Mosquito Management Procedures

Mosquito management is a multi-disciplinary subject that combines the art of understanding mosquito behavior with the science of knowing how to locate and control mosquito populations. All mosquito management programs worldwide have their own unique control measures for their own specific management problems. However, the primary goal of all mosquito management programs is to enhance the health and comfort of the citizens.

As with all career fields, the mosquito control industry has its own specific terminology. The following is a list of some of the more common terms.

- Adulticide: an insecticide used to kill adult insects.
- Larvicide: an insecticide used to kill larval (immature) insects.
- Ultra Low Volume: commonly known as ULV, a method of applying adulticides at volumes less than 10 ounces per acre.
- Thermal Fog: commonly known as fogger, a method of applying adulticides mixed with a carrying agent, usually diesel fuel, and heating it to form a fog.
- Drift: the direction and distance the spray travels after leaving the spray head.
- Crepuscular: the hours between one-half hour before and after sunset and one-half hour before and after sunrise.
- Atomize: to reduce to minute particles or a fine spray.
- Landing Rate: a surveillance method used to determine adult mosquito populations by counting the mosquitoes that land on the front half of your body for one minute.

Mosquito Biology

There are approximately 45 different species of mosquitoes in Lake County. However, only a few of these species have the potential of transmitting diseases and, therefore, are a primary concern for management purposes.

