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Zika Vector Control for the Urban Pest Management Industry[1]

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Zika Virus

Incidence and Distribution

Zika is a mosquito-transmitted virus that has spread to the Americas. Zika virus (ZIKV) was discovered in 1947 in Africa where it was isolated from a Rhesus monkey in the Zika forest of Uganda. Initially, ZIKV occurred in a very narrow range in Africa and parts of Asia. In 2007, a disease outbreak occurred on the Yap Islands in Micronesia, and in 2013, an outbreak occurred in French Polynesia. In 2015, a large outbreak occurred in Brazil, and ZIKV has since spread through Central and South America. According to the World Health Organization (WHO), at least 89 countries have reported local transmission of ZIKV, and many have reported travel-associated cases of the virus.

According to the Centers for Disease Control and Prevention (CDC), in 2016, there were 5,168 Zika cases in the United States, with 224 resulting from local transmission and 4,897 travel-associated cases. In that same year, there were 36,512 cases in US territories, mostly from local transmission. There were 45 cases of sexually transmitted cases within the United States in 2016. Only 2 cases of travel-related Zika occurred in 2019, with no local transmission. The number of ZIKA cases has decreased considerably in recent years, so the risk of outbreaks in Florida and the United States has declined to acceptable levels (Figure 1).

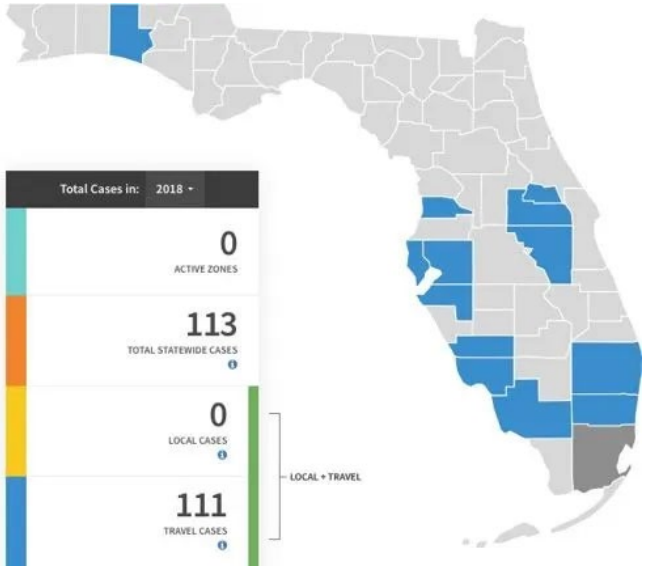

Figure 1. Florida counties that have reported Zika cases in 2018 highlighted in blue (travel-related cases only) or dark gray (travel plus undetermined cases). Credit: https://zikafreefl.org/map/

Transmission and Symptoms

The primary mode of transmission for ZIKV is through the bites of female *Aedes* species mosquitoes, particularly *Aedes aegypti* (yellow fever mosquito) and *Aedes albopictus* (Asian tiger mosquito) in the Americas. For a female mosquito to become infected, she must first feed on an infected human or primate host. The virus from the human blood the female mosquito ingests begins to increase in number and moves throughout the mosquito's body. This process, known as the "extrinsic incubation period," takes approximately 10 days. If the virus makes it to the mosquito's salivary glands, she may transmit the virus to future hosts through her bite. It is estimated that humans are infectious for the first 3–12 days of the illness.

Other modes of transmission include from pregnant mother to child, sexual transmission, and blood transfusion. For more information on these modes of transmission, consult your local health department or https://www.cdc.gov/zika/prevention/index.html.

