017	0.017	0.000	0.000	0.000
Culicidae					
Aedes melanimon (larva)	0.017	0.000	0.000	0.000	0.000
Culex tarsalis (larva)	0.042	0.017	0.025	0.013	0.000

from gut contents. When dissecting field captured individuals, the diet may be ascertained. A survey of the feeding habits of *Hydrophilus triangularis* Say has been performed by Wilson (1923) and by Veneski and Washino (1970).

Washino (1969) has observed that an effective mosquito predator must remain abundant throughout the activity period of the prey. One species, *Tropisternus lateralis* (Fabricius) apparently fits that criterion. Further, it is tolerant of considerable climatic and environmental extremes, and is widely distributed. Lewallen (1962) found rather low mortality in laboratory populations exposed to low-level applications of several organophosphate insecticides.

This report will analyze the predation pattern and seasonal abundance of both *T. lateralis* and *H. triangularis* in a California rice field, including differences in feeding among larval instars.

MATERIALS AND METHODS.–Adult and larval collections of *T. lateralis* and *H. triangularis* were made in an untreated rice paddy at the Rice Research Foundation field station at Biggs, Butte Co., California. Samples of all aquatic organisms were taken at weekly intervals during the spring and summer of 1977, using 8 aquatic light traps and dipping. Weekly dissections of at least ten individuals each of both species and all larval stages were made when available. More specimens were dissected when peak abundances occurred.

RESULTS AND DISCUSSION.–Veneski and Washino (1970) reported the effectiveness of *H. triangularis* as a mosquito predator to be limited by lack of specificity in feeding, short duration in the predator stage, and the incongruity of peak seasonal distribution of predator and prey. The first criterion appears to be true for *T. lateralis* (Table 1), but individuals of that species are present throughout the season.

We collected *T. lateralis* larvae from mid May until late August, with peak abundances occurring in both mid June and late July (Figure 1). At the June maximum, the number of *T. lateralis* larvae exceeded the number of *H. triangularis* larvae sixfold. *H. triangularis* larvae exhibited a single mid June peak.

Relative size of predator (Table 2) and prey appear to be an important limiting factor in predation by *T. lateralis*. Remains of small organisms such as crustaceans and chironomids were the most common prey found in their alimentary tracts. No remains were found in 1st instar *T. lateralis*. Further, the number and variety of victims consumed per *H. triangularis* larva greatly exceeded that of the smaller species.

Culex tarsalis Coq. and *Aedes melanimon* Dyar were the only mosquito species found in dissected larvae, and the occurrence was rare. Third instar *H. triangularis* contained the most

Table 2.–Mean size (mm) of dissected larvae.

Type of Larva	Head Capsule Width	Length of Larva	N
H. triangularis			
3rd instar	6.06 ± 0.13	40.33 ± 4.64	120
2nd instar	3.67 ± 0.16	19.65 ± 3.01	60
1st instar	1.96 ± 0.14	11.82 ± 1.20	40
T. lateralis			
3rd instar	1.86 ± 0.10	13.78 ± 1.18	155
2nd instar	1.25 ± 0.08	6.90 ± 0.69	95
1st instar	0.97 ± 0.09	6.35 ± 0.76	120

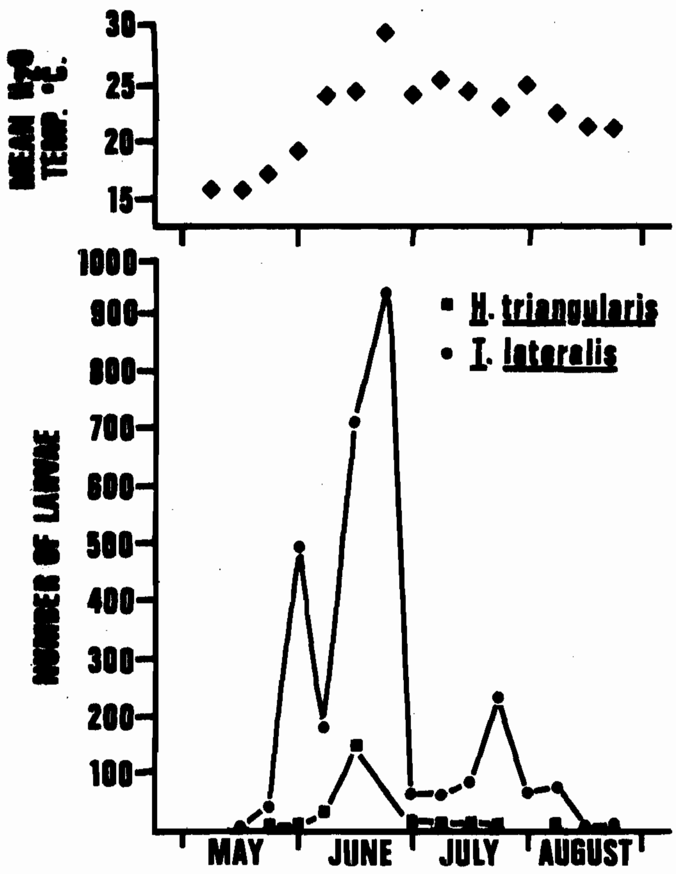

Figure 1.–Abundance of *T. lateralis* and *H. triangularis* collected in aquatic light traps at Biggs, California, 1977, with temperature data.

mosquito larvae, and were the only hydrophilids that held *A. melanimon*. Predation of *A. melanimon* was limited to mid May, while *C. tarsalis* was taken throughout June and in mid July by both beetle species. This feeding data corresponds to previous records of peak larval populations of both mosquito species sampled in rice paddies at Biggs (Markos and Sherman 1957).

T. lateralis has been found to be an efficient predator in certain situations such as small, roadside pools where predator and prey are concentrated (Neilsen and Neilsen 1953). Our data indicate that *T. lateralis* and *H. triangularis* are not effective mosquito predators in the rice field habitat. Both species are generalists in their feeding habits, mainly preying upon chironomid midges and various crustaceans. *H. triangularis* is further limited by relatively low seasonal abundance, and *T. lateralis* by size. Additional study might indicate that mosquito larvae occupy rice field microhabitats sufficiently removed from hydrophilids that they seldom become available as prey items.

ACKNOWLEDGMENTS.–This study was supported in part by the California Rice Research Advisory Board and a graduate research grant from the Department of Entomology, University of California, Davis. Technical assistance from R. P. Meyer, R. K. Washino, C. K. Fukushima and C. A. Hekkanen was greatly appreciated.

REFERENCES CITED

James, H. G. 1964. The role of Coleoptera in the natural control of mosquitoes in Canada. Proc. Intl. Congr. Entomol. 12:357-358.

Lewallen, L. L. 1962. Toxicity of certain insecticides to hydrophilid larvae. Mosq. News 22:112-113.

Markos, B. G. and E. J. Sherman. 1957. Additional studies on the distribution of mosquito larvae and pupae within a rice field check. Mosq. News 17:40-43.

Neilsen, E. T. and A. T. Neilsen. 1953. Field observations on the habits of *Aedes taeniorhynchus*. Ecol. 34:141-156.

Veneski, R. and R. K. Washino. 1970. Ecological studies of *Hydrophilus triangularis* Say in the laboratory and in a rice field habitat. A preliminary report. Proc. Calif. Mosq. Control Assoc. 38:92-93.

Washino, R. K. 1969. Progress in biological control of mosquitoes - invertebrate and vertebrate predators. Proc. Calif. Mosq. Control Assoc. 37:16-19.

Wilson, C. B. 1923. Life history of the scavenger water beetle, *Hydrous (Hydrophilus) triangularis* and its economic relation to fish breeding. Bull. U.S.Bur. Fish. 39:9-38.

LABORATORY STUDIES ON *NOTONECTA UNIFASCIATA* GUERIN AND *BUENOA SCIMITRA* BARE AS PREDATORS OF MOSQUITO LARVAE

Richard J. Stewart and Takeshi Miura

University of California

Mosquito Control Research Laboratory

5544 Air Terminal Drive, Fresno, California 93727

ABSTRACT

Individuals of *N. unifasciata* and *B. scimitra* were brought into the lab to test their comparitive effectiveness as predators of mosquitoes. Lab studies showed that while *N. unifasciata* adults have an overall higher daily killing rate of 4th instar larvae than *B. scimitra*, on a weight basis they may be much the same. *B. scimitra* adults are able to tolerate higher crowding levels than *N. unifasciata* and are less cannabalistic in earlier developmental stages.

In recent years various studies have demonstrated the effectiveness of backswimmers as predators of immature mosquitoes (Lee 1967; Ellis and Borden 1970; Toth and Chew 1972a; Garcia, Voight, and DesRochers 1974; Hazelrigg 1974; Sjogren and Legner 1974; Hazelrigg 1976). The most studied group has been the various species of *Notonecta* which have been studied in laboratory and simulated field situations. The relatively common western species of *Buenoa* have been suggested as control predators of mosquitoes (Toth and Chew 1972b) but have received little recent attention as to efficacy. This study compares the predatory behavior and laboratory feeding capacity of *Notonecta unifasciata* to the less studied *Buenoa scimitra*.

METHODS.–Adult *B. scimitra* and *N. unifasciata* from an outdoor colony were brought into the laboratory in September 1977 for predation studies. *B. scimitra* adults were held in the lab at 27°C under 14 hr light-10 hr dark conditions and were kept in a series of 4 liter tanks. Individuals of *N. unifasciata* were held in a single 40 liter tank under the same light conditions and at 24 ± 2°C. Both groups of backswimmers were held at least 96 hrs in the lab prior to testing and were fed 4th instar mosquito larvae ad lib. The test containers used were one gallon wide mouth glass jars with loose fitting lids. The jars were filled with one liter of tap water and were allowed to stand for 24 hrs at test conditions prior to entry of the backswimmers. All tests were run at 27°C with a 14 hr light-10 hr dark cycle. Immediately prior to entry in the test containers the backswimmers were sexed, with equal numbers of males and females used in each test. Prey mosquitoes used were *Culex pipiens quinquefasciatus* 4th instar larvae from a laboratory colony whose live weights averaged 3.3 mg. Four feeding levels were established for each species of backswimmer. In *B. scimitra* tests mosquito larvae were added at the rates of 5, 10, 20 and 30 per day. For *N. unifasciata* tests larvae were added at the rates of 10, 20, 30 and 40 per day. Tests were run with 6 replicates at each feeding level for five consecutive days. At 24 hr intervals the remaining mosquito larvae were counted and removed with new larvae added for the next interval. At the end of the feeding tests the backswimmers were removed, anesthetized, dried on absorbent paper, and weighed on an analytical balance.

RESULTS AND DISCUSSION.–The mean daily killing rates of *B. scimitra* and *N. unifasciata* on 4th instar mosquito larvae are shown in Table 1. *B. scimitra*, after initial testing, was started at lower prey densities as it became apparent that they would not kill as many larvae per day as *N. unifasciata*.

Table 1.–Mean predation rates on 4th instar mosquito larvae and adult weights of *Buenoa scimitra* and *Notonecta unifasciata*.

Prey Density	Mean Predation Rate/Day	S. D.	95% C. L.
	B. scimitra[a]		
5	3.2	1.40	0.500
10	4.6	2.02	0.722
20	3.5	1.88	0.672
30	4.2	2.64	0.944
	N. unifasciata[b]		
10	7.6	1.98	0.705
20	11.2	4.18	1.495
30	12.6	5.80	2.076
40	13.0	7.67	2.740

[a]Mean weight females 15.2 ± 0.10 mg
males 12.9 ± 0.03 mg

[b]Mean weight females 48.3 ± 0.90 mg
males 38.9 ± 0.69 mg

B. scimitra in Figure 1 shows a relatively flat response to increasing prey densities. Male *B. scimitra* generally had lower daily killing rates than females and were smaller in size as well as weighing less. *N. unifasciata* showed a different trend as to response to increasing prey densities, at higher prey densities more were killed. Males of *N. unifasciata* like those of *B. scimitra* killed fewer mosquito larvae per day than females and were also smaller and lighter. It was seen within the species that weight alone was a pretty good predictor of killing rates. A comparison of predatory rates of *B. scimitra* and *N. unifasciata* in relation to body weight is shown in Figure 2. While *N. unifasciata* has an overall higher daily killing rate of mosquito larvae than *B. scimitra*, weight comparisons show they may be much the same on a body weight basis.

The resting and attack behavior of these two species of backswimmers contrasts greatly. *B. scimitra* adults tend to float in groups suspended at some depth from the surface. Toth and Chew (1972b) reported depth selection of *B. scimitra* at from 5 to 15 cm below the surface. In the test containers used in this study water depth was 6.5 cm and *B. scimitra* individuals oriented themselves in the lower one-third of the water column. *B. scimitra* adults tended to remain almost motionless until disturbed or when moving to the surface to breathe. Most attacks by *B. scimitra* on mosquitoes were from below on larvae hanging at the surface. Attacks were seldom made on larvae moving through the water or to the surface. *N. unifasciata* in contrast is a much more solitary predator, rarely were they seen in aggregations except during mating. Adult *N. unifasciata* are much more jerky swimmers than *B. scimitra* and seldom float in one place in the water column. This species usually initiates attacks on mosquito larvae from either the surface or some submerged object. *N. unifasciata* individuals were seen to capture mosquito larvae not only at the surface but also as the larvae moved through the water.

N. unifasciata nymphs, and to a lesser extent adults, are cannibalistic under crowding conditions whereas *B. scimitra* is not appreciably so. Toth and Chew (1972b) reported being able to keep hundreds of 1st and 2nd stage *B. scimitra* nymphs in one aquarium. Since *B. scimitra* can tolerate higher crowding levels than *N. unifasciata* and shows a similar body weight to killing rate ratio for mosquito larvae, the potential exists for equal effectiveness of these two predators as control agents.

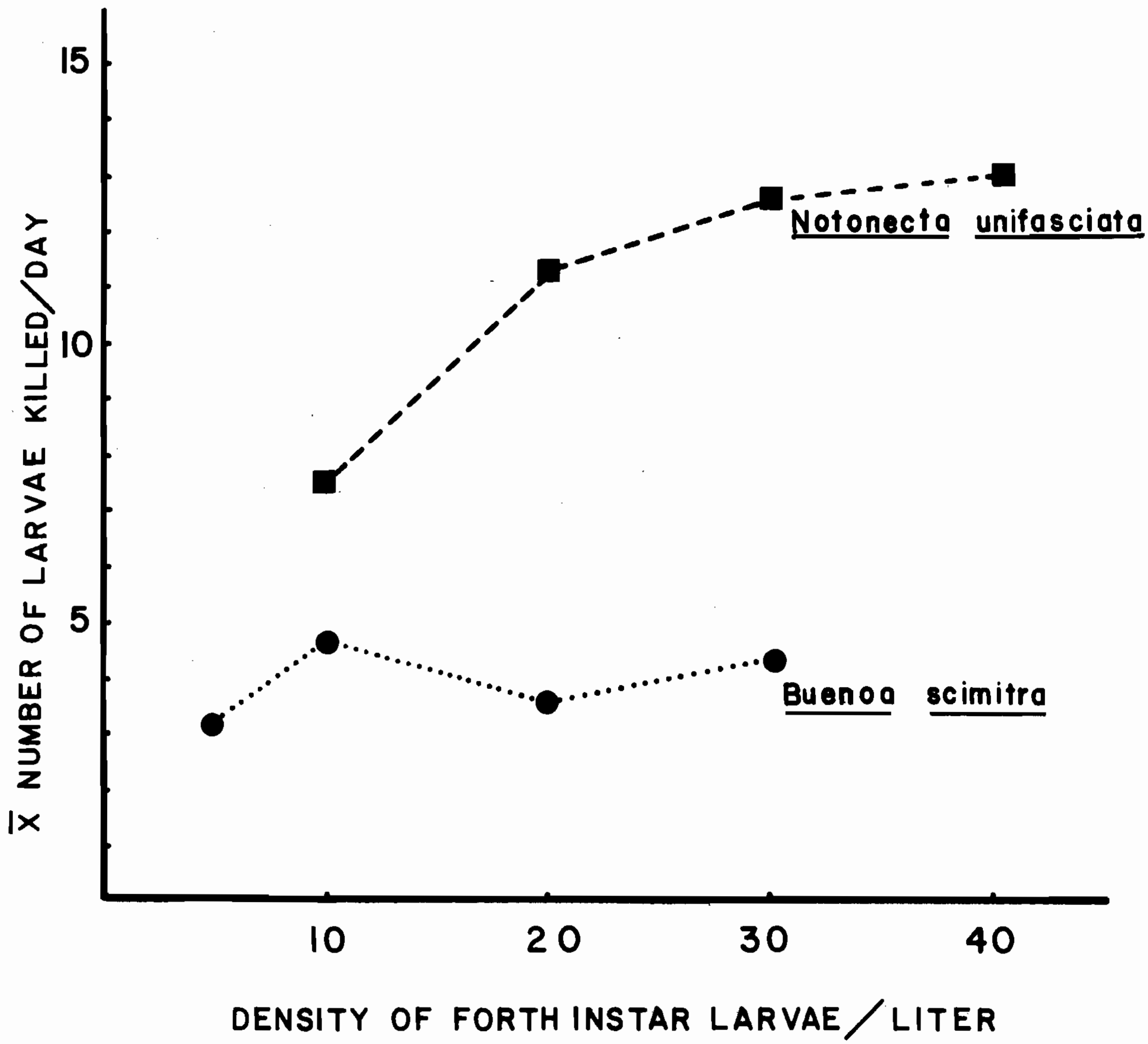

Figure 1.–Mean number of 4th instar mosquito larvae killed per day at different densities by *Buenoa scimitra* and *Notonecta unifasciata.*

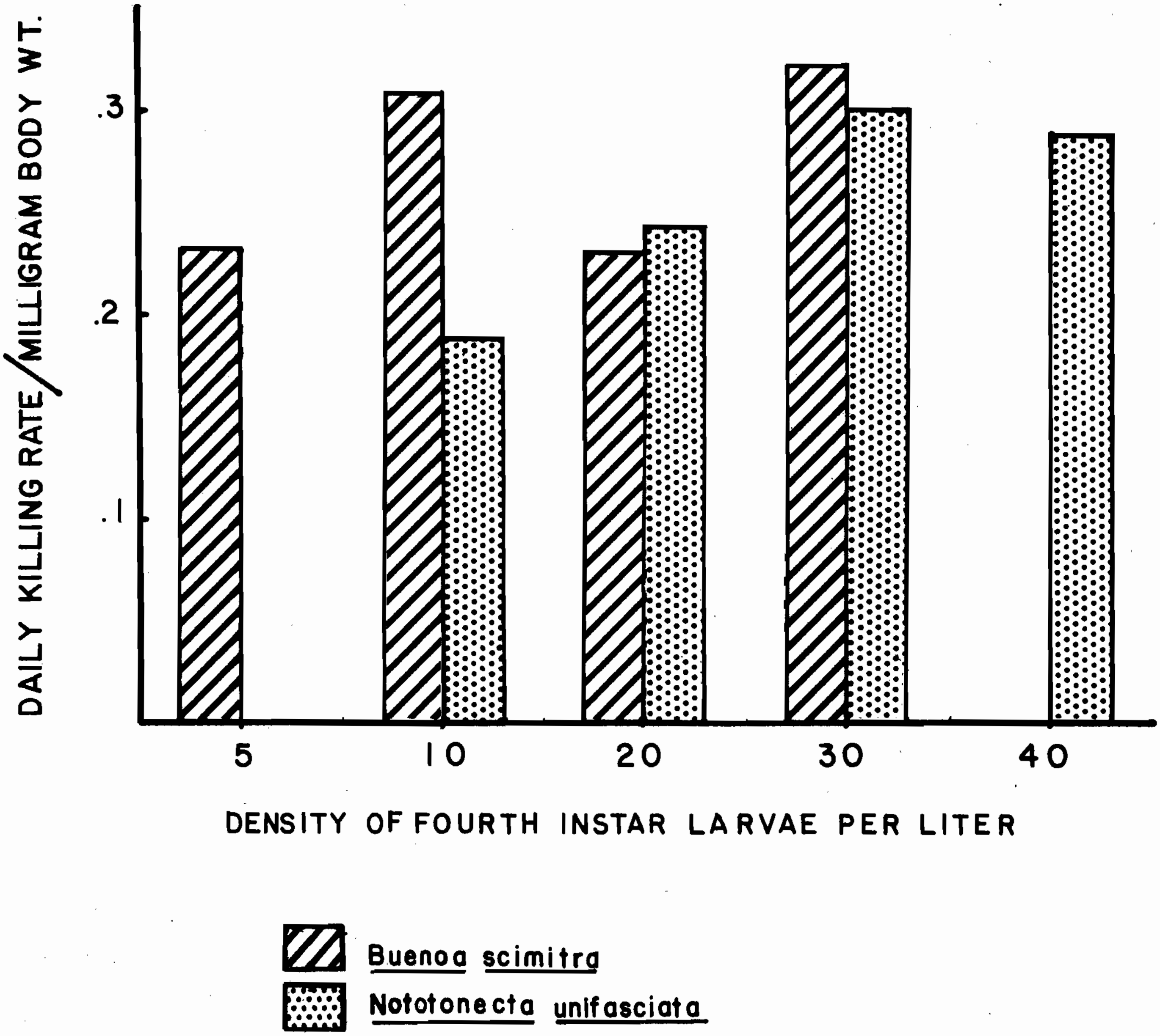

Figure 2.–Daily killing rate of 4th instar mosquito larvae per milligram of body weight of *Buenoa scimitra* and *Notonecta unifasciata*.

REFERENCES CITED

Ellis, R. A. and J. H. Borden. 1970. Predation by *Notonecta undulata* (Heteroptera:Notonectidae) on larvae of the yellowfever mosquito. Ann. Entomol. Soc. Am. 63:963-73.

Garcia, R. W., W. G. Voigt and B. S. DesRochers. 1974. Studies of the predator behavior of notonectids on mosquito larvae. Proc. Calif. Mosq. Control Assoc. 42:67-70.

Hazelrigg, J. E. 1974. *Notonecta unifasciata* as predators of mosquito larvae in simulated field habitats. Proc. Calif. Mosq. Control Assoc. 42:60-65.

Hazelrigg, J. E. 1976. Laboratory rate of predation of seperate and mixed sexes of adult *Notonecta unifasciata* (Guerin) on fourth-instar larvae of *Culex peus* (Speiser). Proc. Calif. Mosq. Control Assoc. 44:57-59.

Lee, F. C. 1967. Laboratory observations on certain mosquito larvae predators. Mosq. News 27(3):332-38.

Sjogren, R. D. and E. F. Legner. 1974. Studies of insect predators as agents to control mosquito larvae, with emphasis on storage of *Notonecta* eggs. Proc. Calif. Mosq. Control Assoc. 42:71-72.

Toth, R. S. and R. M. Chew. 1972a. The development and energetics of *Notonecta undulata* (Hemiptera:Notonectidae) during predation on *Culex tarsalis*. Ann. Entomol. Soc. Am. 65(6):1270-79.

Toth, R. S. and R. M. Chew. 1972b. Notes on behavior and colonization of *Buenoa scimitra* (Hemiptera:Notonectidae), a predator of mosquito larvae. Environ. Entomol. 1(4):534-35.

IMPROVED REARING PROCEDURES FOR *ROMANOMERMIS CULICIVORAX*

E. G. Platzer and A. M. Stirling

University of California

Department of Nematology, Riverside, California 92521

INTRODUCTION.–The effects of several abiotic factors on the infective and parasitic stages of *Romanomermis culicivorax* Ross and Smith have been studied in this laboratory (Brown and Platzer, 1977, 1978; Hughes and Platzer 1977); however, similar investigations with the postparasitic stages of this mermithid nematode have failed. This failure was caused by a chytridiomycetous hyperparasite, *Catenaria anguillulae* Sorokin, which invaded and killed the postparasitic stages of *R. culicivorax* (Platzer and Brown 1976). Recently we found that low pH inactivated the infective units, zoospores, of *C. anguillulae* (Stirling and Platzer, 1978). Accordingly, this finding was used to modify our standard cultural technique for *R. culicivorax* to control the chytridiomycetous hyperparasite.

MATERIALS AND METHODS.–The standard cultural technique for *R. culicivorax* was a modification of the method described by Petersen and Willis (1972). Autogenous *Culex pipiens* L. were used as the hosts (Brown and Platzer 1977). The following procedures are summarized in Table 1. The temperature of the rearing room was 27°C. Thirty polyethylene washpans, 28 cm x 33 cm x 13.5 cm deep, were the rearing containers. Tapwater (2.5 liters) with an average conductivity of 500 micromhos was placed in each container and dechlorinated with four drops of 5% sodium thiosulfate. Eighty mg of finely ground mosquito food was added to each pan. The mosquito food was prepared by grinding Purina® rabbit chow, collecting the powder that passed through a 50 mesh sieve, and mixing 3 parts of this powder with 1 part of brewer's yeast. Twenty egg rafts of *Cx. pipiens* were added to provide 1,300 mosquito larvae per rearing pan. Infective larvae of *R. culicivorax* were obtained 8 hours after flooding mermithid eggs stored on moist sand with declorinated water. After estimation of the concentration of infective larvae, 2,800 infective larvae were added to each pan to give a nematode:mosquito ratio of 2.2:1. The mosquito larvae were fed daily with 80 mg of mosquito food per pan. On days 3 and 5, the water in each pan, usualy pH 7.5, was acidified to pH 4.0 - 4.5 by the addition of 40% acetic acid (approximately 2 ml per pan). The infected mosquitoes were collected on day 7 by pouring the contents of each pan through a 20 mesh sieve. The infected mosquitoes were washed with tapwater and transferred to a nematode emergence chamber containing tapwater at pH 4.5.

Postparasitic nematodes were collected daily and washed in tapwater by alternate suspension and gravity sedimentation in a 5-liter battery jar. The volume of postparasites was measured by placing suspensions of nematodes in 50 ml graduated centrifuge tubes and centrifuging for 2 min at 220 g (1000 rpm; 269 rotor in a PR-J International Centrifuge®). Approximately 10 ml of postparasites were placed in paraffin-coated aluminum cake pans (33 x 24 x 5 cm deep) containing one liter of sterilized medium coarse sand (Table 2) and 1,200 ml of tapwater. After storage for three weeks at 23° - 25°C, the water was removed by decantation and blotting with paper towels. The moist nematode cultures were stored at room temperature, 21° - 25°C, in plastic bags to maintain the moisture content. The total yield of preparasites was estimated by counting preparasites from nematode cultures 24 hours after flooding pans with 1 liter of dechlorinated water. Yields were expressed as total preparasites recovered per nematode culture and per ml nematodes used per culture.

RESULTS AND DISCUSSION.–This rearing procedure was modified from that described by Petersen and Willis (1972). The weekly yield of nematodes was 25 ± 3 (S. E., n = 10) ml of nematodes. Each milliliter of nematodes contained 1,013 postparasites. The male:female ratio was 1:1. Before the introduction of the pH change in the rearing procedure, 61% of the nematodes were lost to *C. anguillulae* infections (Table 3). After the inclusion of the acidification step, *C. anguillulae* infections decreased precipitously and only ca 4% of the postparasites were lost to the fungus infection.

Table 1.–Modified procedures for rearing *Romanomermis culicivorax* in autogenous *Culex pipiens* at 27°C.

Time (days)	Procedure
0 (Friday)	Dechlorinate tapwater in each rearing pan. Add 20 egg rafts (1,300 *Cx. pipiens* larvae) to each pan. Add 80 mg mosquito food to each pan. Add 2,800 preparasites (hatched within 8 hours) to each pan.
1 (Saturday)	Add 80 mg mosquito food to each pan.
2 (Sunday)	Ditto
3 (Monday)	Ditto Adjust pH of water in each pan to 4.0 to 4.5 with 40% acetic acid.
4 (Tuesday)	Add 80 mg mosquito food to each pan.
5 (Wednesday)	Ditto Adjust pH of water in each pan to 4.0 to 4.5 with 40% acetic acid.
6 (Thursday)	Add 80 mg mosquito food to each pan.
7 (Friday)	Collect infected mosquito larvae on 20 mesh sieve, wash off excess food, and place mosquito larvae in emergence containers. Initiate new rearing cycle (see Day 0).

Table 2.–Particle size analysis of sand used for maturation, egg-deposition and storage of *Romanomermis culicivorax*.*

Nominal Particle Size	Name of Separate	p**
mm		%
2 - 1	Very coarse sand	11.11
1 - 0.5	Coarse sand	53.44
0.5 - 0.25	Medium sand	19.85
0.25 - 0.1	Fine sand	13.63
0.1 - 0.05	Very fine sand	1.93
0.05 - 0	Silt	0.03

*After dry sieving method in Day (1965).

**p = (weight of fraction) (100/weight of washed sand).

Table 3.—*Romanomermis culicivorax*: Nematode survival and preparasite yields.*

Treatment	Vol. Per Container (ml)	% Loss (Nematode Vol.)	Total Yield (X 10^6)	Yield/ml Nematodes (X 10^6)
Before pH	12.3 ± 2.8	61 ± 9.8	1.86 ± 0.7	0.33 ± 0.05
After pH	7.5 ± 1.7	ca. 4	1.89 ± 0.3	0.28 ± 0.05

*$\bar{x}$ ± S. E., 6 replicates.