Mosquito Species of Primary Concern

Aedes aegypti
Aedes albopictus
Aedes vexans

Anopheles crucians
Anopheles quadrimaculatus

Culex nigripalpus
Culex quinquefasciatus
Culex salinarius

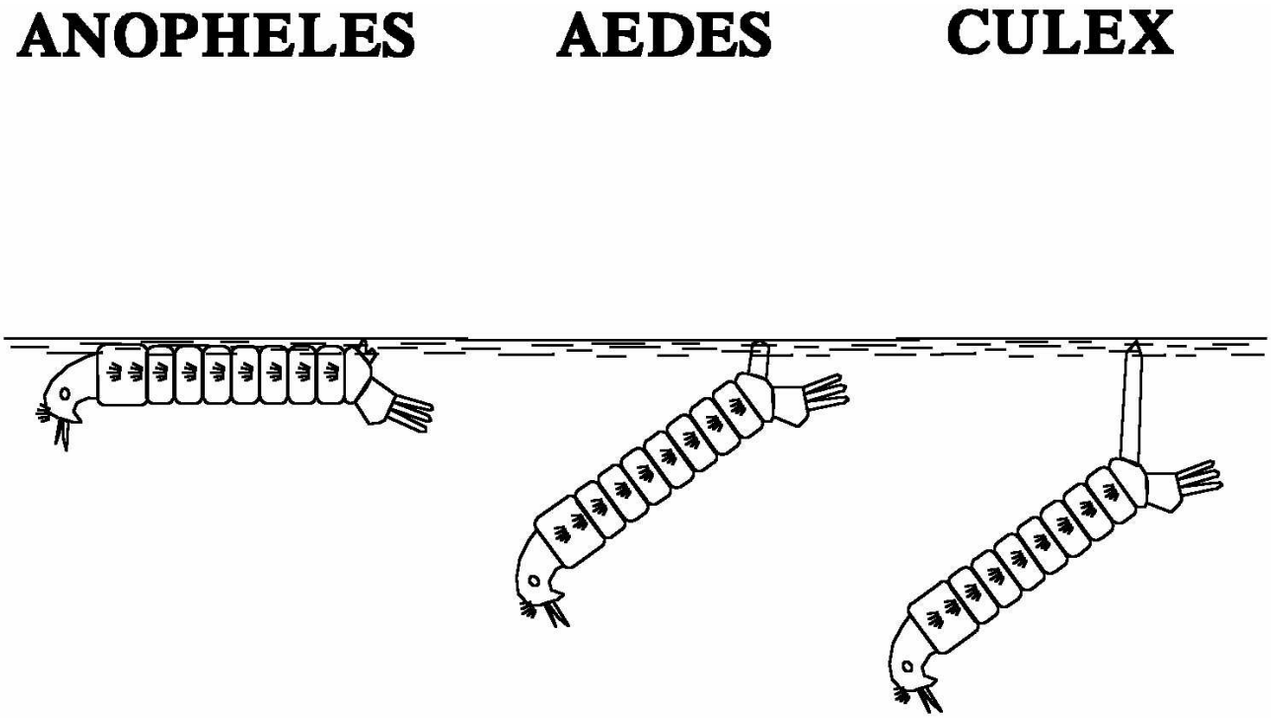
Culiseta melanura

Coquillettidia perturbans

Mansonia dyari
Mansonia titillans

Mosquito eggs are generally cylindrical in shape, tapered at the top and rounded at the bottom. Each mosquito species prefers certain localities for depositing eggs. Some prefer very clean water, others slightly polluted water, while others thrive in extremely polluted water. There are five distinct types of oviposition:

- Single On Water: *Anopheles* and *Toxorhynchites* lay their eggs one at a time on the water surface.
- Single In Soil: most *Aedes* and *Psorophora* lay their eggs one at a time on a moist substrate, such as mud and decomposing leaf litter.
- Single On Cavity Walls: *Wyeomyia*, *Orthopodomyia*, and certain *Aedes* deposit eggs in tree holes, water-holding plants, or artificial containers. The eggs are placed just above the waterline.
- Rafts On Water: Most *Culex*, *Culiseta*, *Coquillettidia*, and *Uranotaenia* lay eggs in masses, called rafts or boats, on the water surface.
- On Plants: *Mansonia* eggs are deposited on the underside, and sometimes on top, of the leaves of certain floating aquatic plants.



Mosquito larvae live in water and have four developmental periods called instars. Each successive instar is larger than the previous one. Larvae feed aggressively until the late fourth instar.

The mosquito pupae are the next stage of development. Pupae react similar to larvae by diving to the bottom when the surface is disturbed or there are changes in illumination. Because pupae do not feed, water quality is of little importance for survival, as long as the surface is free of oils that suffocate the insect.

The male mosquito develops slightly faster than the female. Sometimes, the male emerges from the pupae stage a day or so earlier than the female in many species. The adult mosquito has three body parts: the head, thorax, and abdomen. The major difference between the male and female mosquito is the male has large, bushy palpi protruding from its head.

Adult Mosquito Activity

All mosquito species have their own specific behavioral patterns that influence activity. However, environmental factors seem to have a more dramatic affect on mosquito activity.

Studies have shown that the majority of mosquito activity occurs at night with over half of this activity occurring during the crepuscular periods. Also, one study showed that up to five times as many mosquitoes are in flight during a "full moon" when compared to a "new moon". Only a few mosquito species are active during the daylight hours.

Temperature plays an important role in mosquito activity. At 68^{o}F mosquitoes in flight begin to decrease and are almost nonexistent at 50^{o}F. Relative humidity also has an effect on mosquito activity. A burst of activity occurs when the humidity reaches 90% and peaks during light showers. However, mosquitoes seek shelter during heavy rain and are rarely in flight.

Mosquito-Borne Diseases

St. Louis encephalitis (SLE) is a mosquito-transmitted virus that is considered to be of greatest medical importance in North America. During epidemics, large numbers of people become seriously ill, sometimes fatally.

The transmission cycle of SLE is thought to accompany infection of various species of wild birds. It takes about 1-2 days after a bird is infected by a mosquito bite to produce enough viruses in its blood to infect other mosquitoes that might feed upon it. The virus disappears about 1-3 days later as the bird recovers. This provides a narrow "window of opportunity" for mosquitoes to pick up the virus and further spread it. After a bird has been infected with SLE, it is immune from another infection.

The mosquito *Culex nigripalpus* has been linked to past SLE epidemics in Florida. Other species that may be involved in SLE transmission but have not, as yet, been implicated are *Culex quinquefasciatus*, *Culex salinarius*, and *Culex restuans*. SLE transmission to birds and humans is most likely to occur from August through November. Populations of *Culex nigripalpus* tend to reach their annual peak during this period. Transmission to birds seems to increase when subsequent heavy rains break long periods of drought.

