

INTEGRATED MOSQUITO MANAGEMENT IN THE TIME OF INVASIVE AEDES MOSQUITOES

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Since the turn of the 21st century, the work of pest control companies in California has been focused on ants, termites, bed bugs, roaches and rodents. These, along with spiders, silverfish, stored-product insects, fleas and other arthropods are considered to be “urban” or “structural” pests because they are most commonly associated with human dwellings in urban and suburban settings. Other types of pests are associated with agriculture, turf and landscapes, post-harvest stored foods, livestock and pets. Some pests can be found in more than type of setting. For example, filth flies can be a nuisance in residential areas and a problem at poultry farms. Mealybugs can be a problem for citrus growers as well as in citrus trees growing in someone’s yard.

Mosquitoes are mainly thought of as outdoor pests in places like campgrounds, wilderness areas, marshes and swamps. They are also considered to be major summertime pests in regions of the U.S. that get lots of rain in the spring and summer. California does not usually come to mind as a state with a huge mosquito problem. However, in the last few years, two invasive mosquitoes that are not native to our state have become a huge problem in some areas. These mosquitoes, the “yellow fever mosquito”, *Aedes aegypti*, and the “Asian tiger mosquito”, *Aedes albopictus*, have a close association with humans which makes them a true urban pest. They have become such a big problem that some pest control companies have even added mosquito control as part of their services.

Controlling mosquitoes is very important not only because they can be extremely annoying, but also because many mosquito species vector (transmit) some very serious diseases. In fact, mosquitoes are the world’s deadliest animal, and cause more human deaths worldwide than any other creature, even humans, sharks, and snakes. Mosquitoes cause death by transmitting deadly diseases, such as malaria, yellow fever, and various types of viruses that cause encephalitis.

Aedes aegypti originated from Africa while *Ae. albopictus* originally came from southeast Asia. Both have spread worldwide throughout the tropics and many temperate regions of the world. The Asian tiger mosquito was found in Los Angeles County in 2011 and the yellow fever mosquito was first found in the Central Valley in 2013. Unlike our native mosquitoes that prefer feeding on birds and other wild animals, invasive *Aedes* mosquitoes prefer to bite humans. They can be found both outside and inside human dwellings and are notorious for being aggressive biters. They are commonly known as “ankle biters” because they tend to bite around the ankles and feet. Both species need very little water to lay their eggs in. The amount of water that fills a bottle cap is all that is needed for these mosquitoes to complete their development. Eggs can survive for several months without water and will hatch once the container they’re in has filled with water.

Since they were first discovered, these mosquitoes have spread north through the Central Valley and throughout Southern California south to San Diego. Now it appears they are making their way north along the Central Coast.

Invasive *Aedes* have several key characteristics that can have huge negative impacts on our quality of life and which make them a public health concern:

- They lay their eggs in anything that fills with water, even in some plants such as bromeliads;
- They carry viruses that can cause serious illness such as yellow fever, Zika – which is known to result in birth defects if pregnant women become infected, and two very debilitating diseases: Dengue and Chikungunya;
- Invasive *Aedes* are very aggressive mosquitoes that bite not only at dawn, dusk and at night, but during the day;
- They tend to stay near human dwellings and they can even breed indoors. These mosquitoes have been found breeding indoors in potted plants – especially in saucers underneath the pots, and surprisingly in cups used for holding toothbrushes, a toilet brush holder in one case, coffee makers, and decorative “lucky bamboo”.

Understanding the mosquito life cycle illustrates why the presence of water plays an important role in mosquito infestations. After a female mosquito feeds on blood, she seeks out stagnant water in which to lay her eggs. After a few days, the mosquito larvae hatch from the eggs and in their final stage of development in the water, the larvae transform into pupae. During the pupal stage, development to the adult stage is completed and the fully-formed adult mosquito emerges from the water. The time between egg and adult can be completed in less than 7 days during warm weather.

Invasive *Aedes* females can lay up to 1,000 eggs during her lifetime, which typically is about 2 to 4 weeks. The eggs can survive without water for several months and they’ll hatch as soon as they become submerged in water.

Mosquito larvae are called wigglers or wrigglers because they wiggle in the water to move around. The pupae look like very tiny shrimp. Pupae are called tumblers because they tumble as they move up and down in the water. You have probably seen wiggling larvae and tumblers in stagnant water.

Adult invasive *Aedes* mosquitoes are small – only 1/8 to ¼ inch long. They have dark bodies with bright white stripes and patches. Some of California’s native *Aedes* mosquitoes look very similar to the invasive *Aedes* but under a microscope a distinct solid line going down the middle of the thorax can be seen on *Aedes albopictus* while *Ae. aegypti* has a distinct lyre pattern on the thorax (a lyre is a type of handheld harp)(Figures 1 and 2).