The rationale for the pH modification was as follows. The nematode cultures were contaminated with resting spores of *C. anguillulae*. When the cultures were flooded, zoospores were released and accompanied the infective larvae introduced into the rearing pans. However, the parasitic stages of *R. culicivorax* were free of fungus infections in the hosts and the fungus multiplied saprophytically during this phase on the mosquito food. When the infected mosquito larvae were placed in the emergence containers, the emerging postparasites were attacked by zoospores released from accompanying mosquito food which was difficult to remove from the mosquitoes trapped by the 20 mesh sieve. Since the viability of zoospores was decreased greatly by low pH (Stirling and Platzer, 1978), acidification of the water used for rearing seemed promising. promising.

Cx. pipiens grew well in pH 4.0 water but the preparasites of *R. culicivorax* were not infective. Therefore, the acidifying step was delayed until day 3 to provide sufficient time for the infection of the mosquitoes. In addition, postparasites tolerated tapwater adjusted to pH 4.5 with acetic acid for 24 - 36 hours but died after prolonged exposure. In contrast, the postparasites survived for long periods in tapwater acidified by the addition of peat moss (pH 4.8) but matured slowly.

The average preparasite yield per pan and per ml nematode was the same before and after the pH treatment. However, the main difference was in the numbers of nematodes required to attain these yields. The previous procedure required 1.6 times more nematodes for an equivalent yield.

Petersen (1975) has estimated that each female produces an average of 2,480 eggs. The females from our acidified procedure yielded 553 preparasites (Table 3). Hence further improvements in the rearing procedures are essential to achieve economic production of *R. culicivorax*. However, the present procedure provides a significant advance since it is a simple technique to provide control of a fungus which has plagued the production of *R. culicivorax* in other rearing facilities (Dr. R. Levy, personal communication). In addition, postparasites free of fungus infections are now available for further studies of physiological ecology of *R. culicivorax*.

REFERENCES CITED

Brown, B. J. and E. G. Platzer. 1977. The effects of temperature on the infectivity of *Romanomermis culicivorax*. J. Nematol. 9:166-172.

Brown, B. J. and E. G. Platzer. 1978. Salts and the infectivity of *Romanomermis culicivorax*. J. Nematol. 10:53-61.

Day, P. R. 1965. Particle fractionation and particle-size analysis. IN C. A. Black, ed. Methods of Soil Analysis. Am. Soc. Agronomy, Inc. Madison. Part I:545-567.

Hughes, D. S. and E. G. Platzer. 1977. Temperature effects on the parasitic phase of *Romanomermis culicivorax* in *Culex pipiens*. J. Nematol. 9:173-175.

Petersen, J. J. 1975. Development and fecundity of *Reesimermis nielseni*, a nematode parasite of mosquitoes. J. Nematol. 7:211-214.

Petersen, J. J. and O. R. Willis. 1972. Procedures for the mass rearing of a mermithid parasite of mosquitoes. Mosq. News 32:226-230.

Platzer, E. G. and B. J. Brown. 1976. Physiological ecology of *Reesimermis nielseni*. Proc. 1st Int. Coll. Invert. Path. and IXth Ann. Mt. Soc. Invert. Path. Queen's Univ., Kingston, Canada, 1976. p. 263-267.

Stirling, A. M. and E. G. Platzer. 1978. *Catenaria anguillulae* in the mermithid nematode *Romanomermis culicivorax*. J. Invert. Pathol. 31:In Press.

ASSESSMENT OF BIOLOGICAL CONTROL AGENTS AGAINST MOSQUITO LARVAE IN NORTHERN CALIFORNIA: A PROGRESS REPORT

R. K. Washino and C. K. Fukushima

University of California
Department of Entomology, Davis, California 95616

Efforts are being continued to evaluate under field conditions the effectiveness of old and newly developed biological and chemical insecticides in the overall scheme of integrated control as programmed by current research developments from rice field and pasture management activities. This report summarizes the progress of work during 1977-78 on two species of fungi, one mermithid nematode, 4 species of flatworms and fish as possible biological control agents of mosquito and gnat larvae in California, and represents the collective efforts of J. B. Christensen, J. L. Fetter-Lasko, J. K. Brown and F. H. Collins.

Previous work established the fact that *Lagenidium giganteum*, an aquatic fungus, was a highly virulent microbial agent against *Culex tarsalis* larvae. Extended studies alluding to the inconsistent pattern of infection with *Anopheles freeborni*, the effects of high temperature and water quality, and susceptibility of nontarget invertebrates, have been discussed elsewhere in the program.

In early 1977, to determine whether or not the fungus could successfully overwinter in an irrigated pasture, thirty sentinel units containing 750 uninfected *Cx. tarsalis* larvae were strategically positioned throughout the over 15,000 sq. ft. area to monitor the presence or absence of the fungus. In addition, approximately 500 early instar *Aedes nigromaculis*, *Ae. melanimon* and *Cx. tarsalis* larvae were collected from the prescribed area and held to check for fungal infection. In contrast to earlier studies in rice fields and associated habitats, fungus in the irrigated pasture did not appear to successfully survive the winter period.

In collaboration with Butte and Sutter-Yuba MADs, the overwintering survival pattern was compared between *Gambusia affinis holbrooki*, the cold-tolerant form of the mosquito fish and *G. affinis affinis*, the form commonly deployed in California mosquito abatement programs. No significant differences were found among the groups of fish tested. The results may be attributed, in part, to the mild winter (1976-77) which did not induce sufficient "cold" stress to the fish population. A similar explanation can probably be applied to results of a study on the effects of fish size and feeding rate on overwintering survival.

In collaboration with Colusa and Sutter-Yuba MADs, a field experiment was conducted comparing rice fields initially stocked with *G. affinis* at rates of 0.2, 0.5 and 1.0 lb/A. Mosquito population in 44 rice fields was assessed every third week starting in late June. Based on the results from 5 sampling dates, no statistical difference was observed on the III-IV stage *Anopheles freeborni* in the control fields and any of the treatments.

A literature compilation was completed on the more significant and recent papers relating to mosquitofish. Of more than 150 papers reviewed 79 were cited. Where applicable, data from some of the papers were reassessed and new interpretations made.

Collaborative field studies to further assess *Romanomermis culicivorax* in rice fields produced infection rates in *An. freeborni* considerably lower than was observed in 1976.

Field and laboratory studies on the four Neorhabdocoel microturbellarians of the family Typhlopyanidae have been described elsewhere in the program.

A new methodology was developed to assess the efficacy of biological control agents against the immature stages of the Clear Lake Gnat. Also, in preliminary field trials involving *Lagenidium giganteum* against the gnat in a farm pond, a suboptimum dosage resulted in a significant decrease in the gnat population over a 5-week period.

Trials to sample mosquito larval population in a rice field habitat by three methods have been reported elsewhere in the program.

The use of De Zuleta drop-net cages and knock-down boxes for estimating mosquito adult population changes were continued in 1977 in conjunction with insecticide application tests in Burney Basin. Low mosquito populations during test trials yielded unmeaningful results. The drop-net cages, however, did trap a rather substantial number of non-target insects (Cicadellidae and Lygaeidae).

PATTERNS OF EXPERIMENTAL INFECTION OF MOSQUITO LARVAE BY *LAGENIDIUM GIGANTEUM*

Joyce Fetter-Lasko and Robert K. Washino

University of California
Department of Entomology, Davis, California 95616

The drought in California during 1977 prevented the flooding of the Colusa County study sites where patterns of infection in mosquito larvae by *Lagenidium giganteum* were measured for the past 3 years. This situation precluded efforts to conduct in situ studies to verify hypotheses concerning limiting factors for the fungus. The results of laboratory studies seemed to be consistent, however, with our earlier conclusion that high water temperatures, as found early in the rice growing season before emergent plants provide shade and stability to the environment, can prevent or reduce *L. giganteum* infections. This finding may have important implications concerning timing of application and/or expected post-inoculation infection rates. Water high in organic waste matter has also been shown to limit *L. giganteum* infections under laboratory conditions. These observations were made by comparing fungal infection rates in either pasture or distilled water for *Aedes nigromaculis* and *Culex tarsalis*. These results may explain the unexpected low infection rates encountered in the 1976 pasture study.

Experiments to study the impact of the fungus on nontarget organisms were continued with several aquatic insects and crustaceans collected from rice fields. All results were negative, giving additional evidence for the narrow host-range of *L. giganteum.*

The results of studies on the susceptibility of *Anopheles freeborni* to *L. giganteum* infection have been inconsistent. Our 1974 data indicated a 72.6% infection rate; a series of trials conducted in 1977 resulted in infection rates of 10% to 60%. The reasons for these differences have not been determined.

In summary, we have tentatively concluded the following from our studies in 1977: (1) Persistent high water temperatures may reduce or prevent infections of mosquito larvae by *L. giganteum* so that consideration must be given to the timing of fungal application; (2) water with a high organic load may reduce infection rate; (3) laboratory results give additional support to a narrow host range of *L. giganteum*; (4) *Anopheles freeborni* vary in degree of susceptibility to infection by *L. giganteum*. In spite of some limitations discussed herewithin, *L. giganteum* continues to show a great deal of promise as a biological control agent.

MICROTURBELLARIANS AS NATURAL PREDATORS OF MOSQUITO LARVAE IN NORTHERN CALIFORNIA RICE FIELDS

F. H. Collins and R. K. Washino

University of California
Department of Entomology, Davis, California 95616

An experimental survey of the survivorship of *Culex tarsalis* larvae in selected northern California rice fields (Case and Washino 1976) disclosed two species of microturbellarians which were apparently responsible for significant (above 50% in one day) larval mortality in field emergence cages. From July through September of 1977 a follow-up study was performed on ten Sutter County rice fields to determine (i) the identity of the previously encountered flatworms, (ii) their general biology, and (iii) their efficacy as natural biological control agents of *Cx. tarsalis* and *Anopheles freeborni*, the two principle mosquitoes associated with rice fields.

The field procedure involved weekly placement of emergence cages at two selected stations in each of the ten fields. Thirty III instar, laboratory-reared, sentinel *Cx. tarsalis* larvae were added to each cage and the contents were analyzed three days later for sentinal larval mortality and microturbellarian density. The in-field density of mosquito larvae was assessed by taking 25 dips (400 ml dipper)/station/week at the time when the sentinel larval mortality was measured. Flatworm densities were estimated by counting the individuals present in the emergence cages.

Of the eight species of flatworms which invaded the emergence cages, the following four neorhabdocoel microturbellarians of the family Typhloplanidae were found to prey upon mosquito larvae under both field and laboratory conditions: *Mesostoma lingua, Mesostoma ehrenberghii, Rhynchomesostoma rostratum* and *Bothromesostoma personatum*. *M. lingua* and *R. rostratum* were the most widely distributed and abundant of the four and were probably responsible for the bulk of sentinel mosquito mortality. Field observations showed that *M. lingua* (3-5mm adult length) occupies virtually any available substrate (aquatic vegetation, algal mats, bottom, etc.), *R. rostratum* (2-3mm adult length) is free swimming, *B. personatum* (2-4mm adult length) prefers the surface film of the water, and *M. ehrenberghii* (5-8mm adult length) is predominantly benthic.

Typhloplanid microturbellarians generally reproduce sexually, although there is evidence which suggests that the California population of *M. lingua* may also reproduce parthogenetically. Two types of eggs are typically produced, a subitaneous egg which hatches immediately prior to or upon deposition and a heavily encapsulated, diapause egg which begins development only after exposure to a low temperature stimulus. The diapause eggs remain dormant over the winter in the dry fields (resisting cold, dessication, and even rice-stubble burning) and hatch with spring flooding. Population growth is rapid. Within three weeks newly hatched *M. lingua* grow to adult size and deposit the first of several complements of subitaneous eggs. Diapause eggs are produced by the older adults.

A uniformly high correlation between sentinel mortality and in-cage microturbellarian density suggests that predation by typhloplanid flatworms was the major cause of sentinel mosquito mortality. Further analysis of the data for correlation between the in-field densities of mosquito larvae and the in-cage microturbellarian densities revealed significant negative correlations ($p <$ than .05) between *M. lingua* vs. *Cx. tarsalis* and *R. rostratum* vs. *An. freeborni*. Whether or not these relationships actually reflect in-field predatory interactions is still problematic.

REFERENCES CITED

Case, T. J. and R. K. Washino. 1976. Continuing studies on the natural mortality of mosquitoes in rice field habitats. Proc. Calif. Mosq. Control Assoc. 44:115.

LABORATORY EVALUATION OF FUNGICIDES FOR THE CONTROL OF *CATENARIA ANGUILLULAE*, A FUNGUS PARASITE OF *ROMANOMERMIS CULICIVORAX* (NEMATODA: MERMITHIDAE)

Major S. Dhillon and E. G. Platzer

University of California
Departments of Entomology and Nematology, Riverside, California 92521

The nematode, *Romanomermis culicivorax* Ross and Smith, parasitizes mosquito larvae (Tsai and Grundmann 1969; Petersen 1976). Its potential as a biological control agent has been explored (Petersen and Willis 1972, 1974; Brown et al. 1977) and the effects of certain abiotic factors on its biology were studied (Peterson 1975; Brown and Platzer 1977, 1978). Although the nematode is a promising pathogen of mosquitoes with good potential for biological control, it is hyperparasitized by a chytridiomycetous fungus, *Catenaria anguillulae* Sorokin (Platzer and Stirling 1978) which caused an epizootic in their laboratory colony. The fungus attacked the post-parasitic stages of *R. culicivorax* within a short time after their emergence from the host.

The control of this hyperparasitic fungus was studied. Six fungicides were tested for control of *C. anguillulae*.

METHODS AND MATERIALS.–The inhibiting effects of fungicides, benomyl (1-butylaminocarbomyl-2-carbamomethoxy-benzimidazole), PCNB (pentachloronitro-benzene), captan (N-trichloromethylthio)-4-cyclohexane-1, 2-dicarboximide), Amphotericin-B, cycloheximide and griseofulvin against *C. anguillulae* were evaluated on YPSS (yeast-peptone-soluble starch) agar plates. The fungus was grown after the procedure of Stirling and Platzer (1978). Each fungicide was mixed with sterile and liquified YPSS agar medium at 60°C. Each treatment of 5, 50, 250 ppm was replicated three times. Controls were run simultaneously. The plates, each containing 25 ml of the medium, were left overnight at room temperature and the following day they were inoculated with 3 mm plugs of the fungus. The diameter of each colony was measured at three-day intervals for 15 days.

Further tests of benomyl, cycloheximide and griseofulvin were carried out at a concentration of 5 ppm in tap water. Two males and two females of *R. culicivorax* were placed in petri dishes (35 x 10 mm deep) each containing 3 ml of the treated water and one gm of sterile sand. Each test was replicated 15 times along with three controls at 27°C. Observations were made periodically until the presence of eggs or preparasitic larvae was observed.

RESULTS AND DISCUSSION.–The results obtained during this study are presented in Table 1. Amphotericin-B and PCNB did not inhibit the growth of *C. anguillulae* at any of the concentrations tested. Captan at high concentrations (50 and 250 ppm) was effective but low concentrations were ineffective. Benomyl, cycloheximide and griseofulvin were inhibitory at all concentrations. These results eliminated the potential use of PCNB, Amphotericin-B and captan for control of the fungus. The rate of development of the fungus was slower at 250 ppm than at 5 ppm in Amphotericin-B treatments while it was the same in all PCNB concentrations (Table 1).

Although benomyl, cycloheximide and griseofulvin completely inhibited the fungal growth on agar, their activity against the fungus in tapwater was very poor; 70 - 80% of the nematodes were still infected with the fungus. Both males and females were infected. The poor fungal control found for these fungicides in tapwater was probably due to their low solubility in tapwater; however, mycelial growth in the treated nematodes was less vigorous than in the controls. It appeared that these fungicides did not affect the germination of the zoospores but did suppress the mycelial growth. Only a few nematode eggs were found and these were infected by the fungus. Benomyl treatments appeared to be nematicidal since some fungus-free nematodes died. The fungal attack was not very severe in cycloheximide and griseofulvin treatments but inhibited the development of the nematode.

In conclusion, chemical control of *C. anguillulae* in *R. culicivorax* with these standard antifungal agents was not feasible.

ACKNOWLEDGMENT.–The assistance and cooperation of Marcelle Stirling during the course of studies is appreciated.

Table 1.–Effects of various fungicides[a] at different concentrations against *Catenaria anguillulae*.

Post-Treatment	Concentrations of fungicides (ppm)									
	PCNB			Amphotericin-B			Captan			
Days	5	50	250	5	50	250	5	50	250	Control
	Colony Growth (in cm)									
3	1.0	0.9	0.8	1.2	1.3	0.9	1.0	0	0	1.2
6	1.4	1.3	1.7	1.5	1.7	1.0	1.3	0	0	1.7
9	2.8	2.8	2.2	3.5	2.6	1.1	3.0	0	0	3.5
12	3.3	3.1	2.7	4.2	3.0	1.4	3.7	0	0	4.3
15	4.3	3.9	3.4	5.0	3.0	1.7	5.2	0	0	5.8

[a]No growth was observed in benomyl, cycloheximide and griseofulvin treatments.

REFERENCES CITED

Brown, B. J. and E. G. Platzer. 1977. The effects of temperature on the infectivity of *Romanomermis culicivorax*. J. Nematol. 9:166-172.

Brown, B. J. and E. G. Platzer. 1978. Salts and the infectivity of *Romanomermis culicivorax*. J. Nematol. 10:53-61.

Brown, B. J., E. G. Platzer and D. S. Hughes. 1977. Field trials with the mermithid nematode, *Romanomermis culicivorax*, in California. Mosq. News 37:603-608.

Petersen, J. J. 1975. Development and fecundity of *Reesimermis nielseni*, a nematode parasite of mosquitoes. J. Nematol. 7:211-214.

Petersen, J. J. 1976. Comparative biology of the Wyoming and Louisiana populations of *Reesimermis nielseni*, parasitic nematode of mosquitoes. J. Nematol. 8:273-275.

Petersen, J. J. and O. R. Willis. 1972. Results of preliminary field application of *Reesimermis nielseni* (Mermithidae:Nematoda) to control mosquito larvae. Mosq. News 32:312-316.

Petersen, J. J. and O. R. Willis. 1974. Experimental release of a mermithid nematode to control *Anopheles* mosquitoes in Louisiana. Mosq. News 34:316-319.

Platzer, E. G. and A. M. Stirling. 1978. Improved rearing procedures for *Romanomermis culicivorax*. Proc. Calif. Mosq. and Vector Control Assoc. 46:87-88.

Stirling, A. M. and E. G. Platzer. 1978. *Catenaria anguillulae* in the mermithid nematode *Romanomermis culicivorax*. J. Invert. Path. 31:In Press.

Tsai, Y. H. and A. W. Grundmann. 1969. *Reesimermis nielseni* gen. et sp. n. (Nematoda : Mermithidae) parasitizing mosquitoes in Wyoming. Proc. Helminthol. Soc. Wash. 36:61-67.

PREDATORS OF *ROMANOMERMIS CULICIVORAX*

E. G. Platzer and L. L. MacKenzie-Graham

University of California
Department of Nematology, Riverside, California 92521

Observations of high populations of aquatic arthropods in rice fields prompted a study on the potential of various aquatic arthropods as predators of the mermithid nematode, *Romanomermis culicivorax*. Predation on two non-parasitic phases in the life history of the mermithid, the preparasitic or infective and postparasitic stages, was studied.

PREPARASITIC STUDIES.–Single preparasites and potential predators were placed in small volumes of water (0.2 to 2.0 ml, in well slides or plastic beakers) and observed regularly over 48 hours. Copepods (*Cyclops vernalis*) were avid predators; the preparasites were attacked and eaten within one hour. Ostracods were predatory but the time for prey location and ingestion was longer than that for copepods. Cladocerans (*Simocephalus vetulus*) consumed preparasites within 24 hours and the young of a gammarid (*Hyallela azteca*) attacked the preparasites within 48 hours. Green hydra did not attack the preparasites.

POSTPARASITE STUDIES.–Single postparasites and potential predators were placed in transparent plastic containers with 250 ml water and observed regularly over 72 hours. Diving beetles (*Laccophilus terminalis*) and gammarids (*H. azteca*) attacked the postparasites of *R. culicivorax* and consumed the prey within one hour. Dragonfly and damselfly naiads, and small crayfish (*Procambarus clarki*) ate the postparasites within several to 24 hours. Isopods (*Asellus* sp.) attacked the postparasites only after 48 hours. Planarians did not attack the postparasites.

Many of the previous studies on *R. culicivorax* have been directed towards elucidation of the abiotic factors in the biology of this mermithid. The current observations demonstrate the importance of biotic factors on the survivorship of *R. culicivorax* and the necessity of evaluating the density of potential micropredators in mosquito-breeding sites before application of this mermithid as a biological control agent.

DIEL AND SEASONAL VARIATIONS IN THE MOVEMENTS OF *GAMBUSIA AFFINIS* IN FRESNO COUNTY RICE FIELDS

David G. Farley and Leonard C. Younce

Fresno Westside Mosquito Abatement District
Post Office Box 125, Firebaugh, California 93622

ABSTRACT

Diel activity peaks and seasonal migration periods for *Gambusia affinis* were studied. Fish were trapped both in the field and in the outflow boxes over several 24 hour periods to determine activity peaks. Outflow traps were set in 11 fields and check daily from May 18 to September 2, 1977, to determine the times of peak migrations out of the field. More than 90% of the mosquitofish caught in the diel trapping were caught during the daylight hours, and a definite midday activity peak was observed. Outflow trapping indicated a four to five week long migration of juvenile mosquitofish out of the fields, beginning six to seven weeks after the initial stocking.

The pattern of movements of mosquitofish, *Gambusia affinis* (Baird and Girard), in rice fields has been little studied. Losses of fish due to migration out of the rice field could have deleterious effects on subsequent mosquitofish populations within the field. Observations of fish leaving rice fields have been made, but no published figures concerning numbers, age composition, time of year, etc. are available. In addition, little is known about the activity peaks exhibited by mosquitofish over a 24 hour period. Activity peaks should correlate with peaks in feeding behavior. Hess and Tarzwell (1942) felt that mosquitofish selectively fed on chaoborid and ceratopogonid pupae at night or during the early morning hours, suggesting an activity peak at those times. Hubbs (1971) found that mosquitofish display an activity peak at about 11:00 a.m. and Johnson (1976) demonstrated that the thermal physiology of the fish would support an activity peak near midday. The present paper is a preliminary report on the diel activity periods and seasonal migration periods observed in *G. affinis* in rice fields.

MATERIALS AND METHODS.--Seasonal movements -- Outflow traps were placed in the outflow boxes of 11 different rice fields. The outflow traps are boxes consisting of a 2 ft by 1 ft by 1 ft aluminum frame with an eight mesh hardware cloth covering. Approximately 80% of the water leaving the field passed through the outflow trap. Trapping was begun on May 18 and concluded on September 2. The traps were placed in the outflow boxes each Monday morning and checked every 24 hours through Friday morning when they were removed. Traps were not placed in the outflow boxes if there was no water flow. During each 24 hour check, the fish were removed from the outflow trap and the trap was returned to the outflow box. Fish were separated into matures and immatures (including immature females and all males) and counted. When large numbers of fish were found in the trap a known volume was counted and the total number was estimated volumetrically.

Diel movements - - In 1976, two fields were sampled to see if fish were primarily caught during the daylight or dark hours. Ten eight-mesh minnow traps were placed in each field, one trap in each of the center 10 paddies. Traps were set when just light enough to see (5:45-6:00 a.m. PDT). The traps were checked just after sundown (8:00-8:15 p.m. PDT) and again at 5:45-6:00 a.m. At the 8:00 p.m. check, the fish from each trap were placed in a plastic bucket and each trap was immediately replaced in the field. The procedure at the 6:00 a.m. check was identical except that the traps were removed from the field. After all the traps had been emptied, the fish were removed from the bucket, counted and discarded.

The same procedure was used in eight fields during 1977. In addition, outflow traps were placed in five of the fields. The outflow traps were not removed after 24 hours, but were checked at 6:00 a.m. and 8:00 p.m. daily for 4 days. At the end of the fourth 24 hour period, the traps were removed.

Minnow traps were placed in two fields to determine the movements of fish during the daylight hours. The traps were placed in the middle ten paddies of each field at 6:00 a.m. They were checked every two hours, and all fish caught were removed and counted. The traps were immediately returned to the field after each check. Trapping in one of the fields was discontinued at 2:00 p.m., but the traps in the other field were checked every two hours until 8:00 p.m.

Outflow traps were placed in eleven fields at 6:00 a.m. and were checked hourly. At each check, fish were removed and counted, and the traps were returned to the outflow box. In seven of the fields, trapping was discontinued at 1:00 p.m. Traps were checked hourly in the other four fields until 8:00 p.m.

RESULTS AND DISCUSSION.--Seasonal movements - - Movement of fish out of the rice fields was difficult to measure in 1977. The drought caused many of the rice growers to reduce or eliminate the amount of water leaving the field. Two of the five fields studied had good outflow throughout the season and yielded interesting results (Figures 1, 2). The other three fields had reduced or non-existent outflows for much of the season. However, the data that was collected from these fields supported the observations shown in Figures 1 and 2.

Movement of fish out of the field outlet began within 24 hours after fish were introduced into the fields. Trapping indicated that the loss of fish was sporadic and light for the first 40-45 days after stocking. During this period, mature fish outnumbered immatures in the outflow traps. Usually fewer than 20 to 30 total fish per night were trapped. During the last week of June or the first week of July (40 to 50 days after stocking) the ratio of matures to immatures reversed and large numbers of immatures left the field. Catches in the outflow traps were generally high for the next four to five weeks with up to 6000 fish per day passing through the outlet box. The large exodus of fish tapered off dramatically around the first week in August and catches in the outflow traps remained fairly low throughout the rest of the season. During the height of the fish movements, each graph shows one day with high numbers of matures in the outflow traps. This does not represent a sudden movement of matures, but rather a judgement error. The immatures leaving the field at this time were just at the point of sexual maturity, but were not gravid (Figures 1 and 2).

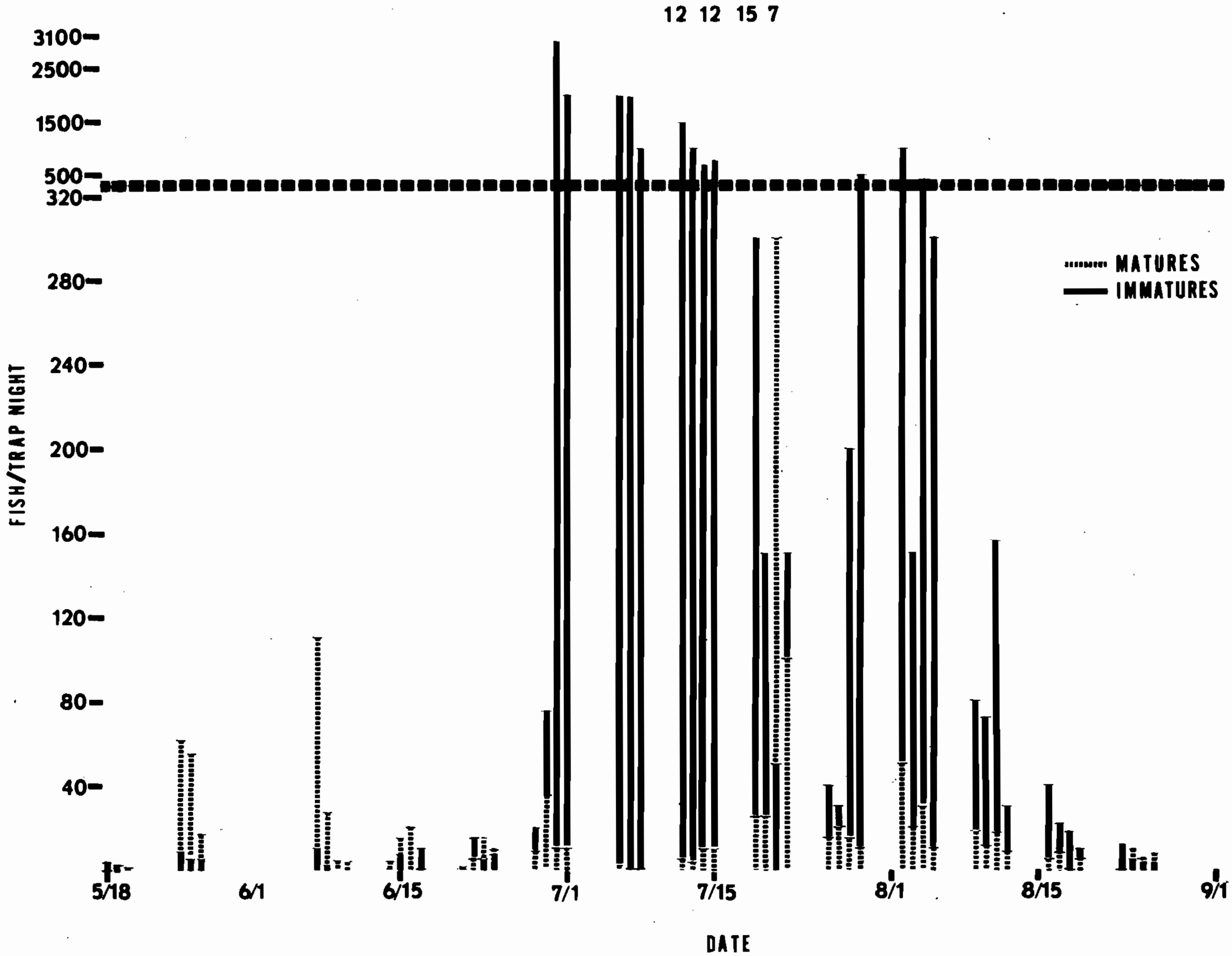

Figure 1.–Numbers of *Gambusia affinis* picked up in outflow traps in field numbers 12 12, 15 7.