There is no vaccine to protect against SLE infection. Also, like all virus infections, SLE cannot be cured. Therefore, the best prevention is to suppress the mosquito populations that may transmit the virus.

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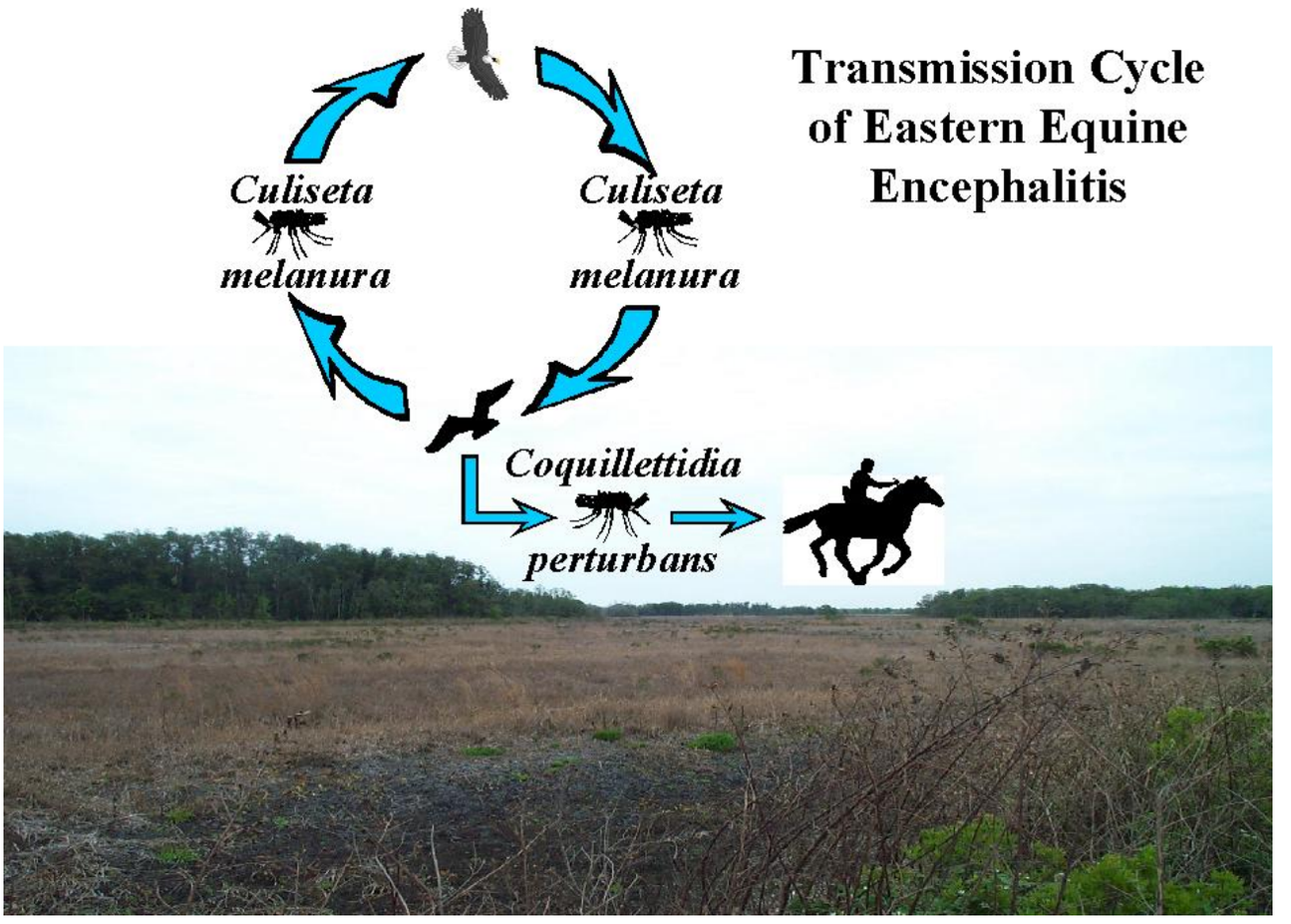
Eastern equine encephalitis (EEE) is a fatal disease of horses and humans caused by a virus carried by mosquitoes. The disease occurs throughout the eastern U.S. and Canada.

