

Florida Resident's Guide to Mosquito Control

INTEGRATED PEST MANAGEMENT FOR
MOSQUITO REDUCTION AROUND HOMES AND
NEIGHBORHOODS



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Cover photo: *Aedes albopictus*, the Asian tiger mosquito, by

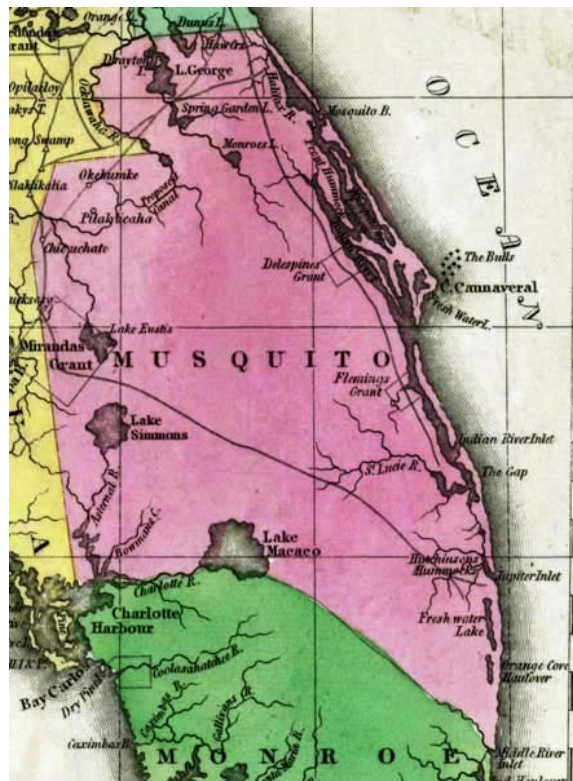
Sean McCann, UF/IFAS/FMEL.

INTEGRATED PEST MANAGEMENT FOR MOSQUITO REDUCTION AROUND HOMES AND NEIGHBORHOODS

Homeowners who actively participate in reducing mosquitoes around the home can help decrease pesticide use, reduce the risk of contracting mosquito-borne diseases, and help ease the financial burden to local governments who are responsible for area-wide control. Modern mosquito control for the homeowner has to be an *integrated pest management* (IPM) program, utilizing a combination of methods that emphasizes source reduction - eliminating areas where mosquitoes thrive whenever possible. Surveillance for mosquitoes is required prior to the application of any insecticide to determine whether or not an application is necessary. Deterring certain mosquitoes can be accomplished by individuals through the use of screening, sanitation, and other techniques described in this document. **The methods recommended in this publication are particularly effective in reducing mosquitoes that transmit diseases.** Ultimately, homeowners who take responsibility for identifying and eliminating sources of mosquito production around their homes and neighborhoods will advance the health and quality of life for all Florida residents.

Mosquito Control Organizations in Florida

Many Florida counties have mosquito control programs that are funded by local taxes. The first organized mosquito control district was established by the Florida Legislature in 1925 in Indian River County. St. Lucie County Mosquito Control District was formed in 1926. There are now over 50 such programs of varying sizes throughout Florida.



Florida map, circa 1825. Note the region on the east coast named "Musquito County" Map courtesy: Special Collections Department, University of South Florida.

The Mosquito Control Section of the Florida Department of Agriculture and Consumer Services (FDACS), Bureau of Entomology and Pest Control, administers mosquito control programs under the authority of the Mosquito Control Act, Chapter 388 of the Florida Statutes and Chapter 5E-13 of the Florida Administrative Code. A directory of mosquito control programs can be viewed at the FDACS website www.freshfromflorida.com

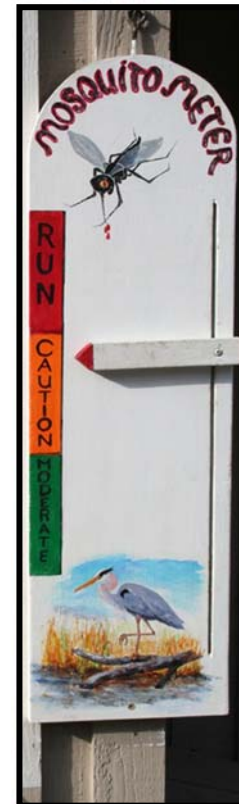


Florida postcard vintage 1930s.

The Florida Coordinating Council on Mosquito Control advises the Commissioner of Agriculture on mosquito control issues. The Council meets three times a year and one of the mandates of the Council is to assist FDACS in resolving disputes arising over the control of arthropods on publicly owned lands.

The Florida Mosquito Control Association is a non-profit group with a mission to promote effective and environmentally sound control of disease-transmitting and pestiferous mosquitoes and other arthropods of public health importance, develop and enhance public interest, awareness, and support for the control of mosquitoes, and provide for the scientific advancement of members through meetings, training and education.

www.floridamosquito.org



Mosquito meter at the entrance to Collier-Seminole State Park. Photo: Jeff Stivers, Collier Mosquito Control District

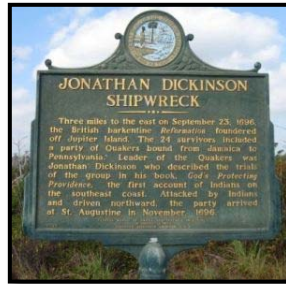
History of Mosquitoes in Florida

1500s

The word “mosquito” first enters the English language. In a 1583 publication “Hakluyt’s Voyages” M. Phillips writes of being annoyed by a kind of fly which the Spaniards called “Musketas.” Jesuit missionary writes from a settlement near Miami where he endured several months of swarms of bloodsucking mosquitoes which prevented him from sleeping many nights.