With such large losses of immatures during July, one would expect a depressed mature population in the fields in August. This proved to be true in our study. The numbers of matures trapped in the high-loss and non-flowing fields were about the same during July. However the trapping done in the middle of August showed that the non-flowing fields had nearly twice as many matures per trap as the two fields with high July immature losses. The last trapping of the season done the last week of August still showed that the nonflowing fields had nearly 1/3 more matures than the two high-loss fields. All of the evidence suggests that if the exodus of immatures can be controlled, larger populations of fish will result in the latter part of the summer when *Culex tarsalis* and *Anopheles freeborni* larvae are most abundant.

Diel movements - - Results of fish trapping in 1976 and 1977 indicated that mosquitofish are much more active during the daylight hours than during the darkness (Table 1). In 1976 an average of 93.1% of the fish caught in two fields over a 24 hour period were caught during the daylight hours. In 1977, eight fields were similarily trapped over a 24 hour period, and 92.9% of the fish were caught during the daylight hours. Trapping the outflows of fish fields in 1977 showed that 97.8% of the 1383 fish caught were caught during the day.

Trapping conducted periodically through the daylight hours indicates an interesting pattern of fish movements throughout the day (Figure 3). Catches in both the "in-field" and outflow traps were lowest early in the morning and late in the evening and peaked about mid-day indicating the greatest movement of fish at this time. The curves for the in-field trapping each represent one field while the curve for the outflow trapping on August 17, 1977 represents the cumulative total of four fields. The August 10-12, 1977 outflow curve represents the mean of trap results for seven fields. Trapping for the August 10-12, 1977 outflow and August 12, 1977 in-field studies were ended at 1:00 p.m. and 2:00 p.m. respectively. However, the outflow traps were picked up again at 8:00 p.m. and it is interesting to note that 52.6% of the fish caught in outflow traps on those days were caught between dawn (6:00 a.m. PDT) and midday (1:00 p.m.) and 47.4% were caught between midday and dusk (8:00 p.m.). This indicates a more or less ball-shaped curve as found in the August 17, 1977 data (54.9% of the total catch on August 17, 1977 was caught by 1:00 p.m.). If movement of

Table 1.–Catch rates for in-field and outflow trapping of *Gambusia affinis* during the day and night.

Field Number	No. Caught/Day	No. Caught/Night	Percent Caught/Day	Percent Caught/Night
12 12 15 2	826	55	93.8	6.2
12 12 15 7	205	6	97.2	2.8
12 12 15 11	300	22	93.2	6.8
12 12 10 14	156	11	93.4	6.6
12 12 10 16	605	15	97.6	2.4
12 12 9 5	277	5	98.2	1.8
12 12 8 9	195	19	91.1	8.9
12 12 15 9	450	100	81.8	18.2
Mean	377	29	92.9	7.1
		In Field Trapping – 1976		
11 12 27 4	830	63	92.9	7.1
11 12 28 10	330	22	93.8	6.2
Mean	580	43	93.1	6.9
		Outflow Trapping – 1977		
12 12 15 2	349	0	100	0
12 12 15 7	363	29	92.6	7.4
12 12 15 11	530	0	100	0
12 12 10 14	26	0	100	0
12 12 10 16	115	2	98.3	1.7
Mean	277	6	97.8	2.2

the fish is indicative of feeding behavior then it appears that feeding activity is at a peak during the late morning and early afternoon, and minimal near dawn and dusk.

The results of this study may have several applications. Since mosquitofish don't move to any great degree at night, draining a pond at night in order to remove mosquitofish would prove futile. Stranding of mosquitofish has been observed in ponds which were drained during the night (Robert Coykendall, pers. comm.). In addition, if one desires to trap large numbers of mosquitofish from a rice field outflow when the field was being drained, it appears that the traps could be set in the morning and removed in the afternoon without significant loss of fish. Trapping a field to determine the resident *Gambusia* population might also be accomplished by removing the traps in the afternoon.

REFERENCES CITED

Hess, A. D. and C. M. Tarzwell. 1942. The feeding habitats of *Gambusia affinis affinis* with special reference to the malaria mosquito, *Anopheles quadrimaculatus*. Amer. J. Hyg. 35(1):142-151.

Hubbs, C. 1971. Competition and isolation mechanism in the *Gambusia affinis* X *G. heterochir* hybrid swarm. Bull. Texas Memorial Museum 19. 1-46.

Johnson, C. R. 1976. Diel variation in the thermal tolerance of *Gambusia affinis affinis* (Pisces:Poeciliidae). Comp. Biochem. Physiol. 55 A:337-340.

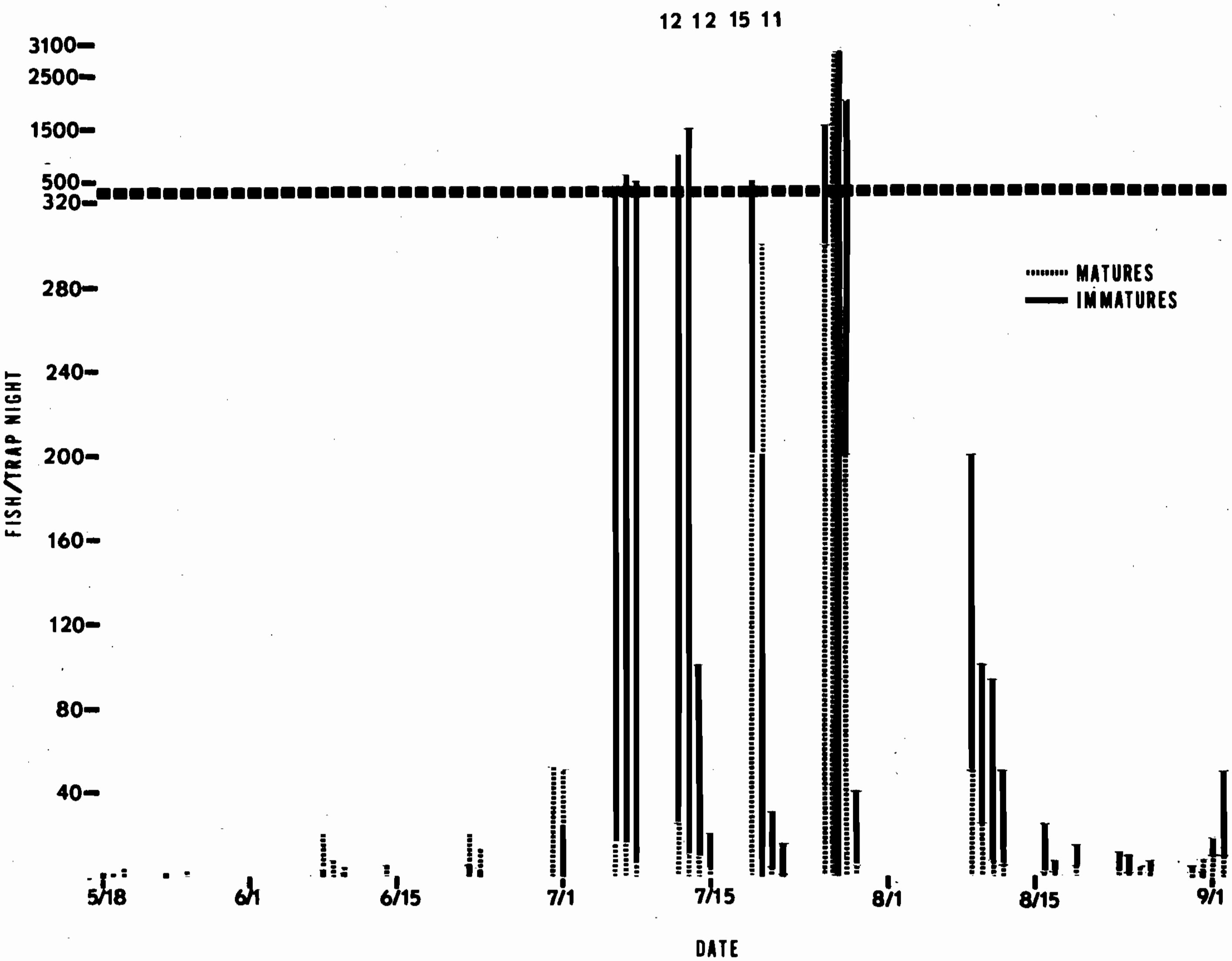

Figure 2.—Numbers of *Gambusia affinis* picked up in outflow traps in field numbers 12, 12, 15, 11.

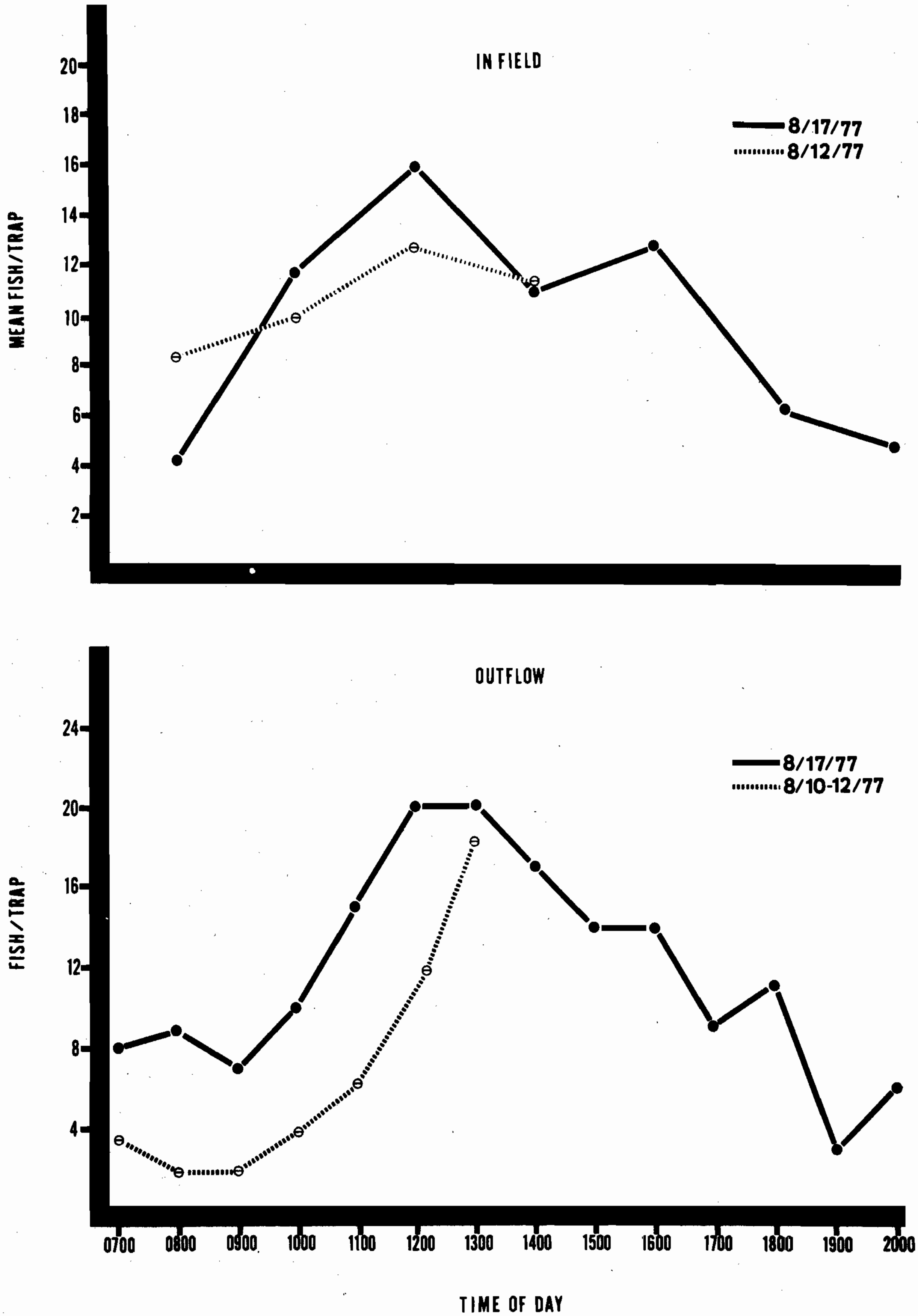

Figure 3.--Comparison of in-field and outflow trap catches over a 14 hour daylight period.

EFFECTS OF STOCKING METHODS ON THE DISTRIBUTION OF *GAMBUSIA AFFINIS* IN FRESNO COUNTY RICE FIELDS

David G. Farley and Leonard C. Younce

Fresno Westside Mosquito Abatement District
Post Office Box 125, Firebaugh, California 93622

ABSTRACT

Studies were conducted in rice fields to determine *Gambusia affinis* distribution patterns based on three stocking methods. Six fields were stocked with the total allotment of fish in one place in the field. Four fields had fish stocked in three spots within the field, and six fields received fish in every other paddy. Distribution was monitored by trapping each paddy bi-weekly using minnow traps. Stocking in every other paddy in the field resulted in a better distribution of fish than did stocking in a single spot. Stocking of fish in three places within the field resulted in distributions as good as those found in the fields stocked in every other paddy.

Mosquitofish, *Gambusia affinis* (Baird and Girard), are being used in ever increasing numbers against rice field mosquitoes in California. Most of the field studies conducted to date have focused on optimum stocking rates (Hoy and Reed 1970, Hoy et al. 1971, Hoy et al. 1972). Farley andYounce (1977) looked at the importance that stocking timing plays on the effectiveness of *G. affinis* in controlling mosquitoes.

Unfortunately, only a few studies have concerned themselves with the distribution patterns of *G. affinis* once they are in the field. This aspect is important because good distribution of fish is necessary for field-wide mosquito control. Norland and Bowman (1976) looked at the distribution patterns of fish within individual rice paddies. Reed and Bryant (1974) stocked fish in every other paddy within a field and found that a large percentage of the fish had found their way into the unstocked paddies within 72 hours after stocking. Green and Imber (1977) reported that within eight weeks, mosquitofish were controlling mosquitoes three miles downstream from the initial stocking point in a stream. Davey and Meisch (1977) indicated a good distribution of fish 14 days after stocking in a 100 acre Arkansas rice field. In their study, fish were stocked into six places in the field. No notation was made, however, concerning the uniformity of distribution. The present paper is a preliminary report on the distribution patterns of mosquitofish in rice fields, and how they are affected by three different stocking methods.

MATERIALS AND METHODS. All of the rice fields in this study were stocked at the rate of ¼ pound of mosquitofish per acre. Six fields ranging from 32 to 95 acres were stocked by planting the total allotment of fish into one spot in the field (the second paddy from the field inlet). These were called "single drop" fields.

Six fields ranging from 35 to 75 acres were stocked in every other paddy beginning with the second paddy from the field inlet. The total field allotment was divided equally among the stocking points in the field. The last paddy in the field was never stocked, even if it fell in the correct succession. Fields stocked in this manner were called "every other paddy" fields (EOP fields).

The third type of stocking method was called the "three drop" method. In this method fish were stocked in the second paddy, the center paddy and half way between the center paddy and the last paddy in the field. The total allotment was divided such that the second and center paddies received about the same number of fish, and the last stocking point, halfway between the center and last paddies, received a lesser amount. Four fields ranging from 40 to 85 acres were stocked using this method.

To determine the distribution of fish, all fields were trapped bi-weekly using eight-mesh minnow traps. One minnow trap was placed in each paddy and was located about 20 feet into the paddy opposite the outlet of the paddy water control box. The traps were left in the field for a 24 hour period after which the fish in each trap were counted and the traps removed.

To determine the speed with which mosquitofish can move through a rice field, the outflow of one 200-acre field was trapped using an outflow trap. Fish were stocked in the field using the single drop method. Outflow trapping was begun two days before stocking to check for natural population of mosquitofish and continued for one week after stocking. The trap was checked every 24 hours.

RESULTS AND DISCUSSION. Comparisons of fish distributions in fields stocked by each of the three methods described are shown in Figures 1 and 2. The histograms for the single-drop fields in Figure 1 are a composite of four fields while the histograms for the EOP fields represent a composite of three different fields. These seven fields were located side by side and all had nearly equal acreage. All received their water from the same canal and all had outlets into a common drain. However, each field was virtually isolated from the others since each field inlet consisted of a pipe and valve directly from the canal and each outlet box formed a barrier to upstream movement. The fields were stocked alternatively by the every other paddy and single drop methods.

Comparison of the trapping results from the two types of fields showed that the fish were better distributed throughout the field in the EOP fields (Figure 1). The bulk of the fish in the single-drop fields stayed near the stocking point throughout the year.

Figure 2 shows the composite results of a comparison of two single-drop fields, four three-drop fields, and three EOP fields. These fields were not as closely associated as the fields shown in Figure 1, but they were all from the same area and each was somewhat isolated from the other so that little movement of fish from one field to another was possible. The distribution of fish in the EOP fields was better than in the single-drop fields. This was especially true in mid-June and mid-July. We feel that a good distribution in mid-July is essential if good mosquito control is to exist in late July and August. Again, the bulk of the population in the single-drop fields remained near the spot in the field where the initial stocking was made.

The histogram also shows that the three-drop fields had distribution nearly as good as the EOP fields in mid-June and mid-July, and better in mid-August. Though the distribution

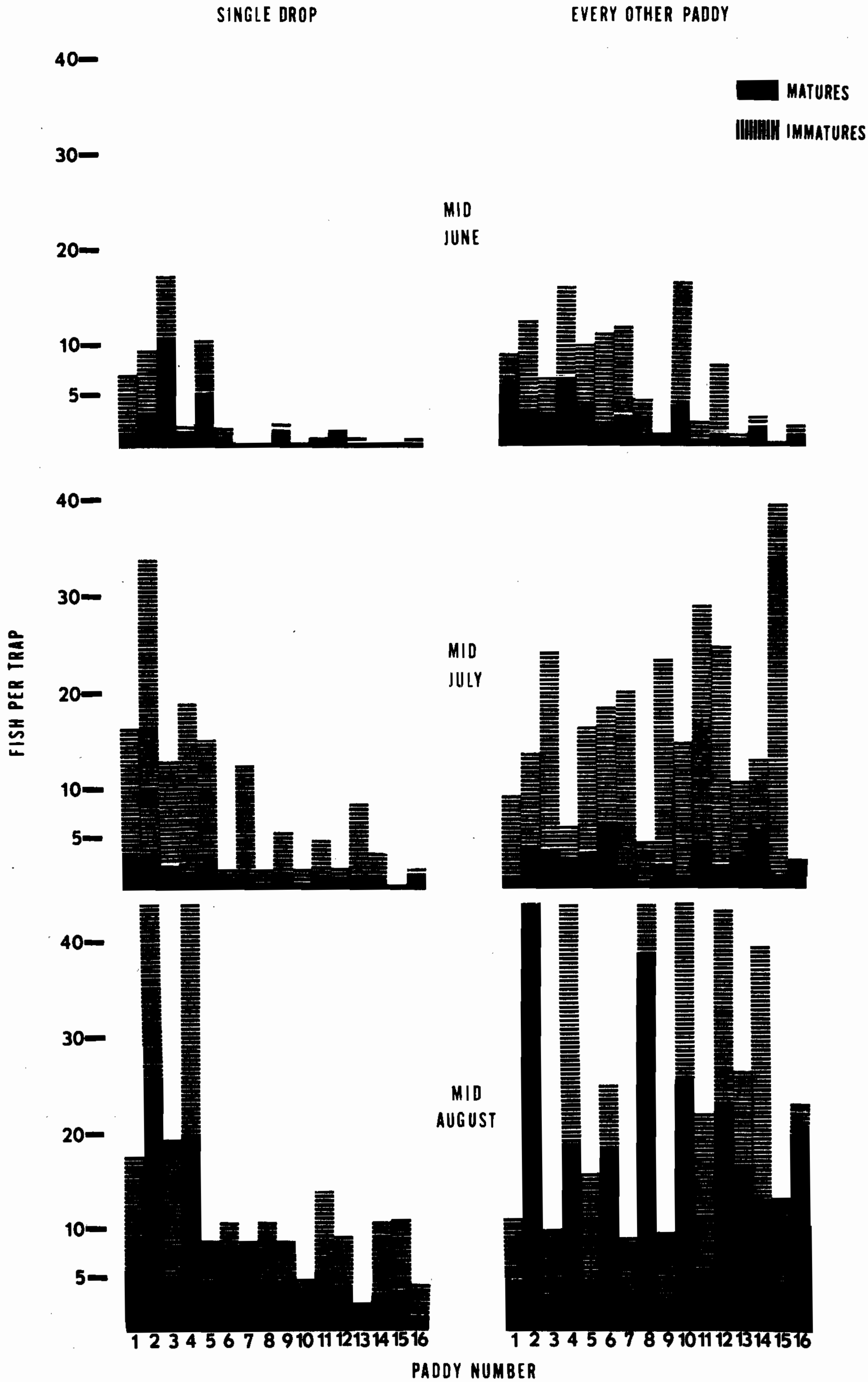

Figure 1.–Comparison of *Gambusia affinis* distribution in rice fields stocked by the "single-drop" and "every other paddy" methods.

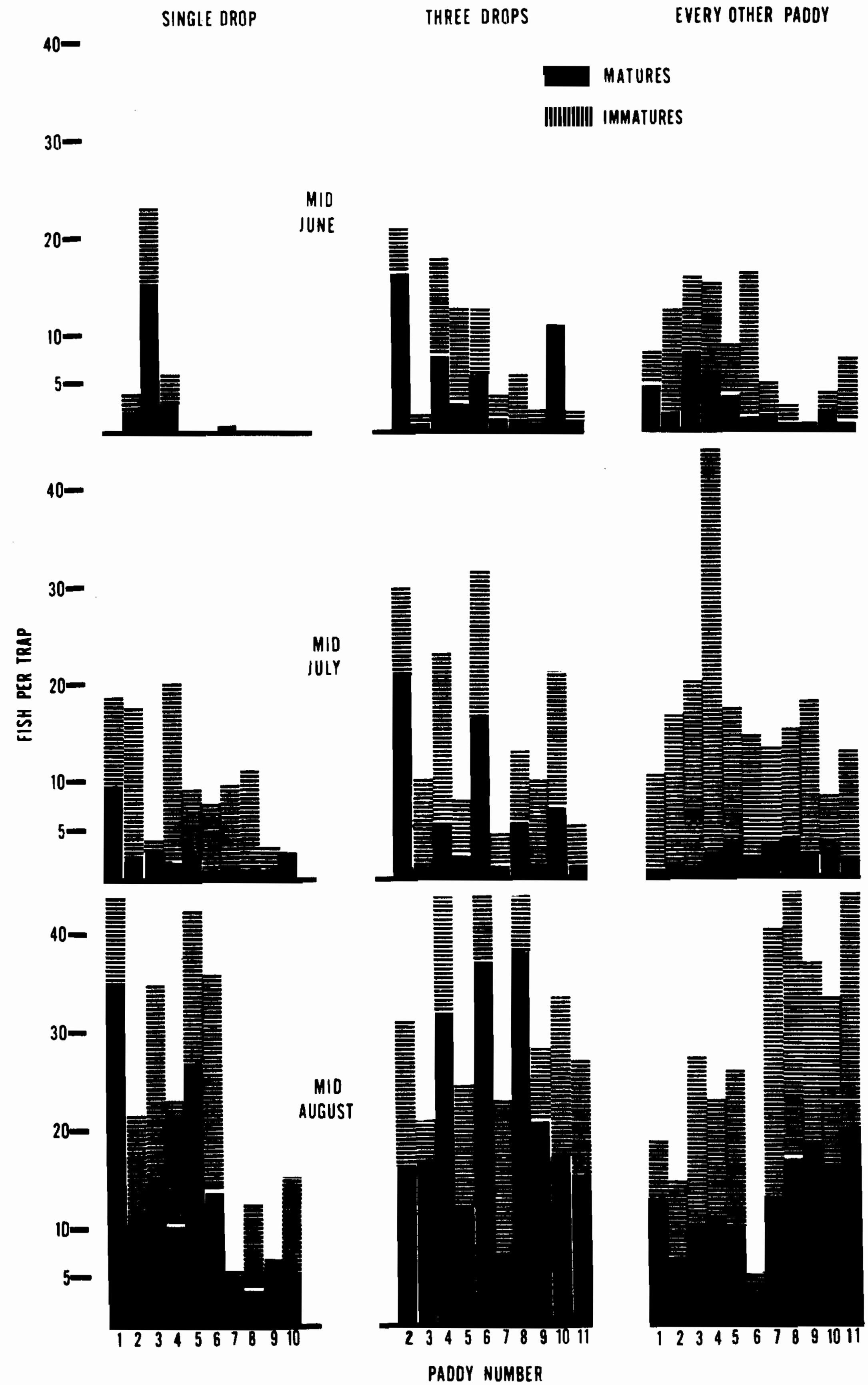

Figure 2.–Comparison of *Gambusia affinis* distribution in rice fields stocked by the "single drop", "three drop", and "every other paddy" methods.

was not quite as good as the EOP fields in mid-July we feel that the distribution was good enough to make this method a good compromise between the simple and quick single drop method and the effective but time consuming EOP stocking. Indeed, larval control was much better in both the three-drop and EOP fields than in the single-drop fields. Control of larvae was virtually the same in the EOP and three-drop fields.

Mosquitofish have the capability of moving quickly through a rice field. In the test made this year in a 200 acre field, fish moved six miles from the stocking point to the outlet box, in less than 48 hours. When fish were stocked into one spot in a field, two groups of fish were seen, the "colonizers" and the "explorers". The colonizers were the larger group and were comprised of those fish which stayed within one or two paddies of the stocking point. The explorer group was comprised of those fish which split off and rapidly traversed the field. These fish were picked up in the outflow traps in fair numbers within two or three days after stocking. However, minnow traps placed in the fields showed very little colonization by this more mobile group early in the season. Colonization spread slowly out from the main group of fish.

If fish are stocked in several areas it is possible that when the explorers from one group encounter the colonizing group from another area in the field, they turn back and colonize the area they have traversed, thus giving a better distribution of fish. We are not proposing a strict territorial behavior as is found in more predatory fishes, but we hypothesize that the explorers are searching for boundaries and a second group of colonizers satisfies the requirement as a boundary. This hypothesis can be tested out more completely if a suitable mass marking method for mosquitofish can be found.

SUMMARY.–When mosquitofish are stocked in only one spot in a field, they do not distribute themselves as well as when they are stocked into several places within the field. Since the distribution of fish is not uniform, field wide mosquito control is not as good in fields stocked by this single-drop method. Fields stocked by the three-drop and EOP methods have comparable distributions and comparable mosquito control potentials.

REFERENCES CITED

Davey, R. B. and M. V. Meisch. 1977. Dispersal of mosquitofish, *Gambusia affinis* in Arkansas rice field. Mosq. News 37(4):777-778.

Farley, D. G. and L. C. Younce. 1977. Stocking date versus efficacy of *Gambusia affinis* in Fresno County rice fields. Proc. Calif. Mosq. & Vector Control Assoc. 45:83-86.

Green, M. F. and C. F. Imber. 1977. Applicability of *Gambusia affinis* to urban mosquito problems in Burlington County, New Jersey. Mosq. News 37(3):383-385.

Hoy, J. B., E. E. Kauffman and A. G. O'Berg. 1972. A large-scale field test of *Gambusia affinis* and chlorpyrifos for mosquito control. Mosq. News 32(2):161-171.

Hoy, J. B., A. G. O'Berg and E. E. Kauffman. 1971. The mosquitofish as a biological control agent against *Culex tarsalis* and *Anopheles freeborni* in Sacramento Valley rice fields. Mosq. News 31(2):222-230.

Norland, R. L. and J. R. Bowman. 1976. Population studies of *Gambusia affinis* in rice fields: sampling design, fish movement, and distribution. Proc. Calif. Mosq. Control Assoc. 44:53-56.

Reed, D. E. and T. Bryant. 1974. The use of minnow traps to monitor population trends of *Gambusia affinis* in rice fields. Proc. Calif. Mosq. Control Assoc. 42:49-51.