The EEE virus is normally found only in wild birds and mosquitoes that live in and around wooded swamps. The mosquito *Culiseta melanura* must be present for the virus to spread from bird to bird. The larvae of this mosquito are found only in the underwater root systems of deciduous trees that grow in swamps. Rarely does this mosquito bite humans or other mammals.

Since *Culiseta melanura* does not bite people, the key to human and horse infection is tied to *Coquillettidia perturbans* that breeds in cattail or grassy marshes found next to the swamps that produce *Culisetamelanura*. During periods when birds have high concentrations of the EEE virus in their blood, other mosquitoes, normally *Coquillettidia perturbans*, feed on these infected birds and become infected as well. It is this "secondary" mosquito that carries the virus to other vertebrate hosts, including horses and humans.



There is a vaccine against EEE for horses but there is no vaccine or cure in humans. As with SLE, the best way to prevent EEE is to control the mosquitoes that carry the virus.

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Malaria in humans is a disease caused by a microscopic protozoan in the genus *Plasmodium*. Although malaria disappeared as a significant problem in the U.S. by the mid-1950's, it is still one of the most important communicable diseases worldwide. In June 1990, a human case of *Plasmodium vivax* malaria occurred in a woman camping in the panhandle of Florida. This is the only acquired infection from a mosquito in Florida in 42 years.

The malaria parasite is transmitted from person to person by the bite of *Anopheles* mosquitoes only. Historically, *Anopheles quadrimaculatus* is considered the most important carrier of the disease in the eastern U.S.

In the early stages, malaria can be treated effectively. If not treated, a malaria infection may persist for many months or years.

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Heartworm disease in dogs is caused by the filarial nematode *Dirofilaria immitis*. Heartworm is distributed worldwide in most tropical and subtropical regions, with increasing frequency in temperate climates. Heartworm is an occasional parasite of humans. During the last 20 years, about 80 cases of human pulmonary dirofilariasis have been reported from Florida.

Heartworm disease cannot be eliminated, but it can be controlled or prevented. Several drugs have been developed for larvae and adult worm control.

Mosquito-Borne Diseases

St. Louis Encephalitis (SLE)	**Malaria**
Eastern Equine Encephalitis (EEE)	**Dengue**
Western Equine Encephalitis (WEE)	**Yellow Fever**
Venezuelan Equine Encephalitis (VEE)	**Dog Heartworm**

Mosquito Surveillance

Mosquito surveillance can be defined as a means of determining when and where mosquitoes are active and breeding. Lake County Mosquito Management uses several methods for locating active mosquito sites and estimating the fluctuations in adult mosquito population levels.

Adult mosquito surveillance can be done by several methods. The easiest is taking a "landing rate count". This method is useful if you are in the field and are not sure if mosquitoes are present.

CDC Miniature Light Traps are used to determine mosquito population levels for specific localities or to identify potential vectors during a disease outbreak. This device is made of a plastic, cylindrical body with a flat, metal hood. A small light bulb located under the hood is used to attract mosquitoes to the trap. Sometimes, dry ice is used for mosquito species not attracted to light. A small fan located in the body sucks the mosquitoes down into a net or killing jar. A 6-volt battery operates the trap.

A countywide adult mosquito surveillance program is conducted year-round in Lake County. New Jersey Light Traps are used to collect mosquitoes. This trap is made of a metal, cylindrical body with a metal, cone-shaped hood. A 25-watt light bulb is used to attract mosquitoes and a fan located in the body sucks the mosquitoes into a killing jar. The trap is plugged into a 7-day timer operated on a permanent 110v power source. The trap should be installed about waist high for optimum mosquito collection.

