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Zika Vector Control for the Urban Pest Management Industry

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Figure 1. *Aedes aegypti* (left) and *Aedes albopictus* (right). Photograph by Florida Medical Entomology Laboratory.

Zika Virus

Incidence & Distribution

Zika is a mosquito-transmitted virus that has recently 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. Until recently, ZIKV occupied 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 has since spread through the Americas. According to the World Health Organization (WHO), 44 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), from January to March of 2016, there were 312 travel-associated cases from 40 states in the US and 349 locally acquired cases in US territories. There have also been 6 cases of sexual transmission of Zika within the US.

ZIKV is expected to spread, but it is difficult to determine how and where it will spread.

Transmission & Symptoms

The primary mode of transmission for ZIKV is through the bites of *Aedes* species mosquitoes, particularly *Aedes aegypti* (yellow fever mosquito) and possibly *Aedes albopictus* (Asian tiger mosquito) in the Americas. For a female mosquito to become infected, she must first feed on an infected human. The virus from the human blood she ingests begins to increase in number and move throughout the mosquito body; this process, known as the "incubation period", takes 2 – 3 weeks. If the virus makes it to the mosquito salivary glands, then she may transmit the virus to future hosts through her bite. It is estimated that humans are infectious for the first 7-14 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 http://www.cdc.gov/zika/transmission/index.html.

The illness caused by ZIKV is very similar to dengue (http://edis.ifas.ufl.edu/in699), but is milder in most cases. Symptoms of ZIKV infection include fever, rash, joint pain, red eyes, and can be accompanied by a muscle aches and headaches. However, approximately 80% of infected individuals are asymptomatic. Although hospitalizations or fatalities are highly uncommon

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Figure 2. The eggs of *Anopheles* (left), *Aedes* (center), and *Culex* (right) mosquitoes. Drawing produced by the Centers for Disease Control and Prevention (CDC) Environmental Health Services (EHS).

for this disease, there is a link between Zika and microcephaly and a possible association between Zika and Guillain-Barré syndrome, a rare disorder where the body's immune system attacks nerves causing paralysis. Infections of ZIKV can be hard to diagnosis due to the similarity in symptoms with two other mosquito-borne diseases, dengue and chikungunya. There are also few laboratories that have the appropriate molecular tests for the virus. Currently, there is 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 the ZIKV is likely immune to future infections.

Biology and ID of the Mosquito Vectors

Outside of Africa, the likely primary vector of Zika is *Aedes aegypti. Aedes albopictus* has not been confirmed as a vector, but it has been implicated as the Zika vector in Gabon. Both *Aedes aegypti* and *Aedes albopictus* are established in the US and *Aedes albopictus* is considered highly invasive and is continuing to expand its range. 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 tires, but natural containers such as tree holes and bromeliad plants are often utilized. The biology of these mosquito species make them a major concern for Zika transmission.

It is important to be able to identify the vectors and their eggs. *Aedes aegypti* and *Aedes albopictus* (Fig. 1) 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.

The eggs of *Aedes aegypti* and *Aedes albopictus* can be distinguished from other genera's eggs by where and how they are laid (Fig. 2). The eggs of *Aedes aegypti* and *Aedes albopictus* are laid singly on dry surfaces such as the edges of containers. These containers will eventually flood, submerging the eggs and allowing them to hatch. *Anopheles* eggs are also laid singly, but they have a 'floats' on either side, unlike the eggs of *Aedes. Culex* eggs are different from both *Aedes* and *Anopheles* because the eggs are laid in rafts on the surface of the water instead of being laid singly.

The vectors of ZIKV are day-biting mosquitoes, which is unlike many of the Florida mosquito species that bite at night. After bloodfeeding, the females will 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 excellent disease vectors and very difficult to control. However, they generally do not travel distances greater than 500 meters.

Integrated Vector Management for Residential Control

Inspection

Before any treatments are made, operators/technicians should do a thorough inspection of the property to identify larval habitats, as well as 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, it is important to 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 back 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 be asked to 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 repellants. 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, overgrown vegetation near the residence should be trimmed.

Pest control companies can also provide their customers with informational flyers or brochures like those produced by the CDC (http://www.cdc.gov/zika/fs-posters/). These flyers cover a wide array of topics, but "Help Control Mosquitoes that Spread Dengue, Chikungunya, and Zika Viruses" and "Mosquito Bite Prevention" would be very useful to homeowners. This will give them information on the effective use of insect repellants, how to mosquito-proof their home, and how to prevent mosquitoes from developing around their home.

