

## OPERATIONAL NOTE

### INTEGRATED VECTOR MANAGEMENT GUIDELINES FOR ADULT MOSQUITOES

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**ABSTRACT.** A written document was developed to clarify the District's adult mosquito-management tactics to other interested individuals and agencies. The program described consists of 7 discrete components: 1) initiation criteria, 2) treatment area delineation, 3) agricultural and land-use practices, 4) meteorological conditions, 5) continuance criteria, 6) termination criteria, and 7) factors influencing implementation. The guidelines were adopted as policy by the District's Board of Trustees in 1998 and have been implemented in each of the last 5 years. The adult mosquito population is monitored with 6 Mosquito Magnet<sup>®</sup> traps strategically located in the rice culture areas. Samples are collected daily and laboratory technicians notify the Adulticide/Airplane Coordinator of collection results before 1:00 p.m.

**Key Words** Mosquito Magnet<sup>®</sup>, rice fields, AC gravid traps, integrated vector management, ultralow volume, *Culex tarsalis*, *Anopheles freeborni*

The Sacramento/Yolo Mosquito and Vector Control District (SYMVCD) encompasses 2 counties in northern California with a total of 2,013 square miles. Twenty-four mosquito species have been identified within the boundaries of the District and develop in a great diversity of natural, domestic, and agricultural sites (Meyer and Durso 1999). Sacramento County is primarily urban and Yolo County rural, with a large portion dedicated to agriculture. Rain ponds, treeholes, roadside ditches, and wetlands represent the majority of immature mosquito-development sites during the spring. Rice fields, row crops, irrigated pastures, and wetlands are the primary focus of the District control efforts in the summer. Duck clubs, wetlands, and reflooded rice fields are the dominant mosquito-development sites during the fall.

Within SYMVCD's boundaries, rice fields represent the primary development site for *Culex tarsalis* Coq., the encephalitis mosquito, and *Anopheles freeborni* (Aitken), the western malaria mosquito, during the spring and summer months. Rice-field mosquito production has been managed by larviciding and adulticiding when rice field regions meet established treatment criteria. Currently, the District has defined 5 rice culture regions, 3 in Yolo County and 2 in Sacramento County. The growers in each area vary their planting dates, acreage, and farming practices, resulting in a production season from May until mid-September. Total rice acreage in the District during 2002 was calculated to be approximately 43,000 acres.

The mild northern California climate (moderate winter temperatures) is conducive to continuous mosquito development. As a result, the District maintains active mosquito and mosquito-borne-

disease surveillance programs throughout the year. Mosquito-borne-disease surveillance consists of monitoring 10 sentinel chicken flocks, submitting mosquito pools for arbovirus testing, mist netting and obtaining blood samples from wild birds for arbovirus testing, and dead bird collections. The adult mosquito population is currently monitored by 10 AC-powered gravid traps, 24 Mosquito Magnet<sup>®</sup> (MMT), and 40 American Light Traps (ALT).

All geographic areas delineated as rice field production regions have a strategic trapping site selected by laboratory staff for at least 1 adult mosquito surveillance device. Currently, the District monitors the adult population in these areas with MMTs. These traps provide samples that contain very few nontargets, making them ideal devices for quick processing of population data. MMTs operate continuously with only a propane tank service once every 4 weeks. Samples are collected on a daily basis by field technicians and returned to the main laboratory, usually before 10:30 a.m. Laboratory technicians are responsible for mosquito identification and notification of collection results to management. Normally, results are reported before 1:00 p.m.

Before 1997, the District implemented the annual rice field ultralow volume (ULV) applications based on a calendar date, usually the first week in July, and treated as weather conditions allowed on a Monday-Friday schedule. It became evident that external factors such as private and government environmental groups would begin to scrutinize and eventually dictate how the District would execute its adult mosquito-management program. To make these management practices defensible, we decided to develop a series of logical reasons to initiate,

continue, and terminate our control program and to organize these guidelines into a document.

In 1998, the District completed development of a written document that would serve as a template for its adult mosquito-management program. The program was titled Integrated Vector Management (IVM), Adult Mosquito Application Guidelines. This program was adopted by the District Board of Trustees in 1998 as a District policy and has been implemented in each of the last 5 years.

The program was intended to be flexible and since its inception has continued to evolve. It has been organized to address the following conditions: 1) What event or circumstance would trigger adulticiding activities? 2) What area should be treated? 3) Do agricultural or land-use practices occur in the treatment area that impact the application of public health pesticides? 4) What environmental conditions should be considered before treatment? 5) What conditions would necessitate additional treatments? 6) What events or conditions would terminate the application program? And 7) what external factors could modify the program?

