Mosquito Control

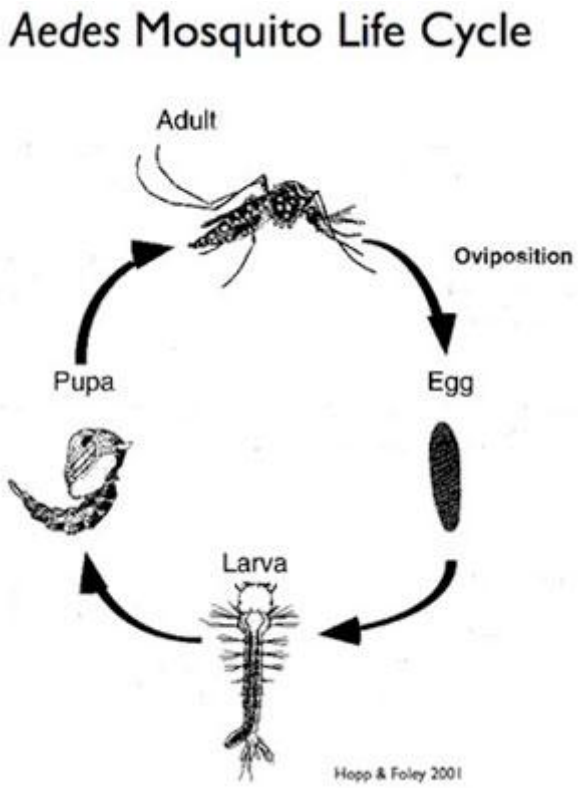
Written by: Michael F. Potter and G. Mark Beavers

Mosquitoes

The persistent and painful bites of mosquitoes are usually just a nuisance. However, these insects have done more harm to human health and well-being than any other insect group. Some species can carry debilitating diseases such as malaria, yellow fever, dengue, chikungunya, and most recently Zika. The most recent threats to human and animal health in Kentucky have been the outbreak of West Nile and the chronic problem of the dog heartworm nematode. Many mosquito species feed on wild and domestic animals but some have *the* potential to transmit diseases from animals to humans. For example, bird-feeding mosquitoes are important in moving encephalitis viruses within the bird population, species that also feed on mammals can transmit these diseases to horses and humans.

Kentucky has over 50 mosquito species. Only the females are blood feeders; males visit flowers for nectar and other plant juices. Female mosquitoes need an additional source of protein (in the form of a blood meal) before they can develop eggs. Females also feed on nectar and plant juices, using this food source for flight and metabolism.

Biology and Habits



Mosquito life cycle (www.stanford.edu)

Mosquitoes undergo complete metamorphosis consisting of four stages: egg, larva, pupa, and adult All stages except the adult occur in water. Mosquitoes are generally small (less than 1/2-inch) and fragile. Their most obvious characteristics include one pair of wings with scales on the wing veins and hind margin, and an elongated beak with piercing mouthparts. Mosquitoes are often confused with midges, punkies, biting gnats, and other flies.

Mosquito with long beak. Fuzzy scales on wing veins is a mosquito characteristic.(www.mosquito.org)

Mosquito eggs are elongate and about 1/40-inch long. They turn dark brown or black when ready to hatch. Depending on the species, eggs are laid singly or in batches of 50-400. Most groups of mosquitoes deposit them on the surface or along the margins of quiet pools of water. However, floodwater and salt marsh mosquitoes, as well as many tree-hole breeders, place them above the waterline in sites that are subject to flooding, overflow, or rainwater. Each mosquito species lays its eggs in a specific type of site.

Mosquito larvae (wrigglers) are legless and have a thorax that is much which is wider than the head or abdomen. Most have a distinct head and prominent breathing tube extending from the last abdominal segment. This stage lasts about 7 days in warm water, longer in cool water.

Mosquito larvae can breed most any naturally occurring collection of fresh, brackish, or polluted water. Depending on the species, breeding sites may be water in tin cans, vehicle tires, hoofprints, treeholes, or still pools along the margins of rivers, streams. Mosquito larvae are quite mobile and will quickly dive to the bottom if disturbed. They will return to the surface shortly. Mosquitoes cannot breed in large bodies of water with steep plant-free edges because the larvae cannot withstand wave action. Most mosquito larvae feed by filtering out microorganisms and organic particles in the water, or by "browsing" microorganisms growing on solid surfaces. Mosquito larvae molt 4 times as they develop, the final molt is to the pupal stage.