The illness caused by ZIKV is very similar to dengue, but it is milder in most cases. Symptoms of ZIKV infection include fever, rash, joint pain, and red eyes, sometimes accompanied by muscle aches and headaches. However, approximately 80% of infected individuals are asymptomatic. Although hospitalizations or fatalities are highly uncommon for this disease, there is a causative link between Zika and microcephaly and an association between Zika and increased risk of Guillain-Barré syndrome, a rare disorder where the body's immune system attacks nerves, causing paralysis. Infections of ZIKV can be hard to diagnose due to the similarity in symptoms with two other mosquito-borne diseases, dengue and chikungunya, and few laboratories have the appropriate molecular tests for the virus. As of June 2019, there was no vaccine available to prevent ZIKV infection in humans, and treatment includes rest, pain relievers, and fever reducers. Aspirin is not recommended until dengue infection has been ruled out due to the increased risk of bleeding. Any person who has previously been infected with ZIKV is likely immune to future infections.

Zika Virus and Infant Microcephaly

Health agencies and multiple scientific journal articles have now confirmed that infection with Zika virus can cause microcephaly. Microcephaly is a condition wherein infants' heads are much smaller than those of typical babies. This neurological condition is rare and only occurs in approximately 2–12 of every 10,000 live births in the United States. However, in 2015, an increased number of microcephaly cases was reported in Brazil that correlated with a recent outbreak of Zika in May of the same year. Zika virus can be passed from a mother to her child in the womb, increasing the risk of microcephaly and other birth defects. The CDC recommends that pregnant women do not travel to areas with local transmission of ZIKV.

Biology and ID of the Mosquito Vectors

Outside of Africa, the likely primary vector of Zika are *Aedes aegypti* and *Aedes albopictus*. Both *Aedes aegypti* and *Aedes albopictus* are established in the United States, and both are considered invasive species that continue to expand their range. Populations of *Aedes aegypti* declined after the introduction of *Aedes albopictus* in the 1980s. However, populations of *Aedes aegypti* are now resurging. These species most often feed on human hosts and live in close proximity to humans. Adult females lay their eggs primarily in containers that can hold water. Examples include flower pots, corrugated pipes, clogged rain gutters, or discarded tires, but natural containers such as tree holes and bromeliad plants are often utilized.

It is important to be able to identify the adult vectors and their eggs and the presence of larvae in aquatic habitats. *Aedes aegypti* and *Aedes albopictus* (Figure 2) are dark-colored mosquitoes (dark brown or black) with white scaling on different parts of their body. The pale white scaling on the thorax of *Aedes aegypti* is lyre-shaped with two lines in between the sides of the lyre shape. *Aedes albopictus* has a single white-scaled line down its thorax. *Aedes aegypti* and *Aedes albopictus* both have bands of white scales on their legs.

Figure 2. *Aedes aegypti* (left) and *Aedes albopictus* (right).
Credit: UF/IFAS Florida Medical Entomology Laboratory

The eggs of *Aedes aegypti* and *Aedes albopictus* can be identified by where and how they are deposited (Figure 3). The eggs of *Aedes aegypti* and *Aedes albopictus* are laid singly on moist surfaces, such as the edges of containers. When these containers eventually flood, the eggs will hatch. *Anopheles* eggs are also laid singly, but they have "floats" on either side, unlike the eggs of *Aedes. Culex* eggs are different from both *Aedes* and *Anopheles* because the eggs are deposited in rafts on the surface of the water.

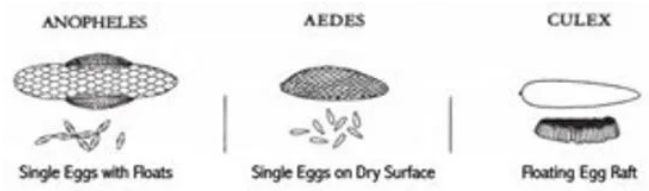

Figure 3. The eggs of *Anopheles* (left), *Aedes* (center), and *Culex* (right) mosquitoes. Individual eggs are approximately the size of a grain of pepper.
Credit: Centers for Disease Control and Prevention (CDC) Environmental Health Services (EHS)

The vectors of ZIKV are **day-biting mosquitoes,** unlike many of the Florida mosquito species that bite at night. After bloodfeeding, the females rest in a shaded area until they are ready to lay their eggs in a container. Their daytime feeding behavior, fondness for feeding on humans, and exploitation of water-holding containers around a home make these mosquitoes efficient disease vectors that are very difficult to control. However, they generally do not fly distances greater than 500 meters.

