Now, whenever a big red fire engine rolls rapidly down the street the people on the streets are, in spite of themselves, more or less thrilled; and I think something of the same impression is created by your pretty red and yellow, green and blue jeeps—somebody's going to have a pink jeep some of these days, I'm waiting to see that — but the people who see that red fire engine often overlook the fact that a real company has done most of its work — it spends most of its time and effort — trying to keep from the necessity of having that equipment roll; and the same think is true of the forward-looking mosquito abatemeit district. They are spending a good deal of their time and a good deal of their effort trying to make it unnecessary to roll those jeeps and do that spraying. The fire company must depend for the success of its work on education, to teach people how to avoid fires, on regulation to handle the people who will not be taught, and of course on proper construction. I think we have a very similar situation with the mosquito work. By education, by regulation, by proper construction, we can reduce the need for spraying. Now, because you use so many jeeps, because you have to do so much spraying in California, people have gained the impression in a great many places that all of California mosquito work is spraying; yet when you dig into what is being done in the different districts you find out that there has been for a long time quite a lot of attention paid to the more permanent methods of mosquito control, and if you will stop for just a minute and consider what we've faced in the way of increased acreage, increased potential mosquito control problem areas, you will see that we must, if we are going to be completely successful in our objectives, find some way to do this job other than by spraying. Now, in attempting to develop this panel I'm very frank to say that I had a lot of help from the people who are going to speak on the panel in developing the outline, and we finally arrived at the thought that we should attempt to present the material in a way which would fit the several broad types of mosquito control which is necessarily being practiced in California, so we have separated our discussion really into five sections or categories, one of those being permanent control on tidewater areas, the second being permanent control in irrigated lands flooded continuously, and the third being permanent control on lands flooded intermittently, again a subject, permanent control in river-bottom areas, and then permanent control on industrial, residential, or other private properties.

Now we hope we may be able to reserve even a little time for discussion at the close of the presentation, so with that little bit of introduction we will go into the presentations by the individuals who will participate, starting with Mr. Gray, and we've asked him to give you a broad objective view of mosquito control methods and processes.

Mr. Gray: Thank you, Mr. Mulhern. I have been just slightly nettled during the course of the Conference by a rather obvious fact, that some of you have heard the words that I have said, but you have not listened to what I said. We'll have them kidding me a little bit about permanent control, and it is not always applicable. You did not hear me say that. The reduction of water to the lowest extent practicable was what I actually said; now you cannot find it practicable to cut the water out of rice fields, so let's understand what terms we are using and the limitations of some of the generalities I put out. Now, these are generalities also which I am going to give you. I have tried to put them precisely so that there can be no misunderstanidng as to what I am saying. I am going to read it, partly for speed and partly for exactness.

A BROAD, OBJECTIVE VIEW OF MOSQUITO CONTROL METHODS AND PROCESSES

By Harold F. Gray

Engineer-Manager
Alameda County Mosquito Abatement District

The primary purpose of all mosquito control measures is to reduce or minimize the numbers of mosquitoes in a particular geographical area. To accomplish this purpose we may use one of three principal methods of attack, or combine two or more methods according to circumstances. Basically, we may (1) eliminate, curtail, or unfavorably modify the available production water; (2) we may kill the immature aquatic forms — eggs, larvae, and/or pupae; or (3) we may kill adults. These measures may be applied (1) against a disease vector species only (species sanitation), or (2) against a pest variety for prevention of economic loss or to promote public comfort, or (3) against all mosquito species in an area, according to the specific requirements of a particular situation, or the economic means available, or the aesthetic and comfort standards of the people.

There are two basic criteria by which mosquito control methods are judged: (1) they must be adequately effective for their intended purpose. and (2) they must be economical — that is, they must be (a) within the ability of the beneficiaries to pay; (b) less in cost than the value of the health or economic gains involved; (c) the least expensive method (in the end) shall be used.

As to the choice of the three principal methods, various factors must be evaluated. So much depends upon the ecology and the habits of the particular species of mosquitoes to be controlled that a valid choice of method can be obtained only after an entomological appraisal of the species involved and an engineering estimate of relative costs and practicability.

In general, under temperate climate conditions, and in areas of average or better than average economic productivity, the elimination or drastic reduction of the area of mosquito production water is ultimately both more effective and more economical than any other possible method. Supplementary larvicidal methods are generally necessary, but become less necessary as the water eliminative measures are completed. The use of adulticides then becomes unnecessary except in emergencies or special situations such as cemeteries.

Methods for the elimination of mosquito production water will vary with the topography of the ground, the amount and seasonal distribution of rainfall, and the extent and type of application of water for irrigation or industry. Dogmatic statements as to what can or cannot be done are either impossible to make, or ill-advised. But a few generalizations can be offered.

Complete elimination of production water may be impracticable, therefore we aim at its reduction to the least practicable area within reasonable costs. At that point.

we should next try to apply those measures which will make the residual water unsuitable to mosquito production. Salinification, controlled flooding and reflooding, constant level flooding with *Gambusia* propagation, are just a few suggestions in this field of operations. We have not adequately explored and exploited such opportunities for mosquito control. Also, I doubt that we have adequately explored and exploited the possibility of using pumps, both stationary and portable, in reducing the area of mosquito production water.

