Overview of Mosquito Control Practices in California

This document provides information about mosquito control practices used in California, and links to additional information about mosquito control related topics.

Fundamentals of Organized Mosquito Control Programs in California

Mosquito control programs conducted by government agencies in California are based on the principles of Integrated Pest Management.

Mosquitoes

Definition of mosquitoes as a pest

Mosquitoes are defined as a pest because their biting is a nuisance and they can transmit diseases to humans and domestic animals.

Disease Transmission:

Some mosquitoes transmit ("vector") disease-causing viruses to humans and domestic animals when they bite. As the number of biting mosquitoes increases, so does the chance that humans and domestic animals may get diseases such as West Nile virus (WNV), Saint Louis encephalitis, and western equine encephalomyelitis.

Annoyance:

Many species of mosquitoes that bite humans and domestic animals do not transmit disease-causing organisms to humans; nevertheless, their bites cause allergic reactions in many people. When populations of mosquitoes are high, they can harm livestock productivity, drive tourists away from outdoors-related businesses, and decrease the quality of life.

Biting Adult Mosquito

Photo Courtesy of Dr. Robert K. Washino
And Sacramento-Yolo MVCD
Web site: www.fightthebite.net/vectors

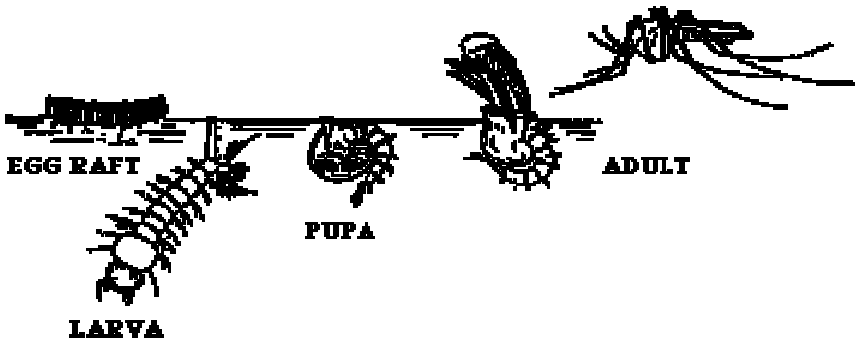
Why do mosquitoes need to be controlled?

Mosquitoes need to be controlled because they are pests and can vector disease-causing organisms, particularly when mosquito populations build to undesirable levels.

Mosquito biology

Mosquitoes have a life cycle that includes egg, larva, pupa, and adult. Standing water is required for the completion of every life stage except the adult.

Mosquito Life Cycle



Graphic Courtesy of American Mosquito Control Association Web Site. www.mosquito.org

The speed of larval development depends on water temperature and may take from 4 days to more than a month for the mosquito to mature from egg to adult. Only adult mosquitoes can fly and bite. After they emerge as adults, mosquitoes can fly up to several miles.

Adult male mosquitoes are not a direct health concern as they feed only on nectar from flowers, and usually live a few days to couple of weeks. In contrast, adult females can live for several months, and feed on nectar and blood.

Mosquitoes live in every area of California, and can be a threat to the health of humans and domestic animals throughout the state.

More information about mosquito biology is available by following the following links to the American Mosquito Control Association (AMCA) web site.

Information about mosquito biology: http://www.mosquito.org/mosquito-information/biology.aspx

Information and frequently asked mosquito questions: http://www.mosquito.org/mosquito-information/faq.aspx

Preventing Mosquito Problems

You are responsible for your own health!

Photo Courtesy of CDC web site.
http:// ww.cdc.gov/ncidod/dvbid/westnile

Citizen responsibilities

It is important for California residents to take action to prevent mosquito production and reduce the number of mosquitoes around their homes while local vector control agencies reduce mosquito populations over large geographic areas.

Californians are responsible for protecting themselves

California residents can take simple and inexpensive precautions to avoid being bitten by mosquitoes, and to eliminate mosquito breeding sites.

These include:

- Use insect repellent while outdoors – particularly at dawn and dusk when vector mosquitoes are most active. Repellents come in many brands and formulations. Repellents containing DEET, oil of lemon eucalyptus, or picaradin are most effective.

Repellents come in many brands and formulations

- Wear loose fitting clothing with long pants and sleeves while outdoors.
- Use screen doors and ensure that window screens are in good repair.

** Use of brand names does not imply endorsement by the California Department of Health Service

It is virtually impossible to prevent mosquitoes from biting domestic animals. Some mosquito-vectored disease such as WNV in horses and dog heart worm can be dramatically reduced through the use of vaccines or other preventive medicines. In some instances high value animals may be protected through repellents approved for use on livestock, and by housing the animal indoors and excluding or controlling mosquitoes inside the enclosure.