Integrated Vector Management for Residential Control

Pest control companies can aid in mosquito control by offering treatments to residential and commercial areas. Below are the components of an Integrated Vector Management plan for control of *Aedes aegypti* and *Aedes albopictus*.

Inspection

Before any treatments are made, operators/technicians should do a thorough inspection of the property to identify larval habitats and adult resting locations. All water-holding containers should be identified and noted, including those that are not easily accessible, such as rain gutters or corrugated pipes. When identifying larval habitats, note that mosquito larvae can develop in containers as small as a bottle cap. Any water-holding containers should be emptied or discarded, if possible. Adult mosquitoes often rest in shaded locations such as overgrown vegetation, the open space beneath a stilt house, or in crawl spaces. Overgrown vegetation can be trimmed to reduce the resting locations of the adults.

Resident Cooperation

In addition to any pesticide treatments that are done by pest control companies or local mosquito control, residents should practice preventative measures to protect themselves and to aid in the mosquito control process. The CDC recommends wearing long-sleeved shirts and long pants, staying in air-conditioned or screened places, and wearing EPA-registered insect repellents. To prevent mosquitoes from developing around the home, residents should empty any containers holding water at least once per week, dispose of discarded tires, clean rain gutters, chlorinate pools, and stock ornamental ponds with fish. Bird baths and other permanent water-holding containers should be scrubbed along the inner walls to remove mosquito eggs. To reduce resting habitats for the adults, residents should trim overgrown vegetation near the residence.

Pest control companies can provide their customers with the "Mosquito Bite Prevention" brochure produced by the CDC (https://www.cdc.gov/mosquitoes/pdfs/mosquitobitepreventionus_508.pdf), which informs homeowners about the effective use of insect repellents, ways to mosquito-proof their home, and ways to prevent mosquitoes from developing around their home.

Larviciding

Larvicidal treatments are specifically applied to water where mosquitoes lay their eggs and larvae are able to develop. Three biologically derived larvicides are *Bacillus thuringiensis israelensis* (Bti), *Bacillus sphaericus* (*Bsph*), and spinosad. These larvicides act as stomach or internal toxins once they have been ingested by the mosquito larvae. Residents should see dead larvae in containers approximately 1–2 days after treatment.

Other larvicides registered for use are known as insect growth regulators (IGRs) and include methoprene, pyriproxyfen, and novaluron. IGRs kill insects by disrupting or preventing mosquito development. Some products used for immature mosquito control must be ingested, and others work by contact, but both types are effective. Residents may notice larvae, but these are not likely to survive until the adult stage.

A list of some active ingredients used for control of mosquitoes in the aquatic stage can be found in Table 1. Reductions in mosquito populations take longer to occur when larviciding treatments are done (~2 weeks or more) because the current adult mosquito population is not being controlled, but the treatments will prevent the next generation of adults from emerging. Product labels should be read thoroughly for specific treatment instructions before any application is done.

Adulticiding

Aedes aegypti and *Aedes albopictus* are difficult to control in the adult stage because they are host-seeking at a different time (during the day) than the majority of other mosquito species. Their host-seeking behavior occurs when humans are most active. Therefore, spraying for these mosquitoes when they are host-seeking results in increased pesticide exposure to humans. *Aedes aegypti* and *Aedes albopictus* also rest in areas that are often protected from pesticide treatments.

It can be hard for mosquito control districts to manage these day-biting mosquitoes. Additionally, mosquito control districts may be constrained financially and may not be equipped to treat all individual residences thoroughly. Also, some counties in Florida do not have an organized mosquito control district.