1600s

After being shipwrecked, Jonathan Dickinson documents in his journal when the party encounters an “abundance of mosquitoes...hindered our rest, to remedy which we digged holes in the sand, got some grass and laid it therein to lie upon, in order to cover ourselves from the flies...” It provided little comfort. Portion of Florida’s east coast labeled “Barra de Mosquitos” by mapmakers.



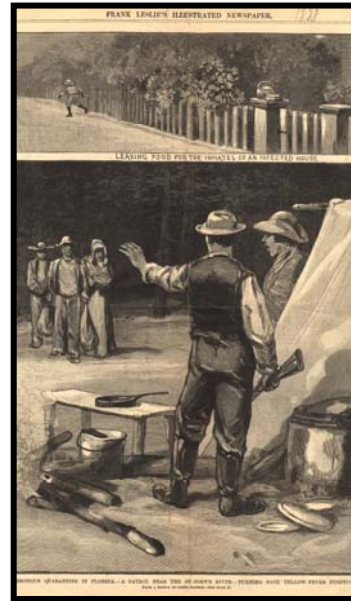
Historic marker in area where the Reformation was shipwrecked in 1696. A Florida State Park is named in honor of Jonathan Dickinson. Photo: Palm Beach Post.

1700s

Yellow Fever epidemics in North America including Florida. Dengue epidemics in Florida.

1800s

Major yellow fever epidemics in Cedar Key, Jacksonville, Key West, Pensacola, St. Marks, and Tampa. Malaria common in Florida. Joseph Y. Porter appointed first state health officer and leads a life-long campaign to wipe out yellow fever and malaria in Florida.



(Top) Leaving food at the house of a family infected with yellow fever virus. (Bottom) Shotgun yellow fever quarantine in Florida, 1888. Image: U. S. National Library of Medicine, History of Medicine Division



Fleeing From *Yellow Fever*

1900s

Malaria Control in War Areas (MCWA) established around military bases in the southern US where malaria was still present. Last cases of Yellow Fever in Florida. Florida Anti-Mosquito Association formed. First mosquito control districts formed in Indian River and St. Lucie counties. *Aedes albopictus*, the Asian tiger mosquito discovered in Florida.

Photo: Archives of Florida, Florida Memory, <http://floridamemory.com/>

2000s

Outbreaks of St. Louis encephalitis and eastern equine encephalitis. West Nile virus found for first time in Florida in Jefferson County. Over 50 mosquito control agencies established in Florida. Florida experiences outbreaks of dengue for first time in over 70 years. Chikungunya diagnosed in Florida residents.



This historic image depicts three public health personnel carrying out tasks involved in Malaria Control in War Areas (MCWA) projects. Photo courtesy: CDC/K. Lord



First Meeting, Florida Anti-Mosquito Association, Daytona Beach, Florida. Dec. 1922. Written on back: Dr. Stewart Thompson, Col Turck, Dr. McDonald Col Porter, Geo W. Simons, Harry Osborn. Photo: George W. Simons, Jr. Planning Collection, Thomas G. Carpenter Library, University of North Florida, Jacksonville, Florida

Mosquitoes

Mosquitoes are two-winged flies that live in humid tropics and subtropics, warm moist climates, temperate and cool zones - everywhere except areas that are permanently frozen. Globally, there are about 3,500 species of mosquitoes, and 80 species occur in Florida.



A flooded salt marsh, a common source of mosquitoes in coastal Florida. Photo: Peter Connelly, AMVAC, Inc.

A mosquito larva. Photo: James Newman, UF/IFAS/FMEL



Adult mosquitoes inside a mosquito trap. Photo: James Newman, UF/IFAS/FMEL



Floodwater mosquitoes feeding on human blood. Photo: Alan G. Curtis, Indian River Mosquito Control District

Mosquito Life Cycle

Mosquitoes develop through 4 different forms during their life: Egg, larva, pupa, and adult.

Eggs are generally one of two major types: floodwater or permanent water. Floodwater eggs are laid on damp soil and surfaces, not on standing water and while they need water to hatch, they must dry out first. Permanent water eggs are laid on the water surface and do not survive if they dry out.

During the larval stage, as the larvae grow, they shed their skin (molt) four times and each stage is called an instar. Larvae develop into pupae are active swimmers, but they do not eat anything during the short time they are in this stage. The larval and pupal stages of the mosquito are aquatic; the adult is terrestrial. Adult mosquitoes are able to fly after their wings dry out.



Floodwater eggs. Photo: Roxanne Connelly, UF/IFAS/FMEL.



Permanent water egg raft. Photo: Sean McCann, UF/IFAS/FMEL.

1st through 4th instar larvae (left to right). Photo: Roxanne Connelly, UF/IFAS/FMEL.



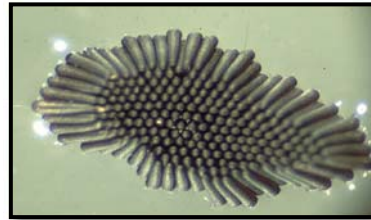
Mosquito pupa. James Newman, UF/IFAS/FMEL.



