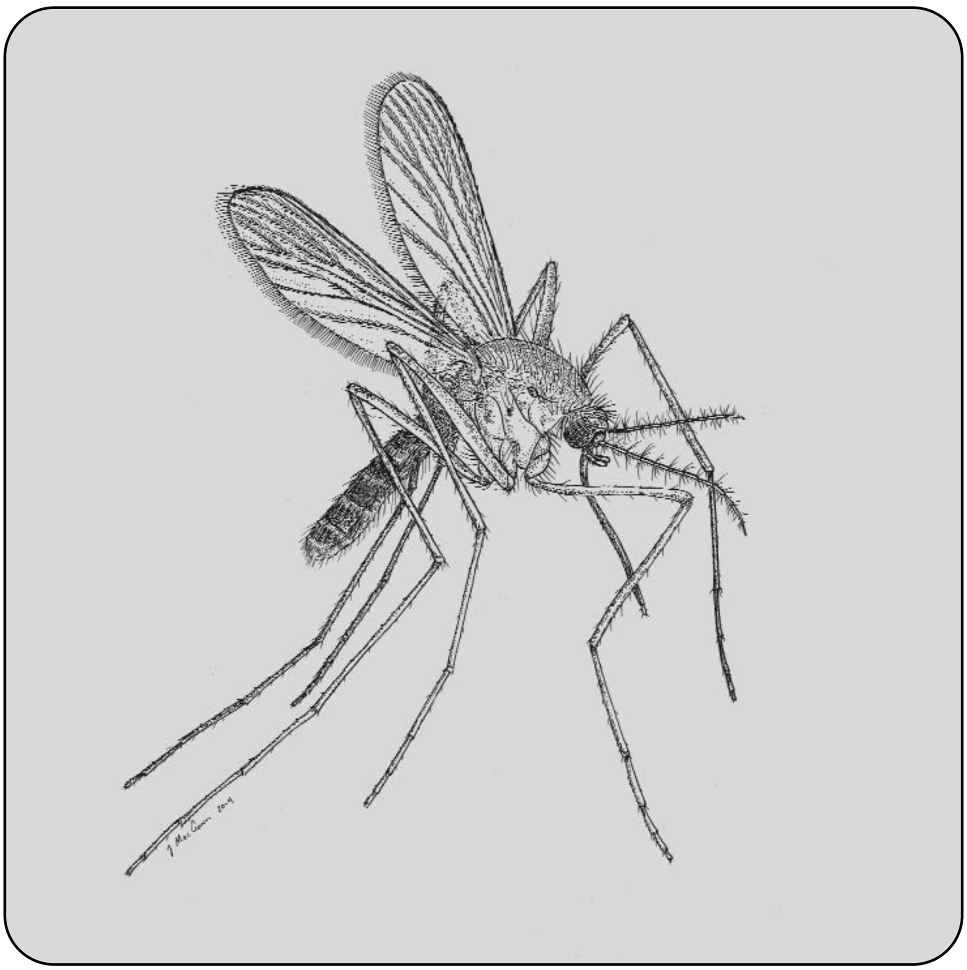
Published August 2004

The Southern House Mosquito and Related Species: Biology and Control



southern house mosquito

Culex quinquefasciatus

The Southern House Mosquito and Related Species

With 210 to 240 frost-free days (temperate climate) and 50 to 60 inches of rainfall per year, Mississippi's climate is favorable for mosquito development. The insect is found on every continent except Antarctica. In fact, Canada has 74 species, some of which develop in snowmelt water. There are a total of 169 mosquito species in North America north of Mexico and at least 53 species in Mississippi.

Mosquito species are in the order Diptera (flies), family Culicidae, and may be placed in several genera, including *Ochlerotatus, Aedes, Anopheles, Culex, Culiseta, Mansonia,* and or *Psorophora*. Nearly half of the mosquitoes in North America belong to the genus Ochlerotatus.

Problems Associated with Mosquitoes

A number of insects and related arthropods feed on blood, but mosquitoes are one of the most prominent members of this group. Depending on conditions, they can occur in high numbers, and their blood feeding habit can limit use of recreation areas from ballparks to barbeques and from beaches to backyard wading pools. The female's bite (Fig. 1) is irritating and, in some cases, an allergic reaction can occur at the feeding puncture. This is probably more pronounced in children than in adults.

Not only is the bite irritating, it can transmit disease. Mosquitoes are the sole transmitters of yellow fever (virus), dengue/dengue hemorrhagic fever (also known as break bone fever, which is a virus), and malaria (protozoa) in countries around the world. Although yellow fever and malaria were rampant in North America at one time, the diseases have been practically eliminated from this area.

Figure 1. Temporary wounds as a result of feeding by female mosquitoes.

An effective vaccination program was one thing that greatly reduced, if not eliminated, yellow fever in the U.S., but the vaccination is not given now as widely as it was. This may or may not be cause for alarm. The yellow fever vector (yellow fever mosquito, Aedes aegypti) and the host (humans) are still present; the only thing missing is the virus causing the disease.