Sonic devices have proven universally ineffective at repelling mosquitoes when subjected to rigorous scientific scrutiny. (1)

Mosquito breeding site - source reduction

Over watering turf and watering trash cans produces mosquitoes in municipal parks

Photo Courtesy of Tim Howard

Mosquito populations in many areas can be reduced by eliminating larval development (breeding) sites. Larvae can develop anywhere water stands for at least 5 days. Vector species prefer stagnant water.

In an urban or suburban setting, homeowners can prevent mosquitoes from developing on their property by eliminating containers holding water and making sure that ponds and fountains are clean and well maintained. Containers that produce mosquitoes in yards include buckets, wading pools, ponds, flower pots, trash receptacles and recycling bins, irrigation control box lids, boats (covered and uncovered), aquariums on porches, bird baths, rain gutters and down spouts. Regular cleaning and maintenance can eliminate many of these mosquito breeding sites. In much of California, residents watering gardens, grass, and potted plants provide the water for backyard mosquito breeding.

Filling in tire ruts, avoiding over-irrigation, maintaining irrigation systems and preventing sprinkler systems from filling trash barrels are management / maintenance practices that can reduce mosquito production. It is also important to maintain swimming pools so that they are free of algae and mosquitoes.

Tire ruts can produce many mosquitoes!

Photo Courtesy of Fairfax County, Virginia Health Department web site.
http://www.co.fairfax.va.us/service/hd/westnile/wnveliminate.htm

Catch basin mosquito problem

In agricultural areas, farmers who use drip or other low volume irrigation systems reduce runoff and mosquito production.

Inside cities and developed areas, runoff from landscape watering, car-washing, and storms often collects in retention devices long enough to produce mosquitoes. Regular inspection and maintenance of these devices reduces water retention and mosquito production.

Removing cattails

Problem eliminated – Temporarily

Everyone can participate in eliminating mosquito larval development sites!

** Catch basin photos courtesy of Marco Metzger, Ph.D. California Dept. of Health Services DCDC-VBDS Caltrans project.

Harborage reduction

Adult mosquitoes seek cool, shady, humid areas of lush vegetation or structures (e.g. under wooden decks, under eaves, in buildings, pipes and culverts) to rest during the daytime. These resting places are called harborage areas.

Mosquito populations can be reduced by mowing grass and weeds as short as possible and thinning shrubs to allow air circulation through plants. Maintenance activities such as screening areas under porches and gazebos; and removing leaves, tree bark, boards, and other debris also reduce mosquito harborage areas.

Vector Control Programs

Role of public agencies in mosquito control

In the past, diseases such as malaria and yellow fever caused significant human suffering and death in the United States. West Nile virus (WNV), Saint Louis encephalitis virus and western equine encephalomyelitis are found in California and can cause serious disease. Public agencies must also maintain vigilance for foreign mosquito-borne diseases such as dengue fever, Japanese encephalitis, and Rift Valley fever that could be introduced into California.

Government agencies at the national, state, and local level have the responsibility to supplement the preventive activities of individual citizens toward protecting humans and domestic animals from mosquito- and other vector-borne diseases. Public health agencies track cases of mosquito-borne diseases. Mosquito and vector control agencies monitor mosquito populations and take actions to reduce mosquito population size.

Governing laws and regulations

In California, local vector control agencies have the authority to conduct surveillance for vectors, prevent the occurrence of vectors, and abate production of vectors. (California Codes: Health and Safety Code Section 2040).
Vector control agencies also have authority to participate in review, comment, and make recommendations regarding local, state, or federal land use planning and environmental quality processes, documents, permits, licenses, and entitlements for projects and their potential effects with respect to vector production. (California Codes: Health and Safety Code Sections 2041)
Web link: http://caselaw.lp.findlaw.com/cacodes/hsc/2040-2055.html

Additionally, agencies have broad authority to influence landowners to reduce or "abate" the source of a vector problem. Actions may include imposing civil penalties of up to $1000 per day plus costs associated with controlling the vector. Agencies have authority to "abate" vector sources on private and publicly owned properties. (California Codes: Health and Safety Code Section 2060-2065).
Web link: http://caselaw.lp.findlaw.com/cacodes/hsc/2060-2067.html

Many Federal and State Laws govern the activities of vector control agencies, including the Clean Water Act (CWA), the Endangered Species Act (ESA), and the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Pesticide application by vector control agencies in California is regulated under FIFRA. FIFRA is administered through the Environmental Protection Agency, and regulates the registration, labeling, and sales of pesticides in the United States. In California, mosquito control agencies are also regulated by sections of the California Health and Safety Code, Food and Agriculture Code, California Code of Regulations, and others.