Larviciding

Larvicidal treatments are specifically applied to water where mosquitoes are able to lay their eggs and larvae are able to develop. A couple of active ingredients used for larvicidal treatments are *Bacillus thuringiensis israelensis* (Bti) and spinosyn. Bti is a naturally occurring soil bacterium and spinosyn is derived through fermentation from naturally occurring soil organisms. Both of 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.

Another form of immature mosquito control is through the use of insect growth regulators (IGRs) such as novaluron, methoprene, pyriproxyfen and novaluron. IGRs kill insects by disrupting or preventing their development. IGR formulations include those that are ingested and those act when the mosquito comes into contact with the product. For IGRs, residents may not see results in the larval stage, but will likely see the most mortality during the pupal stage. Some adults may attempt to emerge, but they will likely have lethal deformations.

A list of some active ingredients available for immature control can be found in Table 1. Reductions in the adult population due to larviciding and the use of IGRs will take longer (~2 weeks or more) to occur because the current adult mosquito population is not being controlled with these methods. These treatments are preventing the next generation of mosquitoes from occurring. Product labels should be read thoroughly for specific treatment instructions before any application is done.

Active ingredient	Chemical type
Bti	Microbial
Bsph	Microbial
Spinosyn	Microbial
Methoprene	Insect Growth Regulator
Pyriproxyfen	Insect Growth Regulator
Novaluron	Insect Growth Regulator
Temphos	Organophosphate

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

Adulticiding - Residual Sprays

Aedes aegypti and *Aedes albopictus* are difficult to control because they are host-seeking at a different time (during the day) than the majority of other mosquito species. For this reason, it can be hard for mosquito control districts to control 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.

Pest control companies can aid in mosquito control by offering treatments to residential and commercial areas. Residual treatments, also known as barrier or surface treatments, are a long-term type of application. These treatments are most easily and thoroughly applied using a mist blower so that the insecticide forms a deposit on the surface. Mosquitoes resting on these residual treatments are in contact with a lethal dose of pesticide. Flying adults can also be affected by residual sprays if they come into contact with the insecticide while a surface is being treated.

Residual applications should be applied to areas where adult mosquitoes rest such as the vegetation near a home. Areas over impervious surfaces cannot be treated with pyrethroid insecticides due to label restrictions. Residual sprays should not be applied to the air. Time of day will not have a significant effect on residual pesticide applications because the operator is targeting adult resting sites instead of flying adults. A list of some residual adulticide active ingredients is available in Table 2.

Active ingredient	Chemical type
Alpha-cypermethrin	Pyrethroid
Bifenthrin	Pyretthroid
Lambda-cyhalothrin	Pyrethroid
Tau-fluvalinate	Pyrethroid
Deltamethrin	Pyrethroid
Imidacloprid/beta-cyfluthrin	Neonicitinoid/Pyrethroid

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

It is important to note that the equipment required for doing a residual treatment for mosquitoes is different from the equipment used by many pest control operators on a day-to-day basis. Compressed-air sprayers are not appropriate for mosquito treatment due to run-off, and poor treatment coverage and particle deposition on vegetation. Power spraying is also not recommended for mosquito treatments because it is not targeted, puts out a great deal of pesticide, and could contribute to further pyrethroid resistance in an area.

Adulticiding - Space Sprays

In locations where residual treatments cannot be completed due to little or no vegetation, space spray applications can be used. Space sprays (Table 3) target mosquitoes that are flying and possibly host-seeking which are sprayed into open air, the space underneath stilt houses, or the 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. 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 no residual activity, but provide immediate-knockdown of flying mosquitoes. The timing of ULV and fogging applications is heavily dependent on when the mosquitoes are flying and host-seeking. Both ULV sprayers and foggers can be handheld machines or mounted on a truck. ULV sprayers can also be used in aerial applications for wide-area control.

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

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

Pyrethroid Resistance

Various counties throughout the state of Florida have reported pyrethroid resistance in container mosquitoes. The extent of resistance in the state is currently under investigation. 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

Figure 4. Standard ovitrap used for monitoring *Aedes aegypti* and *Aedes albopictus*. Photograph by Casey Parker, University of Florida.

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 3.