Lake County is divided into 10 spray regions and 4 New Jersey Light Traps are randomly located at permanent sites in each of the regions. The traps are set to collect mosquito samples on Sunday and Wednesday night for 6 hours each night, starting just before the crepuscular period. Mosquito Management staff collect the trap samples on Monday and Thursday. The samples are brought back to the lab and the mosquitoes are sorted and identified to species. This information is then entered into a surveillance database.

The intent of this surveillance program is not to monitor mosquito populations at any given trap site but, rather, to determine fluctuations in mosquito population levels compared to an established

baseline for each spray region. The Bidlingmeyer Abundance Index Equation is used for this purpose:

AI = [LOG (A+1)-LOG (B+1)] / LOG(C+1)

where AI = Abundance Index,

A = mean trap sample for any given trap day,

B = mean baseline over a three year period, and

C = standard deviation of the mean baseline.

An abundance index is determined for each of the 10 spray regions and plotted on a graph for easy reference. The baseline is referenced at "0.00" on the graph. Abundance indices greater than 0 show an increase in mosquito population levels and indices below 0 indicate a decrease. This information is used to help direct and monitor our adulticiding activities.

Inspection and Larviciding

Immature mosquitoes can be found where standing water is present. Some representative sites are listed below.

Common Mosquito Breeding Sites

Swamps	**Tree Holes**
Roadside Ditches	**Refuse/Debris Sites**
Pastures	**Pet Watering Dishes**
Retention/Detention Ponds	**Potted Plants**
Small Natural Ponds	**Rain Gutters**
Waste Tires	**Floating Aquatic Plants**

The primary tool used for surveying immature mosquito sites is a "dipper". The dipper is a pint-sized plastic cup attached to a 4' stick. It is thrust into the water in a swift but careful manner so as to capture mosquito eggs, larvae, and pupae before they dive beneath the surface. With tree holes, waste tires, and other small areas, a syringe can be used.

If a mosquito problem is suspected at an area, you should first visually check for any pools of standing water. If none are immediately seen, you may have to perform a more thorough search. After locating a pool of water, use a mosquito dipper, siphon, or any other inspection tool to check for immature mosquitoes. You may want to note the types of immature mosquitoes found. This information will be useful to determine if a potential disease vector exist.

Female mosquitoes are constantly laying eggs. Therefore, if no immature mosquitoes are found during your initial inspection of a site, you should perform periodic checks, especially during the summer months.

Individuals frequently call our office for mosquito abatement service. All pertinent information about the request is recorded and distributed to the Mosquito Management employees. The problem is investigated to determine appropriate control measures. Usually, the mosquito problem is of a "domestic" nature. This means the mosquitoes are breeding around the home or neighborhood. Typical "domestic" breeding sites found around an individual's home are listed below.

Common Domestic Breeding Containers

Rain Gutters	**Pools**
Wheel Barrows	**Ponds**
Rain Barrels	**Boats**
Potted Plants	**Bird Baths**
Tree Holes	**Tires**
Drink Bottles	**Water Cans**
Dog Dishes	**Buckets**

After investigating a service request, the Mosquito Management employee fills out a service request brochure and leaves it with the homeowner. If the individual is not home, he will place it on the front door.

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Mosquito larviciding is an activity that incorporates biological and chemical control of immature mosquitoes. This can range from simply dumping a pale of water to applying larvicides.

Biological control, or biocontrol, involves the use of predator fish, insects, or pathogens to control immature mosquitoes. Lake County's mosquito management personnel primarily use predator fish, such as *Gambusia*, *Fundulus*, and *Poecilia* species, for biocontrol. These fish can be found in most permanent pools of water and are collected by net. The fish are placed in an aerated container for transport to the breeding site. Also, these fish are kept in fish rearing tanks located at the Mosquito Management facilities.

Chemical control involves the application of larvicides to reduce the numbers of immature mosquitoes. Like all pesticides, larvicides are toxic to living organisms and must be used according to the label directions. By following the prescribed label procedures, control of the target pest is accomplished without causing significant damage to non-target organisms or the environment. Several approved larvicides are available for purchase by the public. Before using any of these products, you should read the label thoroughly and the material safety data sheet (MSDS) should be reviewed for safety instructions. Some of the more common mosquito larvicides are listed below.