Mosquito and vector control programs that enter into a cooperative agreement with the California Department of Health Services are exempted from some pesticide related laws under Title 3 of the California Code of Regulations section 6620. Specifically, these agencies are exempted from “Consent to Apply” (Title 3 California Code of Regulations Section 6616), “Notice” (Title 3 California Code of Regulations Section 6618), and the “Protection of Persons, Animals, and Property” (Title 3 California Code of Regulations Section 6614). Essentially, these provisions obviate the vector control agency from having to notify or get permission from landowners prior to applying a pesticide to their property in the interest of preserving the public health.
Web link: http://www.dcpr.ca.gov/docs/legbills/calcode/030201.htm

A vector control technician working at a vector control agency must be a “certified technician” or work under the direct supervision of a “certified technician” to apply pesticides. Vector control technicians achieve certification through an examination process administered by the California Department of Health Services.

Vector control agencies cannot use any pesticide not registered for use in California, and are required to keep detailed records of each pesticide application, including date, location, and amount applied. All pesticides must be applied in accordance with the labeling of the product as registered with the EPA.

Surveillance

Vector control agencies determine the need for mosquito control by conducting routine surveillance. These regular surveillance activities enable the agency to monitor mosquito populations, species composition and help determine where and when control activities should be initiated.

Mosquito Surveillance

Dipper with mosquito larvae

Photo Courtesy of Tim Howard

Vector control agencies regularly inspect areas of standing water for immature mosquitoes. Mosquito larvae will develop in nearly any standing water, from marshes and flooded fields to urban runoff catch basins and backyard swimming pools.

Adult mosquito monitoring trap
carbon dioxide baited

Photo Courtesy of Tim Howard

Adult mosquitoes are monitored with mosquito traps and reports of mosquito annoyance.

Virus Surveillance

Vector control programs monitor mosquito-borne viruses through testing adult mosquitoes and chickens from special flocks. With the appearance of WNV, cataloguing and testing of dead birds can provide additional information about virus transmission in areas of California that have no other surveillance system in place.

Dead American Crow
(*Corvus brachyrhynchos*)

Photo Courtesy of Center for Disease Control and Prevention

Finally, public health and agriculture agencies share information on cases of mosquito-borne virus infections in humans and horses with vector control agencies. All these sources of information are important in determining which actions will have the most effect in reducing vector populations, and when and where action should be taken to reduce mosquito populations.

Integrated Pest Management

When surveillance efforts indicate that mosquito control is necessary, vector control agencies rely on a multi-pronged approach called integrated pest management (IPM). IPM is a strategy that incorporates a variety of methods to control mosquitoes. These methods include habitat modification, biological predators, and chemical application. When properly implemented, IPM is an effective, environmentally sensitive, and cost-effective approach to mosquito control. Regular internal and external review ensure that IPM programs in California meet these objectives while adhering to the highest scientific and safety standards available.

Habitat Modification

Wetlands, swamp lands, and salt marshes can be important areas for mosquito production. In the past, marshes and wetlands were drained to reduce mosquito populations. The recognized value of these limited resources as vital components of the ecosystem has led to their protection under state and federal environmental laws. Mosquito control districts in California currently work with many other government agencies and conservation groups to implement practices that decrease mosquito production without harming these environmentally sensitive areas. Some of these approaches include:

- Ditching to maintain water circulation into and out of the marshes. This disperses stagnant water and provides natural biological control organisms like fish improved access to the marshes.

- Periodically burning cattail, bull rush, and other wetland vegetation on a several year rotation to reduce dead vegetation in the system, and maintain water movement. Burning has the ancillary benefit of also destroys some mosquito eggs.

Dusk at Carpinteria Salt Marsh Reserve – Santa Barbara County

Photo Courtesy of University of California Natural Reserve System
http://nrs.ucop.edu/reserves/carpinteria/Carpinfo.html

Link to the UC Davis web site: http://www.mosquitoes.org/downloads/8117.pdf to find additional information about mosquito control on constructed wetlands In California.

Biological Mosquito Control

Biological control of mosquito larvae is the preferred method in many permanent mosquito breeding sites when site modification or elimination is not possible or practical.

Mosquito fish

In California, many mosquito control agencies rear and stock small fish (*Gambusia affinis*) that eat mosquito larvae. These fish can be placed in ornamental ponds, stock watering tanks, ponds without game fish, and a variety of other locations as a biological control for mosquito larvae. Although the fish are not native to California, the California Department of Fish and Game and the US Fish and Wildlife Service allow their use in most areas. Other fish species including guppies (*Poecilia reticulata*) are also used for larval control.