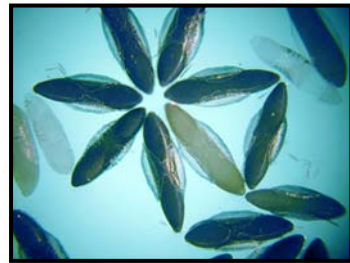
Male mosquito (left), female mosquito (right). Photo: Roxanne Connelly, UF/IFAS/FMEL.



Mosquito Eggs



Egg raft containing over 200 eggs. The actual size of this entire egg raft is about the same as a grain of rice. Photo: Roxanne Connelly, UF/IFAS/FMEL



Eggs with floats, present on Anopheles species of mosquitoes. The actual size of each egg is just a bit smaller than a grain of ground pepper. Photo: Roxanne Connelly, UF/IFAS/FMEL



Floodwater eggs. Photo: Roxanne Connelly, UF/IFAS/FMEL

The type of egg and how it is deposited varies among the different species of mosquitoes. Eggs are generally oblong, tapering at the top end and rounded at the bottom end. Some mosquito species have eggs with floats on the side, and some eggs are covered with small bumps. These details of the egg can be seen with the aid of a microscope.

Mosquito eggs are white when they are first laid, but darken after a few hours as the outer layer hardens.

Eggs that are deposited on the water surface, called permanent water eggs, cannot withstand drying out and usually hatch within a day or two. Eggs that are deposited on a moist substrate, called floodwater eggs, require a period of drying out, and then will hatch when covered with water.

Mosquito eggs vary in size depending on the species, but most are smaller than a grain of ground pepper.

Mosquito Larvae

Mosquito larvae live in the water and come to the surface to breathe with their breathing “siphon”. One type of mosquito, *Anopheles*, does not have siphons and breathe at the water surface through openings called “spiracles” located on the abdomen.



Anopheles larva at water surface. Photo: James Newman, UF/IFAS/FMEL

Out of water, mosquito larvae will not survive. As they grow, they shed their skin, or molt, four times before they transform into pupae. Each stage is called an instar. Larvae feed on organic matter and living organisms by filtering water through their mouthparts.

Mosquito larvae are called “wrigglers” because of the way they swim through the water, using an s-shaped motion. The larval stage can last from several days to several months depending on the water temperature and the mosquito species.



1st—4th instar larvae (left to right). Photo: Roxanne Connelly, UF/IFAS/FMEL

Towards the end of the 4th instar, larvae stop feeding and prepare for the next stage of life as a pupa.



Larva with a long breathing siphon. Photo: George O'Meara, UF/IFAS/FMEL

Mosquito Pupae

Pupae are aquatic and will not survive for long out of water. Pupae have to come to the water surface to breathe through their “trumpets” (two appendages that allow them to take in oxygen).

The developing adult can be seen through the skin of the pupa. Pupae cannot feed because the mouthparts are inside the pupal skin and are not functional during this life stage.

Mosquito pupae are called “tumblers” because of the way they appear to dive down and tumble through the water when disturbed. Generally, the pupal stage lasts about two to three days.



Mosquito pupa. Photo: James Newman UF/IFAS/FMEL

Emerging Adult



*Adult mosquito emerging from the pupal case.
Photo: James Newman
UF/IFAS/FMEL*

At the end of the pupal stage, the combined head and thorax splits open and the adult mosquito crawls out onto the water surface. The wings must dry and harden before the mosquito can fly. It takes about four minutes for the adult to emerge. During this time, if the water is disturbed enough, the mosquito can fall over and be trapped in the water and die.

Adult Mosquito



Female Culex quinquefasciatus, Southern House Mosquito, obtaining a blood meal from a human. Photo: James Newman UF/IFAS/FMEL

What do mosquitoes eat?

Larvae

Mosquito larvae can eat algae, bacteria, copepods (small crustaceans), yeast, other organic matter and microorganisms in the water. Some species can eat other mosquito larvae.

Pupae

Mosquito pupae do not have functional mouthparts, so they do not feed during this life stage. They survive this stage by using remaining energy reserves from the larval stage.

Adults - male and female

Both male and female mosquitoes feed on nectar to obtain sugar as an energy source for flying. Nectar sources include flowers, injured plants, honeydew (excreted by other insects while they feed on plant sap), and fruit juices.



Adult female

Female mosquitoes need blood to nourish their developing eggs. Some species can develop their first batch of eggs without a blood

Floodwater mosquitoes covering the legs of a mosquito biologist. There are times in Florida when the mosquitoes can be this bad! Photo: Alan Curtis, Indian River Mosquito Control.

meal. The source of blood for female mosquitoes varies depending on host availability and mosquito species.



*Mosquitoes feeding on a southern toad.
Photo: Erik Blosser, UF/IFAS/FMEL*

Does anything eat mosquitoes?

Like other living organisms, mosquitoes are eaten by other organisms that are known as predators. While there are no organisms that are known to feed exclusively on mosquitoes, many animals will feed on them.

Fish, copepods (small crustaceans), dragonfly and damselfly nymphs, and frogs will eat mosquito larvae. Frogs, dragonfly and damselfly adults, birds, and bats will eat adult mosquitoes.