Figure 1. Adult yellow fever mosquito, *Aedes aegypti* (left) and Asian tiger mosquito, *Ae. albopictus* (right).

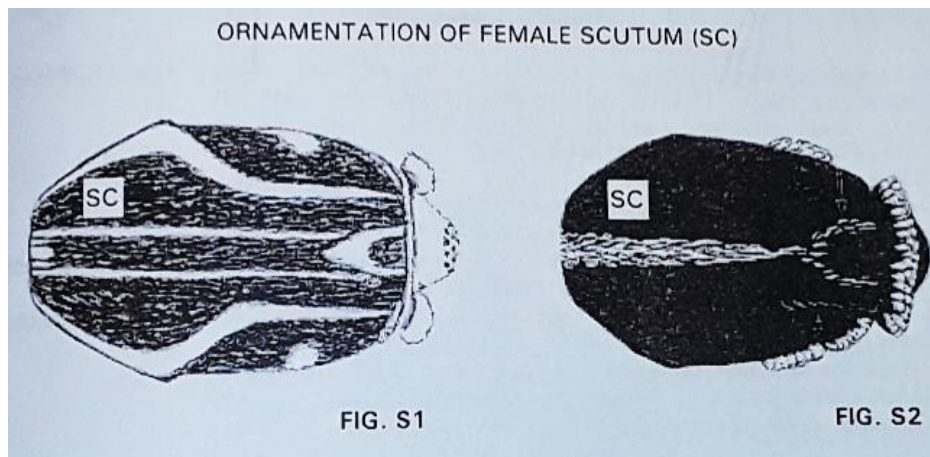


Figure 2. Detail of the thorax patterns on *Aedes aegypti* (left) and *Ae. albopictus* (right).

As mentioned previously, water is very important for mosquitoes. They can't complete their life cycle without stagnant water to lay their eggs in and for the larvae and pupa to complete their development. Mosquitoes lay their eggs in anything that can hold water. Outdoors, notorious and common mosquito breeding sites include discarded tires, birdbaths, non-functioning water fountains, buckets and vases in cemeteries. Neglected swimming pools and hot tubs can breed hundreds, even thousands of mosquitoes.

A huge cultural control to aid in reducing mosquito populations is to get rid of standing water. Check on your property for anything holding water and drain, tip, dump, toss the water. Change the water in birdbaths and pet bowls on a regular basis. Unclog pipes, drains and rain gutters so that water won't accumulate in them.

As stated before, invasive *Aedes* are capable of vectoring some very serious diseases. In order for localized spread of disease by these mosquitoes to occur these components must be present:

- 1.) Stagnant water sources for mosquito development;
- 2.) A competent vector – that is, the specific mosquito species that can carry and transmit a particular virus or parasite – most viruses and parasites can only be transmitted by a specific mosquito species. Our native mosquitoes can't transmit the diseases that invasive *Aedes* vector;
- 3.) A competent host –in the case of invasive *Aedes* this would be humans;
- 4.) The pathogen, which is a virus or parasite that causes illness.

So now here in California we have three of the four components needed for localized transmission of yellow fever, Zika, Dengue and Chikungunya. Fortunately, to date, there haven't been any cases of localized disease spread by invasive *Aedes* in California. However, there have been numerous cases of what is called "travel-related" cases of Zika and Dengue – that is, cases where people have been infected by these viruses abroad and have returned to California and become sick. The concern now is that a person with a travel-related infection could be bit by an invasive *Aedes* here in California and those mosquitoes could then vector the viruses to people in the local population.

Because of the great potential of disease spread by these mosquitoes in California, what can be done to manage these mosquitoes? Currently, there are about 70 mosquito control districts in California responsible for controlling native and non-native mosquito populations. There are several different methods of chemical control commonly used by these agencies. Organic pesticides in the form of dry granules and briquets, with the active ingredient Bti and Bts (derived from the bacteria *Bacillus thuringiensis* and *B. sphaericus*), Spinosad (derived from a soil fungus) and the insect growth regulator Methoprene, are applied to aquatic breeding sources. These active ingredients are very specific for mosquito larvae and cause very little effects on the environment. Many districts also apply ultra-low volume sprays, basically like a fog, which targets adult mosquitoes. In other parts of the country and the world there have been releases of genetically-modified mosquitoes and sterile males to reduce invasive mosquito species. However, invasive *Aedes* mosquitoes are so widespread and difficult to eradicate that the Districts alone cannot do the job. This is where private pest control companies come in. As invasive *Aedes* become more widespread in California, these companies can help meet the demands for increased mosquito control in residential areas.

Finally, and this is very important, public education, outreach and public awareness will be extremely, extremely important in slowing the spread of invasive *Aedes* and reducing local populations. The very simple act of getting rid of water sources for the mosquitoes to lay their eggs in and complete their development can have a tremendous impact on controlling mosquitoes.