Mosquito Fish (*Gambusia affinis*)

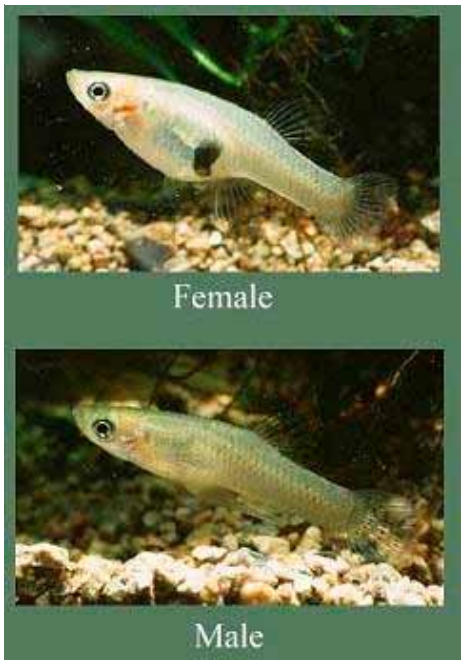


Photo Courtesy of Shasta MVCD web site
http://www.snowcrest.net/mosquito

Biological control reality and myths

There are many myths about the ability of bats, birds, dragonflies, and other species to control mosquito populations. All of these species (and many others) do prey upon mosquitoes; however in most mosquito producing habitats, their contribution to reducing mosquito numbers is insignificant compared with the other methods described here.

In general, permanent water bodies with stable water conditions do not produce large numbers of mosquitoes. Wave action in larger water bodies and a diverse community of predatory aquatic invertebrates reduce mosquito production in these habitats. Most mosquito sources that produce large populations of mosquitoes are either temporary in nature, highly variable in water level, or are in other ways not conducive to an overall diverse invertebrate community.

Bats and birds

Bats and birds (such as martins and swallows) do consume some mosquitoes; however the bulk of their diet consists of larger organisms and their impact on mosquito populations is negligible.

Little Brown Bat
(*Myotis lucifugus*)

Photo Courtesy of Missouri Department of Conservation
www.conservation.state.mo.us/help/copyrite.html

Setting out martin boxes and bat roost boxes may benefit these species and is not harmful if the boxes are placed away from homes or other buildings; however this will not affect the local mosquito population. (2, 3, 4)

Frogs

Adult frogs in California consume adult mosquitoes; however the bulk of their diet is larger organisms. Adult frogs do not eat enough mosquitoes to have a significant impact on mosquito populations.

Immature frogs (tadpoles) are commonly thought to consume mosquito larvae. Tadpoles actually feed on algae and other small organic debris and are not a significant predator on mosquito larvae.

Others

Many aquatic invertebrate species such as dragonfly naiads, damselfly nymphs, and aquatic beetles feed on mosquito larvae. Some of these organisms may be useful for biological mosquito control; however there are practical limitations and unanswered biological questions that prevent using them for mosquito control at the present time.

California dragonfly – Skimmer
(*Libellula sp.*)

Photo courtesy of Rod Miller California Dragonflies and Damselflies www.sonic.net/dragonfly

Biological mosquito control is an important tool – one that scientists in California continue to develop as new control organisms are considered or alternative methods of using existing organisms are identified.

Chemical Control of Mosquitoes

To prevent or control large populations of mosquitoes, vector control agencies implement more direct efforts to combat them. Often these measures entail the application of chemicals. Each local program manager uses mosquito and virus surveillance data to determine how and when chemical control of mosquitoes is required.

Mosquito Control Decisions

Chemical control of mosquitoes is implemented when mosquito populations reach a level that health officials feel represents an unacceptable increase in the risk of disease transmission to humans or domestic animals, or when biting mosquitoes become intolerable to the local population. The action level or "threshold" is determined by each mosquito control program and varies according to local conditions.

The threshold for larval control is usually quite low, often a single larva in one dipper full of water.

Larval development site inspection and treatment

Photo Courtesy of Lewis C. Keenan

The threshold for adult mosquito control is variable and depends on several local factors including:

- The tolerance of local citizens to nuisance mosquitoes
- Presence of mosquito-borne disease in the region
- Percentage of mosquito population that are vector species
- The local citizen's acceptance of mosquito control activities

Way above any treatment threshold!
(460,000 mosquitoes from one trap in one night)

Photo Courtesy of Thomas Janousek, Ph.D.

Pesticides

Pesticide basics

According to the United States Environmental Protection Agency (US EPA) Web Site:

> A pesticide is any substance or mixture of substances intended for: preventing, destroying, repelling, or mitigating any pest.

Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. (Web address: http://www.epa.gov/pesticides/about)

Pesticide related industries are some of the most highly regulated in the United States. Scientific scrutiny of the effectiveness of the product, the potential harmful effects to humans, and the potential non-target effects is intense.

Pesticide labels are legal documents that direct the use of the product for each pest species and location where it can be used. In addition to the label, a Material Safety Data Sheet (MSDS) has been prepared for each pesticide. The MSDS gives a great deal of additional information about the product.

Pesticide label - Larvicide

Links to product labels and MSDS for at least one product with each active ingredient used in California are provided in Tables 1 and 2.