It is never a good idea to rely solely on natural predators to protect yourself from mosquito-borne diseases as the



*Northern cardinal. Photo:
Roxanne Connelly, UF/IFAS/
FMEL*

predators are not able to consume every living mosquito. All it takes is one probe from an infected female mosquito to infect a human.



Damselfly. Photo: Tyler Jones, UF/IFAS

Female mosquito blood feeding

Female mosquitoes are attracted to carbon dioxide. Humans and other animals exhale carbon dioxide with every breath.

After locating and landing on an attractive host, the mosquito probes the skin with her mouthparts (known as a proboscis) to find a capillary in the skin. She pierces the skin with her serrated proboscis, not really biting, but sucking blood. She injects a pain killer, present in her saliva, which makes the piercing less noticeable. Her saliva also contains a blood thinner so that the blood will flow into her, rather than clot. If her salivary glands are infected with a pathogen, it may be transmitted to the host when she takes the blood meal.

The volume of blood one female can ingest depends on her size. Generally, mosquitoes take in about five microliters of blood. How much is that? When blood is donated, the typical amount taken is a pint. It would take 94,600 of the five microliter bites to get a pint of blood!



Aedes aegypti female with a full blood meal in her abdomen. Photo: James Newman, UF/IFAS/FMEL.

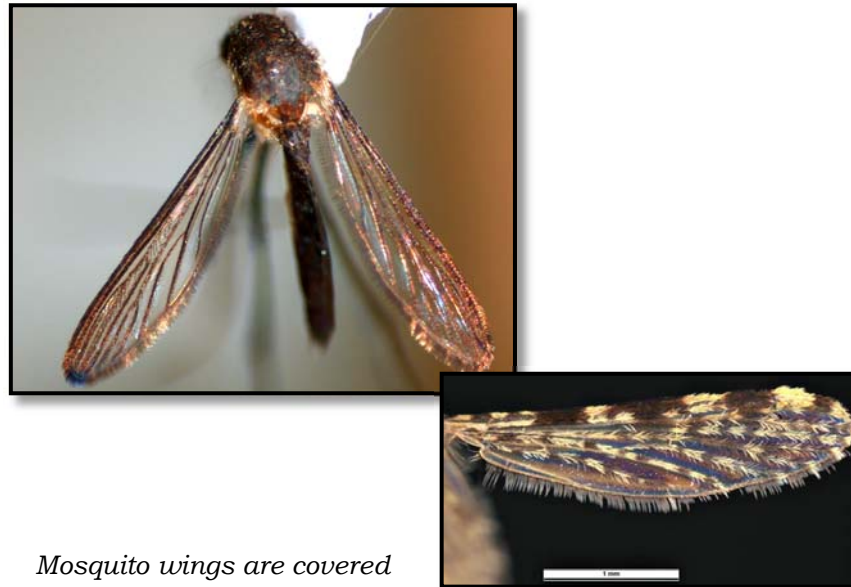
Mosquito Flight

Mosquitoes fly to mate, find blood sources, escape predators, lay eggs, and to find resting places. The frequency of the mosquito wing beat ranges from 300 – 600 beats per second.

Males and females of the same species recognize each other by listening to wing beat frequency.

Flight activity is reduced at temperatures around 60°F, and mosquitoes are inactive at 50°F and lower.

How far a mosquito flies from the aquatic habitats varies with species. Some go only 500 feet from where they emerged; some move dozens of miles from the larval habitat.



Mosquito wings are covered with scales and hairs. Photos: (left) Roxanne Connelly, UF/IFAS/FMEL; (right) Michele Cutwa, UF/IFAS/FMEL.

Mosquito Habitats

All mosquitoes require water for the eggs to hatch, and for the larvae and pupae to grow. Different mosquito species prefer different types of water for laying eggs and completing their aquatic stages of life.

The three major types of aquatic habitats are permanent, floodwater, and containers. Permanent water habitats remain wet most of the time, floodwater habitats are transient and can change quickly depending on weather conditions. Container habitats can be natural, such as tree holes and bromeliad plants, or human-made including bottles, tires, buckets, and more.



*Flooded salt marsh. The dark areas in the water are millions of *Aedes taeniorhynchus* (salt marsh mosquito) larvae. Photo: Trey English ADAPCO, Inc.*

Permanent water habitats



Cattails. Photo: UF/IFAS



River backwaters. Photo: UF/IFAS

Floodwater habitats

*Drying salt marsh mud. Photos:
Peter Connelly, AMVAC, Inc.*



*Dairy lagoon. Photo: Roxanne
Connelly, UF/IFAS/FMEL*

Container habitats



*Wheelbarrow holding water. Photo:
James Newman, UF/IFAS/FMEL*



*Tires holding water. Photo: James
Newman, UF/IFAS/FMEL*



*Bromeliad plants (left) and
bird bath (right).*

*Photos: Roxanne Connelly,
UF/IFAS/FMEL*



Floridians need to be familiar with these five mosquitoes.

There are 80 different species of mosquitoes known to occur in Florida. Some are pests; some transmit pathogens that cause disease. Here are a few that feed on humans:



Photo: James Newman, UF/IFAS/FMEL

Scientific name: *Aedes aegypti*

Common name:

Yellow fever mosquito

Larvae are found in water-holding objects found around the home and yard such as flower vases, tires, toys, bottles, conch shells, cans, refrigerator drain pans, barrels, bromeliad plants, and other containers.