EFFORTS TO CONTROL *HYDRILLA VERTICILLATA* ROYLE WITH HERBIVOROUS *TILAPIA ZILLII* (GERVAIS) IN IMPERIAL COUNTY IRRIGATION CANALS

E. F. Legner

University of California

Division of Biological Control, Riverside, California 92521

ABSTRACT

Feeding studies with *Tilapia zillii* (Gervais) on the aquatic weed, *Hydrilla verticillata* Royle, in 40-L aquaria showed that larger fish, 151 vs 92 mm, effectively consumed this weed. The combination of *H. verticillata* with *Potamogeton pectinatus* L. produced ca. 1/3rd more total weed biomass consumption, indicating a nutritional advantage of feeding on both weed species. Thus, practical control in irrigation canals through fish stocking might be expected.

The aquatic weed, *Hydrilla verticillata* Royle was first discovered wild in the United States in Florida around 1960, where it had been introduced from South America for use as an aquarium plant. Although of apparent central African origins (Haller 1976), it causes serious problems throughout the tropical regions of the world. Since the production of tubers allows it to pass adverse conditions such as cold weather and drought (Haller 1976), the weed also poses a threat to aquatic ecosystems of temperate climates.

Hydrilla first became conspicuous in the All American Canal a few miles east of the city of Calexico, California in June, 1977. By the end of the summer it had spread many miles downstream reaching the vicinity of Westmoreland. It could not be determined if an area-wide biological aquatic weed control program using the herbivorous fish *Tilapia zillii* (Gervais) (Hauser et al. 1976, 1977; Legner and Pelsue 1977; Legner et al. 1975) would contain the build-up and spread of this new pest weed. The feasibility was questioned especially since preliminary feeding trials with small 90-cm long *T. zillii* in aquaria and shallow experimental ponds indicated that the fish would not consume the main stem of *Hydrilla*, which contains ca. 80% of its biomass.

Therefore, further nutritional studies were initiated using two size groups of *T. zillii* to determine their respective impact on *H. verticillata* compared to *Potamogeton pectinatus* L., the principal aquatic weed species thus far in the irrigation system. The latter species can be adequately controlled by *T. zillii*.

METHODS AND MATERIALS. Small fish (92 mm) were obtained at random from the Holtville No. 6 drain and large fish (151-156 mm) from the Rositas Canal in the Imperial Valley, California. The *Hydrilla verticillata* and *Potamogeton pectinatus* plants used for feeding experiments were secured directly from the All American and Rositas canals, respectively, at each feeding interval. Fish were introduced separately into 40 L plexiglass aquaria, containing aerated tap water, the temperature of which was maintained at 27.5 ± 2°C with 75 watt, Jewell-Combination heater thermostats. Four replicated aquaria each for 3 feeding regimes were used as follows: (1) *Hydrilla* only, (2) *Potamogeton* only, and (3) an equal mixture of both weed species.

Weeds were introduced into aquaria by placing them on the surface of the water where ca. 90% remained during a test. The remainder dispersed in the water. Sufficient weed biomass was supplied to produce ca. 30% residual weed mass at each of 21 feeding intervals, spaced ca. 1.8 days apart (total 37 days experimental time). At each feeding interval, fish were removed from the aquaria, measured and weighed on a single pan, top-loading Mettler balance. Weeds were spun-dried in a dip net followed by further drying between two cloth towels. They were then weighed on the same Mettler balance.

Significant differences were tested with Duncan's New Multiple Range test, or a Student's "t" test in the case of dual comparisons (Steel and Torrie 1960). Raw data were converted to percentages, and transformed to the arcsin$\sqrt{\%}$ before analysis.

Table 1. Comparison of the nutritional quality of *Hydrilla verticillata* with *Potamogeton pectinatus* for *Tilapia zillii* in 40 L aquaria at 27.5 ± 2°C over 37 days.

		Average of 21 Observations[1]			
Feeding Regime	Fish Size	Fish wt. gain or loss (g)	Fish length gain (mm)	Weed biomass consumed/day (g)	
Hydrilla only	small	$+1.1^{a}$	4.8		7.7^{a}
	large	-9.2^{b}	5.0		21.7^{b}
Potamogeton only	small	-0.2^{a}	3.8		9.1^{a}
	large	-8.1^{b}	5.3		22.2^{b}
Hydrilla + *Potamogeton*	small	$+0.4^{a}$	4.3	*Hydrilla* = 3.4) *Potamogeton* = 6.0)	9.4^{a}
	large	-4.0^{c}	3.0	*Hydrilla* = 14.8) *Potamgeton* = 16.5)	31.2^{c}

[1]Numbers followed by different letters are significantly different at Duncans's 0.05 level.

RESULTS AND DISCUSSION.—Small fish consumed only the lateral leaves of both aquatic weed species, leaving their stems untouched. On the other hand, the larger fish consumed the entire *Hydrilla* plant, although they also left the main stem of *Potamogeton*. In the irrigation canals of south California where *P. pectinatus* can be successfully controlled through stocking *T. zillii*, it has been repeatedly observed that larger fish, ca. 200 mm, are able to effectively consume the main stem of this weed also.

Larger fish in the experiment lost weight at all three feeding regimes (Table 1), but this loss was significantly less (5% level) when a mixture of both weeds was used (Table 1). All fish gained in length with no significant differences recorded for any feeding regime.

Weed consumption was expectedly greater by the larger fish, but neither size category reduced significantly more of either weed's biomass when fed singly; although there was a nonsignificant trend for the smaller fish to consume more *Potamogeton* than *Hydrilla* (5% level), this preference being more pronounced in the smaller fish (Table 1).
(5% level), this preference being more pronounced in the smaller fish (Table 1).

The combination of both weeds apparently stimulated feeding in the larger fish, causing them to consume ca. 1/3rd more total weed biomass than when either weed was fed alone (Table 1; signif. at 5% level). A similar increase in feeding was not observed in the smaller fish.

The present data is encouraging in that it indicates *Tilapia zillii* may be able to significantly reduce *Hydrilla* in Imperial Valley canals. In fact, the addition of *Hydrilla* may nutritionally benefit the *Tilapia* population and could result in an increased growth rate of individuals, if not the reproductive rate as well. Measurements of the impact of *Tilapia* on *Hydrilla* in Imperial Valley canals will be made in 1978 to judge their ultimate usefulness.

REFERENCES CITED

Haller, W. T. 1976. *Hydrilla*, a new and rapidly spreading aquatic weed problem. Univ. of Florida, Agric. Expt. Sta. Cir. 245. 13 p.

Hauser, W. J., E. F. Legner and F. E. Robinson. 1977. Biological control of aquatic weeds by fish in irrigation channels. Proc. Water Management for Irrigation and Drainage, ASCE/Reno, Nevada/July 20-22, 1977, pp. 139-145.

Hauser, W. J., E. F. Legner, R. A. Medved and S. Platt. 1976. *Tilapia*--a management tool for biological control of aquatic weeds and insects. Bull. Amer. Fisheries Soc. 1(2):15-16.

Legner, E. F. and F. W. Pelsue. 1977. Adaptations of *Tilapia* to *Culex* and chironomid midge ecosystems in south California. Proc. Calif. Mosq. & Vector Control Assoc. 45:95-97.

Legner, E. F., W. J. Hauser, T. W. Fisher and R. A. Medved. 1975. Biological aquatic weed control by fish in the lower Sonoran Desert of California. Calif. Agric. 29(II):8-10.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics, with special reference to the biological sciences. McGraw-Hill Book Co., Inc., N.Y. 481 p.

GENETIC VARIATIONS IN *CULEX TARSALIS*

S. Monica Asman

University of California
Division of Entomology and Parasitology
Department of Biomedical and Environmental Health Sciences
408 Wellman Hall, Berkeley, California 94720

ABSTRACT

Understanding the genetic organization of a species is basic to the ultimate goal of constructing complex genetic systems that have potential for controlling *Culex tarsalis*. Accumulating such genetic information begins with the identification, isolation, and expansion to colony size of characteristics that have good penetrance and are predictably heritable.

Some important and specific uses of these mutations in genetic and ecological studies are: (1) to develop genetic chromosome maps, useful in the clarification of spatial relationships in the chromosomal organization; (2) to identify induced aberrant chromosomes such as translocations; and (3) as tracers in behavioral studies such as flight patterns and range, and longevity and survival studies; or to obtain indices for population estimates, etc. In addition, a mutation that is lethal, semi-lethal, or conditionally lethal can contribute to population control when inserted into a native population.

Fifteen monofactorial mutations have been isolated in *Cx. tarsalis* and established in laboratory colonies. These affect eye color and structure, wing structure, body and scale pigment, and the structures of palps and antennae. Some have been combined to form 8 multiple-marker lines, that is, lines that carry at least 1 genetic marker on each of the 3 chromosome pairs.

OUTDOOR CAGE TESTS OF GENETIC STRAINS OF *CULEX TARSALIS* FOR FUTURE FIELD RELEASES[1]

P. T. McDonald[2], S. M. Asman[2,3], M. M. Milby[3], J. Bruen[3] and R. Ainsley[2]

ABSTRACT

Reproductive characteristics of genetic strains of *Culex tarsalis* were measured in field cages. Outdoor trials in 4 large walk-in cages revealed differences in results among cages. Oviposition rates were higher in cages that faced south than in adjacent cages. The laboratory-adapted strain had higher oviposition rates in small cages than in large cages. The field-collected populations had reduced oviposition rates in small cages and performed best in large cages.

Two mutants, carmine and black eye, were allowed to compete with wild populations in the large cages. These mutants were competitive, as judged from their representation in the progeny from the matings. Another mutant, fringe wing, dispersed and mated in outdoor cages on a par with wild types.

Translocation heterozygote males from each of 3 genetic backgrounds competed successfully with wild males for wild females in outdoor cages. Males that carried 2 different translocations did not compete successfully in similar trials. Males that carried a translocation plus a semi-lethal fringe mutant conveyed these additive lethal effects in outdoor cage matings.

Outdoor cages provide the opportunity to study the performance of insect populations under natural climatological conditions. Laboratory and field strains of *Culex tarsalis* were first tested in 1976 in outdoor cages located on the grounds of the Kern Mosquito Abatement District (MAD) (Terwedow et al., 1977), and the results provided a basis to judge the suitability of a laboratory strain for pilot field release. Outdoor cage experiments were continued in 1977. The purposes of the studies were: (1) to determine the effect of cage location and size on the oviposition success of females; (2) to test mutant markers, with emphasis on the recovery of mutants in the generation following release; and (3) to evaluate the competitiveness of males bearing a double translocation, T(1;2;3)1A, in combination with various genetic backgrounds.

MATERIALS AND METHODS.—Seven outdoor cage experiments were conducted from June through November. Two large, screened, Quonset-shaped structures, as described by Terwedow et al. (1977), provided 4 equal cages, each measuring 6 x 5.5 x 3 m. A small cage, measuring 60 x 60 cm, was placed in the shaded portion of each large cage for some experiments. Additional humidity was provided by overhead sprinklers operated for a short time each day. In late August, a second layer of screening was added to the north end of each structure to reduce wind movement, and structural repairs were made to prevent escape or infiltration of mosquitoes. Caged chickens, provided as a blood-meal source in all experiments, were randomly allocated to cages at the beginning of each trial after August, to minimize the effect of individual chickens which may have been refractory to mosquito attack.

In each trial, 2-4 day old virgin adults were released into the cages and allowed to mate, feed and oviposit. Egg rafts were collected and counted for at least 10 days following the first oviposition. In 3 trials, the hatch rate, defined as (no. of hatching eggs minus no. of dead 1st stage larvae attached to raft)/(total no. of eggs), was determined for each raft. CDC light traps baited with dry ice (CO_2/light traps) were operated nightly in cages during 2 experiments; the ovarian state of trapped females was recorded during 1 of these. Trapped females and those remaining in small cages at the termination of a trial were dissected to determine the proportion inseminated.

RESULTS.—Studies on cage position and size.—Females of the KL (Knights Landing) and males of the KL and car ble (carmine and black eye mutants, Asman 1976) laboratory strains were released in the large cages on 14 June to study the effect of cage location on oviposition rate (Table 1). Release ratios were approximately 1♀ : 2♂. The 2 south-facing cages produced more than twice the number of rafts per female than did the 2 north-facing cages. A choice of male genotypes did not appear to enhance oviposition rates.

Table 1.—Effects of cage exposure on oviposition in *Culex tarsalis*.

Cage	Exposure	♀♀	♂♂	Oviposition Total rafts	Oviposition Egg rafts/♀
1	SE	725 KL	1676 KL	260	0.355
2	NE	746 KL	833 KL 955 car ble	73	0.098
3	SW	723 KL	751 KL 947 car ble	206	0.285
4	NW	705 KL	1747 KL	143	0.203

KL = Knights Landing, laboratory strain.
car ble = carmine and black eye, laboratory strain.

KL and RM (Rowlee-Merced, reared from field-collected pupae) adults were released in large and small cages on 30 September to study the effects of cage size on insemination and oviposition rates of laboratory and field-collected females exposed to laboratory or field-collected males (Table 2). Approximately equal numbers of each sex were released into each cage. Chickens were removed after 6 days. A sample of 25 females from each small cage was dissected at the end of the experiment to determine ovarian and insemination status. The number of rafts per female was similar in each of the 4 large cages, but was significantly higher for KL females than for RM females in the small cages. RM females in this sample were less successful in mating with either type of male than were KL females, and a majority of the RM females were gravid but did not oviposit.

[1]This research was supported by U. S. Army Contract/Grant No. DAMD-17-74-C4128, U. S. Army Medical Research and Development Command, Washington, D.C. and by Research Grant AI-03028, National Institute of Allergy and Infectious Diseases.

[2]Division of Entomology and Parasitology, University of California, Berkeley, California 94720.

[3]Department of Biomedical and Environmental Health Sciences, School of Public Health, University of California, Berkeley, California 94720.

Table 2.–Effects of cage size on laboratory and field strains of *Culex tarsalis*.

Cage	♀♀	♂♂	Oviposition : egg rafts/♀ Large cage	Small cage	Captured ♀♀* Inseminated	Gravid
1	197 RM	197 KL	0.102			
1.1	198 RM	185 KL		0.025	12/25	24/25
2	199 KL	192 KL	0.075			
2.1	194 KL	195 KL		1.021	20/25	6/25
3	197 KL	190 RM	0.076			
3.1	197 KL	185 RM		1.046	22/25	9/25
4	197 RM	191 RM	0.117			
4.1	198 RM	190 RM		0.056	17/25	23/25

RM = Rowlee-Merced, field collected.
KL = Knights Landing, laboratory strain.
*At termination of experiment.

Mutant marker studies.- -An experiment designed to demonstrate if long-term laboratory colonized stocks and/or hybrids between such stocks and field-collected strains could succeed in field introductions was begun on 14 September. Males of the car ble strain and hybrid males produced by mating car ble females with WPC (Poso West, reared from field-collected pupae) males were released into cages 3 and 1 respectively, with equal numbers of McV (McVan, reared from field-collected pupae) males and females (Table 3). First generation male progeny from each cage were mated with car ble females in the laboratory, and second generation progeny were examined to determine the presence of the mutant eye colors. If the laboratory (car ble / WPC or car ble) and field (McV) males had been equally competitive in mating, the expected proportion of second generation progeny bearing each mutant would have been 12.5% from cage 1 and 25% from cage 3. The observed proportions of each eye mutant were significantly higher than expected in progeny from both cages.

The fringe wing mutant (Asman 1977) carries abnormal scales on the wing costa and on the wing veins. Adults of this strain were released into a large cage on 4 November to determine if they could mate and fly in a large area. KL adults were released simultaneously into a second cage to serve as a control group. CO_2/light traps were operated nightly in each cage for 10 nights. The insemination status of most trapped females was determined. The traps collected a much larger proportion of the fringe mutants of both sexes than of the KL strain (Table 4). The insemination rate of the fringe females was also higher than that of the KL females.

Translocation release studies.- -Competitiveness of T(1;2;3)-1A heterozygote males with 3 alternative genetic backgrounds

Table 4.–Outdoor cage relase of *Culex tarsalis* carrying the fringe wing mutant.

Cage	♀♀	♂♂	Trapped in 10 days No. ♀♀	No. ♂♂	Trapped ♀♀ inseminated
2	985 KL	979 KL	87	29	56/61
4	269 fr	234 fr	94	105	60/62

KL = Knights Landing, laboratory strain.
fr = fringe (wing), laboratory strain.

was tested against KL males in a release beginning 11 July (Table 5). Hatch rates were determined for all rafts. The translocation heterozygote males with the KL maternal background were the most competitive, markedly shifting the distribution of fertility toward low hatch values (Figure 1). Male progeny of 2 medium hatch rafts from each of the 3 competition cages were confirmed as translocation heterozygotes in laboratory tests.

Another translocation male was derived from crossing the male-linked T(1;2;3)1A strain with a strain bearing an autosomal translocation, T(2;3)5A . These males were released into a large cage on 5 August, to test their competitiveness against the WPC field strain (Table 6). The reduction in mean hatch rate was slight, indicating that these hybrid males did not compete effectively (Figure 2).

Approximately 26% of the fringe mutants die on the water while attempting to emerge from the pupal case. A hybrid male derived from combining the fringe mutant with T(1;2;3)-1A heterozygote sterility was tested to measure the effect this

Table 3.–Outdoor cage release of *Culex tarsalis* carrying eye color mutants.

Cage	♀♀	♂♂	First generation No. egg rafts hatching	Second Generation* No. sampled	% car OBS	% car EXP	% ble OBS	% ble EXP
1	739 McV	739 McV 739 car ble /WPC	50	5911	24	12.5	18	12.5
3	566 McV	566 McV 566 car ble	29	6329	31	25	30	25

McV = McVan, field collected.
car ble = carmine and black eye, laboratory strain.
car ble /WPC = progeny of car ble X field collected West Poso Creek.
* From cross of car ble ♀♀ X first generation ♂♂.

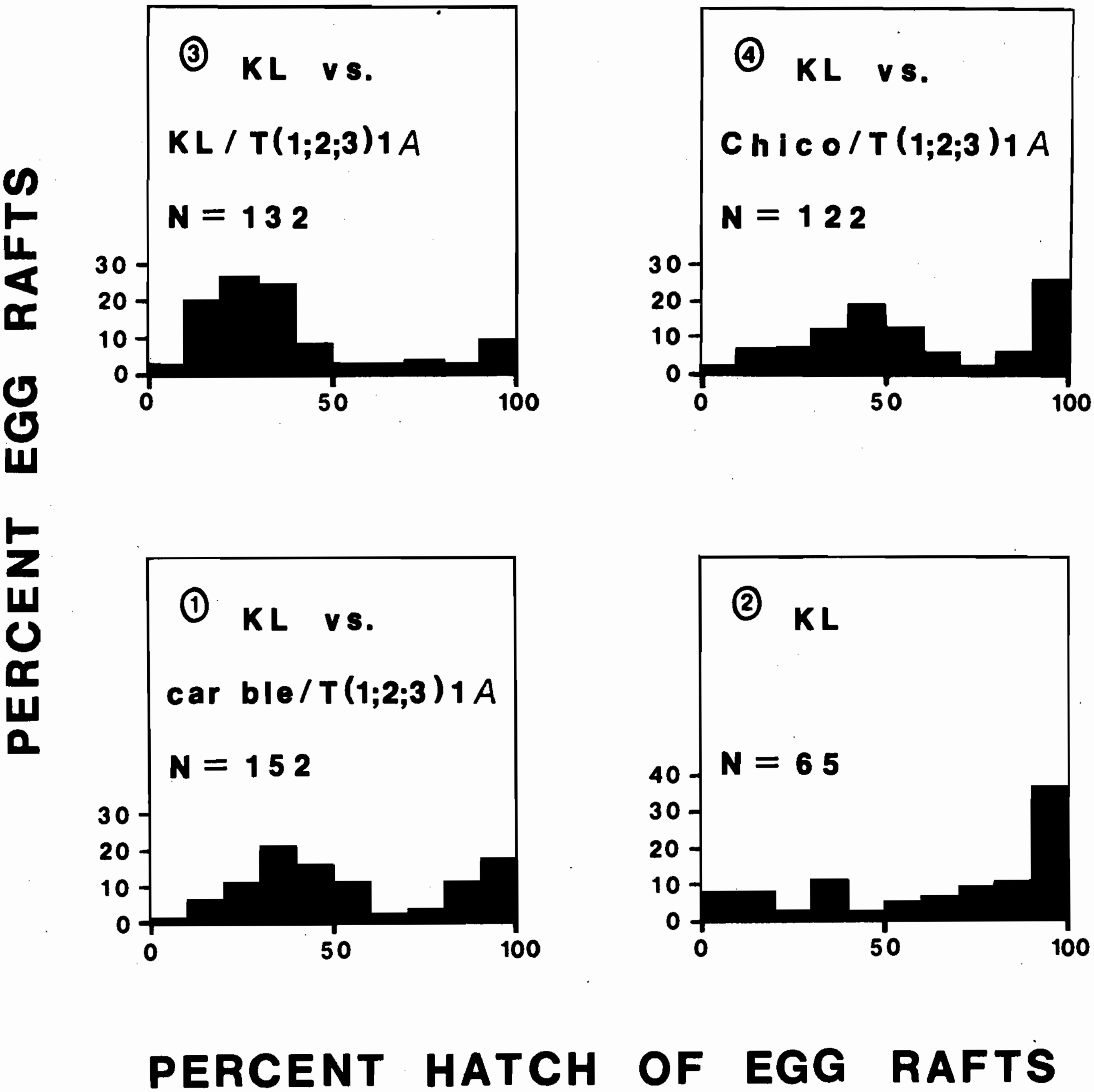

Figure 1.–Hatch rate distribution of egg rafts from KL vs. T(1;2;3) 1A competition and control tests. The translocation strain was crossed to either car ble, KL, or Chico strains. Circled numbers refer to cages used.

Table 5.–Outdoor cage release of T(1;2;3)1A male *Culex tarsalis* with 3 different genetic backgrounds.

Cage	♀♀	♂♂	No. rafts hatching	Mean hatch rate
1	949 KL	979 KL 979 car ble/T(1;2;3)1A	152	55%
2	891 KL	2000 KL	65	66%
3	995 KL	1000 KL 1000 KL/T(1;2;3)1A	132	37%
4	814 KL	1000 KL 1000 Chico/T(1;2;3)1A	122	57%

Table 6.–Outdoor cage release of *Culex tarsalis* carrying 2 translocations.

Cage	♀♀	♂♂	No. rafts hatching	Mean hatch rate
1	227 WPC	223 WPC 225 T(2;3)5A/T(1;2;3)1A	45	82%
3	225 WPC	446 WPC	38	95%

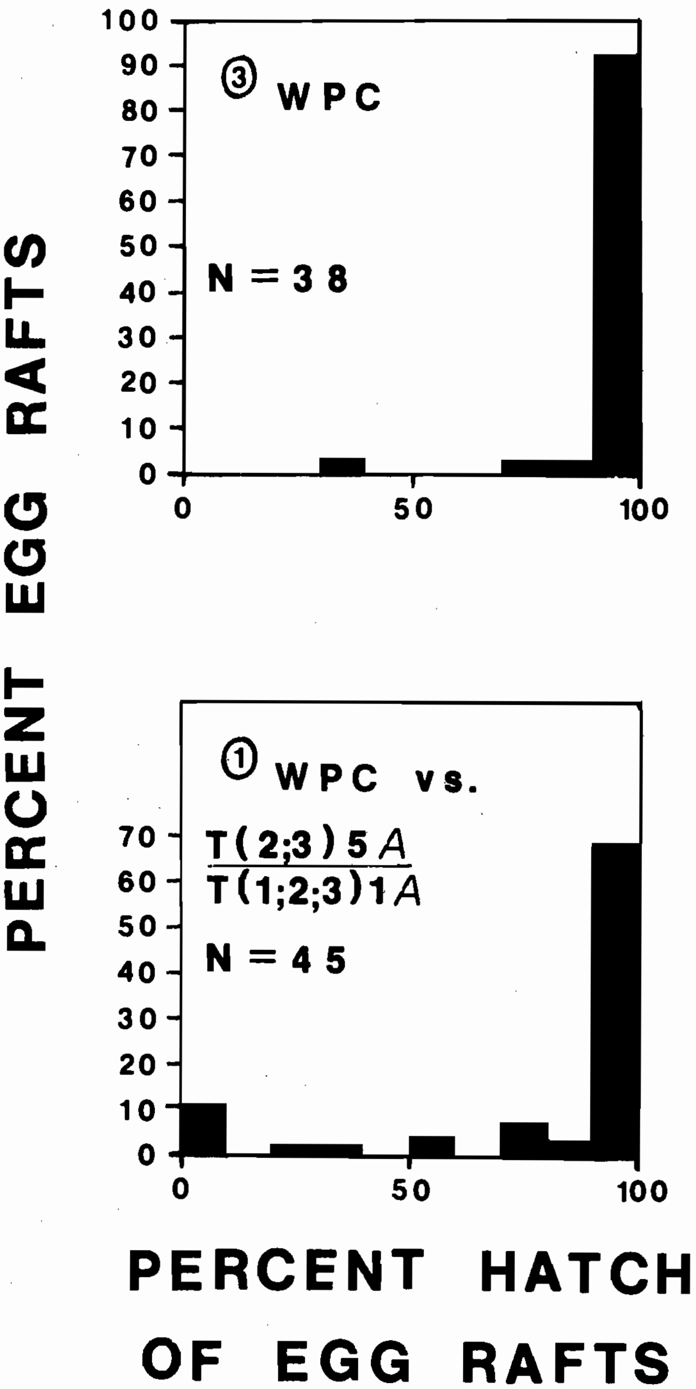

Figure 2.–Hatch rate distribution of egg rafts from WPC vs. T(2;3) 5A plus T(1;2;3) 1A competition and control tests. Circled numbers refer to cages used.

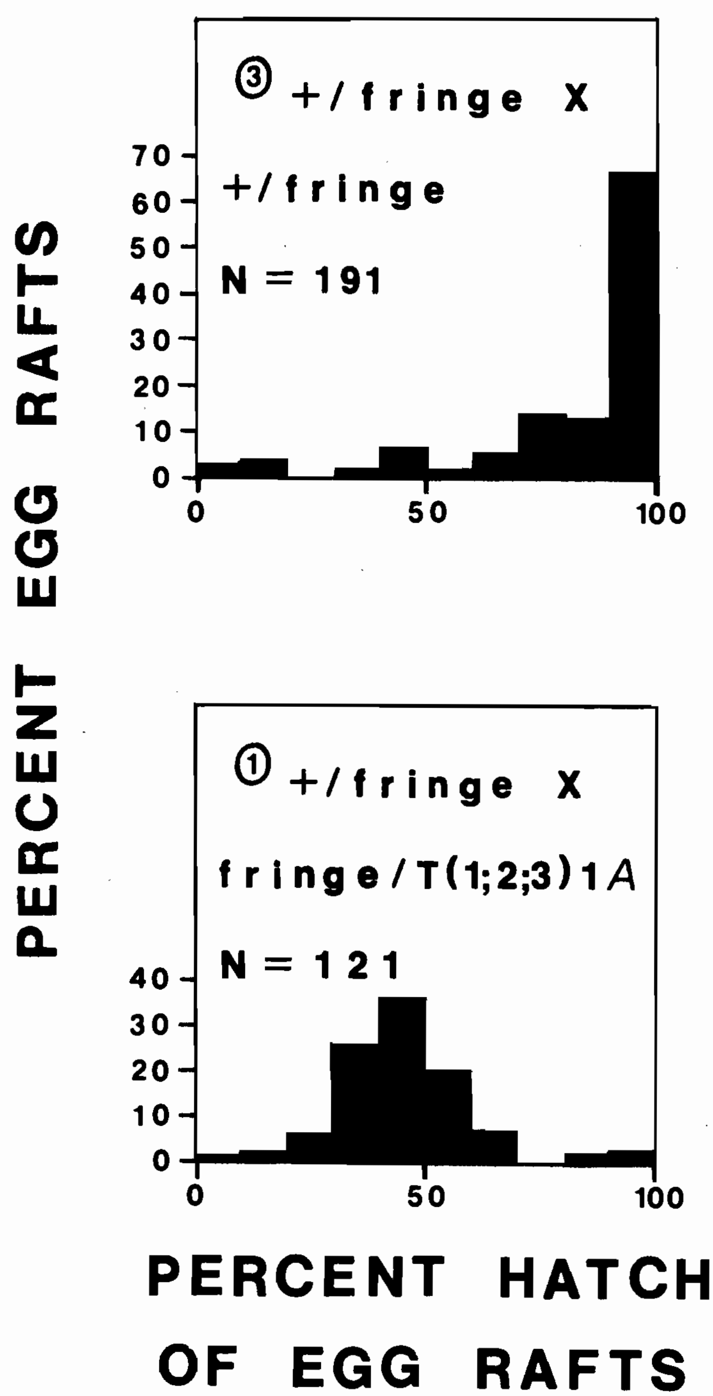

Figure 3.–Hatch rate distribution of egg rafts from inbred +/fringe and from +/fringe ♀♀ X fringe/T(1;2;3) 1A ♂♂. Circled numbers refer to cages used.

inherited factor would have in subsequent generations. On 23 October, 199 +/fringe females and 205 fringe/T(1;2;3)1A males were released into cage 1, and 732 +/fringe females and 748 +/fringe males were released into cage 3. As expected, partial sterility from the translocation was observed in some rafts from cage 1 (Figure 3). The mean hatch rate for rafts from cage 1 was 44%, compared to 88% for rafts from the control cage. Progeny from both cages were reared in the laboratory. From cage 1, 47-48% of the females were expected to be homozygous for fringe because fringe is sex-linked, but only 33% (158/482) were observed. Thirty-seven percent of the fringe females died at emergence. From cage 3, 2-3% of the females were expected to be fringe, through genetic recombination, and 0.4% (3/729) were observed. All of these emerged successfully.