The pupa (tumbler) stage, which is shaped like a large comma, is short, usually 2-3 days. It has a pair of breathing horns on top of the thorax and paddle-like flaps on the end of the abdomen. The pupa swim actively with a tumbling motion and is easily disturbed. When alerted, it will swim to deeper water. The adult mosquito emerges from the pupal case at the surface of the water.

Male mosquitoes usually live 1 to 2 weeks. Females with ample food may live for several months. However, during the summer, survival may be closer to 2 weeks. Some species have only one generation a year. Others may have 4 or more generations per year. Mosquitoes are must abundant in late summer.

Some mosquito species can fly no more than a few city blocks, while others can travel up to 20 miles. Most are active only at night, although some feed during the day. When they are not active, adult mosquitoes rest in quiet areas with high humidity. Examples include: dense vegetation, along drainage ditches, in sewers, and under the eaves of buildings.

Common Mosquitoes in Kentucky

The Asian tiger mosquito (*Aedes albopictus*) is **black with white bands on its legs and a distinctive single thin white band along the middle of the thorax**. It is an aggressive daytime biter that has the potential to transmit several diseases including dengue, yellow fever, La Crosse encephalitis, eastern equine encephalitis, West Nile virus, Zika virus, and dog heartworm. It **breeds in artificial containers, principally vehicle tires**. The movement and improper storage of used tires is the primary means of dispersal in this country.

(photo: Susan Ellis, Bugwood.org)

The eastern tree hole mosquito *(Aedes triseriatus*), is black with silver-white scales on the sides of the thorax. There are no bands on the legs. This mosquito breeds in tree holes, tires, and other artificial containers. Its bites are painful and annoying but it does not fly far from its breeding site. This species is the principal vector of La Crosse encephalitis in Kentucky.

(photo: Susan Ellis, Bugwood.org)

The inland floodwater mosquito (*Aedes vexans*) is a medium-sized brown mosquito with narrow rings of white scales on the feet and a "V"-shaped notch at the middle of each band of white scales on the upper surface of the abdomen. Common breeding sites are rain pools, floodwaters, roadside puddles, and just about all temporary bodies of freshwater. The eggs are laid on the ground above the waterline and hatch when flooding occurs. Adults can fly long distances from their breeding sites with flights of 10 miles being common. Adults are vicious biters and are especially annoying at dusk and after dark. They rest during the day in grass and other vegetation. This mosquito overwinters in the egg stage. It is a secondary vector of eastern equine encephalitis.

(photo: Texas Agricultural Experiment Station, Texas A & M University)

Anopheles quadrimaculatus is a large, dark-brown mosquito with 4 dark spots near the center of each wing and dark legs. This species is the most important vector of malaria in the eastern U.S.and can be found in houses. Its bite is less painful than many other mosquitoes and often goes unnoticed. The larvae develop in permanent, freshwater pools, ponds, and swamps that contain aquatic vegetation or floating debris. City park ponds, sluggish streams, and shallow margins of reservoirs and lakes can contain many larvae. During the day adults rest in cool, damp, dark shelters such as buildings, caves, and under bridges. These mosquitoes feed at night and will readily enter houses to feed on humans. Cows, horses, mules, pigs, and chickens are also attacked. Adults usually remain within one-half mile of their breeding site. Breeding occurs throughout the summer months.

(photo: Edward McClellan, Center for Disease Control and Prevention)