Found in all Florida counties.

Vector of dengue and chikungunya viruses.

Scientific name: *Aedes albopictus*

Common name:

Asian tiger mosquito

Larvae found in water-holding objects found around the home and yard such as flower vases, tires, toys, bottles, cans, barrels, tree holes, bromeliad plants, and other containers. Found in all Florida counties, but does not occur in the Florida Keys.

Vector of dengue and chikungunya viruses.



Photo: Sean McCann, UF/IFAS/FMEL



Photo: James Newman, UF/IFAS/FMEL

Scientific name:
Culex nigripalpus

Larvae are found in ditches, containers, grassy pools, dairy lagoons, furrows in citrus groves. Found in all Florida counties, abundant throughout the state.

Vector of dog heartworm, St. Louis encephalitis virus, West Nile Virus.

Scientific name:
Aedes taeniorhynchus
Larvae are found in salt marshes. Found in all Florida counties, strong fliers. Major pests during summer and early fall.
Vector of dog heartworm.



Florida Medical Entomology Laboratory
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Photo: James Newman, UF/IFAS/FMEL



Photo: Sean McCann, UF/IFAS/FMEL

Scientific name:
Psorophora ciliata
Larvae are found in ditches, containers, grassy pools, furrows of citrus groves, pasture areas. Found in all Florida counties, abundant throughout the state.

Not known to vector any mosquito-borne pathogens.

Diseases

Several of the mosquito species that inhabit Florida are capable of transmitting pathogens that sometimes cause disease in humans, horses, and some companion animals like dogs and cats. The following is a list of mosquito-borne diseases that have been detected in Florida:

Chikungunya

Affects humans. No vaccine.

Dengue

Affects humans. No vaccine.

Dog heartworm

Affects dogs and cats.

Preventatives available from veterinarians.

Eastern equine encephalitis

Affects humans, horses, and some exotic birds.

Vaccine is available for horses.

St. Louis encephalitis

Affects humans. No vaccine.

West Nile fever and West Nile encephalitis

Affects humans and horses.

Vaccine available for horses.

For more information on the mosquito-borne diseases that affect humans, visit http://www.cdc.gov/ncidod/diseases/list_mosquitoborne.htm or <http://www.floridahealth.gov/>.

What's attractive to mosquitoes?

A female mosquito seeking blood to nourish her eggs is primarily attracted to carbon dioxide. When humans exhale, carbon dioxide is released.

After feeding on blood, the female mosquito needs to find a resting spot while her body digests the blood, this can take up to three days. She looks for dark, shady, well protected areas to rest to avoid being eaten and to stay warm and humid.

Both male and female mosquitoes will look for places to rest in between the times they are feeding and mating. They look for dark, moist, protected areas and can be found around wet bags, dark corners inside barns or on porches, around damp mops and other wet items, and in dense vegetation.



When the female mosquito has digested a blood meal and is

Vegetated areas around homes are where adult mosquitoes like to rest. Photo: Roxanne Connelly, UF/IFAS/FMEL

ready to lay eggs, she is attracted to various water sources. Some mosquito species are very picky about where they lay their eggs and will search until they find the perfect water source for their tastes.

How to repel mosquitoes

The U.S. Centers for Disease Control and Prevention (CDC) recommends the use of certain products containing active ingredients which have been registered by the U.S. Environmental Protection Agency (EPA) for use as repellents applied to skin and clothing. EPA registration of repellent active ingredients indicates the materials have been reviewed and approved for efficacy and human safety when applied according to the instructions on the label.

CDC evaluation of information contained in peer-reviewed scientific literature and data available from EPA has identified several EPA registered products that provide repellent activity sufficient to help people avoid the bites of disease carrying mosquitoes. Products containing these active ingredients typically provide reasonably long-lasting protection:

DEET (Chemical Name: N,N-diethyl-m-toluamide or N,N-diethyl-3-methyl-benzamide)

Picaridin (KBR 3023, Chemical Name: 2-(2-hydroxyethyl)-1-piperidinecarboxylic acid 1-methylpropyl ester)

Oil of Lemon Eucalyptus* or **PMD** (Chemical Name: para-Menthane-3,8-diol) the synthesized version of oil of lemon eucalyptus

IR3535 (Chemical Name: 3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester)

*Note: This recommendation refers to EPA-registered repellent products containing the active ingredient oil of lemon eucalyptus (or PMD). “Pure” oil of lemon eucalyptus (e.g. essential oil) has not received similar validated testing for safety and efficacy, is not registered with EPA as an insect repellent, and is not covered by this CDC recommendation.

In general, higher concentrations of an active ingredient provide longer duration of protection, regardless of the active ingredient. Note that concentrations above ~50% do not offer a marked increase in protection time. Products with <10% active ingredient may offer only limited protection, often from one to two hours. Products that offer sustained release or controlled release (micro-encapsulated) formulations, even with lower active ingredient concentrations, may provide longer protection times. Regardless of what product you use, if you start to get mosquito bites reapply the repellent *according to the label instructions* or remove yourself from the area with biting insects if possible.