DISCUSSION. Cage effect studies.- -The differences in oviposition rates between cages facing north and south during the June experiment were similar to those observed between cages 1 and 2 during midsummer, 1976 (Terwedow et al., 1977). Structural and operational improvements, such as additional screening and randomization of chickens, were reflected in more comparable results from later experiments.

When laboratory and field strains were compared in large and small cages, the degree of adaptation of the females to cage conditions was evident. Field-collected females oviposited more in large cages and laboratory females oviposited more in small cages. For either female strain, both laboratory and field males appeared to produce equal results. Similar findings of female-dependent stenogamy have been reported for *Aedes taeniorhynchus* (O'Meara and Evans 1974). In the small cages, 48% and 68% of the field-collected females were inseminated, and almost all had remained gravid through a full week after the blood-meal source was removed yet an oviposition site was available constantly. It seemed that reproduction of field-collected *Cx. tarsalis* in outdoor cages was most critically affected by oviposition behavior. This is unlike the situation reported for *Ae. taeniorhynchus*, in which mating success was the critical factor in colonization attempts (O'Meara and Evans 1974).

Mutant marker studies.- -Testing well-established laboratory strains carrying mutant markers as either homozygous inbred or heterozygous outbred stocks is a desirable preliminary step before field introductions. Although few rafts were collected in the test of homozygous and heterozygous car ble males, the recovery of greater-than-expected proportions of carmine and black eye mutants among second generation offspring was encouraging, and opened possiblities of using these genetic markers to uncover facets of the genetics and population dynamics of *Cx. tarsalis* in the field.

A failure of fringe mosquitoes to disperse and mate in the large outdoor cage would have qualified them as conditional lethals, i.e., reproducing poorly under field conditions despite their reproductive success in laboratory cages. Their observed ability to fly and mate in the large outdoor cage did not demonstrate the hoped-for conditional lethality of the fringe mutant.

Translocation release studies.- -Trials with hyrid males of T(1;2;3)1A in competition with KL or WPC males were comparative only on the basis of mean hatch rates and distribution of hatch rates. Competitiveness values could not be calculated as in the 1976 trials (Terwedow et al. 1977) because translocation control cages either were not used or provided too few rafts. Nevertheless, the translocation males clearly had an impact on sterility in the large cages. Rafts with medium hatch were proven to result from translocation matings by laboratory testing in subsequent generations. Hatch rates of 50-70% associated with translocation matings were not unexpected. Although a hatch rate of 29% is typical for matings between translocation males and car ble females, outcrosses in a 1976 trial resulted in elevated hatch rates (Terwedow et al. 1977). In isolating the translocation from such rafts in 1977, the hatch rates of translocation descendants crossed with car ble females returned to lower values. Investigations are needed to determine the basis of elevated hatch rates associated with this outcrossing.

The use of lethal mutants and chromosomal sterility as synergistic autocidal systems has been developed by Whitten et al (1977) for the sheep blowfly. The combination of the fringe mutant with T(1;2;3)1A was a similar example, with the mortality at emergence affecting 14% of total females or 37% of fringe females. Since this mortality occurs under laboratory conditions as well, it is doubtful if the benefits derived from inserting this mutant into a field population would compensate for difficulties imposed on mass rearing of adults for field release.

ACKNOWLEDGMENT. - The authors wish to express their gratitude to Dr. Henry A. Terwedow, Jr. for contributions made in the designing of several of the experiments.

REFERENCES CITED

Asman, S. M. 1976. Multiple-marker lines for genetic studies in *Culex tarsalis*. Proc. Calif. Mosq. Control Assoc. 44:60-61.

Asman, S. M. 1977. Two sex-linked mutations in *Culex tarsalis*. J. Hered. 68:195-197.

O'Meara, G. F. and D. G. Evans. 1974. Female-dependent stenogamy in the mosquito, *Aedes taeniorhynchus*. Anim. Behav. 22:376-381.

Terwedow, H. A., Jr., S. M. Asman, P. T. McDonald, R. L. Nelson and W. C. Reeves. 1977. Mating competitiveness of *Culex tarsalis* double translocation heterozygote males in laboratory and field cage trials. Ann. Entomol. Soc. Am. 70:849-854.

Whitten, M. J., G. G. Foster, W. G. Vogt, R. L. Kitching, T. L. Woodburn and C. Konovalov. 1976. Current status of genetic control of the Australian sheep blowfly, *Lucilia cuprina* (Wiedmann) (Diptera: Calliphoridae). Proc. XV Int. Congr. Entomol.:129-139.

LABORATORY MATING COMPETITIVENESS OF *CULEX TARSALIS* COLONIES[1]

R. W. Ainsley[2], S. M. Asman[2,3] and P. T. McDonald[2]

The development of chromosomal translocations for the genetic control of the mosquito, *Culex tarsalis*, has progressed to a point where evaluation of the mating competitiveness of translocation males is necessary. Our first attempts to evaluate the mating competititveness of translocation males followed the experimental design of Fried (1971) (McDonald et al. 1978, Terwedow et al. 1977). This design developed for sterilized males was difficult to employ since translocation males are only partially sterile. In an effort to improve the efficiency of mating trials, the genetic mutant, carmine eye (Asman 1975b), was investigated to determine its effect on mating competitiveness. If the effect is insignificant, then carmine could be used to genetically tag competing males in a manner similar to that done recently by Seawright et al. (1975a,b).

MATERIALS AND METHODS. Two series of mating trials were carried out. The first summarized in Table 1, consists of 4 replicates of wildtype (+/+) males competing against carmine (car/car) males for carmine (car/car) females. The second series consisted of 6 replicates of wildtype (+/+) males competing against carmine (car/car) males for carmine heterozygote (car/+) females which had a wildtype phenotype. Except for one replicate in the first series, all replicates consisted of 100 males of each type and 100 virgin females. The one exception had 80 males of each type and 80 females. All mosquitoes were fully mature 3 to 4 day old virgin adults. Replicates were housed in large laboratory cages measuring 18 inches wide, 24 inches long and 24 inches tall. Each cage was placed in an incubator and maintained at approximately 75°F. Large open water pans were placed in each incubator to maintain high humidity. A light cycle was provided by 14 hours of high intensity light from a fluorescent bulb daily and an additional 1½ hours of artificial dawn and dusk was provided by a 4 watt incandescent bulb. Sugar cubes and water were continually available in each cage. Blood meals were provided by restrained mice placed into the cages only 1 or 2 nights so as to minimize multiple oviposition.

All egg rafts produced were isolated in separate vials and allowed to hatch. First instar larvae from rafts with at least 50 hatched eggs were then scored for carmine color ocelli. This scoring procedure must be preceeded by a short exposure to strong light which develops wildtype eye pigments to avoid misclassifying all larvae as carmine eye types. All progeny of wildtype fathers had wildtype phenotypes. Those of fathers bearing car were either entirely carmine (from car/car mothers) of a mixture of carmine and wildtype. Since multiple insemination is rare (Asman 1975a), and even then one male's sperm predominate, the parentage of each raft could be unambiguously determined in the second series using car/+ females.

RESULTS. The results of the first series of mating trials in which wildtype and carmine heterozygote males competed for carmine heterozygote mates are summarized in Table 1. The percentage of the rafts fathered by carmine males varied from 44 to 55% in the 4 replicates. The overall percentage was 47%. The 95% confidence interval ranged from 42 to 52%. The results of the second series of mating trials in which wildtype males competed with carmine heterozygote males for carmine heterozygote females are summarized in Table 1. The percentage of the rafts fathered by carmine males varied from 37 to 72%. The overall percentage for six replicates was 56% and the 95% confidence interval ranged from 49 to 63%. Production of egg rafts in the second series was low. This appeared to be related to poor availability of sugar cubes.

Table 1.- +/+ vs. car/car males for car/car females.

Total adult♀♀	Total rafts	Progeny car	Progeny +	% Families with car
100	76	34	42	45
80	63	30	33	48
100	45	20	25	44
100	20	11	9	55
Total	204	95	109	47%

Table 2.- +/+ vs. car/+ males for car/+ females.

Total adult ♀♀	Total rafts	Progeny car	Progeny only +	% Families with car
100	32	16	16	50
100	36	26	10	72
100	19	12	7	63
100	16	10	6	62
100	24	9	15	37
100	7	2	5	-
Total	134	75	59	56%

DISCUSSION. Carmine males competed as well as wildtype males for mates. However, the carmine stock was initiated and maintained independently of the Chico wildtype stock used in this study. Consequently many genes unrelated to carmine also differed between the two stocks. Evaluation of carmine lines recovered after multiple backcrosses to Chico wildtypes are in progress and should help to resolve further the effect of carmine eye color on male mating competitiveness.

[1]This research was supported in part by U. S. Army grant contract No. DAMD-74-C-1428, and NIH research grant AI 03028 from the National Institute of Allergy and Infectious Diseases.

[2]Department of Entomological Sciences, 408 Wellman Hall, Berkeley, California 94720.

[3]Department of Biomedical and Environmental Health Sciences, School of Public Health, Berkeley, California 94720.

REFERENCES CITED

Asman, M. 1975a. Observations of mating behavior in *Culex tarsalis*. Ann. Entomol. Soc. Am. 68:777-778.

Asman, S. M. 1975b. The genetics of two new eye color mutants in *Culex tarsalis*. J. of Heredity 66:297-300.

Fried, M. 1971. Determination of sterile-insect competitiveness. J. Econ. Entomol. 64(4):869-872.

McDonald, P. T., S. M. Asman, M. M. Milbe, J. Bruen, R. Ainsley. 1978. Outdoor cage tests of genetic strains of *Culex tarsalis* for future field releases. Proc. Calif. Mosq. & Vector Control Assoc. 46:105-109.

Seawright, J. A., P. E. Kaiser and D. A. Dame. 1975. Mating competitiveness of chemosterilized hybrid males of *Aedes aegypti* (L.) in outdoor studies. Mosq. News 35:308-314.

Seawright, J. A., P. E. Kaiser, D. A. Dame and N. L. Willis. 1975. Field competitiveness of males of *Aedes aegypti* (L.) heterozygous for a translocation. Mosq. News 35:30-33

EFFECTS OF DIMILIN® ON NONTARGET ORGANISMS DURING A *CHAOBORUS* FIELD TRIAL

A. E. Colwell[1] and C. H. Schaefer[2]

ABSTRACT

The study was conducted at Lakeport, California in nine experimental ponds, each having a surface area of 0.01 ha. Five of these ponds were treated with diflubenzuron (Dimilin ®) yielding an average concentration of 13.3 ppb in the pond water. The water residues decreased and reached the lowest detectable limit (0.2 ppb) at ca. 14 days post-treatment.

After the diflubenzuron treatment the waterflea populations declined rapidly and remained below pre-treatment levels for nearly 6 weeks. Copepod populations also declined, and returned to pre-treatment levels by 3 weeks after the treatment. Diflubenzuron treatment did not result in major changes in the abundance of planktonic rotifers, aquatic worms, benthic insect larvae, or aquatic snails.

Black Crappie in the ponds exhibited a 32 fold accumulation (relative to the concentration in the water) of diflubenzuron by one day post-treatment. The residues in the fish then declined to below detectable limits (8 ppb) by 7 days after the treatment.

Black Crappie were feeding primarily on zooplankton, which declined in abundance after the treatment. The fish temporarily switched to feeding principally on mayfly nymphs and other benthic insect larvae until the zooplankton populations recovered. The temporary dietary switch did not result in major or long term differences between fish from control and treated ponds in the stomach fullness indices, stomach content percent dry weights, fish growth rates, fish percent dry weights, or fish condition factors.

[1]Lake County Mosquito Abatement District, 410 Esplanade, Lakeport, California 95453.

[2]University of California Mosquito Control Research Laboratory, 5544 Air Terminal Drive, Fresno, CAlifornia 93727.

RESIDUES OF PYDRIN^{TM} IN PASTURE WATER, SOIL AND VEGETATION FOLLOWING MULTIPLE AERIAL APPLICATIONS

C. H. Schaefer, E. F. Dupras, Jr. and F. S. Mulligan, III

University of California
Mosquito Control Research Laboratory
5544 Air Terminal Drive, Fresno, California 93727

ABSTRACT

In order to obtain required data for possible registration of Pydrin as a mosquito control agent, an irrigated pasture in Kings County was sprayed by aircraft three time at 14 day intervals. One half of this field was treated at 0.1 and the other at 0.2 lb AI/acre (2 and 4 times the projected use rate, respectively). Samples of water, soil and vegetation were collected for residue analyses. The residue concentration of Pydrin in water only reached 0.1 ppm at either rate and then declined steadily to below detectable limits by ca. 96 hrs. The lack of difference in residues of water samples between the 0.1 and 0.2 AI/acre rates is apparently due to its very limited water solubility. Residues on vegetation were high (as was anticipated) but were proportional to rate applied; these declined slowly and steadily following each application. These findings suggest that Pydrin should be formulated on granules in order to avoid high residues on vegetation. In soil, the highest residue found was 0.3 ppm; soil residues declined after each application but still could be measured 56 days after the third application.

INTRODUCTION.—Research is continuing to find new or different structural types of compounds in order to provide effective means for controlling organophosphorus-resistant strains of mosquitoes. In 1975 it was shown that Pydrin [SD-43775 or benzeneacetic acid, 4 chloropha-(1-methylethyl)-cyano-(3-phenoxyphenyl) methyl ester] was equally effective against OP-S and OP-R strains of *Culex pipiens quinquefasciatus* Say and *Culex tarsalis* Coquillett larvae in the laboratory; also field applications of 0.05-0.1 lb AI/acre gave good control of field populations of *Aedes nigromaculis* (Ludlow) and *Aedes melanimon* Dyar larvae (Schaefer et al. 1976). Pydrin has been shown to be highly toxic to mosquitofish, *Gambusia affinis* (Baird and Girard) at rates used for mosquito control and some nontarget insect populations were also depressed (Miura and Takahashi 1976; Miura et al. 1977).

In order to obtain data on the persistence of Pydrin in mosquito breeding habitats, it was necessary to collect and analyze residue samples (water, soil and vegetation) from fields that had received multiple aerial applications; those data are reported here.

MATERIALS AND METHODS.—A 15 acre irrigated pasture in Kings County was selected for the study site. Saddle horses were allowed to graze on the field throughout the study except that a 20 x 20 ft fenced enclosure was constructed on each half of the field to allow sampling vegetation that had not been grazed. One half of the field was treated at 0.1 and the other at 0.2 lb AI/acre following each of three consecutive irrigations on 7/19, 8/8 and 8/29/77. These treatments represent 2 and 4 times the projected use rate of Pydrin for mosquito control. A 2.4 lb AI/gal EC was diluted with water to apply 0.1 lb AI in 1 gal water/acre by aircraft; the half of the field treated at 0.2 lb AI/acre was flown twice.

Soil samples were collected from open areas which were scraped free of vegetation prior to the first treatment. Prior to each treatment and on a schedule of 2 hrs and 1, 3, 7 and 14 days following each treatment and also at 21, 28, and 56 days following the third treatment, residue samples of soil and vegetation were collected and held at -20°C until analysis. Water samples, taken just prior to each treatment and on a schedule of 2 hrs and 1, 2, 3 and 4 days, were analyzed immediately.
each was partitioned 3X against 200 ml dichloromethane; the combined organic phase was reduced to 1 ml and analyzed by gas-liquid chromatography, using an electron capture detector. Soil and vegetation samples were extracted and subjected to clean-up by column chromatography prior to gas chromatographic analysis (details are described in Shell Development Company analytical methods MMS-R-456-1 10/76 and MMS-R-425-1 4/75).

For confirmation of the peak assigned to Pydrin in these analyses, two samples having the highest residues in vegetation and two in soil were subjected to gas chromatography-mass spectroscopy.

The recoveries of Pydrin from water, soil and vegetation were determined following fortification of pretreatment samples and the amounts found in posttreatment samples were corrected accordingly.

RESULTS AND DISCUSSION.—When 600 ml water samples were fortified with 0.1, 0.01 and 0.001 ppm Pydrin, the recoveries were 98.2, 99.8 and 98.0%, respectively; the minimum detectable amount was 0.003 ppm (2X background noise level). Soil samples were fortified at 0.1 ppm and recoveries varied from 93.7 to 104.1%. Vegetation samples were fortified at 0.05 and 0.1 ppm and recoveries varied from 82 to 84%.

Table 1 shows residues of Pydrin in the pasture water. Immediately following treatments about 0.1 ppm was found in water from each treated area; these values steadily declined during the three or four days that samples could be collected. There is no apparent difference in the amount of Pydrin in water between treatment rates. It appears that the amount of Pydrin that would dissolve, or be suspended on solid particles within this pasture water, was maximum following treatment at 0.1 or 0.2 lb AI/acre. Pydrin is known to be highly hydrophobic which apparently accounts for these results.

Pydrin residues in pasture soil were quite variable (Table 2); however in all but one case (20 days after the first treatment), the concentration in soil was greater for that part of the field treated at the higher rate. Pydrin residues declined in pasture soil with time but still could be measured at 56 days after the third treatment.

The residues found on pasture vegetation are high (Table 3) as would be expected based on the known photostability of this compound. While the values were variable, the higher treatment rate did generally result in greater concentrations. Residues on vegetation declined slowly and persisted at relatively high levels throughout the study period.

Gas chromatography-mass spectroscopy determinations confirmed the assignment of Pydrin to the major peak in all

Table 1.—Residues of Pydrin in pasture water before and after three successive aerial applications of 0.1 and 0.2 lb AI/acre.

Sampling time	Date (1977)	Rate (lb/acre)	Average[a] residue (ppm)
Pre-first application	7/10	0.0	ND[b]
	7/19	0.0	ND
First application	7/19		
2-hrs	7/19	0.1	0.081
2-hrs	7/19	0.2	0.15
1-day	7/20	0.1	0.018
1-day	7/20	0.2	0.016
2-day	7/21	0.1	0.0026
2-day	7/21	0.2	0.0080
3-day	7/22	0.1	0.0034
3-day	7/22	0.2	0.00067
Second application	8/ 8		
2-hrs	8/ 8	0.1	0.093
2-hrs	8/ 8	0.2	0.053
1-day	8/ 9	0.1	0.031
1-day	8/ 9	0.2	0.0091
2-day	8/10	0.1	0.017
2-day	8/10	0.2	0.0040
3-day	8/11	0.1	0.0081
3-day	8/11	0.2	0.0027
4-day	8/12	0.1	0.0030
4-day	8/12	0.2	0.00087
Third application	8/29		
2-hrs	8/29	0.1	0.094
2-hrs	8/29	0.2	0.095
1-day	8/30	0.1	0.0035
1-day	8/30	0.2	0.0085
2-day	8/31	0.1	0.0016
2-day	8/31	0.2	0.0011
3-day	9/ 1	0.1	ND
3-day	9/ 1	0.2	0.00065

[a]Average of duplicate samples.

[b]ND = Not detected (<0.003 ppm).

Table 2.—Residues of Pydrin in pasture soil before and after three successive aerial applications of 0.1 and 0.2 lb AI/acre.

Sampling time	Date (1977)	Rate (lb/acre)	Residue[a] (ppm)
Pre-first application	7/18	0.0	ND[b]
	7/18	0.0	ND
First application	7/19		
2-hrs	7/19	0.1	0.0017
2-hrs	7/19	0.2	0.040
1-day	7/20	0.1	0.011
1-day	7/20	0.2	0.056
3-day	7/22	0.1	0.012
3-day	7/22	0.2	0.044
7-day	7/26	0.1	0.013
7-day	7/26	0.2	0.074
14-day	8/ 2	0.1	0.0068
14-day	8/ 2	0.2	0.033
20-day	8/ 8	0.1	0.084
20-day	8/ 8	0.2	0.030
Second application	8/ 8		
2-hrs	8/ 8	0.1	0.12
2-hrs	8/ 8	0.2	0.30
1-day	8/ 9	0.1	0.0086
1-day	8/ 9	0.2	0.052
3-day	8/11	0.1	0.020
3-day	8/11	0.2	0.046
7-day	8/15	0.1	0.010
7-day	8/15	0.2	0.046
14-day	8/22	0.1	0.0057
14-day	8/22	0.2	0.044
21-day	8/29	0.1	0.0095
21-day	8/29	0.2	0.014
Third application	8/29		
2-hrs	8/29	0.1	0.0086
2-hrs	8/29	0.2	0.082
1-day	8/30	0.1	0.0083
1-day	8/30	0.2	0.058
3-day	9/ 1	0.1	0.0056
3-day	9/ 1	0.2	0.079
7-day	9/ 5	0.1	0.0093
7-day	9/ 5	0.2	0.058
14-day	9/12	0.1	0.019
14-day	9/12	0.2	0.15
21-day	9/19	0.1	0.0055
21-day	9/19	0.2	0.041
28-day	9/26	0.1	0.0045
28-day	9/26	0.2	0.035
56-day	10/24	0.1	0.0072
56-day	10/24	0.2	0.017

[a]Average of duplicate samples; corrected for % recovery and adjusted to dry weight basis.

[b]ND = Not detected (<0.003 ppm).

Table 3.—Residues of Pydrin on pasture grasses before and after three successive aerial applications of 0.1 and 0.2 lb AI/acre.

Sampling time	Date (1977)	Rate (lb/acre)	Residue[a] (ppm)
Pre-first application	7/18	0.0	ND[b]
	7/18	0.0	ND
First application	7/19		
2-hrs	7/19	0.1	24.23
2-hrs	7/19	0.2	30.11
1-day	7/20	0.1	24.14
1-day	7/20	0.2	24.38
3-day	7/22	0.1	33.84
3-day	7/22	0.2	27.86
7-day	7/26	0.1	28.32
7-day	7/26	0.2	49.52
14-day	8/ 2	0.1	14.60
14-day	8/ 2	0.2	34.03
20-day	8/ 8	0.1	28.32
20-day	8/ 8	0.2	27.84
Second application	8/ 8		
2-hrs	8/ 8	0.1	37.75
2-hrs	8/ 8	0.2	43.81
1-day	8/ 9	0.2	89.16
3-day	8/11	0.1	50.92
3-day	8/11	0.2	31.74
7-day	8/15	0.1	48.66
7-day	8/15	0.2	53.32
14-day	8/22	0.1	21.84
14-day	8/22	0.2	39.74
21-day	8/29	0.1	34.23
21-day	8/29	0.2	14.85
Third application	8/29		
2-hrs	8/29	0.1	34.10
2-hrs	8/29	0.2	32.89
1-day	8/30	0.1	33.27
1-day	8/30	0.2	38.99
3-day	9/ 1	0.1	30.51
3-day	9/ 1	0.2	39.52
7-day	9/ 5	0.1	29.83
7-day	9/ 5	0.2	38.48
14-day	9/12	0.1	25.18
14-day	9/12	0.2	28.52
21-day	9/19	0.1	19.28
21-day	9/19	0.2	52.34
28-day	9/26	0.1	13.57
28-day	9/26	0.2	30.29
56-day	1-/24	0.1	6.23
56-day	10/24	0.2	21.57

[a]Corrected for % recovery and adjusted to dry weight basis.

[b]ND = Not detected (<0.04 ppm).

cases. Because of the lower concentrations of the soil samples, selective ion monitoring was employed for those extracts.

Should registration of Pydrin for mosquito control be undertaken, it appears that the development of a granular formulation would greatly reduce residues on vegetation, as has been demonstrated for another photostable compound (Schaefer and Dupras 1977).

ACKNOWLEDGMENT.—This study was supported in part by Shell Development Company. We gratefully acknowledge the help of Dr. Roy Holmstead, Division of Entomology and Parasitology, University of California at Berkeley, who conducted the gas chromatography-mass spectrography analyses. We are also indebted to personnel of the Kings Mosquito Abatement District who assisted throughout this study.

REFERENCES CITED

Miura, T. and R. M. Takahashi. 1976. Effects of synthetic pyrethroid, SD43775, on nontarget organisms when utilized as a mosquito larvicide. Mosq. News 36:322-326.

Miura, T., R. M. Takahashi and F. S. Mulligan, III. 1977. Field trials with Pydrin, a synthetic pyrethroid, against *Culex tarsalis* and its impact on nontarget organisms. Proc. Calif. Mosq. & Vector Control Assoc. 45:137-139.

Schaefer, C. H. and E. F. Dupras, Jr. 1977. Residues of diflubenzuron [1-(4-chlorophenyl)-3-(2, 6 difluorobenzoyl) urea] in pasture soil, vegetation and water following aerial applications. Jour. Agric. Food Chem. 25:1026-1030.

Schaefer, C. H., W. H. Wilder and F. S. Mulligan, III. 1976. Evaluation of Dimilin, BAY MED6046, SD41706 and SD43775 as mosquito control agents. Proc. Calif. Mosq. Control Assoc. 44:97-99.

THE EFFECTIVENESS OF ALTOSID® BRIQUETS IN CONTROLLING *CULEX PIPIENS* IN CATCH BASINS

Robert F. Schoeppner

San Mateo County Mosquito Abatement District
1351 Rollins Road, Burlingame, California 94010

ABSTRACT

Altosid® briquets were used experimentally for the control of *Culex pipiens* in catch basins in two large residential areas in San Mateo County, California. The results of the tests indicate that the briquets were effective and are more economical than Flit MLO® for control of *Cx. pipiens* in the basins.

INTRODUCTION.--At the 45th Annual Conference of the California Mosquito and Vector Control Association two papers were presented that dealt with mosquito control problems encountered in a developing bayside community (Jewell 1977; Schoeppner 1977). Those papers described the contiguous lagoons of Foster City, a residential development bordering San Francisco Bay, and illustrated the mosquito control problems associated with waters permanently impounded within the underground drainage system that empties into these lagoons.

Because of increased levels of resistance of *Culex pipiens* to organophosphorus insecticides and because of problems in applying lethal doses to this mosquito in the Foster City drainage system, the San Mateo County Mosquito Abatement District (SMCMAD) endeavored to test other insecticides and application techniques for mosquito control. This paper describes the results of our work with one insecticide and several application techniques.

MATERIALS AND METHODS.–In 1976 the SMCMAD tested Altosid® briquets containing a methoprene formulation for the control of *Cx. pipiens* in a limited number of catch basins. Methoprene, an insect growth regulator, had been formulated into a slow-release, 400 mg. charcoal briquet by Zoecon Corporation, Palo Alto, California. Encouraged by favorable test results, we selected two study areas for treatment with briquets in 1977, one in San Mateo Park and the other in Foster City.

The study areas differ in topography, vegetative cover, and exposure to sunlight. In San Mateo Park, conifer and broadleaf shade trees dominate the rolling landscape, effectively limiting direct sunlight. Catch basins in that area had been clogged by leaf litter for several years. In Foster City no mature trees shade the flat terrain. Catch basins in that area were relatively free of organic litter.

The Foster City drainage system warrants further consideration. The system consists of catch basins and lines that converge toward the contiguous lagoons mentioned previously. The lines vary from 12 in. in diameter near the levee surrounding the city to 54 in. in diameter at their point of discharge into the lagoons. The basins and lines are partially filled with salt water intruding from San Francisco Bay. The salt water within the drainage system is covered by a layer of fresh water from runoff. This fresh water layer creates an ideal breeding habitat for *Cx. pipiens*. Because the level of the lagoons rarely fluctuates, even the basins and lines at the highest elevation of the drainage system seldom lack impounded water. When the lines are filled to the maximum level, the surface area exposed in a basin is approximately 12 sq. ft. If the water level recedes and exposes the drainage line at the bottom of a basin, a surface area that extends the entire length of the drainage line might be exposed. Treatment of a basin with oils or organophosphorus insecticides usually affects only the immediate area within the basin whereas the lines remain untreated and shelter adult mosquitoes that often emerge after an application of insecticide.

Catch basins within the two study areas were treated with one or more Altosid briquets; other basins were left untreated as checks. The mosquito pupae in all basins studied were sampled randomly on a weekly basis. Each sample consisted of pupae from more than one basin that had been treated with the same dose of insecticide. Efforts were made to collect 50 pupae per sample. However, in treated basins, pupae were so scarce that less than 50 could be collected per sample in many instances. Collected pupae were reared in the laboratory, and the emerged adults were identified to species and counted. Control was considered to be satisfactory if adults emerged from less than 20 percent of the total collected pupae.

RESULTS AND DISCUSSION.–San Mateo Park.- -On April 13, 1977, catch basins in San Mateo Park were treated with one Altosid briquet per basin. For purposes of sampling the population of immature mosquitoes, the study area was divided into a central and peripheral region. Separate samples were taken from each region to determine whether the central region of the study area could benefit from control of mosquitoes in the peripheral region. Results appear in Table 1.