Adulticiding—Residual Sprays

Residual treatments, also known as barrier or surface treatments, are long-term applications typically lasting several weeks. These treatments are most easily and thoroughly applied using a mist blower so that the insecticide forms a deposit on surfaces. Mosquitoes resting on these treated surfaces come in contact with a lethal dose of pesticide.

Residual applications should be applied to areas where adult mosquitoes rest such as the vegetation near a home. There are many label restrictions on many pyrethroid insecticides, so it is important to read, understand, and follow all label language. Areas over impervious surfaces cannot be treated with insecticides, and residual sprays should not be applied to the air. A list of some residual adulticide active ingredients is available in Table 2.

The equipment required for doing residual treatments for mosquitoes is different from the equipment used by many pest control operators for general household pests. Compressed-air sprayers are not appropriate for mosquito treatment due to poor coverage on vegetation, and power spraying is also not recommended for mosquito treatments because it is not targeted, puts out too much pesticide, and could contribute to further insecticide resistance in mosquitoes.

Adulticiding—Space Sprays

Some locations, such as areas with little or no vegetation, are not suitable for residual sprays but can be treated with space sprays. These sprays (Table 3) target mosquitoes that are flying and are therefore sprayed into open air. It is important to target areas such as the space underneath stilt houses, under crawl spaces, or shaded regions with no vegetation. Space sprays contribute to immediate knockdown of mosquito populations but do not provide long-term control and should not be applied to surfaces. Due to the short-term nature of space sprays, they should be reapplied as needed, according to the label. Space sprays use equipment such as ultra-low-volume (ULV) sprayers or foggers. Space spray applications have no residual activity but provide immediate knockdown of flying mosquitoes. Applications made during periods of maximum flying and host-seeking activity are often the most effective.

Insecticide Resistance

Various counties throughout the state of Florida have reported permethrin and bifenthrin resistance in these mosquitoes. Resistance to pyrethroids is widespread in the state. To delay and prevent further insecticide resistance, it is important to practice an integrated approach that includes, in order of priority, source reduction, larviciding, and adulticiding. Monitoring the mosquito population and resistance status should be a part of all mosquito control activities. Rotation of chemicals can also be useful in delaying insecticide resistance. However, pyrethroids and a pyrethroid/neonicotinoid mixture are the only chemical classes available for residual sprays, making rotation difficult. For space sprays, both organophosphates and pyrethroids are available for vector control. Major differences between residual sprays and space sprays are presented in Figure 4.

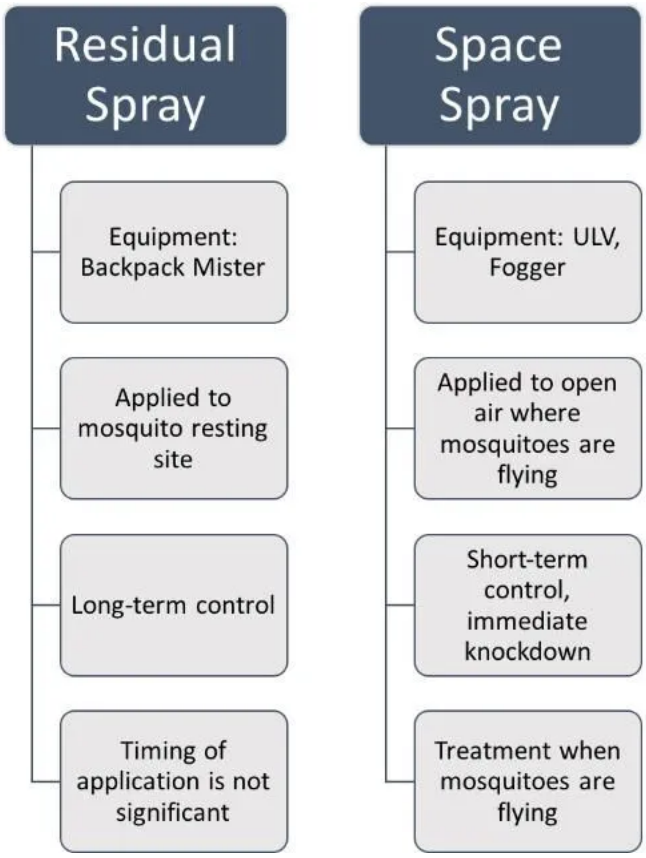

Figure 4. Differences between residual sprays and space sprays.