Repellents for use on clothing:

Certain products containing **permethrin** are recommended for **use on clothing, shoes, bed nets, and camping gear**, and are registered with EPA for this use. Permethrin is highly effective as an insecticide and as a repellent. Permethrin-treated clothing repels and kills ticks, mosquitoes, and other arthropods and retains this effect after repeated laundering. The permethrin insecticide should be reapplied following the label instructions. Some commercial products are available pretreated with permethrin.



Application of mosquito repellent. Photo: Centers for Disease Control <http://www.cdc.gov/media/dpk/2014/dpk-whd.html>

EPA recommends the following precautions when using insect repellents:

Apply repellents only to exposed skin and/or clothing (as directed on the product label.) Do not use repellents under clothing.

Never use repellents over cuts, wounds or irritated skin.

Do not apply to eyes or mouth, and apply sparingly around ears. When using sprays, do not spray directly on face—spray on hands first and then apply to face.

Do not allow children to handle the product. When using on children, apply to your own hands first and then use the material on your hands to apply it to the child. You may not want to apply materials to children's hands to avoid the chance they could transfer the materials to the eyes and mouth.

Use just enough repellent to cover exposed skin and/or clothing. Heavy application and saturation are generally unnecessary for effectiveness. If biting insects do not respond to a thin film of repellent, apply a bit more.


After returning indoors, promptly wash treated skin with soap and water. This is particularly important when repellents are used repeatedly during the day or on consecutive days. Also, wash treated clothing before wearing it again. (This precaution may vary with different repellents—check the product label.)







If you or your child gets a rash or other reaction from an insect repellent, stop using the repellent, wash the repellent off with mild soap and water, and call a local poison control center for further guidance. If you go to a doctor because of the repellent, take the repellent with you to show the doctor.

Note that the label for products containing oil of lemon eucalyptus specifies that they should not be used on children under the age of three years. Other than those listed above, EPA does not recommend any additional precautions for using registered repellents on children or on pregnant or lactating women.

For additional information regarding the use of repellent on children, please see CDC's Frequently Asked Questions about Repellent Use. [http://www.cdc.gov/ncidod/dvbid/west Nile/qa/insect_repellent.htm]

The University of Florida's Florida Medical Entomology Laboratory has tested and published the results on the efficacy of the following repellents. Average Complete Protection Time is the time that elapses between the proper application of a repellent until the first mosquito lands on the protected area.

 = 60 minutes protection time

<p>OFF! Deep Woods 23.8% DEET 5 hours</p> 	<p>Sawyer Controlled Release 20% DEET 4 hours</p> 
<p>OFF! Skintastic 6.65% DEET 2 hours</p> 	<p>Repel Lemon Eucalyptus Insect Repellent p-menthane 3,8-diol (PMD) 2 hours</p> 
<p>Bite Blocker for Kids 2% soybean oil 1.5 hours</p> 	<p>OFF! Skintastic for Kids 4.75% DEET 1.5 hours</p> 
<p>The following provided less than 25 minutes protection time:</p> <p>Skin-so-soft Bug Guard Plus: 7.5% IR3535 Natrapel: 10% citronella Herbal Armor: 12% citronella, 2.5% peppermint oil, 2% cedar oil, 1% lemongrass oil, 0.05% geranium oil Green Ban for People: 10% citronella, 2% peppermint oil Buzz Away: 5% citronella Skin-so-soft Bug Guard: 0.1% citronella Skin-so-soft bath oil: unknown Skin-so-soft Moisturizing Suncare: 0.05% citronella</p>	<p>The following provided zero protection time:</p> <p>Gone Original Wristband: 9.5% DEET Repello Wristband: 9.5% DEET Gone Plus Repelling Wristband: 25% Citronella</p>



Mosquito feeding on arm of individual using a repellent bracelet, demonstrating the ineffectiveness of the bracelet. Photo: Roxanne Connelly, UF/IFAS/FMEL

How to reduce mosquitoes

There are many gimmicks for sale that do not work, so be an educated consumer and don't waste your money on impulse buys! The tips listed here do work to reduce mosquitoes.

Source Reduction is the most important technique that homeowners can employ to reduce mosquitoes. Since mosquitoes need water to live, removing water sources around the home goes a long way to prevent mosquitoes from occurring.

- When water is intentionally collected for use, such as in rain barrels, the water holder should be modified to prevent mosquitoes from laying eggs on or near the water. Add screening to the top to prevent mosquitoes from laying eggs, or cover the rain barrel with a lid.
- For water not intentionally collected, such as water that collects in discarded cans, bottles, and buckets, it is best to properly dispose of water holding containers or empty the water from the containers.
- In Florida, it is best to flush out containers such as bird baths, and bromeliad plants, every three to four days during the summer.
- Take used tires to a local facility that will accept them.
- Dispose of old appliances that are sitting outdoors.
- Clean out the roof gutters to remove leaves that may clog the drain and cause water to be retained.
- Check for and repair leaky faucets.
- Check for standing water in your yard, areas that may pool and remain after rainfall events. Make sure these areas can drain well. Or add Bti to kill the mosquito larvae (see page 34 for more information).