Information about every pesticide registered for use in California by the US EPA and the California Environmental Protection Agency - Department of Pesticide Regulation (DPR) is available at: http://www.cdpr.ca.gov/docs/label/m4.htm

Pesticide resistance

Mosquito control programs have worked to reduce mosquito populations in California since 1909. Pesticides have been applied to kill mosquitoes in California for over 70 years. During that time there have been some small but important genetic changes that have made the mosquitoes able to survive exposure to some pesticides. The increased ability to survive pesticide exposure is called resistance. Development of resistance to a pesticide can produce resistance to other pesticides with a similar active ingredient or that work in a similar manner. The ability to survive exposure to a chemical is often passed on genetically and will spread through a population.

Pesticide resistance to older pesticides including organophosphates has been documented in many mosquito populations in California. Resistance to pyrethroid insecticides has been demonstrated in some species of mosquitoes in limited areas of California. This means that some pesticides should not be used in some areas of California because only a portion of the mosquito population would be killed when sprayed at the maximum legal rate.

Throughout California, mosquito control professionals in conjunction with state and federal agency personnel and university researchers are working to develop effective mosquito control strategies that maximize the efficiency of pesticides and minimize their use. This helps ensure that when chemical control of mosquitoes is necessary, there will be effective chemicals to use against them.

Larval Control

Control of larval mosquitoes is the backbone of most mosquito control programs in California. Pesticides added to the water to kill mosquito larvae are called larvicides. These products may be applied by hand, with a power backpack, from all terrain vehicles (ATV's) or trucks, and in very large or inaccessible areas with helicopters and airplanes.

Larval control products

There are 4 families of larvicides with a total of 7 active ingredients registered for use in California. (Table 1).

1. Bacterial Products

Bacillus thuringiensis var. *israelensis* (Bti) and *B. sphaericus* (Bs) sold under various trade names are bacterial products that are commonly put into the water to control mosquito larvae. When a larva consumes the bacteria, proteins produced by the bacteria bind with and destroy the stomach lining of the mosquito larva. The products remain effective for about 24 to 48 hours. Bs products contain live bacteria and if conditions are favorable remain effective for more than 30 days. These are very mosquito-specific products and when properly used pose little threat to non-target species, including humans.

2. Surface Agents

Mosquito larvae and pupae breathe at the water's surface through special tubes that extend above the water surface. Surface agents are highly refined mineral oils or monomolecular films that spread across the surface of the water. Mineral oil works by clogging the breathing tubes causing the immature mosquitoes to suffocate. Mono-molecular films work by reducing the surface tension of the water causing larvae and pupae to drown. Surface products are effective for a few hours to a few days, depending on the product. These products may also affect other organisms (like aquatic beetles) that have do not have gills and breathe at the water's surface. Surface agents are the only products effective against mosquito pupae.

3. Insect Growth Regulators (IGR's)

Early spring larviciding

Photo Courtesy of Lewis C. Keenan

Methoprene and dimilin are chemicals that are added to the water to disrupt the normal maturation process of mosquito larvae. The effective life of the product varies with the formulation. One formulation of methoprene has an effective life of 150 days. Methoprene can be applied in known larval development sites prior to flooding.

Dimilin is a restricted use pesticide because it is potentially toxic to aquatic invertebrates. Methoprene is not a restricted use product, and has minimal non-target effects.

Like Bti, methoprene poses little health concern for mammals and is safe to use in human drinking water sources.

4. Chemical Larvicides

Temephos is currently the only organophosphate registered for use as a larvicide in California. This product can be safely and effectively utilized in areas of temporary water where there are few non-target organisms and livestock are not present. Effective life span of temephos is up to 30 days depending on formulation of the product. This product can be applied to known larval development sites prior to flooding.

Common larvicides registered for use in California are listed in Table 1.

Table 1: Larvicides Registered in California

Classification	Active Ingredient	Trade Name	EPA Reg. #
Bacteria			
	Bacillus sphaericus (Bs)	Vectolex CG	275-77
		Vectolex WDG	73049
		Vectolex WSP	73049-20
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	Bacillus thuringiensis var. *israelensis* (Bti)	Vectobac 12AS	73049-38
		Vectobac G	73049-10
		Vectobac G	275-50
		Vectobac technical powder	73049-13
		Aquabac 200G	72637-3
		Bactimos briquettes	6218-47
		Teknar HP-D	73049-404
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
Surface film			
	monomolecular film	Agnique MMF	2302-14
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	petroleum oil	GB-1111	8329-72
Label and MSDS link: Http://www.clarkemosquito.com/product_detail.cfm?productid=112&categoryid=6&parentlist=4.6			
Insect growth regulator			
	dimilin	Dimilin 25W	400-465
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	S-methoprene	Altosid pellets	2724-448
		Altosid ALL	2724-446
		Altosid briquettes	2724-375
		Altosid SBG	2724-489
		Altosid XR-G	2724-451
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
Organophosphate			
	temephos	5% Skeeter abate	8329-70
		Abate 2-BG	8329-71
Label and MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=106&categoryid=6&parentlist=4,6			

Refer to Appendix 1 for explanation of pesticide formulation abbreviations.