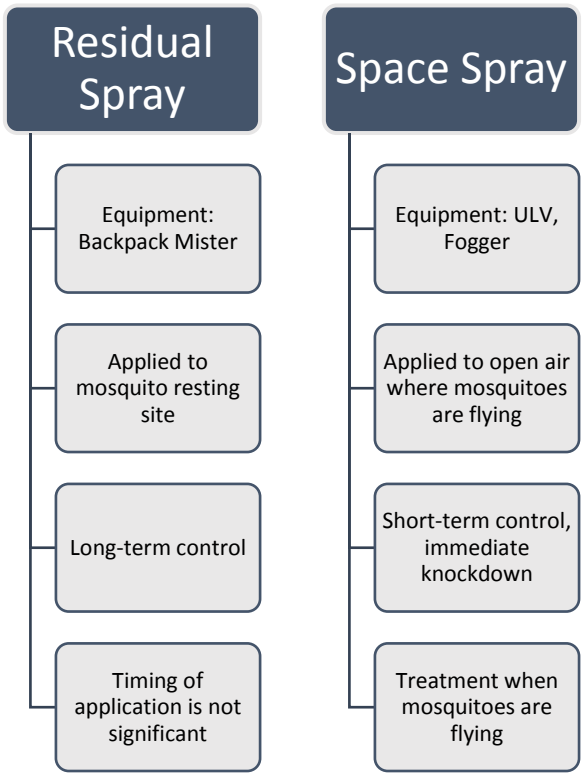

Figure 3. Differences between residual sprays and space sprays.

Monitoring

Effectiveness of treatment for container mosquitoes can be monitored through the use of a standard ovitrap (Fig. 4). Standard ovitraps consist of a dark plastic cup (~500 ml) with two holes on either side of the cup for water drainage. Two tongue depressors are secured on the interior of the cup using two binder clips and the cup is filled with water up to the water drainage holes. These ovitraps should be put 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. Standard ovitraps should be checked weekly for the presence of eggs (Fig. 4) on the tongue depressors. If eggs are present (Fig. 5), a retreatment of the house should be done unless the label prohibits the use of the pesticide within a certain time frame. 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. Many mosquito control districts 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.

Figure 5. Tongue depressor from a standard ovitrap with mosquito eggs. Photograph by Casey Parker, University of Florida.

Equipment, Personnel, and Personal Protective Equipment (PPE)

Equipment

Mist blowers are a type of low volume sprayer used to control both larval and adult populations of mosquitoes. Mist blowers are characterized by

relatively low fluid pressures, with flow rates of several ounces per minute. Dispersal of liquid insecticides is done using high air velocity. Typically, the product is run through hoses to a metering device which may or may not be connected to a conventional nozzle. Mist blowers dispense mists of pesticide though a nozzle mounted within an open cylinder. The cylinder 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. The main advantage over power sprayers is the lower volume of formulated product needed for treatment. Mist blowers are particularly useful in mosquito control for applying a thorough residual application for adult control to individual properties. 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.

Personnel and PPE

Any person conducting insecticide treatments for container mosquitoes should wear long sleeves and long pants in addition to using mosquito repellants. 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/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 their pants and long sleeves. 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.

FDACS Rules and Certification

An applicator may spray for mosquitoes under Florida Statute Chapter 482 (The Structural Pest Control Act) or 388 (Mosquito Control) depending on the location, size of the treatment area, and type of spray being used. If a person is doing community-wide distribution through aerial spraying or other large scale methods through neighborhoods, agricultural areas, other public areas, or in contract agreement with a local mosquito control district, then he or she must have a Public Health (PH) license or be operating under the direct supervision of an individual holding a public health pest control license.

Pest control companies licensed under Section 482.071, Florida Statutes 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.
Mosquito misters may be regulated under 482 or 388. Please contact the department for more information regarding automated mosquito misters.
Below is rule language pertaining to the administration of the Mosquito Control Program in 5E-13 F.A.C:

- **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-13.040 (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.
- **5E-13.021 (11)** "Adulticide" – a pesticide intended to affect an adult arthropod.

  (12) "Use" – any act of handling or release of a pesticide or exposure to man or the

environment of a pesticide through acts including but not limited to:

a) Application of a pesticide, including mixing and loading and any required supervisory action in or near the area of application; Please contact the Department for more information on the licensing and certification requirements under Chapters 482 or 388, Florida Statute.

Contact: Tamara James
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