Monitoring

Effectiveness of treatment for mosquitoes that develop in containers can be monitored through the use of standard ovitraps (Figure 5), which consist of dark plastic cups (~500 ml) with two holes on either side of the cup for water drainage. Two tongue depressors are secured on the interior with binder clips, and the cup is filled with water. These monitors should be placed in a shaded area around the home near vegetation. Cups can be secured with small tent stakes so that they are not knocked over by wind or animals. The monitors should be checked weekly for the presence of eggs, and new tongue depressors should be installed. If eggs are present (Figure 6), a retreatment of the house should be considered. If possible, count the number of eggs on the tongue depressors weekly with the aid of a microscope to detect any reductions in the population over time.

Figure 5. Standard ovitrap used for monitoring *Aedes aegypti* and *Aedes albopictus*.
Credit: Casey Parker, UF/IFAS

Figure 6. Tongue depressor from a standard ovitrap with mosquito eggs.
Credit: Casey Parker, UF/IFAS

Many mosquito control programs throughout the state routinely do adult surveillance of mosquitoes and may be able to provide historical or current data on *Aedes aegypti* or *Aedes albopictus* populations in an area. This data may aid in treatment of an area and understanding of the historical mosquito pressures.

Equipment, Personnel, and Personal Protective Equipment (PPE)

Equipment

Mist blowers are low-volume sprayers used to control both larval and adult populations of mosquitoes. Mist blowers use high air velocity with relatively low fluid pressures and flow rates of several ounces per minute. Mist blowers dispense small droplets of pesticide though a nozzle mounted within an open cylinder that can be aimed, permitting precise treatment of mosquito resting areas. Backpack-sized units can be used to treat areas up to several acres quickly and efficiently. Mist blowers are particularly valuable if they are used to administer thorough residual applications to hard-to-treat areas that likely harbor resting adult mosquitoes. Backpack-type power mist blowers are highly portable and allow rapid treatment of up to several acres by individual vector-control technicians. Although mist blowers are best suited for liquid applications, some manufacturers offer the option of equipping them with hoppers for use with larvicidal pellets or granules.

Space sprays use equipment such as ultra-low-volume (ULV) sprayers or foggers that deliver small particle droplets (< ~30 microns) that can impinge on the mosquito cuticle and deliver a lethal dose of pesticide. These types of applications have minimal residual activity but provide immediate knockdown of flying mosquitoes. Both ULV sprayers and foggers can be handheld machines, or they can be mounted on a truck. Ultra-low-volume sprayers can also be used in aerial applications for wide-area control.

Personnel and PPE

Any person conducting insecticide treatments for mosquitoes should wear long sleeves and long pants in addition to using mosquito repellents. The CDC recommends DEET, IR3535, oil of lemon eucalyptus (OLE), and picaridin for long-lasting protection from mosquitoes. DEET is a commonly used repellent and is highly effective. Repellents should be provided to operators or technicians doing mosquito work. Repellents should be applied to exposed skin and clothing but not worn underneath clothing. They should not be applied over irritated skin such as cuts or wounds. They should also be removed after completing treatments and returning indoors.

When doing mosquito pesticide applications, operators should wear eye protection and gloves in addition to long pants and long-sleeved shirts. Face masks, dust masks, or respirators can be worn as an added precaution. Some insecticide labels recommend the use of a respirator when products are being applied. Refer to insecticide label instructions for required PPE for different products.