Seven weeks after the first application of insecticide, control in the peripheral region failed; control in the central region failed after 13 weeks. The catch basins were treated with one briquet per basin again on July 15 and October 25, 1977, respectively. The second application suppressed the mosquito population for 13 weeks in the peripheral as well as in the central region. The third application failed after 5 weeks and provided only limited suppression of the population during this period. We suspect that the poor control might be attributable to cooler water temperature and to the reduced photoperiod.

The number of service requests from persons living adjacent to the study area, a realistic evaluation of the success of treatment, was reduced from 20, in each of years 1975 and 1976, to 9 in 1977. The timing of the requests in 1977 coincided with the deterioration of the methoprene prior to retreatment.

Foster City.- -On May 4, 1977, catch basins in Foster City were treated with one Altosid briquet per basin. Results shown in Table 2 indicated only a slight reduction in the number of adult mosquitoes that emerged from pupae collected in treated vs. untreated basins. Three additional applications of insecticide (one briquet per basin) were made during a 17-week period until substantial suppression of the mosquito population

Table 1.–Effects of Altosid® briquets (one per basin) on the percent of adult *Culex pipiens* emergence from catch basins in San Mateo Park, San Mateo, California, 1977.

	Percent Emergence per Week													
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
April 13														
1st Test														
Central Area	0	0	0	2	0	0	0	0	0	.3	0	0	14	
Peripheral	0	11	0	8	6	29	2	94	14	45	48	23	20	
Untreated	100	92	96	91	91	74	100	96	93	90	100	98	94	
July 15														
2nd Test														
Central Area	0	0	0	0	4	13	10	2	14	6	0	2	2	50
Peripheral	0	2	0	0	0	0	0	0	6	0	23	16	0	48
Untreated	94	98	83	94	95	95	100	96	94	100	100	76	97	76
October 25														
3rd Test														
Central Area	2	5	3	*	11	71								
Peripheral	2	5	6	*	24	26								
Untreated	100	100	100	*	100	100								

*no sample taken in fourth week

Table 2.–Effects of Altosid® briquets (one per basin) on the percent of adult *Culex pipiens* emergence from catch basins in Foster City, California, 1977.

	Percent Emergence Per Week										
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
May 4											
1st Test											
Treated Basins	88	49	60								
Untreated Basins	100	92	88								
May 25											
2nd Test											
Treated Basins	24	26	41	21	65	30					
Untreated Basins	96	94	93	89	88	98					
July 6											
3rd Test											
Treated Basins	42	18	30	88	68	61	67	62			
Untreated Basins	92	100	83	73	*	*	100	94			
August 31											
4th Test											
Treated Basins	6	0	0	0	0	0	0	7	0	11	48
Untreated Basins	90	91	91	92	72	84	92	94	95	93	100

* no sample taken on this date

was achieved on September 6, 1977. Based on the results of these tests, we believe that a substantial concentration of methoprene had to accumulate in the drainage lines connecting the catch basins before satisfactory control would persist for 10 weeks.

In separate drainage lines, we attempted to control mosquitoes in catch basins with multiple Altosid briquets. Results appear in Table 3. Satisfactory control was achieved in the lines treated with 3 and 4 briquets per basin for a period of 5 weeks. Thereafter, the percent emergence of adult mosquitoes became erratic, ranging from 0 to 80 percent. The application of 2 briquets per line exhibited poor control.

Because the surface water in the catch basins and drainage lines remains stationary, we tested a briquet, specially prepared by Zoecon Corporation, that would float and slowly release a layer of methoprene at the surface where resting larvae would receive the greatest exposure to the insecticide. We believe that a briquet that sinks (the type used in the aformentioned tests) would release methoprene throughout the volume of water in the basins and lines, thereby yielding concentrations sublethal to mosquito larvae.

One drainage line in Foster City was selected for study and each catch basin along the line was treated with one floating

Table 3.—Effects of Altosid® briquets on the percent of adult *Culex pipiens* emergence from catch basins in Foster City, California, 1977.

Number of briquets	Percent Emergence Per Week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Two	4	9	25	48	33	48	53	0
Three	13	23	0	20	0	0	38	0
Four	4	0	4	0	0	38	20	33
Control	100	94	90	91	91	92	72	84

Table 4.—Effects of floating Altosid® briquets on the percent of adult *Culex pipiens* emergence from catch basins in Foster City, California, 1977.

	Percent Emergence Per Week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Treated Basins	0	13	15	42	0	21	28	74
Untreated Basins	100	94	90	91	91	92	72	84

briquet. Results indicated that a satisfactory level of control lasted for about 6 weeks after treatment. The large percent emergence of adult mosquitoes collected from basins during the fourth week might be attributable to an influx of pupae from the drainage lines where sublethal levels of methoprene probably existed.

Comparison of Costs: Methoprene vs. Flit MLO.- -Three applications of Altosid briquets successfully surpressed the mosquito population in San Mateo Park from mid-April through the end of November 1977 at an approximate cost for materials of $0.78 per catch basin treated. The estimated annual cost for materials and labor, exclusive of vehicle operation costs and time spent in response to service requests, would average about $1.39 per catch basin for treatment with Altosid briquets and $2.14 per basin for Flit MLO. Thus, the use of Altosid briquets would save $0.75 per catch basin treated.

CONCLUSION.—Because Altosid briquets proved successful in controlling *Cx. pipiens* in catch basins, particularly for the San Mateo Park study area, the SMCMAD has decided to use this insecticide in catch basins throughout the District.

REFERENCES CITED

Jewell, D. J. 1977. Mosquito problems in a developing bayside community. Proc. Calif. Mosq. & Vector Control Assoc. 45:193.

Schoeppner, R. F. 1977. Methods used to suppress mosquito populations in a bayside community. Proc. Calif. Mosq. & Vector Control Assoc. 45:194-196.

ALTOSID®: A UNIQUE TOOL FOR USE IN AN INTEGRATED MOSQUITO CONTROL PROGRAM

Robert E. Lucas

Zoecon Corporation

975 California Avenue, Palo Alto, California 94304

The term "Integrated Pest Management" (IPM) has been popularized in the past few years and is frequently lauded as a new development or concept in pest control. Likewise, it is frequently construed by the lay person to be synonomous with biological control. Neither one is true. A modest literature search in preparing for this presentation showed that the concept of integrated control was well understood and being practiced in the western world over 100 years ago. There is also evidence that the Chinese practiced integrated control of pests before the third century. I'm sure the main reason that this concept has its roots in antiquity is that it is merely a common sense approach to the problem.

About 10 years ago a group of F.A.O. experts on integrated pest control defined the concept as follows:

> "A pest management system that is the context of the associated environment and the population dynamics of the pest species utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury."

In 1972 the Council On Environmental Quality further defined the concept by citing three main components of an IPM Program. They were:

1. Maximizing controls predominantly by cultural methods to prevent the build-up of pests;
2. Monitoring the concentration of pests and natural control factors present to determine the need for further measures;
3. Using the most appropriate technique or combination of pest suppression techniques only when necessary, to prevent economic damage to the crop.

Looking at these three components through the eyes of a relative newcomer to the mosquito control industry, I find the IPM concept to be the cornerstone of the practice of the majority of the districts I have visited across the country.

MAXIMIZING NATURAL CONTROLS.–No professional pest control operator is more cognizant of this basic control measure than is the Mosquito Abatement District Manager. Source reduction rightfully continues to be the preferred way to reduce or eliminate mosquito problems.

MONITORING THE CONCENTRATION OF PESTS AND NATURAL CONTROL FACTORS.–All will agree, I'm sure, that most Mosquito Abatement Districts have done an outstanding job of monitoring and taxonomically classifying the mosquitoes in the area under their jurisdiction. Monitoring natural control factors such as rainfall, wind and tides is also widely practiced. Monitoring the prey-predator, parasite or pathogen relationship, however, is not likely ever to be feasible except in isolated situations.

This then leaves the third step in the IPM Program which is to select the appropriate technique or combination of pest suppression techniques. This means integrating the most acceptable biological and/or chemical control products into a program which is ecologically compatible with your mandate to suppress populations of pestiferous and disease vectoring mosquitoes.

The chemical control programs that have been available to professional mosquito control workers in the past for the most part have been used in a responsible manner. The development of resistance to certain classes of pesticides has developed, in my opinion, not so much from misuse as from a combination of factors which includes a lack of alternative control measures, contributing agricultural pesticide pressure against mosquito populations and the frequent and rapid recycling of new mosquito generations in an irrigated cropping system such as we have here in California.

While many California district managers have been dealing with chemical resistance for several years, it is just now becoming a problem in some other areas of the country. Additionally, there are other growing resistance factors to contend with that now or soon will affect the alternative programs available to the professional mosquito control manager. They are of environmental and economic origin.

Resistance to source reduction is best understood by those managers who have felt the weight of the environmental impact statement required to drain the swamp. Environmentalist's activities expressed in restrictive legislation and regulation will undoubtedly continue to exert pressure against the manipulation of water in natural breeding sites.

The economic resistance to new chemical development for mosquito control may be the most significant problem this industry has yet to face. This economic resistance is a direct result of skyrocketing costs associated with the registration of new pesticides, the bureaucratic boondoggling of the Environmental Protection Agency coupled with the fact that, chemically speaking, mosquito control is small business and represents very limited marketing opportunities. The brunt of this problem sooner or later will be borne by you people in this room today as the number of alternative chemical control products in your arsenal diminishes.

What does all of this tell us? In my opinion just this - - It is incumbent on all of us to use the most rational control programs available to protect not only the public whom we serve but also the products and practices that are still available to us. It is in this context that I want to restate some of the characteristics of methoprene (Altosid®) that make it a truly unique chemical control agent for use in a bio-rational IPM program. More specifically I want to describe a new formulation, "Altosid Briquets", and tell you how they work and what makes them an extraordinary IPM tool.

Chapman, writing in the 1974 Annual Review of Entomology, indicates that there are more than 220 invertebrate predators of mosquito larvae. Additionally there are again as many pathogens or parasites which attack mosquito larvae.

We haven't screened methoprene against all of these natural control candidates. We have, however, screened enough of them to know that at normal use rates of the Altosid SR-10 formulation very little, if any, alteration of the natural predator complex will take place. At the normal use rate of 3-4 ounces of SR-10 per acre the concentration of active ingredients in six inches of water is equal to .015 to .20 ppm. This is roughly 30 to 40 times more methoprene than would be required for control of mosquitoes if the product were chemically stable. These high use rates are required to ensure continued release of effective levels of the compound until the majority of a developing brood of larvae pass through the sensitive fourth instar. Hundreds of toxicity studies conducted on nontarget invertebrate predators, other pathogens, parasites and botanical species attest to the fact that not only is methoprene highly specific for dipteran insects but the safety margin on most nontargets is extremely high. This makes it unlikely that slow release formulations will cause irreversible alteration of the nontarget species composition in the breeding site.

The unique biological characteristic that sets methoprene apart from other chemical control measures and ensures its viability as an IPM control tool is the way in which its activity is evidence. Mosquito larvae, as well as most nontarget predators, parasites and pathogens can live in waters containing effective levels of methoprene. The development of the mosquito is interrupted only after it has proceeded to a stage in which it is no longer acceptable as a food source for most predators or as a host for most pathogens or parasites. Accordingly, treated larvae provide an uninterrupted source of food or an acceptable host for biological control organisms. The end result is the best possible chance of establishing a predator or parasite complex which, if not overstressed by subsequent broods or adversely affected by some other variable environmental factor, may provide a degree of natural control on a maintenance basis. Parasites such as *Romanomermis culicivorax* can live, molt, mate, and lay eggs. The eggs can hatch, infect mosquito larvae, emerge and start the process all over again in the presence of an effective level of methoprene. Likewise, the mosquito larva which hosts this parasite during its development is unaffected by the methoprene until after the nematode has completed its life cycle. Therefore, if you are attempting to establish this parasite in a particular breeding site, you can do so without either sacrificing control while waiting for the parasite complex to build to an effective level or by having to overwhelm the mosquito population with massive releases of the biological control you want to institute. The high specificity of methoprene coupled with its mode of action allows the IPM oriented manager to HAVE HIS CAKE AND EAT IT TOO! You can enjoy excellent short term chemical control while maximizing your biological manipulation capabilities for maintenance control. Careful monitoring of the prey/predator ratios may call for repeat methoprene treatments periodically; these can be carried out without disrupting the established predator complex.

Long term slow release formulations such as Altosid Briquets are even more compatible with predator system establishment programs because they avoid the heavier "slug" treatment associated with a sprayable release system like Altosid SR-10.

Altosid Briquets work in two ways to control mosquitoes. The biological activity is due in part to the release of the active ingredient from the briquet into true solution in the water. Cuticular absorption and ingestion of this dissolved methoprene is complemented by ingestion of charcoal particles containing methoprene. The formulation takes into consideration that mosquito larvae are indiscriminate feeders that browse on particles in the size range of 5 to 20 microns. Bits of charcoal in this range slough off the Briquet and tend to float towards the surface where the foraging larva will comb them out of the water. The end result is that less methoprene is required to give longer term control. Operational users of the formulation have advised us that frequently natural biological control is seen long after the briquet has disintegrated. This is usually evidenced by a loack of pupae in the treated sites, in spite of the continued presence of early instar larvae which indicates continuous reinfestation.

We encourage both the operational user and the mosquito control researcher to continue to share with us their observations on the effects of these formulations. We are particularly appreciative of the assistance of the San Mateo Mosquito Abatement District and the Department of Biological Sciences of Stanford University for their work in the practical demonstration of the compatibility of Altosid and *Romanomermis culicivorax* in an operational control program.

SYNTHETIC PYRETHROIDS FOR THE CONTROL OF RESISTANT MOSQUITOES IN IRRIGATED PASTURES

H. A. Darwazeh[1], M. S. Mulla[1] and B. T. Whitworth[2]

ABSTRACT

Aerial application of the synthetic pyrethroids FMC-45498 EC 0.21 [(-) - (cyano)-3-phenoxybenzyl-(+) cis-3-(2,2-dibromovinyl)-2,2-dimethyl-cyclopropane-1-carboxylate] and FMC-33297 or Ambush® [3-phenoxybenzyl (±) cis-trans- 3-(2,2-dichlorovinyl)-2,2-dimethyl-cyclopropane carboxylate] produced excellent control of multi-resistant larvae of the mosquito *Aedes nigromaculis* Ludlow in irrigated pastures in Tulare County, California. At the rate of 0.025 lb/acre, FMC-33297 (Ambush) controlled the 3-4th stages of larvae completely, while 98% reduction of the late stages was achieved 24 hr after treatment. FMC-45498 EC 0.21 was found to be 10 times more effective than FMC-33297, yielding complete and 96% control at the rates of 0.005 and 0.0025 lb/acre respectively.

INTRODUCTION.–Several synthetic pyrethroids recently have been reported to be exceptionally active against larvae of stagnant and floodwater mosquitoes when applied as aqueous sprays with ground equipment. Materials such as FMC-45498, FMC-45497, FMC-33297 and FMC-35171 gave complete control of *Culex tarsalis* Coquillett, *Culiseta inornata* Williston and *Anopheles franciscanus* McCracken in mosquito breeding ponds at the rates of 0.005, 0.001, and 0.025 lb/acre respectively. In tests against *Psorophora columbiae* (Lynch-Aribalzaga), excellent control was obtained at the rate of 0.001 lb/acre of FMC-45498 evaluated in alfalfa fields in the Palo Verde Valley. Similar results were also obtained in evaluations against *Aedes nigromaculis* Ludlow in Kern and Tulare Counties of the Southern San Joaquin Valley of California, where larvae of this species are known to be highly resistant to chlorinated hydrocarbons and most of the organophosphorus larvicides (Gutierrez et al. 1976). FMC-33297 also was highly active against both species of floodwater mosquitoes, and complete control of larvae was obtained at the rate of 0.025 lb/acre (Mulla and Darwazeh 1976, Mulla et al. 1977a). These materials were found to possess a wide margin of safety at mosquito larvicidal rates for some nontarget insects, mosquitofish, and other species of freshwater fishes including rainbow trout (*Salmo gairdneri*), desert pupfish (*Cyprinodon macularius*), and *Tilapia mossambica* (Mulla et al. 1977 a,b).

In previous field experiments, rates effective when applied by ground equipment failed to produce similar results when applied by air. Lack of adequate control was attributed to several factors including drift and lack of penetration into vegetative growth (Mulla and Darwazeh 1975). The following studies, therefore, were initiated to determine the efficacy of aerial application of two synthetic pyrethroids for optimum larval control of *Ae. nigromaculis* under natural field conditions.

METHODS AND MATERIALS.–Emsulifiable concentrates and 25 WP formulations were utilized in all tests. The required amounts of materials were mixed with water and applied with a Pawnee aircraft calibrated to deliver 0.7 gal of aqueous spray per acre. 25 WP, EC 2 and EC 3.2 formulations of FMC-33297 (Ambush®) [3-phenoxybenzyl (±) cis-trans -3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylate], and EC 0.21 of FMC-45498 [(-)-(cyano)-3-phenoxybenzyl-(+) cis -3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylate], were evaluated against various immature stages of *Ae. nigromaculis* at several locations in Tulare County. Dosage rates, mosquito larval stages, and test locations are described in Tables 1 and 2.

Prior to chemical applications, test plots were inspected for obstacles which might influence coverage and penetration. These included electrical power lines adjacent to the test area or dense vegetation in the field. Selected test areas were divided into 70 ft swaths and were marked with stakes and surveyor's tape, utilizing a different color for each material or rate. During application, each swath was flagged by two men to insure correct line of flight and coverage. Twenty dips per swath were taken prior to treatment and 6 and 24 hours after treatment, and percent reductions were calculated on the basis of pre- and posttreatment counts of larvae and pupae in the treated plots.

RESULTS AND DISCUSSION.–At the rate of 0.025 lb/A, FMC-33297 (Ambush) yielded 98% control of 3-4 stage larvae and 79% control of the late 4th instars and pupae 6 hours after treatment. Complete control of 3-4 stage larvae was achieved at 24 hr posttreatment as compared with 98% control of the later stages. Similar results were obtained at the higher rate of 0.04 lb/A (Table 1).

At the rate of 0.001 lb/A, which was highly effective against *Culex tarsalis* in natural breeding ponds, FMC-45498 EC 0.21 failed to produce adequate control of *Ae. nigromaculis* larvae in irrigated pasture. Poor results also were obtained at 0.002 lb/A. However, at 0.0025 and 0.005 lb/A, complete control of larvae at the higher rate was achieved 6 hours after treatment, while only 93% reduction was obtained at the lower rate (Table 2).

From the data presented, 0.025 lb/A of FMC-33297 (Ambush) appears to be the effective rate for *Ae. nigromaculis* larval control in irrigated pasture. FMC-45498, as reported earlier against other mosquito species, was found to be more effective than FMC-33297, giving excellent control of *Ae. nigromaculis* larvae at the rate of 0.0025-0.005 lb/A. As shown in Table 2, satisfactory larval control with this material can be achieved at rates as low as 0.0025-0.003 lb/A of active material.

[1]University of California, Department of Entomology, Riverside, California 92521.

[2]Tulare Mosquito Abatement District, Post Office Box 1476, Tulare, California 93274.

Table 1.–Aerial application of the synthetic pyrethroid Ambush® for the control of larvae of the mosquito *Aedes nigromaculis* in irrigated pastures. (Tulare County, California, July-Aug., 1977).

Material and Formulation	Source	Rate lb/acre	Stages	No. of larvae and pupae/20 dips pre- and posttreatment: Pretreat L	Pretreat P	6 hr post L	6 hr post P	6 hr post %R	24 hr post L	24 hr post P	24 hr post %R
				Test 1[a]							
Ambush 25 WP	ICI U.S.A. Inc.	0.025	3-4	284	0	6	0	98	0	0	100
Check	--	--	3-4	108	0	126	0	0	727	10	0
				Test 2[b]							
Ambush EC 2	ICI U.S.A. Inc.	0.025	4-P	251	33	11	49	79	0	5	98
			3-4	171	0	0	0	100	0	0	100
Check	--	--	4-P	247	10	274	45	0adults			
				Test 3[c]							
FMC-33297 EC 3.2	Food Mach. Corp.	0.04	3-4	335	0	3	0	99	0	0	100
Check	--	--	3-4	420	0	720	0	0	1020	0	0

[a]Toste Pasture

[b]Kings County Truck Lines Pasture

[c]Pocha Pasture

Table 2.–Aerial application of the synethic pyrethroid FMC-45498 (EC 0.21) for the control of larvae of *Aedes nigromaculis* in irrigated pastures. (Tulare County, California, July- Aug. 1977).

Material and Formulation	Rate lb/acre	Stages	No. of larval and pupal/20 dips pre- and postreatment: Pretreat L	Pretreat P	6 hr L	6 hr P	6 hr %R	24 hr L	24 hr P	24 hr %R
			Test 1[a]							
FMC-45498 EC0.21	0.001	2-3	617	0	128	0	79	138	0	78
		3-4	336	0	89	0	74	256	0	24
		4th (late)	342	0	86	0	75	211	0	38
Check	--	3-4	247	0	274	0	0	356	0	0
			Test 2[b]							
FMC-45498 EC 0.21	0.002	3-4	360	0	150	0	58	125	0	65
Check	--	3-4	860	0	1000	0	0	1320	0	0
			Test 3[c]							
FMC-45498	0.0025	3-4	98	0	7	0	93	4	0	96
EC 0.21	0.0050	3-4	116	0	0	0	100	0	0	100
Check	--	3-4	128	0	136	0	0	163	0	0

[a]Toste Pasture

[b]Stephen Pasture

[c]Kings County Truck Lines

REFERENCES CITED

Gutierrez, C. M., E. P. Zboray and P. A. Gillies. 1976. Insecticide susceptibility of mosquitoes in California: Status of organophosphorus resistance in larval *Aedes nigromaculis, Culex tarsalis*, and *Culex pipiens* subspp. Calif. Vector Views 23:27-33.

Mulla, M. S. and H. A. Darwazeh. 1975. Field evaluation of aliphatic amines against immature mosquitoes. Mosq. News 35:57-62.

Mulla, M. S. and H. A. Darwazeh. 1976. Field evaluation of new mosquito larvicides and their impact on some nontarget insects. Mosq. News 36:251-256.

Mulla, M. S., H. A. Navvab-Gojrati and H. A. Darwazeh. 1978. Biological activity and longevity of new synthetic pyrethroids against mosquitoes and some nontarget insects. Mosq. News 38:90-96.

Mulla, M. S., H. A. Havvab-Gojrati and H. A. Darwazeh. 1977. Toxicity of synthetic pyrethroids to 4 species of freshwater fishes. Bull. Environ. Contam. Toxicol. (in press).

EFFECTIVENESS AND RESIDUAL ACTIVITY OF POLYMER FORMULATIONS OF MOSQUITO LARVICIDES

M. S. Mulla and H. A. Darwazeh

University of California
Department of Entomology, Riverside, California 92521

INTRODUCTION.–In recent studies reported by Evans et al. (1975), a controlled-release formulation of chlorpyrifos yielded excellent control of several species of stagnant and floodwater mosquito larvae in Woodland pools for 22 weeks at the rate of 1 ppm of active ingredients. Similar results were also reported earlier by Miller et al. (1973a) and Roberts et al. (1973). Excellent control of floodwater mosquito larvae, *Psorophora confinnis* (Lynch and Arribalzaga), was also achieved for 11 weeks at the rate of 2 ppm, utilizing controlled-release formulation of chlorpyrifos (Nelson et al. 1976). The same formulation at an extremely high rate, 5 ppm, was found to be highly active for 18 months in artificial pools, preventing mosquito larval breeding for 2 seasons (Miller et al. 1973b). However, such a high rate of application is not practical and very costly.

These findings indicate that the polymer formulations of mosquito larvicides such as chlorpyrifos and temephos could produce adequate control of mosquito larvae for an entire season with one application in the range of 1 ppm of active ingredients, resulting in a substantial savings of material costs and labor over that of frequent treatments. The current studies were initiated to determine the efficacy and longevity of two polymer formulations of temephos and chlorpyrifos against mosquito larvae in the laboratory and under field conditions in Riverside and the lower desert in the Coachella Valley of southern California.

METHODS AND MATERIALS.–Laboratory.- -0.13 grams of chlorpyrifos or Dursban [O,O-diethyl-O-(3,5,6-trichloro-2-pyridyl) phosphorothioate] 10CR (10% controlled-release), and 0.22 grams of (6.3%) Abate® (temephos) [O,O-dimethyl) phosphorothioate] were placed separately in one gal. glass jars containing 3500 ml of tap water, yielding 4 ppm expected concentration, if all the active ingredients were released into the water. Two replicates per formulation were used and 2 jars left untreated as checks. At intervals indicated in Table 1, sufficient amount of water was aspirated by taking an equal amount from the top and bottom of each jar and added to tap water in a cup with larvae. Twenty 4th stage larvae of laboratory maintained colony of *Culex pipiens quinquefasciatus* (Say) were placed in 4-oz. treated dixie cups, each containing 100 ml of tap water, and the required amount of treated water from the jars was added to the cups to yield the desired expected concentration (ppm) in ranges that will produce sufficient mortality. After 24 hrs of exposure, mortality reading was taken and percent release of larvicide was determined utilizing the following formula:

$$\%R = \frac{A}{B} \times 100$$

where A = ppm of toxicant found corresponding to observed mortality, and B = ppm of expected toxicant applied to jars, if the material was completely released into the water. Extent of release was not possible to calculate for 100% mortality because it is not possible to ascertain exactly the concentration producing this mortality.

Field.–Tests were conducted at the Aquatic Research Facilities at the University of California, Riverside, and at the Coachella Valley of southern California. Detail descriptions of these facilities are given elsewhere (Mulla et al. 1970). The required amount of material was broadcast from the sides of the mosquito breeding ponds to insure complete coverage of entire surface area. Mosquito populations at the Riverside facilities consisted of *Culex tarsalis* Coquillett, and those in the Coachella Valley consisted mostly of *Cx. tarsalis*, but *Culiseta inornata* Williston and *Anopheles franciscanus* McCracken were also present in small numbers (5-10%).

Prior to treatment and at intervals after treatment, 5 dips per pond were taken and extent of control was calculated by the fomula:

$$\% \text{ Control} = 100 - \left(\frac{C_1}{T_1} \times \frac{T_2}{C_2}\right) 100,$$ where C_1 = pre-treatment count in check, C_2 = post-treatment count in check, T_1 = pre-treatment count in treated, T_2 = post-treatment count in treated.

Two polyethelene formulations of temephos (6.3 and 7.2 percent) along with Dursban 10CR in polyvinyl chloride were evaluated at 0.5, 1.0 and 2.0 lb a.i./acre. Two ponds were used for each dosage and the check.

RESULTS AND DISCUSSION.–In the laboratory at the rate of 1 ppm, the Dursban 10CR polymer formulation in 2 days released sufficient toxicant to cause eomplete larval mortality exposed for 24 hrs. At the lower rates, 0.5 and 0.25 ppm, complete mortality was possible after 7 and 14 days post-treatment, respectively (Table 1). At the same intervals and theoretical concentration, the temephos formulations failed to induce any larval mortality (data not presented to save space).

Under field conditions, both temephos (at 1.25 and 2.5 lb/acre) and chlorpyrifos (at 1 and 2 lb/acre) polymer formulations failed to produce adequate larval control in ponds at the Aquatic Research Facilities at Riverside, where water flow into each pond on the average was in excess of 4 gals per min. (Table 2). Water evaporation and percolation rates were high, and continuous addition of water through float valves resulted in dilution of the larvicides released from the polymer formulations. At the rate of 2.5 lb/A, temephos, however, reduced larval population markedly 4-7 days after treatment, but recovery occurred after 2 weeks. Dursban 10CR even at 2 lb/A, failed to produce any appreciable reduction in the mosquito larval population, and the presence of pupae 2 weeks post-treatment indicates lack of efficacy under such conditions where constant dilution of treated water is a problem.

At the Coachella Valley Aquatic Research Facilities where dilution due to continuous inflow of water was minor (less than 1 gal/min/pond), Dursban 10CR showed good activity

Table 1.–Evaluation of polymer formulation of Dursban 10CR against 4th-stage larvae of ***Culex pipiens quinquefasciatus*** in the laboratory.

Expected Conc. (ppm)	1 M	1 R	2 M	2 R	3 M	3 R	4 M	4 R	5 M	5 R
0.05	0	0	0	0	0	0	0	0	0	0
0.10	0	0	0	0	0	0	0	0	20	0.5
0.25	0	0	21	0.2	55	0.4	100	-[a]	100	-[a]
0.50	58	0.2	85	0.3	100	-[a]	100	-[a]	100	-[a]
1.00	96	0.3	100	-[a]	100	-[a]	100	-[a]	100	-[a]

Column heading: Average (%) mortality (M) and % cumulative release (R) (days)

[a]Not calculable, but it is very likely to be close to 0.2-0.5% at the higher concentration.

Table 2.–Evaluation of OP polymer controlled-release formulations against *Culex tarsalis* in experimental ponds[a]. (University of California, Riverside, August-September 1977).