The document currently has 7 components: 1) initiation criteria, 2) treatment area delineation, 3) agricultural and land-use practices, 4) meteorological conditions, 5) continuance criteria, 6) termination criteria, and 7) factors that influence implementation. The program was organized as a flow chart with a series of conditions that must be attained before implementing the application of pesticides.

At present, 7 separate conditions have been recognized as program triggers. The circumstances that initiate the adult mosquito-management program currently are 1) a mosquito-borne disease isolated from a mosquito or mosquito pool within the District boundaries, 2) serological conversion to a mosquito-borne disease in a sentinel chicken or other animal within the District boundaries, 3) a mosquito-borne disease detected in a live or dead bird or other animal within the District boundaries, 4) human illness caused by a mosquito-borne pathogen within the District boundaries, 5) an MMT or encephalitis virus surveillance (EVS) trap collection within the District boundaries with 100 or more female *Culex tarsalis* per collection for 3 consecutive days, and/or 150 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species per collection for 3 consecutive days, and/or 200 or more total female mosquitoes per collection for 3 consecutive days, 6) an ALT collection within the District boundaries with 10 or more female *Culex tarsalis* per collection for 3 consecutive days, and/or 25 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species per collection for 3 consecutive days, and/or 50 or more total female mosquitoes per collection for 3 consecutive days,

or 7) a 1-min sweep net or landing-count collection within the District boundaries with 10 or more female *Aedes* or *Ochlerotatus* species and/or 25 or more total female mosquitoes. If any 1 of the 7 events or conditions is attained, the scope of the ULV activities is then determined.

Before ricefield cultivation begins each year, the Adulticide/Airplane Coordinator is responsible for determining the location, acreage, rice variety, and grower for each rice field within the District boundaries. Variation in soil types and available irrigation water from the Sacramento River has created 5 distinct rice culture regions. Within each of these areas, ground ULV spray routes are designed based on vehicle access, acreage to be treated, and coverage.

Once an initiation or continuance criterion is attained within a rice culture region, the agricultural and land-use practices within that region are then considered. If the initiation or continuance criterion is outside the rice culture region, the Adulticide/Airplane Coordinator defines the treatment zone boundaries and the agricultural and land-use practices within that treatment area are then considered.

Changes in agricultural and land-use practice within SYMVCD during the last 10 years have resulted in the District amending the adult mosquito-management measures. For example, 1 rice culture region has been established on a wildlife refuge and the rice is organically grown. At present, 3 conditions posed as questions must be met before environmental conditions are considered. The first question is: Are endangered or threatened species present within the treatment area? Within the District boundaries, 6 animal species, Swainson's Hawk, *Buteo swainsoni*; Greater Sandhill Crane, *Grus canadensis tabida*; Western Yellow-billed Cuckoo, *Coccyzus americanus occidentalis*; Bank Swallow, *Riparia riparia*; Giant Garter Snake, *Thamnophis gigas*; and Valley Elderberry Longhorn Beetle, *Desmoceras californicus dimorphus* are listed as either endangered or threatened. All except the Valley Elderberry Longhorn Beetle are found in both Sacramento and Yolo Counties. All of these species inhabit or frequent potential adult mosquito-management sites such as agricultural fields, rice fields, irrigated pastures, wetlands, marshes, and waterways. Other than the Valley Elderberry Longhorn Beetle, which is present only from January until May, most are present when mosquito populations are active. The program currently considers the presence of endangered or threatened species within a delineated treatment area.

If endangered or threatened species are not present, the next question posed is whether the treatment area is an environmentally sensitive habitat. The District has defined environmentally sensitive habitats as vernal pools; wetlands; riparian

areas; organic farms; state, federal, local wildlife areas; or other areas posted as such. In addition, 5 protected communities, California bunch grass prairie, California oak woodlands, California ocutt grasses, northern hardpan vernal pools, and riparian systems exist in the District. Many of these habitats have specialized flora and fauna that are not compatible with adult mosquito-management measures. These concerns are addressed before treatment and application routes are eliminated or adjusted accordingly.

The last agricultural and land-use practice that has an impact on the adult management program is whether the presence of organically grown crops are within the treatment area. A major challenge to the program has been the increase of organically grown rice adjacent to standard rice fields. At present, the District meets the organic standard criteria for larviciding. Unfortunately, no effective adulticides registered in California are approved by the California Certified Organic Farmers. As a result, the District does not adulticide within a half-mile perimeter of these fields.