Regulatory Corner: Mosquito Spraying Regulations

It is important that licensed pest control companies understand the regulations concerning mosquito control, which are set by either the Structural Pest Control Act (FS Chapter 482) or the Mosquito Control Act (FS Chapter 388).

Pest control companies licensed in the categories of General Household Pest (GHP) or Lawn and Ornamental (L&O) may perform pest control, including mosquito control in, on or under a structure, lawn, or ornamental

(Florida Statutes Section 482.071). This law refers to spraying residential and commercial properties as a part of normal business practices. However, if a company is doing community-wide mosquito control using handheld, truck-mounted, or aerial large-scale methods throughout neighborhoods, agricultural areas, other public areas, or in a contract agreement with a local mosquito control program, then the company must have a Public Health (PH) license or be operating under the direct supervision of an individual holding a Public Health pest control license. See the following regulations and contact the regulatory agency shown below if you have any further questions.

The Public Health (PH) license is substantially different from the GHP or L&O license of the Structural Pest Control Act. The rules implemented by the Florida Department of Agriculture and Consumer Services (FDACS) for the PH license are:

- **5E-13.021 (21)** "Public health pest control"—a category or classification of licensure that includes private applicators, federal, state, or other governmental employees using or supervising the use of general or restricted-use pesticides in public health programs for the management and control of pests having medical and public health and nuisance importance.
- **5E-13.039 (2)** Applicators licensed in public health pest control may directly supervise no more than 10 unlicensed employees.
- **5E-13.040 (1)** It is a violation of these rules for a person to apply a pesticide intended to control arthropods on property other than his own individual residential or agricultural property unless he is licensed to do so or is working under the direct supervision of a licensed applicator, as allowed under subsection 5E-13.039(2), F.A.C.
- **5E-13.021(28)** "Direct supervision"—supervision by licensed applicators, who are responsible for the pesticide use activities and actions of unlicensed individuals. The licensed direct supervisor must be in immediate contact, either directly or by electronic means, including, but not limited to, cell phones, radios, and computers.

Contact FDACS for more information on the licensing and certification requirements under Chapters 482 or 388, Florida Statute.

Bureau of Licensing and Enforcement
Division of Agricultural Environmental Services
Florida Department of Agriculture and Consumer Services
(850) 617-7997
AESCares@FreshFromFlorida.com

Table 1. Active ingredient and chemical type for some residual larvicides.

Active Ingredient	Product Type
Bti	Microbial
Bsph	Microbial
Spinosad	Microbial
Methoprene	Insect Growth Regulator
Pyriproxyfen	Insect Growth Regulator
Novaluron	Insect Growth Regulator
Temphos	Organophosphate

Table 2. Active ingredient and chemical type for some residual adulticides.

Active Ingredient	Chemical Type
Alpha-cypermethrin	Pyrethroid
Bifenthrin	Pyrethroid
Lambda-cyhalothrin	Pyrethroid
Tau-fluvalinate	Pyrethroid
Deltamethrin	Pyrethroid
Imidacloprid/beta-cyfluthrin	Neonicotinoid/Pyrethroid

Table 3. Active ingredient and chemical type for some space sprays.

Active Ingredient	Chemical Type
Etofenprox	Pyrethroid
Permethrin	Pyrethroid
d-Phenothrin (Sumithrin)	Pyrethroid
Pyrethrins/Pyrethrum	Pyrethroid
Deltamethrin	Pyrethroid
Chlorpyrifos	Organophosphate
Malathion	Organophosphate
Naled	Organophosphate

[1] This document is ENY-891, one of a series of the Department of Entomology and Nematology, UF/IFAS Extension. Original publication date May 2016. Revised June 2019 and December 2025. Visit the Ask IFAS website at https://ask.ifas.ufl.edu/ for the currently supported version of this publication.

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