Material and formulation	Expected Rate lb/A	Expected A.I. ppm	Pre-treat L	Pre-treat P	1 L	1 P	1 (%C)	2[b] L	2[b] P	2[b] (%C)	4[c] L	4[c] P	4[c] (%C)
Dursban	1.0	0.3	99	0	270	31	40	243	158	0	155	18	49
(10% CR)	2.0	0.6	160	0	295	25	60	100	15	66	164	22	66
Abate	1.25	0.4	40	0	40	5	78	18	21	53	154	0	0
(6.3%)	2.50	0.8	50	0	30	0	88	101	57	0	104	13	32
Check	-	-	33	0	165	3	-	60	9	-	110	4	-

Column heading: Average no. of larvae and pupae/5 dips post-treat (weeks) and % control (C)

[a]August waterflow 4.3 GPM/pond.

[b]Ponds were allowed to dry for one week.

[c]Assessed one week after reflooding.

Table 3.–Evaluation of OP polymer controlled-release formulations against *Culex tarsalis* in experimental ponds[a]. (Coachella Valley, November 1977 - April 1978).

Material and formulation	Rate lb/A	A.I. ppm	Pre-treat L	Pre-treat P	1 L	1 P	1 (%C)	3 L	3 P	3 (%C)	5[b] L	5[b] P	5[b] (%C)	20[c] L	20[c] P	20[c] (%C)
Dursban	1.0	0.4	88	12	13	0	87	0	0	100	1	0	96	20	0	0
(10% CR)	2.0	0.8	29	12	0	0	100	0	0	100	0	0	100	5	0	37
Abate	1.0	0.4	66	1	18	2	70	15	0	59	20	0	0	25	0	0
(6.3%)	2.0	0.8	57	4	18	0	86	12	0	64	10	2	27	18	0	0
Abate (7.2%)	0.5	0.2	75	5	20	1	74	14	0	68	12	2	35	13	0	17
(Ecopro 1700)	1.0	0.4	101	12	30	2	72	11	0	82	6	1	77	18	0	18
	2.0	0.8	34	1	2	0	94	2	0	90	7	0	26	18	0	0
Check	-	-	110	8	110	9	-	65	0	-	28	4	-	23	0	0

Column heading: Average no. of larvae and pupae/5 dips pre- and post-treat. (weeks) and % control

[a]*Culiseta inornata* and *Anopheles franciscanus* were also present in small numbers (5-10%).

[b]The ponds were allowed to dry for 3 months.

[c]Assessed 10 days after reflooding.

and prevented mosquito larval breeding for over 35 days at the rates of 1 and 2 lbs/A. At the high rate of 2 lb/A, the smaller size polymer particles of temephos (Ecopro-1700) was somewhat superior than the larger size particles of the same material, producing excellent reduction in the population for 21 days, while the larger size formulation was effective for one week only (Table 3). Five weeks after treatment when the ponds were allowed to dry for 3 mos., mosquito larval breeding occurred in all the ponds within 10 days after reflooding.

Based on the data presented here, both formulations of temephos are inadequate for mosquito larval control in a stagnant water habitat. Dursban 10CR, however, could be used successfully to yield satisfactory mosquito larval control for the entire season at a rate in the range of 1-2 lb/A (0.5-1.0 ppm), depending on water depth in the mosquito breeding source.

The longevity and efficacy of these formulations against floodwater mosquitoes have yet to be determined. Therefore, plans are underway to evaluate this polymer formulation of Dursban 10CR as prehatch treatment against *Psorophora columbiae* and *Aedes nigromaculis* larvae in the lower desert of southern California and in the central San Joaquin Valley of California. It is possible that one application could produce satisfactory larval control for the entire sequence of irrigations during a season, resulting in a great deal of saving in mosquito abatement costs.

REFERENCES CITED

Evans, Jr., E. S., J. H. Nelson, N. E. Pennington and W. W. Young. 1975. Larvicidal effectiveness of controlled-release formulation of chlorpyrifos in a Woodland pool habitat. Mosq. News 35:343-350.

Nelson, J. H., E. S. Evans, Jr., N. E. Pennington and N. M. Meisch. 1976. Larval control of *Psorophora confinnis* (Lynch-Arribalzaga) with a controlled-release formulation of chlorpyrifos. Mosq. News 36:47-51.

Miller, T. A., L. L. Nelson, W. W. Young, L. W. Roberts, D. R. Roberts and R. N. Wilkinson. 1973a. Polymer formulations of mosquito larvicides. I. Effectiveness of polyethylene and polyvinyl chloride formulations of chlorpyrifos applied to artificial field pools. Mosq. News 33:148-55.

Miller, T. A., L. L. Nelson and W. W. Young. 1973b. Polymer formulations for mosquito larvicides. IV. Larvicidal effectiveness of polyethylene and polyvinyl chloride formulations of chlorpyrifos during an 18 months field test. Mosq. News 33:172-175.

Mulla, M. S., H. A. Darwazeh, A. F. Geib, D. J. Ramke and P. A. Gillies. 1970. Materials and techniques for mosquito control with emphasis on field evaluation. Proc. Calif. Mosq. Control Assoc. 38:9-18.

Roberts, L. W., D. R. Roberts, T. A. Miller, L. L. Nelson and W. W. Young. 1973. Polymer formulations of mosquito larvicides. II. Effects of a polyethylene formulation of chlorpyrifos on *Culex* populations naturally infecting artificial field pools. Mosq. News 33:155-161.

THE DEVELOPMENT AND CONTROL OF *CULEX QUINQUEFASCIATUS* SAY AND *CULEX PEUS* SPEISER IN URBAN CATCH BASINS

Allan R. Pfunter

Northwest Mosquito Abatement District
6851 Granite Hill Drive, Riverside, California 92509

ABSTRACT

Culex quinquefasciatus Say and *Culex peus* Speiser required 10 to 11 days and 13 to 14 days to achieve pupal and adult stages, respectively, in a mean temperature range approximating 78° to 80°F, (26° to 27°C). Golden Bear 1356 (oil) and 1% Abate® granules provided acceptable (90% or better) larval mortality. GB-1356 also yielded an acceptable pupal kill. Larval reinfestation in oil treated basins was observed three days post-treatment; that of Abate treated basins was four days post-treatment. Control achieved with methoprene (Altosid®) 4% briquets was variable, ranging from less than seven to over 38 days.

INTRODUCTION.—In the urban/suburban areas encompassed by the Northwest Mosquito Abatement District, a total of over 1700 catch basins are routinely treated to suppress mosquito breeding. The majority of these catch basins are of an old design that allows water to remain trapped. Several of the basins are constructed so as to be self-flushing. Unfortunately, debris collects at the exit pipe, eventually plugging the hole and creating breeding sites.

As a result of continued residential construction in the District, catch basin breeding sites are increasing yearly. Such increases necessitate either the hiring of additional personnel to monitor and treat the sources or changes in control methods and materials to allow the operator to assume responsibility for a greater number of sources. Kimball and Perruzzi (1970) found that by treating urban sources on a bi-weekly treat- rather than weekly, the area serviced could be expanded greatly with no detectable loss in the quality of control provided. The questions pursued, then, were whether a bi-weekly treatment cycle of catch basins could be instituted in the Northwest MAD area and what chemicals would be appropriate to employ.

MATERIALS AND METHODS.—An evaluation of larval and pupal samples collected from urban sources in 1975, the majority being catch basin and curb gutters, showed *Culex peus* Speiser and *Culex quinquefasciatus* Say to be the predominant species (50% and 35%, respectively). Other species collected were *Culex tarsalis* Coquilett, *Culiseta incidens* Thomson), and *Culiseta inornata* (Williston).

During the period from July 15, 1976, through August 12, 1976, several concrete catch basins were observed for breeding activity. Nine of these basins were selected as being of a typical design commonly encountered (curb-side inlet, about 25 cubic feet in volume, with or without an exit pipe near the bottom). In addition, mosquito breeding (*Cx. peus* and *Cx. quinquefasciatus*) was found to be routinely present at weekly intervals.

To initiate the developmental study, the catch basins were sprayed with a mixture containing 0.1% pyrethrins in kerosene to kill the immature forms present. Any egg rafts found were removed manually by a one-pint (0.47 liter) enamel dipper. A maximum/minimum recording thermometer (Taylor Instrument Co., Arden, N.C., number 5458) was placed in each catch basin. On a daily basis, excluding Saturdays and Sundays, each basin was checked for new egg rafts. When the first rafts were noted, the developmental cycle was deemed to have begun. After this point in time, all rafts were removed on a daily basis for a period of three days. In addition, information regarding water temperatures, water level and/or flow, and general weather conditions were recorded. Periodically, water quality tests such as pH, nitrates, ammonia, and chlorine were performed using commercial kits (Hach Chem. Co., Ames, Iowa, numbers A1-36-WR, 1468-03, 12524-00, 12526-00). Larval and pupal densities were monitored by dipping each corner of the basin and the middle. The range and average of the five dips, and percent pupae, were recorded. Observations were terminated when the pupal stage was completed. The basin was then sprayed with the pyrethrins/kerosene mixture, any egg rafts removed, and the observation cycle begun again. The time period involved was from August 17, 1976, through October 22, 1976.

In order to reduce field variables, primarily water level fluctuation and the introduction of foreign substances into the water, three artificial catch basins were constructed. These basins were merely holes dug in the ground 2 feet (0.6 m) square x 1.5 feet (0.45 m) deep, lined with plastic and provided with a wood lid. The water level was maintained at 12 inches (30 cm) and the lid situated so as to provide exposure to the outside via a six inch (15 cm) gap between the edge of the lid and the wall of the basin. Observations were similar to those described for the concrete catch basins above, except that egg rafts of an age of 24 hours or less were obtained from the concrete catch basins and transferred to one quart (0.95 liter) plastic cups containing 24 fl. oz. (0.71 liters) of tap water. The cups were placed in styrofoam rings and floated in the artificial basins. Each cup contained one egg raft, with up to eight cups per basin. The cups were individually covered with screened lids to prevent unwanted oviposition. In addition, screened one quart cups were inverted over each floating cup when pupae were present in order to record adult emergence. Overcrowding was prevented by removing larvae in excess of about 100 specimens per cup. Larvae were fed by placing a small nugget of dry dog food (Chuck Wagon®) weighing between 0.018 to 0.028 ounces (0.5 to 0.9 grams) into each floating cup soon after the eggs hatched. Feeding was repeated three to four times during larval development. On a daily basis, newly emerged adults were removed by aspiration, then sexed and counted. The day at which the greatest number of adults appeared was taken as the median. Observations were terminated when no remaining live pupae were noted. The experimental period was from July 6, 1977, through August 31, 1977.

Chemical control tests utilizing three types of materials were performed during the period of August 20, 1976, through October 29, 1976. Golden Bear 1356 oil (WITCO

Chem. Corp., Los Angeles, CA) was applied to two actively breeding concrete catch basins at the rate of 0.5 fl. oz. (15 ml) per basin using an eye dropper. Temephos (Abate®) granules (1%) were applied to two other actively breeding catch basins at the rate of 0.035 ounces (one gram) per basin. In both the GB-1356 and Abate treated basins, all egg rafts present the day of application were removed. Observations of the basins were performed daily to determine the presence of new egg rafts. Any rafts deposited subsequent to this time were removed, for a period of three days. Also, on a daily basis, the stages present and their approximate densities were recorded. Lastly, methoprene (Altosid briquets, 4%) were tested in four actively breeding basins. Mortality was determined by removing pupae from the basins and observing emergence in the laboratory in plastic cups at a room temperature of about 72° F (22°C).

RESULTS AND DISCUSSION.--The duration of the developmental times for the stages of eggs through pupae of *Cx. peus* and *Cx. quinquefasciatus* in concrete catch basins averaged slightly over 10 days for combined populations at an average water temperature of 80°F (27°C) (see Table 1). The average temperature is a mean of the median values of each observed temperature range as recorded on the maximum/minimum thermometers. A possible error of up to 24 hours must be added to the average time, based upon an egg raft age range of zero to 24 hours. Most probably the error is closer to a maximum of about 12 hours as most oviposition occurs in near darkness (DeMeillon and Thomas 1966; Gerberg 1970). De Meillon and Thomas (1966) showed *Cx. quinquefasciatus* to reach 80% pupation at day seven when kept at a temperature of 29°C (84°F). At 26.7°C (80°F), maximum pupation occurs on days eight and nine according to Gerberg et al.

Table 1.--Developmental information for *Culex quinquefasciatus* Say and *Culex peus* Speiser in concrete catch basins (August 17 through October 22, 1976).

Catch Basin Number	Immatures Density*	Predominant Species (%)**	Developmental Duration (Days)*** 50% Pupae+; Pupal Range	Temperature (°F) Average ++; Range	Cycles Observed
1	10-100	Cq(100)	10;9-12	78;70-83	2
2	5-50	Cq(50)Cp(50)	10;9-12	77;70-80	2
3	25-300	Cq(70)Cp(30)	10;9-11	79;72-88	2
4	10-50	Cq(70)Cp(30)	10;8-11	81;72-92	1
5	10-50	Cq(50)Cp(50)	10;8-11	83;76-93	2
6	5-25	Cq(60)Cp(40)	10;9-12	81;74-89	2
7	5-25	Cq(50)Cp(50)	11;10-13	77;71-82	1
8	5-25	Cq(50)Cp(50)	11;9-12	79;72-90	2
9	5-15	Cq(50)Cp(50)	10;9-12	81;73-92	2

*Expressed as a range obtained in five samples using a one pint dipper.

**Cq = *Cx. quinquefasciatus*, Cp = *Cx. peus*.

***A possible error of up to 24 hours must be added due to varying egg raft age.

+Mean of total number of observations to nearest whole unit.

++Mean of median values for observation period.

(1969). The previous citations were observations made under laboratory conditions. Comparisons to the field results presented here show a small variance, as would be expected. No comparative information is available for *Cx. peus* regarding the developmental time span between oviposition and the appearance of pupae.

The developmental time period required for *Cx. peus* to reach adulthood in the artificial catch basins was found to be 13 to 14 days at an average temperature of about 78°F (26°C) (see Table 2), assuming a maximum egg age of 24 hours. A mean developmental time period of 21 days for *Cx. peus* (egg to adult) at 72°F (22°C) was reported by Gerberg (1970). This information was probably based upon the data of Ball and Chao (1956). However, Gerberg's interpretation may be in error as Ball and Chao actually stated the 21 day time span to be a period starting at the parental female's blood meal and ending at the adult stage of her first offspring. Assuming an oviposition time (blood meal to egg laying) of 6-10 days (Gerberg 1970), an immature developmental period of 12-16 days results. Such a range would seem reasonable based upon the present experiment. The adult sex ratio was approximately 1:1 with the males emerging first.

Tekle (1960) showed *Cx. quinquefasciatus* to require an average of 11 days for 50% of the specimens to reach adulthood at 30°C (86°F) and 13 days at 25°C (77°F). De Meillon and Thomas (1966) relate *Cx. quinquefasciatus* to take 9-10 days at 29°C (84°F). Gomez et al. (1977) reported a total developmental time of 10-11 days at 26°±2°C (78.8°±3.6°F). In the present study an average time period of about 13 to 14 days occurs between the egg and adult stages (assuming egg age to be zero to a maximum of 24 hours) at approximately 78°F (26°C) (see Table 2). Considerable variation (up to 3 days) exists in the laboratory situations cited. It would seem, assuming the laboratory conditions to be similar, that different strains of *Cx. quinquefasciatus* develop at different rates. The validity of this statement, however, has not been established.

Chemical tests performed on the water in the concrete catch basins and in the breeding cups in the artificial catch basins are presented in Tables 3A and 3B, respectively. Note that the trend toward higher ammonia nitrogen in the concrete catch basin is reversed in the breeding cups. The basis for this reversal was not investigated but it apparently has no affect on

Table 2.–Developmental information for *Culex quinquefasciatus* Say and *Culex peus* Speiser in artificial catch basins (July 6 through August 3, 1977).

Catch Basin Number	Species Observed*	Developmental Duration (days)** Adult Median***; Range	Temperature (°F) Average +; Range	Cycles Observed
1	*Cx. peus*	13;12-15		3
	Cx. quinquefasciatus	13;11-15	77;70-81	4
2	*Cx. peus*	13;11-15		3
	Cx. quinquefasciatus	14;12-16	78;71-82	3
3	*Cx. peus*	13;12-15		5
	Cx. quinquefasciatus	13;12-14	78;70-82	6

*Immature density maintained at a maximum of 100 specimens per cup.
**A possible error of up to 24 hours must be added due to varying egg raft age.
***Day on which greatest number of adults emerged.
+Average of total number of observations to nearest whole number.

Table 3.–Summary of water quality tests.

Date	Nitrate Nitrogen* Mean**; Range	Ammonia Nitrogen* Mean**; Range	Chlorine*	pH range
A. Concrete Catch Basins				
Aug. 17, 1976	1;0-8	13;5-32	<0.5	6.5-7.0
Sept. 1, 1976	2;0-8	14;5-40	<0.5	6.0-7.5
Oct. 22, 1976	1;0-5	11;5-20	<0.5	6.5-7.5
B. Breeding Cups in Artificial Catch Basins				
Jul. 13, 1977	14;13-15	7;6-8	<0.5	7.0-8.0
Aug. 3, 1977	14;12-16	7;5-8	<0.5	7.0-8.0
Aug. 30, 1977	14;13-15	6;5-7	<0.5	7.0-8.0
Jul. 13, 1977 Tap water	7	1	<0.5	7.5

*Values expressed as mg/1.
**Values rounded to nearest whole unit.

the immature stages reared in the cups as development progressed in a normal fashion.

Golden Bear 1356 effected 90 to 100% mortality at 24 hours on the immature stages in the concrete catch basins (see Table 4). Kimball and Perruzzi (1970) obtained similar results using Flit MLO Oil (Exxon Oil Co.). Occasionally, some first and second instar larvae survived the oil treatment. Egg rafts were noted at 48 to 72 hours post-treatment. First instar larvae were also found 72 hours post-treatment. Subsequent observations revealed apparently normal larval development with a few pupae present on the eleventh day but most occuring on the twelfth day after treatment. Pupal samples obtained from the basins treated with GB-1356 and reared in the laboratory produced adults of normal external morphology. No tests were performed regarding any possible changes in anatomy, physiology, or behavior. Assuming a possible developmental time minimum of eleven days (see Table 2) to reach adulthood, some adult emergence could occur if treatment were performed on a bi-weekly cycle. Theoretically, though, the majority of the mosquito population would be in the pupal stage at the time of treatment. Overlapping growth stages were usually found to exist in the catch basins, hence any first or second instar larvae not killed at the treatment time could reach adulthood prior to the next oil application. However, the volume of adults produced from this lack of 100% mortality would be minimal.

Catch basin treatment with 1% temephos (Abate) granules yielded 100% mortality of the larval stages at 24 hours post-treatment (see Table 4). Egg rafts were observed in the basins at 24 hours post-treatment. However, live first instar larvae were not found until four days after application of the insecticide. Didia et al. (1975) reported a reduction in mortality after 48 hours when using 2% Abate granules at 2.5 to 5.0 pounds per acre. In the present study, use of 1% Abate at the stated rate of one gram per basin (about five to eight pounds per acre) would require weekly treatments as the larval stage would begin terminating on approximately the twelfth day post-treatment.

Methoprene (Altosid) briquets yielded variable results, probably due to water flow as suggested by Stewart (1977) (see Table 5). In the basin having little or no observed flow, a minimum dosage of one briquet per 10 cubic feet (0.28 cubic

Table 4.—Evaluations of chemical treatments on concrete catch basins (mean temperature of 78°F).

Material	% Mortality 24 hours Post-treatment	Days Post-treatment Egg Rafts Noted*	Days Post-treatment Live Larvae Noted*	Days Post-treatment 50% Pupae Noted*	Cycles Observed
GB 1356	90-100**	2	3	12	6
Abate® 1% granules	100	1	4	13	4

*Mean of total number of observations to nearest whole unit.
**Some early instar larvae survived treatment.

Table 5.—Evaluation of Altosid® in concrete catch basins.

Catch Basin	Water Volume (cu. ft.)*	Number of Briquets Used	% Control 7 days**	% Control 14 days**	Maximum Period of Control (days)***
1	16-24	2	95	90	21
2	20-27	3	95	90	19
3	30-37+	4	70	40	<7
4	15-20	2++	100	100	38

*Water level varied.
**As determined by adult emergence from pupae sampled.
***Time period in which mortality was 90% or better.
+High flow of water through basin.
++Rate is twice that recommended by manufacturer, based upon water depth.

meters) provided acceptable control (mortality of 90% or better) for at least 38 days. Results obtained from the other test basins indicated a need for weekly or bi-weekly applications to attain 90% or better mortality. Though admittedly a small sample size (four catch basins), it appears that each basin would have to be monitored individually in order to ascertain the appropriate treatment schedule to effect acceptable mortality in isolated situations.

ACKNOWLEDGMENTS.—Thanks must be extended to L. Lino Luna, Manager, Northwest Mosquito Abatement District, for his authorization to perform this study. I am indebted to Mr. Kenji Ota, U.C. Riverside, for his assistance in gathering the data presented.

REFERENCES CITED

Ball, G. H. and J. Chao. 1965. Laboratory colonization of *Culex stigmatosoma*. Mosq. News 16:306.

De Meillon, B. and V. Thomas. 1966. *Culex pipiens fatigans* Wied., p. 101-114. IN C. N. Smith, Insect Colonizations and Mass Production. Academic Press, N. Y.

Didia, V., R. LaSalle, and K. Leim. 1975. The effects of Abate 2G® mosquito larvicide on selected non-target organisms collected from forested temporary pools. Mosq. News 35(2):227-228.

Gerberg, E. J., T. M. Hopkins and J. W. Gentry. 1969. Mass rearing of *Culex pipiens* L. Mosq. News 29:382-385.

Gerberg, E. J. 1970. Manual for mosquito rearing and experimental techniques. Amer. Mosq. Control Assoc. Bul. No. 5. 109 p.

Gomex, C., J. E. Rabinovich and E. E. Machado-Allison. 1977. Population analysis of *Culex pipiens fatigans* Wied. (Diptera:Culicidae) under laboratory conditions. J. Med. Ent. 13:453-463.

Kimball, J. H. and N. D. Perruzzi. 1970. Flit MLO preferred for mosquito control in residential areas. Mosq. News 30:128-130.

Tekle, A. 1960. The physiology of hibernation and its role in the geographical distribution of populations of the *Culex pipiens* complex. Am. J. Trop. Med. and Hyg. 9:321-330.

Stewart, J. P. 1977. Field testing of Methoprene (Altosid®) briquets for *Culex* mosquito control. Proc. Calif. Mosq. & Vector Control Assoc. 45:154-156.

DROP-ZONE DETERMINATION FOR AIRBORNE NOZZLES

Bryan T. Whitworth

Tulare Mosquito Abatement District
Post Office Box 1476, Tulare, California 93274

ABSTRACT

In order to obtain a more uniform deposition of droplets on the ground throughout the widest practical swath, tests were done to delineate the "drop-zone" of each nozzle site all along the boom of an airplane.

Cursary examination of the literature indicates that an even and regular placement of nozzles along the boom of an airplane will result in a pattern of droplet-deposition which, when graphed, resembles a range of saw-toothed mountains skewed toward the port side of the airplane. In theory at least, the ideal placement of nozzles would result in a deposition pattern whose graph would resemble a steep-sided plateau rising from the floor of a flat plain.

The placement of nozzles along the boom is usually done empirically; i.e., if the resulting pattern is too heavy or too light in spots, nozzles are moved inboard, outboard, removed, or added to compensate for the discrepancy. The configuration which is finally chosen will usually represent a compromise based on a series of guesses about where the spray from any individual nozzle is ultimately deposited after it enters the air-stream.

In order to properly fix the location of any given nozzle, we numbered all the nozzle positions along the boom of a Piper Pawnee 235 airplane. Beginning at the portside with "PI" at the first regular position; no. 1 as the next position; no. 2 as the next, all were numbered through position no. 41 (which was next-to-the-last on the starboard side). The very last regular position on the aircraft's right-hand (starboard) boom was number SI. (Later, we mounted an additional nozzle into the end-caps of the boom, and called these new nozzle positions PII and SII, respectively.)

Prior to the beginning of our drop-zone experiments, we flew a series of test patterns using the regular nozzle configuration we had always used in our operations. That configuration was: PI, 4, 6, 8, 11, 14, 17, 19, 21, 22, 25, 27, 31, 33, 37, 39 and SI. It resulted in a pattern such as that shown in Figure 1.

Due to variable winds, a site was selected which offered a 360° unimpeded flight path over the test tapes. Such a site was chosen so that the tape could be rotated in any direction throughout the compass in order to nullify any side winds which might have caused lateral drift of the spray droplets.

The droplets to be measured were deposited on a 3½ inch wide adding-machine tape which was laid out at right angles to the flight path and held flat on the ground by a series of four-inch-long pieces of re-enforcing steel. Where the aircraft was to cross, the tape was marked "C" and three men stationed themselves in the line-of-flight as a "rifle-sight" for the pilot.

In order to save flight time during the drop-zone tests, we tested two nozzles at once - all other nozzles positions were plugged off. Because preliminary test flights, using only one nozzle at a time, had indicated an individual nozzle-drop-zone width of 8 to 14 feet, we chose a nozzle separation of about 15 feet along the boom. In other words, we tested nozzles no. 1 and 22; then we tested no. 2 and 23, etc. This separation began near the port side and was moved one-space-at-a-time toward starboard as testing progressed sequentially along the boom.

There were at least five test flights made for each nozzle at 26 PSI (i.e., pressure employed for routine operations) and all flights were made either during dead calm or with a tail wind not exceeding 5 mph. The aircraft flew at a speed of 90 mph and a boom height of 8 feet spraying water (which had been brightly dyed with Rhodamine B) through no. 8 nozzles.

After each flight, the "port side" of the tape was marked with the flight number, the word "Port", and the degree and speed of any cross-wind which, if significant, would have invalidated that particular flight. Taken to the office, the tapes were marked off sequentially (in one-foot increments) from both sides of the center-mark prior to any formal examination of droplet deposition.

The tapes were then examined with the naked eye for gross droplet deposits. A minimum of ten visible droplets per square inch was taken as an arbitrary level of adequacy. The starboard-to-port swath distance for each nozzle during all five flights was noted and the swath width of each nozzle's deposit was determined by using their arithmetic averages.

In order to measure the number of droplets, the tapes were examined under 20X magnification. Using a transparent plastic "C-Thru" ruler, marked with a one-inch rectangle, three randomly-selected sites in each linear foot were examined for droplets-per-square-inch. Droplets which appeared to be less than one millimeter in diameter were not counted, but the averages of all other droplets were noted and graphed as droplets per square inch.

In order to measure quantity of deposits in each linear foot, five randomly-selected droplets were examined using a glass micrometer disc. The second-widest diameter of those five droplets was measured and their arithmetic average size in microns was used as a multiplicand (with the number of droplets per square inch) for that particular linear foot. The product was noted and graphed as (a relative) quantity.

The graph of drop zones for individual nozzles was revealing to us because any given nozzle's drop zone was not where one might expect it to be. A nozzle, inboard by a space or two from another nozzle, might place it's deposit in the outboard position. Or two nozzles, separated from one another by five or six spaces, might deposit onto an identical area on the tape.

The swath-width of the nozzles ranged from a minimum of 3½ feet for no. 27 (just outboard of the propeller's downward thrust) to a maximum of 12½ feet for no. SII, which was the outer-most starboard nozzle mounted into the cap on the very end of the boom. The over-all average swath of any individual nozzle, however, was 8½feet. Not surprisingly, the widest swaths were from those nozzles nearer the wing-tips where the "vortex effect" has it's greatest influence.