- Water gardens and ornamental ponds are popular, but aerate them or stock with fish to reduce mosquito populations. See page 30 for more information on fish.
- Repair torn window and door screens to exclude mosquitoes from indoors.
- Clean up vegetation that has fallen from trees. Areca palm fronds, for example, hold water when they are on the ground.
- For homes with windows that don't have screens, use mosquito netting around the bed to prevent mosquitoes from biting while residents are sleeping.
- Fans can be used to keep mosquitoes away. Mosquitoes are weak flyers. Operating a fan on high will help keep flying mosquitoes out of the area.
- Organize community efforts to help everyone locate and remove sources of water where mosquitoes can live. If your neighbors are not reducing mosquitoes, you are still at risk for mosquito bites.

Some items that are **not effective** for reducing mosquitoes:

Mosquito plants

Bug zappers

Consumption of garlic, vitamin B, and bananas

Repellent bracelets and wristbands

Ultrasonic devices and cell phone apps

Dragonfly mimics

Predators of Mosquito Larvae

FISH

For ornamental ponds, aquatic plant nurseries, abandoned swimming pools, and sources of standing water that are intentionally placed for a specific use (feeding wildlife, rainwater for gardens, etc.), the addition of some small native fish can help to keep the mosquito larvae population to a minimum.

Fish native to Florida that can be used for mosquito control include (* = game fish)

Eastern Mudminnow (*Umbra pygmaea*)

Pygmy Killifish (*Leptolucania ommata*)

Lined Topminnow (*Fundulus lineolatus*)

Golden Topminnow (*Fundulus chrysotus*)

Sailfin Molly (*Poecilia latipinna*)

Eastern Mosquitofish (*Gambusia holbrooki*)

Least Killifish (*Heterandria formosa*)

Banded Pygmy Sunfish (*Elassoma zonatum*)

Everglades Pygmy Sunfish (*Elassoma evergladei*)

Bluespotted Sunfish (*Enneacanthus gloriosus*)

*Flier (*Centrarchus macropterus*)

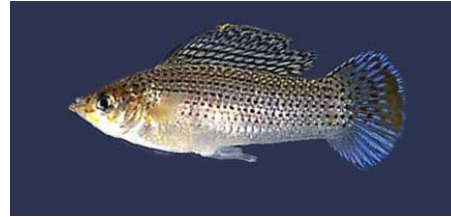
*Spotted Sunfish/Stumpknocker (*Lepomis punctatus*)

*Bluegill or Bream (*Lepomis macrochirus*)

*Redear Sunfish or Shellcracker (*Lepomis microlophus*)

Most of these fish can be found in local water sources such as ditches and canals. If they are not game fish*, they can be collected with a net, minnow trap, or barbless hook. Hook and line need to be used for game fish (see page 30 for list of game fish), and there are limits for game fish; check with Florida Fish and Wildlife Conservation Commission on the limits.

<http://myfwc.com/>



Sailfin Molly. Poecilia latipinna. Photo: USGS



Eastern Mosquitofish. Gambusia holbrooki. Photo: Jorge Rey, UF/IFAS/FMEL

Check with your local mosquito control agency because in some Florida counties, the mosquito control program includes raising fish to provide to pond owners when requested.



Everglades Pygmy sunfish. Elassoma evergladei. Photo: Brian Gratwicke, Wikimedia commons.



Bluegill. Lepomis macrochirus. Photo: Wikimedia commons.

Predators of Mosquito Larvae

COPEPODS

Copepods are aquatic crustaceans that occur in both fresh and salt water. They will eat early instars of mosquito larvae and can be added to areas where water cannot, or is not meant to, drain. Copepods can be collected from ponds, ditches, and other standing water sources with a mosquito dipper or turkey baster. Place the collected water into a container with a white background (they are transparent, so they are best viewed with a white background) and you should be able to see the copepods swimming along the bottom. The adult copepods are about the size of a grain of rice, and the young are about half that size. Transfer the copepods to the water source where mosquitoes are likely to occur. The copepods need water to survive, so if the area where they are placed becomes dry, the copepods will need to be replenished.



Copepod (left); mosquito dipper and turkey baster (right)

Photos: Jorge Rey, UF/IFAS/FMEL

Mosquito Control Products

Before using any products to control mosquitoes, it is the homeowner's responsibility to read the label and apply the product only as directed. The label is the law; deviating from the instructions is illegal.

There are several products that will work to kill mosquitoes around the home that can be found at local hardware and retail stores. Prior to purchasing an insecticide, check to determine if you can reduce the mosquitoes through one of the source reduction techniques described elsewhere in this brochure. Otherwise, decide whether it is the larval (aquatic) stage or the adult stage of the mosquito that needs to be targeted. Repellents that are labeled for use on the skin should NOT be sprayed onto the soil or water for control of adult or larval mosquitoes.

If it is the adult stage that needs to be managed, the product must be an adulticide, meaning the label must indicate that the product is for flying insects. These products provide immediate, but temporary relief. Most products available to homeowners for adult mosquito control come in the form of aerosols, foggers, and coils and contain active ingredients known as pyrethrins or pyrethroids. Pyrethrins are plant-derived insecticides that work by altering nerve function in insects. The end result is that the insect is paralyzed and eventually dies.

Pyrethroids are the synthetic versions of pyrethrins. Their structure is based on the pyrethrins and they work on the insects in the same manner. Examples of pyrethroids on the label are: allethrin, cypermethrin, permethrin, phenothrin, pyrethrins, and tetremethrin. There may be other types available but their name commonly ends in "thrin". Another type of insecticide available to homeowners for control of adult mosquitoes includes organophosphates (malathion).