One permanent and 2 trailer-mounted weather stations are maintained at fixed sites and are used to monitor meteorological conditions within the District boundaries. Two stations are located in rice-culture areas, 1 in each of the counties; and the third is located in southern Yolo County to monitor marine weather conditions. The weather stations are equipped with temperature probes set at heights of 5 and 33 feet to detect inversions and an anemometer situated at 33 feet to monitor wind speed and direction. Each weather station is linked via phone modem to a computer at the District's main facility, thereby providing real-time weather data.

Beginning about a half hour before dusk, meteorological conditions are monitored by the Adulticide Airplane Coordinator. If a 1° or better temperature inversion exists between the temperature probes and winds are less than 8 miles per hour at dusk, approval is given by radio to truck-mounted ULV units to apply appropriate public health pesticides. If conditions do not meet criteria, then the event is rescheduled for the following day. Adverse weather (windy conditions), the result of marine air moving through the Carquinez Straits from the San Francisco Bay area, is the primary reason treatment criteria are not achieved on a consistent basis.

Once the initiation criteria have been achieved, subsequent daily pesticide applications are triggered by any of the following continuance criteria: 1) a previous 24-h MMT or EVS trap collection with 100 or more female *Culex tarsalis*, and/or 150 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species, and/or 200 or more total female mosquitoes, 2) a previous 24-h ALT collection with 25 or more female *Culex*

*tarsalis*, and/or 50 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species, and/or 75 or more total female mosquitoes, or 3) a 1-min sweep net or landing count collection of 10 or more female *Aedes* or *Ochlerotatus* species and/or 25 or more total female mosquitoes.

If a mosquito-borne disease is detected within the District boundaries, the continuance criteria are automatically lowered to the following levels: 1) a 24-h MMT or EVS trap collection with 25 or more female *Culex tarsalis*, and/or 50 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species, and/or 75 or more total female mosquitoes or 2) a 24-h ALT collection with 10 or more female *Culex tarsalis*, and/or 25 or more of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species, and/or 50 or more total females. Once activated, the program will continue until a termination criterion has been attained.

During the first season the program was instituted, we realized that criteria should be developed to justify the conclusion of adult-management measures. During the last 5 years, the current termination standards have worked well, ending the rice-field portion of the program within a time frame between middle September to early October. The program is terminated once any of the following conditions are attained: 1) a calendar date after December 1st, 2) MMT or EVS trap with less than 100 female *Culex tarsalis* per collection for 5 consecutive days, and/or less than 150 of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species per collection for 5 consecutive days, and/or less than 200 total female mosquitoes a collection for 5 consecutive days, 3) an ALT with less than 10 female *Culex tarsalis* per collection for 5 consecutive days, and/or less than 25 of any female *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, or *Orthopodomyia* species per collection for 5 consecutive days, and/or less than 50 total female mosquitoes per collection for 5 consecutive days, 4) a 1-min sweep net or landing-count collection less than 10 female *Aedes* or *Ochlerotatus* species during the next sampling period and/or less than 25 total female mosquitoes a night for the next sampling period, or 5) 10 consecutive nights with unfavorable environmental conditions for adult mosquito-management measures. Until a termination criterion has been attained, continuance criteria are evaluated. Typically, once the program is initiated in July, it continues until the rice fields are drained in August and September.

From the beginning, 1 of the primary program objectives was to build in flexibility to address an ever-changing adult mosquito-management environment. To address possible external

modifications to our current approaches and unforeseen events, we added factors that could influence implementation of the program. Seven potential influences are recognized: 1) availability of a suitable adulticiding material, 2) susceptibility of mosquito populations to adulticiding materials, 3) environmental conditions not listed in the program, 4) availability of District funding or resources, 5) legal or political legislation, 6) unforeseen biological conditions, or 7) presence or absence of mosquito-borne disease. To this point in time, none of these factors has been significant. However, California's continuing budget crisis or the arrival of West Nile virus in California may require the District to modify the program in the near future.

IVM programs have been successfully implemented in California for over 25 years (Boyce and Rosenfeld 1980). To our knowledge, this is the first written document to outline an adult mosquito IPM program. The program has been operational for the last 5 years and, in our opinion, has been very successful in establishing standards to manage rice field mosquitoes. In addition, the District has

received positive input from other stakeholders, such as the U.S. Fish and Wildlife Service as well as state and local agencies interested in mosquito-management approaches in and near sensitive areas. We believe this document has allowed us to define our program and provides others a clear understanding for the need to implement effective adult mosquito-management practices within our District.

A copy of the program flow chart is available by contacting Ken Boyce at [kboyce@sac-yolomvcd.com](mailto:kboyce@sac-yolomvcd.com) or Dave Brown at [dabrown@sac-yolomvcd.com](mailto:dabrown@sac-yolomvcd.com).

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