Mosquito Larvicides

Bacillus spp. (Bti and Bs)

Monomolecular oils

IGR's (Methoprene)

Adulticiding

Adulticiding is defined as a process for safely and efficiently dispersing insecticides to control adult mosquitoes. It can be performed by truck for localized ground applications or by aircraft for broad aerial applications. Lake County's Mosquito Management Section primarily uses mosquito spray trucks. However, aircraft may be used during times of a mosquito-borne epidemic or high infestations of pestiferous mosquitoes.

There are various chemicals used for mosquito adulticiding. The two most often used by Lake County are malathion (Fyfanon) and permethrin (Permanone 31+66). Malathion is applied as a straight formulation and permethrin is mixed with a diluent at various concentrations.

Mosquito Adulticides

Malathion (Fyfanon)

Permethrin (Permanone 31+66)

Naled (Dibrom 14)

Fenthion (Baytex)

Resmethrin (Scourge)

Homeowners around private property can perform mosquito adulticiding activities. However, trained professionals who are licensed by the state in Public Health Pest Control should perform adulticiding applications benefiting more than one property owner. Before adulticiding begins, the spray unit is calibrated to deliver 4.3 ozs/min while driving 10 mph. With an average swath of 300 ft, this is equivalent to an application rate of 0.71 ozs/acre.

For some adulticides, especially malathion, the size of the droplets after leaving the spray head is of great concern. Droplets too small may not be effective while droplets too large may cause damage to automobile paint finishes. The correct air pressure at the spray head is critical to "atomize" the insecticide for optimum droplet size. The ideal air pressure is 80 psi, but a range of 75 to 85 psi is sufficient. Because of the mechanics involved in air pressure regulation, this will not be covered. However, the malathion label lists specific guidelines for determining droplet size.

Droplet Size For Malathion

- **The Mass Median Diameter (MMD) of the droplets should not exceed 17 microns.**
- **Spray droplets should not exceed 32 microns in size. Three percent of the**

droplets (6 out of 200) can exceed 32 microns providing the MMD does not exceed 17 microns. No droplets can exceed 48 microns.

- **More than 1/2 of the total spray mass must consist of droplets in the 6 to 18 micron range.**
- **A minimum of 2/3, preferably 4/5, of the total spray mass must consist of droplets not exceeding 24 microns in range.**

The Mosquito Spray Truck Operators conduct most of the adulticiding activities at night. Occasionally, these activities are performed during the early morning hours to respond to service requests or to control mosquitoes in isolated areas.

Mosquitoes and Aquatic Plants

The three most important mosquito species that utilize aquatic plants as a primary habitat for egg deposition and larval development are *Mansonia dyari*, *Mansonia titillans*, and *Coquillettidia perturbans*.

If adult *Mansonia* species are discovered through routine surveillance monitoring, a thorough survey of the immediate area is conducted to locate fresh water sources containing water hyacinths and water lettuce. If a suspected fresh water source is found, a larval survey is conducted. *Mansonia* mosquitoes attach to the root structures of floating aquatic plants. If disturbed, the larvae will immediately release and fall to the bottom. When collecting these larvae, place a shallow pan under the floating vegetation. Care must be taken not to disturb the aquatic plants or surrounding area. Once in place, slowly lift the pan and plant out of the water. Clean water may be added to the pan to accurately view and count the mosquito larvae.

Coquillettidia perturbans can travel several miles. Therefore, a more widespread survey of fresh water sources containing cattails, sedges, aquatic grasses, or arrowhead may have to be done. The eggs and larvae of this mosquito are usually found in the detritus material at the base of the aquatic plants. A mosquito dipper or siphon can be used to collect the larvae. However, the water may have to be placed in a pan containing clean water for accurate viewing and counting.

Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques may be ineffective. Predator fish are usually not effective because of the dense vegetation. Monomolecular oils do not work because the immature mosquitoes are located below the water surface. Bti may be effective if the product is applied directly to the infested areas. This may be difficult and labor intensive if the aquatic vegetation is dense. Eradication or maintenance level control of the aquatic plants is the best method of managing these mosquitoes.