There are products labeled for treating vegetation that mosquitoes may land on to rest. The idea is that they will pick up the insecticide on their body when they rest on the shrubs.

The adulticides mentioned above are broad-spectrum insecticides and not specific to mosquitoes. Therefore, they should be applied at times and places where there is limited activity of other insects.



Pump-up sprayers for treating vegetation around the home.

When controlling the larval stage of the mosquito, the products are called larvicides.

There are several forms of larvicide that contains a strain of bacteria that is toxic to the mosquito larvae after they ingest it. The bacteria is named *Bacillus thuriengensis israelensis*, or Bti. This active ingredient does not harm butterflies, bees, fish, frogs, or other non-target species; it is very specific for mosquitoes, midges, and black flies. It comes in the form of granules, or bits, and dunks.

Methoprene is an insect growth regulator that prevents the mosquitoes from developing into adults.



*Bacillus thuriengensis israelensis (Bti) granules.
Photo: Roxanne Connelly UF/IFAS/FMEL*

Interesting facts about Florida mosquitoes

One of the smallest mosquito species in Florida is called *Uranotaenia lowii*. The adults are about 2.5 millimeters in length and adorned with iridescent blue scales. This mosquito species feeds on frogs, toads, and salamanders.



Adult *Uranotaenia lowii*. Photo: Roxanne Connelly, UF/IFAS/FMEL

The two largest mosquito species in Florida are *Psorophora ciliata* and *Toxorhynchites rutilus*. Each of these two species have a wingspan of about 6—7 millimeters. *Psorophora ciliata* is also known as the “gallinipper”, nicknamed by those who claimed the mosquitoes take a gallon of blood when they bite.

Toxorhynchites rutilus is a mosquito that never feeds on blood. Females use sugar from plant sources for the developing eggs. Both *Psorophora ciliata* and *Toxorhynchites rutilus* are predatory while they are in the larval stage and will eat other mosquito larvae.



Toxorhynchites rutilus
(left).

Photo: Roxanne
Connelly, UF/IFAS/
FMEL.

Psorophora ciliata
(right).

Photo: Sean McCann,
UF/IFAS/FMEL



Genetically Engineered Mosquitoes

Genetic engineering involves inserting genetic material controlling a specific trait into the genome (genetic make-up) of an organism where it is subsequently passed on to its descendants. These techniques are now being applied to control insects, particularly insect pests that attack humans such as mosquitoes and agricultural pests that attack crops and reduce yields. The expression of this genetic material once inserted into an insect's genome will vary depending on the traits chosen. For example, it could include making an insect fluoresce or glow, or it could kill the insect.

There are many different ways in which GE mosquitoes could be used to control or change a mosquito population and reduce disease. These methods generally fall into two broad groups; population replacement and population control.

Population replacement; the genes inserted into the mosquito are designed to produce an effect that helps prevent disease transmission; the genetic material inserted into the mosquito affects changes that either alter the insect's physiology so that the pathogen (e.g., virus) cannot survive, or change the insect's behavior so that transmission ceases. For example, it might make the insect itself more resistant to infection so it no longer transmits disease. The concept here is that the genetically modified mosquito population **replaces** the wild mosquito population.

Population reduction; the genes inserted into the mosquito causes sterility, either making the male sterile or causing the offspring that inherit the gene to die. Releasing the GE males reduces the size of the pest population and so reduces its capacity to transmit disease. The concept therefore is to **reduce** the mosquito population; without the insect there is no capacity to transmit disease.

Both of these types of GE mosquito control are being researched today, however the following discussion highlights a population reduction method that has been extensively examined and may be used by mosquito control districts in the near future.

If genetically engineered males are released in the wild en masse, mate with the local population of female mosquitoes, the resulting offspring will inherit the altered genetic material and die before becoming adults. Over time with repeated releases of genetically engineered males the population of *Aedes aegypti* mosquitoes should exhibit a significant decline.

This technology is currently being reviewed for safety and efficacy by regulatory authorities in the US. It has been trialed in the Cayman Islands, Brazil, Malaysia and Panama and shown to reduce *Aedes aegypti* populations by over 80%; a higher rate than current control methods for *Aedes aegypti*.

- The GE males that are released do not bite or transmit disease.
- The GE males will only mate with their own species, meaning that only *Aedes aegypti*, the main mosquito that transmits dengue, will be removed.
- The offspring die and the males only survive a few days; nothing persists in the environment when a control program using these mosquitoes stops.
- The introduced genes produce proteins that are innocuous; they are neither a known toxin nor allergen. The materials that make up these insects will decompose into elementary organic matter.
- This control method uses the natural ability of male mosquitoes to search for females. This makes it very effective, particularly at low mosquito population levels.

There are a number of mosquito species in Florida that are considered to be nuisance pests, that is, they are not known to transmit diseases, but they make it unbearable to be outdoors at times. Nuisance mosquitoes includes the salt marsh mosquitoes and some other floodwater species. The potential importance of using genetically engineered mosquitoes as a control measure is more public health (disease control) than control of mosquitoes as a nuisance.

For more information see; <http://keysmosquito.org/modified-mosquito-release/>.

Resources

Mosquito Information Website. <http://mosquito.ifas.ufl.edu>

Solutions for your life. For plant and insect questions, start with our local University of Florida County Extension Service Office. <http://sfyl.ifas.ufl.edu/map/>

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