Adult Mosquito Control

Adult mosquito control is a means to rapidly knockdown biting adult mosquitoes. This can become necessary when larval control measures are insufficient or not feasible. Adult mosquito spraying is an important part of an IPM mosquito control program. In some areas of California, chemical control of adults is the only mosquito control option. Chemicals used for adult mosquito control can be dispersed into the air to target flying mosquitoes, or applied to vegetation and structures to kill resting mosquitoes.

ULV spraying

Most products used for adult mosquito control (adulticides) are formulated for use via ultra-low volume (ULV) spray technology. ULV spraying (also occasionally called cold fogging) is the process of putting very small amounts of liquid (typically 4 ounces per acre or less) into the air as a fine mist of droplets. These droplets float on the air currents for up to 1 hour and quickly kill mosquitoes that come into contact with them. ULV adulticides are applied when mosquitoes are most active – typically sunset and early evening.

Truck mounted ULV spraying

Photo Courtesy of Mike McGinnis

ULV spraying is usually done over large geographic areas consisting of several acres to several square miles. Unlike agricultural or structural pesticide applications where the chemical is applied directly to a crop or structure, a ULV formulation is sprayed into the air column where it can contact and kill active mosquitoes. Aerial movement of the ULV product is an essential part of the application. ULV applications are only done during environmental conditions that insure desirable product movement.

Aerial ULV in a mountain valley

Photo Courtesy of Mike McGinnis

ULV products are most effective when applied during the period just before sunset into the early evening. A shorter window of time around dawn can also be an effective time to spray.

ULV applications can be done from the ground using vehicle mounted

sprayers, or from the air using helicopters or airplanes. All spray equipment is required to be regularly calibrated to insure safe and effective applications.

Non-Target Effects

In general, the risk of adverse effects from ULV applications to people living in the area being sprayed is low. Nevertheless, individuals with existing health problems such as severe asthma, emphysema, other respiratory impairments, or highly chemically sensitive conditions should contact the local vector control agency when they move into an area. Often, the local vector control agency will be able to provide individuals with information on which products are used and when the products will be applied. Some local agencies maintain lists of residents who indicate their property should be excluded from adult mosquito spraying.

By spraying a very small volume of insecticide per acre, using small droplets, and spraying after sunset or at dawn, ULV applications are able to target mosquitoes while minimizing the affects to other insects.

Barrier spraying

Backpack barrier spray

Photo Courtesy of Lewis C. Keenan

The other common type of adult mosquito control application is a “barrier” spray. This process is typically used prior to an outdoor event (like a wedding reception or family reunion). Barrier applications can be done on private property by a vector control agency, a private pest control contractor, or a private individual on their own property. Treatment may be effective in an area of up to several acres for a few days.

In a barrier application, a broad spectrum insecticide is applied directly to vegetation and other surfaces where a mosquito may land (under decks, gazebos, etc.). When mosquitoes land on the treated area they absorb a fatal amount of pesticide.

Non-target effects

Barrier sprays are effective because they use a higher rate of pesticide application than other adult mosquito control activities. The increased amount of pesticide will kill most insects for a few days where the product is applied. Pesticides used for barrier applications in California break down into inert chemicals rapidly under environmental conditions and have very low toxicity to mammals.

Adult Control Products

As of June, 2008, there are at least 2 families of pesticide with a total of 9 active ingredients registered for adult mosquito control in California.

1. Organophosphates

Organophosphates (OPs) are neurotoxins that cause uncontrolled, repeated firing of neurons. Malathion and naled are OPs registered for use in California. Malathion is most frequently used early and late in the season, with pyrethroids being used as adulticides during the bulk of the mosquito control season.

2. Pyrethrin (natural)

Pyrethrins are natural insecticides derived from plants, primarily chrysanthemums. Pyrethrins act to block chemical signals at nerve junctions. Pyrethrins are broad spectrum insecticides that are widely used in agricultural and structural pest control.

2. Pyrethroids (synthetic)

Permethrin, resmethrin, sumithrin, and deltamethrin are all active ingredients classified as pyrethroid insecticides. Pyrethroids are synthetic pesticides that are very similar to natural pyrethrum in their chemical structure and mode of action.

Insecticides with either natural pyrethrins or synthetic pyrethroids as the active ingredient usually incorporate a synergizing agent, piperonyl butoxide (PBO). PBO reduces the ability of the insect to break down the active ingredient, allowing the insecticides to be effective with less active ingredient than would otherwise be required.

Pyrethroids can be toxic to fish. These products will not affect fish when used according to the label instructions, because there is a large safety margin built into the label restrictions. The products have very low toxicity in mammals, including domestic animals and people. In fact, flea and tick sprays that are applied directly on dogs and cats have much larger amounts of pyrethroids than mosquito control products but are not harmful to the animal.