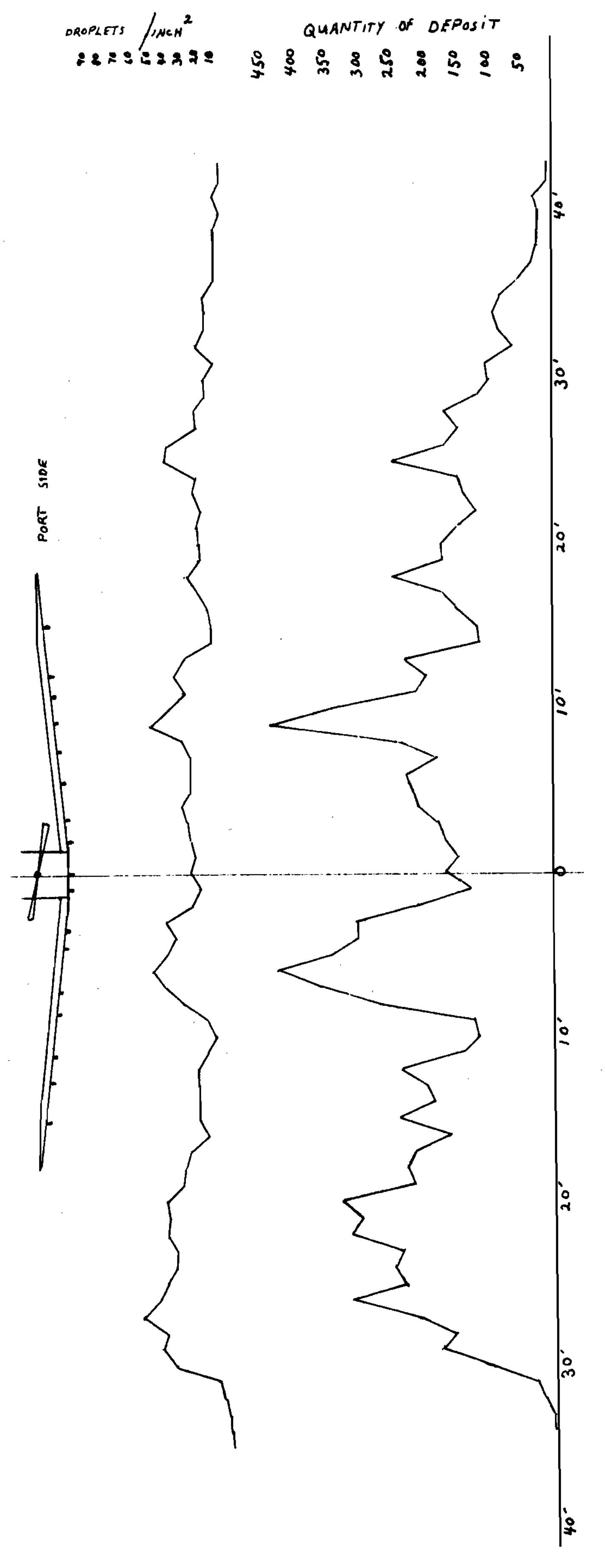

Figure 1.–Old pattern.

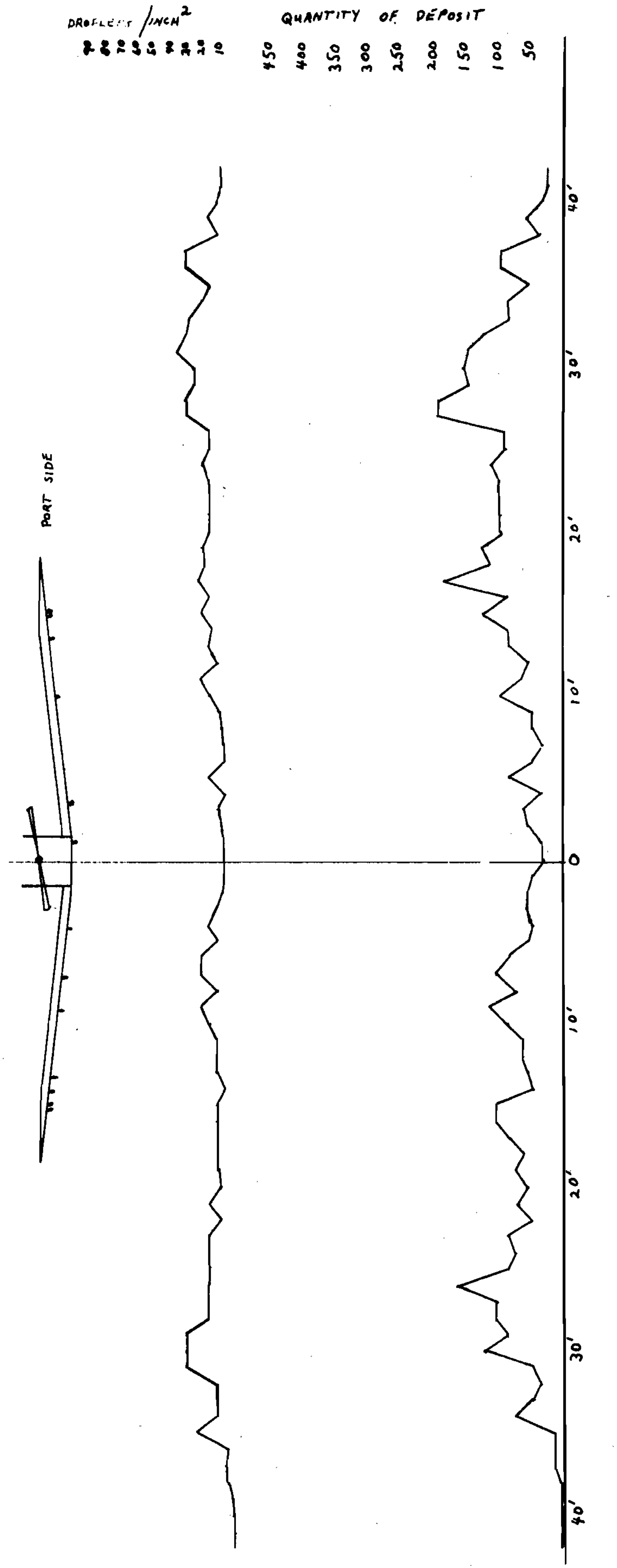

Figure 2.–New pattern.

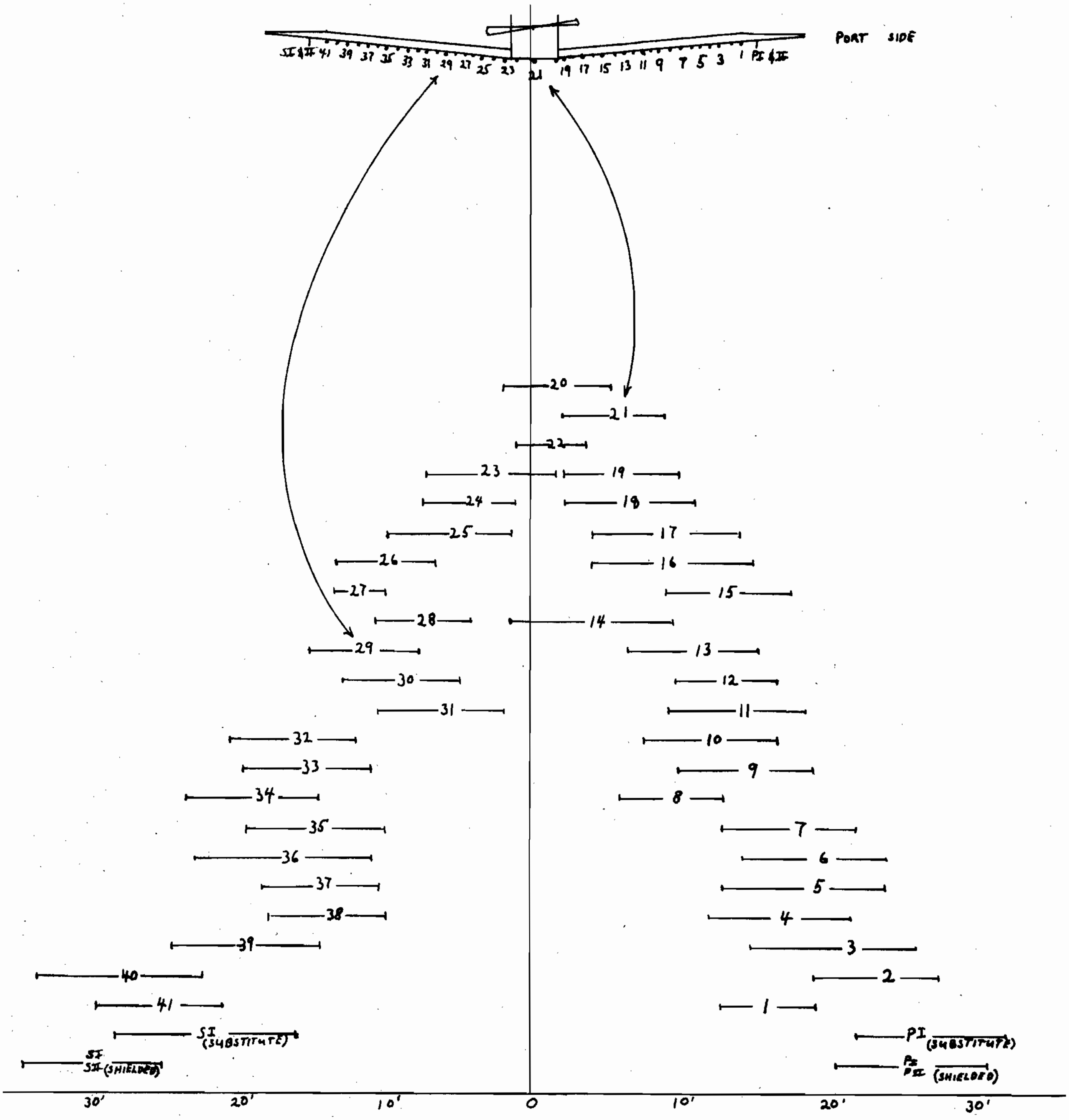

Figure 3.–Swath width of individual nozzles.

By examining the completed graph of all the nozzles (Figure 3) and noting their beginning and ending distances from center, it appeared simple to choose a nozzle configuration which would just exactly fill the entire effective swath width with minimal overlapping and no missed spots. The logical choice was PI sub (an experimental out-pointing, solid-stream, shielded nozzle), and nozzles 7, 8, 20, 31, 36, and 40.

We rigged the boom with that configuration and found that "multiple-tests" (of three tapes laid parallel and separated by ten feet) demonstrated the choice to be adequate for coverage, but limited in droplets-per-square-inch near the outer reaches of the desired swath.

Referring back to the chart of the nozzle drop-zones (Figure 3) showed us the remedy. Therefore nozzles were selected which would deposit more spray where it was formerly lacking. Further flights have shown the effectiveness of the newer configuration. The final choice uses nozzles PI & PII, 2, 7, 17, 20, 26, 31, 34, 40, 41, SI, and SII. By comparing a graph of the pre-test flights (Figure 1) with a graph of a flight using the new configuration (Figure 2) it can be seen that we achieved a reduction from a configuration of 17 nozzles to one using only 13 nozzles with production of a more even (and wider) swath with 25% less output.

During the early part of the tests, we had tried to overcome the vortex effect by substituting the regular nozzles on the boom ends with out-pointing solid-stream nozzles (with shields to eliminate wind-shear) but our effort was not successful. However, we were able to reduce the "vortex effect" somewhat by changing the angle-of-depression from 15° to 0° (directly backward) on each of the two outermost nozzles, PII & SII.

Although the deposition pattern of any given nozzle position would probably change in response to different pressures, aircraft velocity, or elevation, the technique of drop-zone determination would be of value to those who need precise aircraft applications at known elevation, velocities, and pressures.

ACKNOWLEDGMENT.—Special thanks to Tulare Mosquito Abatement District Staff members L. James, W. Stemmler, and J. Thompson for their help and support during these tests.

MOSQUITO CONTROL INVESTIGATIONS IN AN URBAN CEMETERY[1]

M. S. Mulla, H. A. Darwazeh and M. S. Dhillon

University of California
Department of Entomology, Riverside, California 92521

INTRODUCTION. -Cemeteries located in the metropolitan areas of California are developed extensively, each with a large number of grave sites, covering vast areas adjoining populated centers. In the Los Angeles area most of the grave sites are provided with 1 qt. size flower vases, and these vases, if not emptied and turned over after removal of wilted flowers, will harbor large numbers of mosquito larvae. Such heavy breeding of mosquitoes creates a potential pest and health problem in the neighboring communities.

Several methods of control were evaluated by Kelly (1941), Aarons (1948), Shanafelt (1969), and Lewis and Christensen (1973). Some of these measures are effective in small (50-100 acres) cemeteries, but they are costly or impractical to utilize in large areas such as Rose Hills Memorial Park in Whittier, Los Angeles County, California, which covers some 2700 acres.

Recently, studies reported by Mulla et al. (1977) revealed that mosquito larval control could be achieved in large cemeteries by utilizing a slow release formulation of the insect growth regulator methoprene in briquet form. One briquet (10 g containing 4% ai) per vase yielded excellent control for over 158 days. Temephos and chlorpyrifos also were highly effective for 14 and 54 days respectively when applied at the rate of 0.2 lb/acre in 100 gal. of spray. At these high volume rates, it is impossible to treat heavy mosquito breeding sites at Rose Hills Memorial Park with the equipment and manpower at hand, especially after major national holidays such as Easter and Memorial Day when 60-70% of the grave sites are visited.

The following studies, therefore, were initiated to determine the weekly visitation rate, the needed man-hour/acre effort required to invert vases when wilted flowers were removed on a weekly basis, to develop the most practical chemical application methods and rates to increase capability and efficiency of available equipment and personnel, and to study timing and frequency of chemical applications for optimum results.

METHODS AND MATERIALS.–Source Reduction.- -In order to determine the feasibility of utilizing source reduction as a means of mosquito larval control in flower vases in cemetery plots, 9 lawns in Rose Hills Memorial Park were selected in various locations representing old and new sections and flat and hilly terrain. These lawns (Japanese Urn Gardens, Terrace of Light, Terrace of Faith, Memorial Chapel Gardens, Pinewood Urn Gardens, Lakeside Gardens, Veterans Memorial, Ivey Lawn and Skyview Lawn) covering 26 acres in all with a total of 5712 flower vases. At the beginning of the study on March 11, 1977, all the vases in these selected lawns were counted and inverted. Every week thereafter, after counting the vases containing flowers, wilted flowers were removed and vases without flowers were emptied and inverted. On each counting day, records were kept indicating the number of flowers remaining, and time required (man-hours) to remove wilted flowers and invert the emptied vases.

Chemical Control.- -Presently, a Hardie Spray Rig is utilized for mosquito larviciding operation, delivering 100 gal. of spray/acre through 10 Spray-System-Jet nozzles, size 8004, at a speed of 4 mph and 50-55 psi of pressure, yielding a 12 ft. swath. In order to reduce the volume of spray from the current 100 gal/acre rate, the spray rig was fitted with smaller size nozzles and calibrated at various speeds at a constant pressure of 50 psi (Table 2).

Two tests were conducted in which 2 speeds of travel were employed. In the first test, 10 T-Jet 8002 nozzles were utilized to apply chlorpyrifos at the rate of 0.2 lb in 8.5 gal/acre of spray. Ninety-six oz of chlorpyrifos EC2 were mixed with 61.5 gals of water, treating 7.25 acres at a speed of 5 mph. At this speed, it was difficult to manuver the spray rig to avoid running into freshly dug graves, trees, and vases with fresh flowers. Therefore, the second application was applied at a speed of 4 mph, while pressure, nozzles and swath width were kept unchanged. Thirty-two oz of chlorpyrifos EC4 were mixed with 67 gals of water, and 10.5 gal of spray at 0.2 lb/acre of chlorpyrifos were applied, treating 5.2 acres.

Prior to treatment and at intervals thereafter, 30 vases in each treated area and the check were inspected for larval breeding density, and the numbers of larvae and pupae present in each vase were counted and recorded.

RESULTS AND DISCUSSION.–Source Reduction.- -Data obtained during these studies (March 1977-January 1978) indicated that mosquito breeding prevention in neglected flower vases could be achieved successfully at Rose Hills Memorial Park during those periods of the year when visitation rates are low (4 - 6%) by inverting the vases after removing wilted flowers.

As shown in Table 1, inverting the vases after removal of wilted flowers, during the year excluding major holidays, does not require a great deal of time and manpower. This feat can be achieved on the average at the rate of 0.5 man-hour per acre.

Inverting the vases, however, was not feasible during major national holidays when visitation rate was extremely high; in those periods it required a great deal of time and manpower not available in such an extensive development. These holidays include Memorial Day, Easter and Christmas when 69, 59 and 45% of the graves were visited (Table 1).

Chemical Control.- -In light of these findings, 1-3 chemical applications/year using 0.2 lb of chlorpyrifos in about 10 gal/acre of spray would produce excellent mosquito larval control for the most of the year, provided that newly used vases are turned when wilted flowers are removed after each treatment.

Frequency of chemical applications during the year depends largely on climatic conditions such as rain and cold temperature. Under these conditions, no treatment is necessary due to the slow development of mosquito larvae in the neglected vases, and lack of adult activity and oviposition in

[1]These studies were conducted in cooperation with Rosehills Memorial Park, Whittier, California, and the Southeast Mosquito Abatement District, South Gate, California. The assistance of Frank Pelsue, Dr. Jack Hazelrigg, Don Fliss and Joe Hernandez was greatly appreciated.

Table 1.—Determination of weekly visitation rates and time required to remove wilted flowers from vases at Rose Hills Memorial Park (March 1977-January 1978).

	Percent sites visited at indicated locations[a]							
	J. Urns	T. Faith	M. Chapel	T. Light	Lakeside	Ivey, Vets, Skyview	Avg. %	Manhour/acre
Holiday	(269)[b]	(781)[b]	(248)[b]	(410)[b]	(3104)[b]	(866)[b]		
April 18, 1977 Easter	67	35	72	51	55	61	59	1.3
May 16, 1977 Mother's Day	53	14	39	21	22	36	31	0.6
June 6, 1977 Memorial Day	100	46	55	50	68	92	69	1.15
June 27, 1977 Father's Day	48	20	39	23	27	29	31	0.6
July 8, 1977 Independence Day	31	9	20	19	17	16	19	0.4
Dec. 2, 1977 Thanksgiving Day	45	16	16	23	22	26	25	-[c]
Jan. 9, 1978 Christmas and New Years Day	65	30	50	35	48	40	45	-[c]

[a]Wilted flowers were removed 7-10 days after the holiday. 4-6% are visited weekly excluding holidays.

[b]No. of vases in the area.

[c]Heavy rain. Counts were interrupted several times over a period of two weeks.

Table 2.—Calibrated discharge rates of Rose Hills Memorial Garden's Hardie Spray Rig.

T-Jet Nozzle	Pressure (psi)	Discharge rate (gal/acre) at indicated speed mph 4	5	6
8001	50	4.9	3.9	3.2
8002	50	10.5	8.5	7.0
8003	50	18.0	14.3	11.8

the area. For efficient and long lasting chemical application, grass should be cut and wilted flowers should be removed prior to treatment to allow better penetration of the chemical into the vases. As indicated in earlier reports by Mulla et al. (1970) and McNeil et al. (1968), chlorpyrifos was found to be highly effective and quite residual in polluted waters, preventing mosquito larval breeding for more than 60 days. Therefore, a treatment immediately after removal of wilted flowers after the major holidays (when inverting of vases is not feasible) will yield adequate mosquito larval control until the following holiday, when another treatment will be required.

The small T-Jet nozzles No. 8001 were found impractical for larviciding purposes using the Hardie Spray Rig available at Rose Hills Memorial Park. Discharge from the nozzles was in a mist form, and was observed drifting from target area. However, no mist was observed with 8002 and 8003 nozzles, delivering 10.5 and 18 gal/acre respectively at a speed of 4 mph (Table 2). At these discharge rates, one sprayer load is enough to treat 5-10 acres, compared to 5-10 loads with the old set-up. At these rates, more acreage can be treated daily, resulting in a more efficient mosquito control operation. All mosquito breeding sites could be treated in a few days compared to months as required for the old set-up. The new mode of operation provides for great savings in time and effort.

In both tests chlorpyrifos yielded excellent control of mosquito larvae at the rate of 0.2 lb in 8.5-10 gal/acre of spray for over 42 days (Table 3-4). For safety purposes, as previously mentioned, the vehicular speed should not exceed 4 mph. In addition, at this speed, better coverage and penetration with the spray was achieved in target areas near hazardous spots such as trees, hedges, flower beds and freshly dug graves. The operator could maneuver the sprayer as close as possible to these areas with ease.

SUMMARY AND CONCLUSIONS.—Data presented here indicate a good possiblity for instituting an effective mosquito prevention and control program at Rose Hills Memorial Park and other cemeteries. Source reduction (inverting vases after flower removal) should be practiced routinely between major holidays, when visitation rates are low. Larvicides should be applied occasionally, especially after Easter and Memorial days in April and June, soon after flower removal. In steep terrain, where inverting vases is strenuous and chemical application is difficult, methoprene briquets could be utilized, by placing ½ -1 briquet (5-10 g containing 4% ai) per vase upon removal of wilted flowers.

MOSQUITO CONTROL INVESTIGATIONS IN AN URBAN CEMETERY[1]

M. S. Mulla, H. A. Darwazeh and M. S. Dhillon

University of California
Department of Entomology, Riverside, California 92521

INTRODUCTION.–Cemeteries located in the metropolitan areas of California are developed extensively, each with a large number of grave sites, covering vast areas adjoining populated centers. In the Los Angeles area most of the grave sites are provided with 1 qt. size flower vases, and these vases, if not emptied and turned over after removal of wilted flowers, will harbor large numbers of mosquito larvae. Such heavy breeding of mosquitoes creates a potential pest and health problem in the neighboring communities.

Several methods of control were evaluated by Kelly (1941), Aarons (1948), Shanafelt (1969), and Lewis and Christensen (1973). Some of these measures are effective in small (50-100 acres) cemeteries, but they are costly or impractical to utilize in large areas such as Rose Hills Memorial Park in Whittier, Los Angeles County, California, which covers some 2700 acres.

Recently, studies reported by Mulla et al. (1977) revealed that mosquito larval control could be achieved in large cemeteries by utilizing a slow release formulation of the insect growth regulator methoprene in briquet form. One briquet (10 g containing 4% ai) per vase yielded excellent control for over 158 days. Temephos and chlorpyrifos also were highly effective for 14 and 54 days respectively when applied at the rate of 0.2 lb/acre in 100 gal. of spray. At these high volume rates, it is impossible to treat heavy mosquito breeding sites at Rose Hills Memorial Park with the equipment and manpower at hand, especially after major national holidays such as Easter and Memorial Day when 60-70% of the grave sites are visited.

The following studies, therefore, were initiated to determine the weekly visitation rate, the needed man-hour/acre effort required to invert vases when wilted flowers were removed on a weekly basis, to develop the most practical chemical application methods and rates to increase capability and efficiency of available equipment and personnel, and to study timing and frequency of chemical applications for optimum results.

METHODS AND MATERIALS.–Source Reduction.–In order to determine the feasibility of utilizing source reduction as a means of mosquito larval control in flower vases in cemetery plots, 9 lawns in Rose Hills Memorial Park were selected in various locations representing old and new sections and flat and hilly terrain. These lawns (Japanese Urn Gardens, Terrace of Light, Terrace of Faith, Memorial Chapel Gardens, Pinewood Urn Gardens, Lakeside Gardens, Veterans Memorial, Ivey Lawn and Skyview Lawn) covering 26 acres in all with a total of 5712 flower vases. At the beginning of the study on March 11, 1977, all the vases in these selected lawns were counted and inverted. Every week thereafter, after counting the vases containing flowers, wilted flowers were removed and vases without flowers were emptied and inverted. On each counting day, records were kept indicating the number of flowers remaining, and time required (man-hours) to remove wilted flowers and invert the emptied vases.

Chemical Control.–Presently, a Hardie Spray Rig is utilized for mosquito larviciding operation, delivering 100 gal. of spray/acre through 10 Spray-System-Jet nozzles, size 8004, at a speed of 4 mph and 50-55 psi of pressure, yielding a 12 ft. swath. In order to reduce the volume of spray from the current 100 gal/acre rate, the spray rig was fitted with smaller size nozzles and calibrated at various speeds at a constant pressure of 50 psi (Table 2).

Two tests were conducted in which 2 speeds of travel were employed. In the first test, 10 T-Jet 8002 nozzles were utilized to apply chlorpyrifos at the rate of 0.2 lb in 8.5 gal/acre of spray. Ninety-six oz of chlorpyrifos EC2 were mixed with 61.5 gals of water, treating 7.25 acres at a speed of 5 mph. At this speed, it was difficult to manuver the spray rig to avoid running into freshly dug graves, trees, and vases with fresh flowers. Therefore, the second application was applied at a speed of 4 mph, while pressure, nozzles and swath width were kept unchanged. Thirty-two oz of chlorpyrifos EC4 were mixed with 67 gals of water, and 10.5 gal of spray at 0.2 lb/acre of chlorpyrifos were applied, treating 5.2 acres.

Prior to treatment and at intervals thereafter, 30 vases in each treated area and the check were inspected for larval breeding density, and the numbers of larvae and pupae present in each vase were counted and recorded.

RESULTS AND DISCUSSION.–Source Reduction.–Data obtained during these studies (March 1977-January 1978) indicated that mosquito breeding prevention in neglected flower vases could be achieved successfully at Rose Hills Memorial Park during those periods of the year when visitation rates are low (4 - 6%) by inverting the vases after removing wilted flowers.

As shown in Table 1, inverting the vases after removal of wilted flowers, during the year excluding major holidays, does not require a great deal of time and manpower. This feat can be achieved on the average at the rate of 0.5 man-hour per acre.

Inverting the vases, however, was not feasible during major national holidays when visitation rate was extremely high; in those periods it required a great deal of time and manpower not available in such an extensive development. These holidays include Memorial Day, Easter and Christmas when 69, 59 and 45% of the graves were visited (Table 1).

Chemical Control.–In light of these findings, 1-3 chemical applications/year using 0.2 lb of chlorpyrifos in about 10 gal/acre of spray would produce excellent mosquito larval control for the most of the year, provided that newly used vases are turned when wilted flowers are removed after each treatment.

Frequency of chemical applications during the year depends largely on climatic conditions such as rain and cold temperature. Under these conditions, no treatment is necessary due to the slow development of mosquito larvae in the neglected vases, and lack of adult activity and oviposition in

[1]These studies were conducted in cooperation with Rosehills Memorial Park, Whittier, California, and the Southeast Mosquito Abatement District, South Gate, California. The assistance of Frank Pelsue, Dr. Jack Hazelrigg, Don Fliss and Joe Hernandez was greatly appreciated.

URBAN OPERATIONAL SPRAY AND MANAGEMENT PROGRAM BY SOURCE

E. L. Geveshausen, J. H. Sides and F. W. Pelsue

Southeast Mosquito Abatement District
9510 South Garfield Avenue, South Gate, California 90280

One of the most important aspects of a mosquito control program is to maintain, update and support a source inventory. The magnitude of such an inventory became evident when undertaken by the Southeast Mosquito Abatement District which had been operating for 25 years with a zone program and all control in each zone having been the responsibility of one operator.

The different types of sources include natural: rivers, creeks; Agricultural: water troughs, dairy drains, irrigated lands; Industrial: loading docks, cooling towers, valve boxes; Domestic: gutters, swimming pools, fish ponds, air conditioners. The number and variety of these to be found in a District comprising 650 sq. miles with a population in excess of 3,000,000 made it necessary to set up a reference log. In such a highly urbanized area, Range and Township maps were not available. Highly developed areas as Los Angeles County do have street guide atlases, such as the Thomas Bros. Guide, which are commercially available. These are usually drawn on a scale of 1 inch to 2800 feet, with each page divided into 1¼ x 1¼ inch blocks, 36 blocks to each page and covering approximately 16 sq. miles.

Upon completion of the inventory of sources by type, the District separated the types of source into subtypes, e.g., Domestic: swimming pools, fish ponds and water falls. Each source was then posted on large wall charts showing type, subtype, address and map reference number. Wall charts are particularly useful for quick reference. All of this information was then compiled into book form for field use.

Personnel of the District are then assigned specific source types and by using the field books inspect and spray if necessary. At the conclusion of a days work each source was dated on wall charts. The type of source which requires the most control is gutters, which carries the runoff from lawn watering. Gutters are so widespread it is impractical to list each gutter as a source, consequently, all are listed as a single source. Eighteen vehicles are used to spray gutters. Each vehicle is assigned a block of 10 sq. miles daily for control work. At the end of each day that block is then color flagged on a large wall map. Reference to records of work completed and work to be done is readily available. Color flagging reduces the chance of duplication. The average distance per month of gutter spraying in the Southeast Mosquito Abatement District is 4,500 miles. This figure represents miles actually sprayed.

Listing of our source inventory is as follows:

1. Natural:
   - A. Rivers
   - B. Creeks
   - C. Lakes
   - D. Flood control channels
2. Agricultural:
   - A. Pastures
   - B. Irrigation and waste ditches
   - C. Water troughs
3. Industrial:
   - A. Waste ponds and sumps
   - B. Waste ditches
   - C. Valve boxes
   - D. Fire barrels
   - E. Loading docks
   - F. Apartment drains
   - G. Coolant towers
4. Domestic:
   - A. Swimming pools
   - B. Fish ponds
   - C. Roadside ditches
   - D. Outfalls
   - E. Freeway drains
   - G. Gutters
   - H. Catch basins

Such a list will not cover every source type but does show the major sources that result in 99% of the service requests received by the District. Sources that cause the remaining 1% of service requests usually necessitate intense survey and inspection to root out the origin.

Results of this program are very promising after the first year of operations. The number of service requests have been reduced, whether from a more intensive spray program or weather conditions, we are not certain. Final determination of the efficacy of this program over the previous zone type program will be made after a three to five year program evaluation. When making a change from one type of program to another it is necessary to involve all of the field personnel and to seek their enthusiatic cooperation. Change in many ways can lead to enthusiasm in the performance of their duties. In conclusion, a change in program emphasis has led to fewer service requests, increased work performance per individual, a reduction in time between receiving a service request and answering the request, and arriving at a satisfactory solution or service level for the complainant.