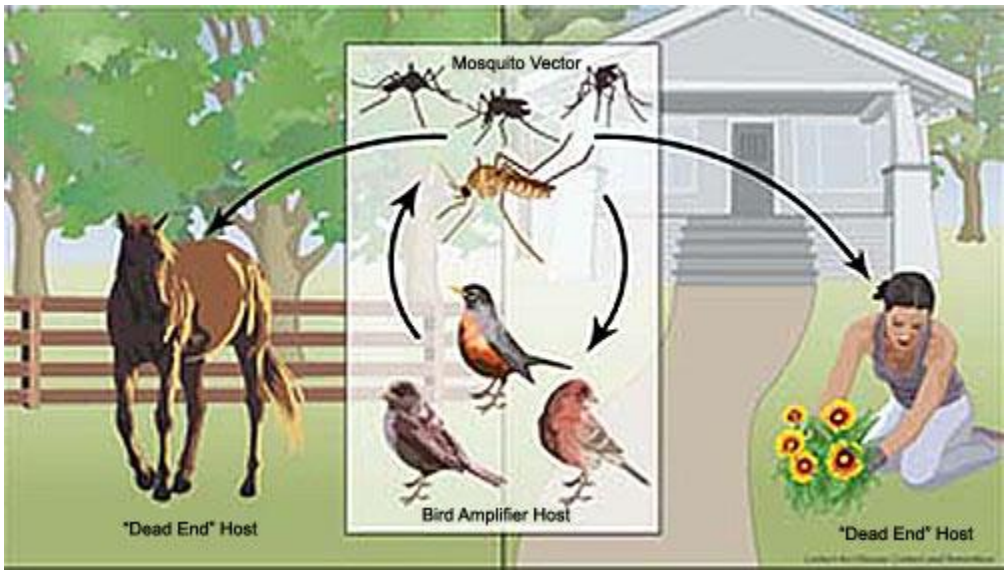
The common house mosquito (*Culex pipiens*) is brown with cross bands of white scales on the abdomen and no other prominent markings. It is a vector of St. Louis encephalitis and dog heartworm. Breeding occurs in rain barrels, tin cans, tires, storm-sewer catch basins, street gutters, polluted ground pools, cesspools, open septic tanks, etc. The flight range is restricted unless great numbers are produced. Adults are active only at night and can be found resting during the day in and around houses, outbuildings, and various shelters near their breeding places. They commonly enter houses.

(photo: Ari Farajollahi, Bugwood.org)

Mosquitoes and Diseases in Kentucky

Mosquitoes are not naturally infected with disease agents. They must be acquired by feeding on infected individuals before they can pass them to healthy ones. For example, a person bitten by *Anopheles quadrimaculatus*, a potential vector of malaria, does not mean that he or she will contract malaria unless the mosquito had first fed on an individual suffering from the parasite. This is unlikely to occur in Kentucky.

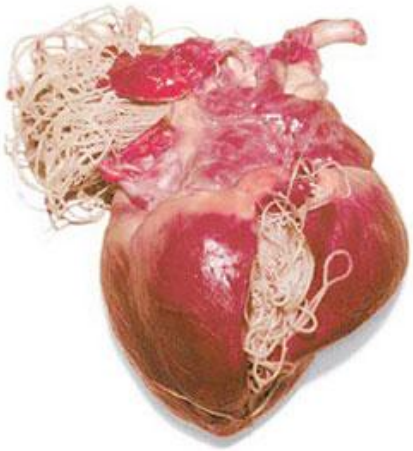
West Nile virus (WNV) is one of the most common arthropod-borne viruses (arboviruses) in the U.S. It is maintained and transmitted among birds, primarily by *Culex* mosquitoes. A person can become ill if they are bitten by an infected mosquito. Infected individuals may experience an abrupt onset of fever, nausea, vomiting, and severe headaches. These symptoms usually develop within 5 to 7 days after someone is bitten. People of any age may contract the disease. However, disease incidence is greater and symptoms more severe in people 60 years or older. Mortality rates range from 2 to 20 percent, with the highest mortality occurring in the oldest age groups.



WNV normally cycles between house mosquitoes and birds.
Mosquitoes can pass the virus to people, horses and other mammals. (www.cdc.gov)

Humans become infected with West Nile virus only after being bitten by a mosquito that had formerly contracted the pathogen from an infected bird. There is no person-to-person transmission via mosquitoes, because the virus concentration in human blood never reaches a sufficient level to infect biting mosquitoes. Humans and horses are considered to be "accidental" or "dead end" hosts for this disease. This means that the amount of virus in their blood is too low for mosquitoes that feed on them to become infected. Disease outbreaks are most likely to occur from mid-summer through early fall when *Culex* populations are at their peak.

Dog heartworm is caused by a filarial worm, *Dirofilaria immitis*. It is a serious disease for most dog breeds. Several mosquito species can transmit this parasite. A mosquito can ingest immature stages of the worms, called microfilariae. After several days, the infected larvae are transmitted via the mosquito's mouthparts to a healthy dog when the mosquito feeds again. The larvae grow and eventually migrate to the right ventricle of the dog's heart where they mature and reproduce. The adult female worm can grow to approximately 11 inches and the male 6 inches.



Large numbers of adult dog heartworms can develop in the host dog.

Mosquito Surveillance

An effective mosquito management program cannot be planned or implemented unless surveys are made to determine which species are present, their relative abundance, and the location of breeding sites. Also, an understanding of the biology of the species involved is essential so that control efforts are not only directed at the proper habitat but also at the right time. Surveys can be labor intensive but they allow personnel to focus control efforts on the species that are causing a problem. This avoids unnecessary intrusion into areas which do not need to be treated, which saves time and money.