A list of products commonly used to control adult mosquitoes in California is presented in Table 2. Links to labels and MSDS for each adult control product are provided, as well as links to commonly asked questions for at least one product from each family of adulticide.

In addition, the exciting agent prallethrin is combined with the toxicant sumithrin in the Clarke mosquito control product "Duet".

Table 2: Adulticides Registered in California

Classification	Active Ingredient	Trade Name	EPA Reg. #
Organophosphate			
	malathion	Fyfanon ULV	4787-8
Information Link: http://www.health.state.ny.us/nysdoh/westnile/education/2740.htm Label and MSDS link: http://www.adapcoinc.com/product_adulticides.jsp			
	Naled	Dibrom concentrate	5481-480
Label link: http://www.stlucieco.gov/pdfs/Dibrome label.pdf MSDS link: http://www.stlucieco.gov/pdfs/Dibrome msds.pdf			
Pyrethrin			
	pyrethrins	Evergreen Crop Protection EC 60-6	1021-1770
		Pyrenone 25-5	432-1050
		Pyrenone crop spray	432-1033
		Pyrocide 7396	1021-1182
Label and MSDS link: http://www.adapcoinc.com/request msds.php			
Pyrethroids			
	resmethrin	Scourge insecticide 4%	432-716
Information Link: http://www.health.state.ny.us.nysdoh/westnile/education/2739.htm Label and MSDS link: http://www.adapcoinc.com/request msds.php			
	sumithrin	Anvil 10+ 10 ULV	1021-1688-8329
Information Link: http://www.atsdr.cdc.gov/consultations/west_nile_virus/phenothrin.html Label link: http://www.clarkemosquito.com/product_detail.cfm?productid=5&categoryid=23&parentlist=4,23 MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=5&categoryid=23&parentlist=4,23			
	permethrin	Aqua-Reslin	432-763
		Permanone RTU	432-1182
		Biomist 4 + 12 ULV	8329-34
Label and MSDS link: http://www.adapcoinc.com/request msds.php Label and MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=2&categoryid=23&parentlist=4.23			
	deltamethrin	Suspend SC	432-763
Label and MSDS link: http://www.backedbybayer.com/bayer/cropscience/backedbybayer.nsf/id/EN_Pest_Labels_MSDS			

Refer to Appendix 1 for explanation of pesticide formulation abbreviations.

Basic Toxicology

Most chemicals and substances have the potential to negatively affect some living organism if they are present in large enough quantities. For a chemical to have a toxic effect, the amount taken in must be enough to overcome the natural protective mechanisms of the organism. Toxicology is the study of the harmful effects of chemicals and substances to living organisms.

Definitions for toxicology

Toxicity: The inherent potential for a chemical or substance to harm living organisms.

Exposure: Coming into physical contact with a chemical or substance. Toxic effects can occur from contact with skin, through breathing, through oral ingestion, or through more than one route.

Dose: The amount of a chemical that gets to a location in an organism where it can cause some change.

Risk: The likelihood of negative health effects associated with some substance.

Relative Risk: Comparing the likelihood of negative health effects associated with different actions taken.

Mosquito control products and human health

Risks to people and domestic animals from mosquito control products are very low because people are exposed to small amounts of chemicals that are not very toxic.

The following was taken from the New York Health Department web site relative to the use of adulticides in New York but is equally applicable to California:

“The risk associated with the use of these products depends on the toxicity of the ingredients and the extent of exposure an individual has to them. The application rates for the active ingredients in the adulticide products are quite low, ranging from 0.0035 to 0.23 pounds per acre. As a result, exposure of the general public to adulticides is likely to be very low. …”

Human health risks associated with larvicides are lower than those associated with adulticides. Larvicides not only are very low in toxicity to mammals, but also are applied to sites where the potential for human contact is negligible. (e.g., storm drains, sewage treatment plants, abandoned swimming pools etc.).

Bottom line – Relative risk

Reported West Nile virus infections in the United States between 1999 and the end of 2004 resulted in 666 human deaths and 8313* cases of neuro-invasive disease. Tens of thousands of birds and thousands of horses have also died or been euthanized as a result of WNV.

* Includes total human case count for 1999 through 2002. Data from 2003 and 2004 was separated into neuro-invasive disease versus milder flu-like illness. Prior to 2003 milder forms of the disease were not routinely diagnosed as WNV related illness. Case data is from the U. S. Center for Disease Control and Prevention and the United States Geological Survey available on their web sites.