To depend upon insecticides for mosquito control, under temperate climate conditions, and particularly in California, as the primary control measure is a serious error, but it is also a mistake to fail to use them adequately and effectively in their proper place as supplements to eliminative procedures. Much ingenuity has been applied in this sector, some of it probably misdirected in emphasis, and some valid ideas which have been broached in the past are still not acted upon. Too much thought has been given to economy in materials, and not enough to effectiveness in results. The DDT-resistant mosquito is the unfortunate end product. And because of high labor costs, more attention probably needs to be given to the concepts of accessibility, convenience, and the overall time factor in insecticide applications, and in the inspectional services to diret them.

Finally, we have adulticidal methods. Adequate eliminative methods with supplemental larvicidal methods should make adulticidal measures unnecessary. But we all make mistakes, we all have failures of inspection, we all at times experience unusual and unforeseen conditions. We will no doubt continue to need adulticides to cover up our mistakes and our failures, but we should limit, except in special conditions, our adulticidal measures to covering up our mistakes and dificiencies.

Mr. Mulhern: It sounds like Harold has made a good start on keeping those fires out of Alameda County. We've asked Jack Kimball to talk a little on

PROGRESS OF ELIMINATIVE WORK IN TIDEWATER AREAS, ORANGE COUNTY, CALIFORNIA

By Jack H. Kimball

Manager, Orange County Mosquito Abatement District

Introduction

The elimination of unnecessary mosquito breeding sources has a major place in the control program of the Orange County Mosquito Abatement District, especially in the tidewater areas along its fifty miles of ocean shoreline. This District was created late in 1947 and includes some 777 square miles of area within Orange County with a population of 200,000 persons. Eleven incorporated cities are within the boundaries of the District. Although the District has had only two years of operating experience, the pattern of mosquito breeding and possible permanent control measures in the tidewater areas has already become apparent. The District approach to this problem can best be summarized by its three objectives, the first two of which have been attained: (1) Learning the problem; (2) Preparation of data for simplified presentation of the problem; and (3) The determination of the most economical solution.

Learning the Problem

In appraising the tidewater breeding problem a coordinated program of entomological statistics, operational experience, and engineering analysis has been followed. During the past two years Entomologist John G. Shanafelt, Jr. has made constant observations and collections of these mosquitoes, and has coordinated their ecology with physical factors such as temperature, rainfall, storm water runoff, habitat, and tidal floodings. Distinct patterns of breeding habitat have been developed for *Aedes taeniorhynchus* and *Aedes squamiger*, and are shown on the large coastal strip map in green and red respectively. These two species have not been found breeding on the same areas. The *taeniorhynchus* have been found only on salt-marsh areas subject to flooding by extreme high tides. The *squamiger* have been found only on salt-marsh areas isolated from tidal floodings by elevation or by the construction of dykes, dams, roads, or other improvements. The flooding of these particular salt-marsh areas by storm run-off produces the breeding source desired by our *Aedes squamiger.*

Cycles of *Aedes taeniorhynchus* breeding during 1948 and 1949 followed closely the cycles of monthly high tides, with first hatches occurring in May and continuing every month through September. Location of breeding sources was complete, and treatment by larviciding with 2% DDT oil solution by means of hand sprayers and power sprayers mounted on our two weasels was satisfactory.

The breeding sequence of *Aedes squamiger*, on the other hand, has been found to be relatively unpredictable, and constant inspection of these areas is required every month of the year. This conclusion was drawn from sad experience during the spring of 1949. Fourth instar larvae of *Aedes squamiger* were first taken on February 11, 1949, and were collected from time to time until April 25th. Although larviciding treatments were effective on the known breeding spots, many sources were undiscovered, since adult *Aedes squamiger* were collected from Huntington Beach, Costa Mesa, and several other inland communities as late as June 3, 1949. On September 23rd another plague of adult *squamiger* was discovered in Huntington Beach. The source of this flight was traced to a nearby reclaimed salt-marsh area that had been flooded by oil well drilling operations and coincidently by a break in the bank of an irrigation drainage ditch.

Intensive inspections were begun following the first seasonal rains early in November and continued at weekly intervals in order to find and eliminate any new "out of season" hatches of *Aedes squamiger.* The first rains soaked into the ground on the larger known breeding sources; however, first instar larvae were found at the mouth of a small canyon just north of San Clemente on November 6, 1949. Rain water from later rains flooded the larger salt-marsh areas extending from Newport Beach into Los Angeles County, and first instar larvae were found throughout these areas on December 28th. Several plots were selected for untreated controls, and are being inspected and records kept of the development of the larvae. The balance of the breeding areas are being larvicided as rapidly as possible, using two weasels equipped with power sprayers for the larger flooded areas and hand sprayers for the spotted areas. At the present time the *squamiger* at San Clemente have just about reached the pupa stage, three months after hatching.