Surveys for eggs and egg-laying sites can be a useful predictor of mosquito abundance. Mosquito egg surveys for floodwater mosquitoes are often used to schedule an effective pre-hatch application of insecticide. Oviposition traps constructed with a black-painted jar or open can, a wooden paddle serving as the oviposition site, and a little water in the trap, have proven valuable in sampling for Asian tiger and eastern treehole mosquitoes.

Dipper for sampling mosquito larvae (www.clark.com)

Larval surveys are the primary means of deciding whether control measures should be applied to aquatic sites. A white dipper equipped with a long handle is the collecting tool most often used. Brown larvae can be easily seen on a white utensil. Some “stealth” is required when dipping for mosquito larvae because they quickly swim to deeper water when disturbed. The surveyor must also not overlook obscure larval sites, such as cattle hoof prints in wet pastures or on the edges of water holes and ponds. For examining tree holes, artificial containers, and similarly inaccessible cavities. A large-capacity rubber suction bulb and flexible extension tube can be used to draw out the water into a white metal pan.

New Jersey light trap (www.cdc.gov)

The New Jersey light trap is an important survey method for collecting adult mosquitoes. The trap consists of an incandescent bulb, which serves as the attractant, and a fan to draw nearby mosquitoes into the killing chamber. Carbon dioxide (a respiratory gas given off by animals) is a strong attractant to mosquitoes. For this reason, dry ice is often used in conjunction with light traps, resulting in significant increases in the number of mosquitoes caught.

Light traps are relatively inexpensive and are easy to set up. They are most useful in determining the presence or absence of a particular mosquito species, and in demonstrating population trends. However, light traps are not effective for determining the absolute number of mosquitoes in an area. Light traps collect only those mosquitoes that are active at night and are attracted to lights. Therefore, light traps may not necessarily collect all the mosquito species present in the area. Another disadvantage of light traps is that they are not selective. They also collect moths, flies, beetles, and other insects attracted to light. Despite these limitations, light traps are an important surveillance tool.

Another technique used in adult mosquito surveillance is the landing/biting count. This method uses humans or animals as the attractant. They wait motionless at a specific location. Mosquitoes are counted as they land to feed and may be they collected with a battery-powered aspirator. This technique is very useful because only those species that bite that particular host will be collected. This technique requires that the host be bitten, and therefore is not recommended when there is a high risk of disease transmission.

Control Techniques

Most successful mosquito management programs concentrate on control of the larvae. This stage of the insect's life cycle is concentrated in specific, identifiable areas. Larval mosquito control can be accomplished either by removing or reducing breeding sites, employing biological control agents, or by applying chemical larvicides (insecticides) to breeding sites that cannot be eliminated.

Breeding Site Reduction

The most effective way to control mosquitoes is to find and eliminate their breeding sites. Eliminating large breeding areas such as swamps, or sluggishly moving streams or ditches may require community-wide effort. The initial investment is usually high but significant savings can be realized over time. In these operations, expert advice must be available to prevent potential environmental problems. For example, filling a swampy area may block normal drainage patterns, creating new breeding sites or interfering with aquatic life.

Clean up breeding sites (www.artemisbiosolutions.com)

In addition to reducing large mosquito breeding sites, individual property owners can take the following steps to prevent mosquito breeding on their own premises.

Dispose of tin and soda cans, old tires, buckets, plastic sheeting, or other containers that can collect and hold water. Water should not be allowed to accumulate at the base of flower pots or in pet dishes for more than 5 days.
Clean debris from rain gutters and remove standing water under or around structures, or on flat roofs.
Drain childrens' wading pools when not in use (or at least change the water weekly).
Change the water in bird baths at least once a week. Remove, drain, or fill tree holes and stumps with mortar.
Eliminate seepage from cisterns, cesspools, and septic tanks.
Eliminate standing water from around animal watering troughs.
Irrigate lawns and gardens carefully to prevent water from standing for several days.
Keep the grass mowed around ponds and other bodies of water, taking care to keep clippings out of the water.
Maintain ponds according to good management practices. Keep banks steep and remove emergent aquatic vegetation which shelters mosquitoes. Stagnant ponds and waste lagoons also can produce very large numbers of mosquitoes.

Biological Control

Nematodes, planaria, microsporidia, and even other predaceous mosquitoes such as *Toxorhynchites* mosquitoes show some promise against mosquito larvae. However, the **most effective biological control agents are predaceous fish: the mosquito fish and the common guppy, which feed feed voraciously on mosquito larvae.**

Chemical Control

The use of insecticides is a temporary measure that should be limited knocking down high populations on in situations for which no other alternatives exist.