WNV clearly poses risks to the health and welfare of humans and domestic and wild animals. Unnecessary exposure to pesticides should be avoided; however the demonstrated health risks from WNV are greater than potential risks associated with mosquito control activities. (5)

Toxicity of Mosquito Control Products

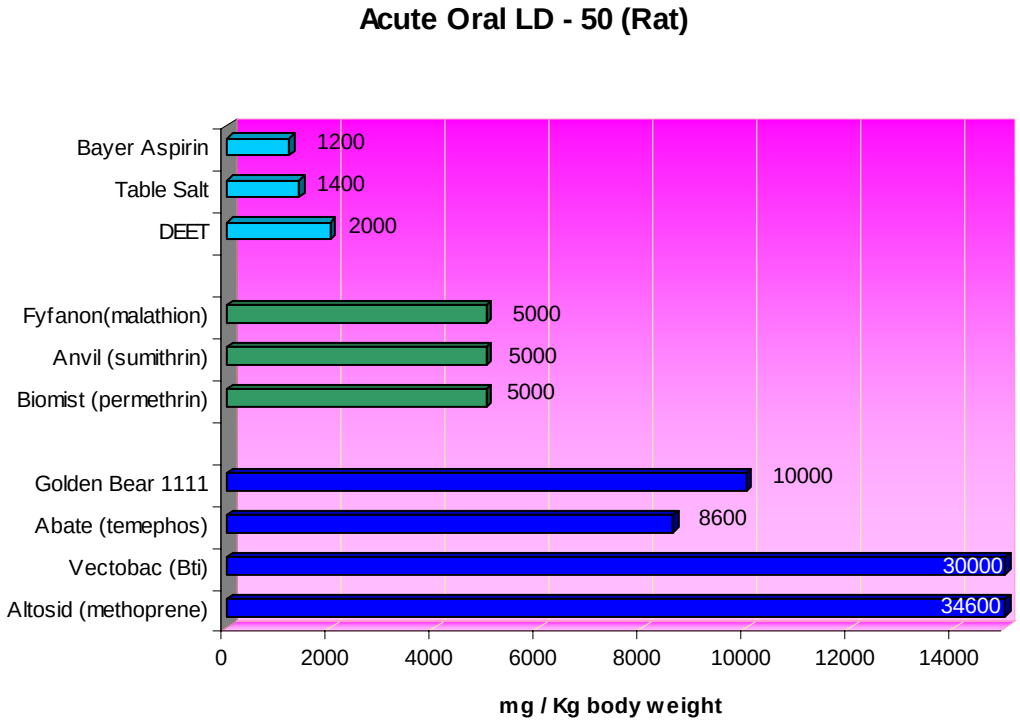
How toxic a substance is to a particular type of animal is often reported as a lethal dose to 50% of a test population (LD–50). Specifically what the LD–50 number indicates is how much of a given chemical it would take to have a 50% chance of killing an organism based on the body size of the organism. LD–50 is a measure of a dose that quickly kills an organism, it does not account for chronic (non-fatal) effects.

Human toxicity is looked at based on the fact that humans are similar in physical make up and function to other mammals. The following chart compares the mammalian oral LD–50 for two substances that humans readily consume to mosquito adulticides and larvicides.

A lower LD–50 means a substance is more toxic - it would take less of the substance to kill the organism ingesting it. What is demonstrated below is that products used to control mosquitoes are less toxic (even when ingested) than Bayer aspirin or table salt. Mosquito control products have much lower dermal (skin exposure) toxicity than oral toxicity.

Chart 1: Relative LD50 Data for Mosquito Control Products

* DEET is the active ingredient found in many insect repellents.



Note 1: shorter lines = lower LD – 50 = more toxic substance.

Additional Sources of Information

Pesticides - Additional information can be obtained from the Oregon State University web site: http://npic.orst.edu

Or from the EPA website: http://www.epa.gov/pesticides

Pesticide Poisoning - Detailed information about symptoms and treatment can be found in EPA publication: Recognition and Management of Pesticide Poisonings, 5th ed. available as a handbook or on Compact Disc. The information is also available on the EPA website:
http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm

Pesticide Labels and MSDS – available on many web sites and an internet search of any pesticide name or EPA registration number will give additional information
http://www.greenbook.net/

West Nile Virus - Additional information is available from the CDC web site:
http://www.cdc.gov/ncidod/dvbid/westnile/

Maps of WNV activity - Available from the United States Geological Survey: (USGS): http://westnilemaps.usgs.gov/

Insect Repellent - Information is available from the CDC web site:
http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect_repellent.htm

DEET - Information is available from CDC web site:
http://www.epa.gov/pesticides/factsheets/chemicals/deet.htm

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Appendix 1

Definitions of pesticide formulation abbreviations

Abbreviation	What it means
CG	clay granule
WDG	water dispersible granule
WSP	water soluble packet
AS	aqueous solution
G	granule
HP-D	high potency dipteran active
MMF	mono-molecular film
W	wettable powder
ALL	Altosid liquid larvicide
SBG	single brood granule
XR-G	extended residual granule
BG	Biodac granule
ULV	ultra low volume
RTU	ready to use
SC	soluble concentrate

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