(1) **Larviciding is the most efficient and effective method and should be the basis of any chemical control program**. Solving a mosquito problem by killing the larvae is the most logical approach because the mosquitoes are being controlled before they become a nuisance. The application of larvicides should only be made at sites where mosquito larvae of the target species are present. The degree of control obtained with larvicide applications depends upon the amount of pollution in the water, as well as the type and amount of vegetative cover present. Where vegetative cover is heavy, granular formulations frequently provide better control than emulsions or oil spays. Repeated insecticide treatments may be needed, especially after heavy rainfall.

(2) Adulticiding is less efficient and should be used only for supplemental or emergency purposes, such as active transmission of a mosquito-borne disease. Adult mosquito control programs are most successful if large areas are to be treated. In general, adulticiding only provides a temporary reduction of populations. However, this may be the most practical technique for local problems or in the event of a disease outbreak. In addition, some adult mosquito species can fly long distances, often making it necessary to supplement larval control measures with adult control.

Aerial Application

Application of insecticides by fixed-wing aircraft or helicopters is a common practice in some areas. However, this is generally not feasible for most areas in Kentucky due to high costs and potential environmental concerns. Aerial applications are most useful under emergency conditions, or when the areas to be treated are too large or inaccessible for treatment with vehicle-mounted equipment.

Aerosol Applications

Aerosol applications are applied to control mosquitoes using specialized equipment that dispenses insecticides in extremely small droplets. Aerosols work as a contact toxicant and have no residual effect. Consequently, they are effective only as a space treatment against actively flying adults. Aerosols are dispensed from the application device and allowed to drift as a fog with the wind through the target area. This technique is effective only where there is little wind. Aerosols can treat a swath of approximately 300 feet. Because the primary activity period for most pest and vector mosquitoes is during the evening hours, aerosol applications are usually most effective during this period.

Aerosol sprayers produce small particles (www.citybugs.tamu)

Indoor Control

Mosquitoes found inside buildings can be killed with most household aerosol sprays that are labeled for flying insect control indoors. Aerosol space sprays containing synergized pyrethrins often produce rapid results. Doors and windows should be kept closed for 15-30 minutes after spraying. Only products labeled for flying insects should be used.

Repellents

Repellents can protect humans from mosquito bites for 1-12 hours, depending on how much a person sweats and rubs the skin, and the percentage of active ingredient in the repellent. Repellents are formulated and sold as aerosols, creams, and liquids. **Repellents containing ingredients such as diethyl-meta-toluamide (DEET) or dimethyl carbate are most commonly used.**

The area of skin to be protected should be covered evenly, because mosquitoes will find and bite spots left untreated. It is often helpful to apply repellents on outer clothing as well as the skin because many mosquitoes can bite through thin, tight-fitting clothing. Do not apply repellents to the eyes, nostrils, or lips.

Repellent logo helps select effective products (www.epa.gov)

DEET is a very effective repellent but should be used according to the product label. Do not apply DEET to the hands of young children. In addition, in very rare cases, use of this product may cause skin reactions. If a reaction to DEET is suspected, wash the affected area and contact the local poison control center.

Additional Control Measures

Vegetation Management

Many adult mosquitoes prefer to rest on weeds and other vegetation. Trimming or eliminating areas of dense vegetation will force mosquitoes to find other, more distant, resting sites.

Mechanical Barriers

Mosquitoes can be kept out of buildings by keeping windows, doors, and porches tightly screened with 12-18 mesh screening.

Insect Electrocutors

Insect electrocutors (“bug zappers”) that use ultraviolet light as an attractant are generally ineffective at reducing outdoor populations of mosquitoes or their biting activity. Light traps using ultraviolet light do capture large numbers of flying insects, including mosquitoes, when used inside buildings. Numerous other devices, including ultrasonics and mosquito-repellent plants, are available which claim to attract, repel, or kill outdoor infestations of mosquitoes. These devices are generally ineffective, too.

Public Education

All good public health programs must include community-wide education of the public to gain and maintain support. This is especially important with mosquitoes. Widespread spraying for mosquitoes can produce anxiety and concern over the effects of pesticides on human health. Homeowners can be of great help by managing their own property to eliminate breeding sources of several mosquito species. The effectiveness of any area-wide public health program can only be helped if people understand the program's benefits and limitations.