Dengue is found in Central and South American, and a number of cases have been reported in the United States over the past 100 years. Given human movement in today's society, cases of dengue may become more common in the United States, and the yellow fever virus could be reintroduced into North America.

Mosquitoes are also involved in transmission of a group of viruses broadly referred to as the encephalitides (arboviruses causing encephalitis). Examples of these viral infections are St. Louis encephalitis (SLE), West Nile encephalitis (WNE or West Nile virus), eastern equine encephalitis (EEE) and LaCrosse encephalitis (LAC). These viruses mostly are associated with a bird/mosquitoes cycle: the virus moves from birds, via the mosquito, to humans and horses. In this way, some encephalitic viruses will reach very high levels (termed viremia) in a bird species. Once this level is reached, feeding mosquitoes will become infected and then can transmit the virus to other birds, horses, or humans. Horses and humans are referred to as "dead-end hosts." In other words, another mosquito cannot become a carrier by feeding on a human or horse that is infected with an encephalitid virus.

Mosquito-Borne Diseases in Mississippi

Eastern Equine Encephalitis – As with SLE and WNE, birds are the primary hosts for eastern equine encephalitis (EEE). Mosquitoes, particularly *Culiseta melanura*, are the carriers from bird to bird. *Culiseta melanura* rarely feed on humans, though. People usually become involved as dead-end hosts when fed upon by infected salt marsh mosquitoes *(Ochlerotatus sollicitans)*, inland floodwater mosquitoes *(Aedes vexans)*, *Coquillettidia perturbans*, and a few other species. The disease will affect persons of any age, with young children and infants being the most susceptible. The mortality rate is more than 50 percent, and children surviving the disease often suffer from some degree of mental retardation or paralysis. Horses are often severely affected by the disease during outbreaks. A horse vaccine is available.

West Nile Encephalitis – West Nile encephalitis, or West Nile virus (WNV), is maintained in nature similarly to St. Louis encephalitis, in a bird/mosquito cycle. Several *Culex* species, including the common house mosquitoes, *Culex quinquefasciatus, Cx. pipiens*, and *Cx. restuans*, and also *Cx. salinarius*, are the main carriers to people. WNV appears to be most dangerous to the elderly or immune-compromised patients. Since WNV has been shown to survive and multiply in several mosquitoes native to Mississippi, it is assumed WNV will be permanently established in Mississippi.

Unlike other mosquito-borne viruses, WNV kills many birds in the U.S., especially crows, blue jays, and raptors. Surveillance efforts to detect the presence of WNV, therefore, can target reporting and testing these three types of dead birds. WNV does not generally cause as serious illness as some other arboviral diseases (such as EEE). In fact, only one out of every 150 to 200 people exposed to the virus will become ill, and fewer than 10 percent of clinically ill patients will die. Still, the public's perception and reaction to local reports of WNV cases cause much anxiety and fear in communities. Local officials are often urged by concerned parents to provide mosquito control to "protect" the people.

St. Louis Encephalitis – The St. Louis Encephalitis (SLE) virus circulates naturally among birds and is transmitted by *Culex* mosquitoes. Humans can become infected only if bitten by an infected mosquito. Humans are "dead-end" hosts, as described earlier in this publication. Not all people infected with the virus develop clinical disease. However, the virus may produce abrupt fever, nausea, vomiting, and severe headache in humans within 5 to 7 days after being bitten. Fatality rates range from 2 to 20 percent, with most deaths occurring in people 60 years old or older. Outbreaks of SLE usually occur in mid summer to early fall. Since wild birds and domestic fowl are reservoirs of this virus, urban areas where large bird populations and abundant Culex mosquitoes are found together are prime sites for a disease outbreak.

A major SLE outbreak occurred in Mississippi in 1975. More than 300 people were affected, and many died. The threat for this to happen again is real. We need to develop good mosquito control practices in disease-prone areas of our state and be prepared to respond promptly to the next outbreak.

LaCrosse Encephalitis – In contrast to most other mosquito-borne viruses that are a risk in Mississippi, LaCrosse (LAC) maintains its cycle in nature via a small mammal/mosquito cycle. Usually, the mosquito carrier is the tree-hole mosquito, *Ochlerotatus triseriatus*, and the reservoir is the gray squirrel or chipmunk. Control efforts for this disease focus on plugging tree holes where mosquitoes breed in small amounts of acidic rainwater. Mississippi recorded its first confirmed cases of LAC in 1967, but the disease was not often diagnosed until eight cases were identified in 2001. LAC most often occurs in children less than 16 and can cause convulsive disorders in affected children. These facts often bring extra demands (by parents) on local officials to implement control measures.

Dengue/Dengue Hemorrhagic Fever – Although currently not found in Mississippi, this disease could come into the state at any time. The Yellow Fever mosquito *(Aedes aegypti)* and the Asian tiger mosquito *(Aedes albopictus)* transmit Dengue virus from person to person. No known bird nor mammal reservoir exists for dengue except humans. A mosquito can become infected with the virus by feeding on a person with the disease, then the virus must go through an eight- to ten-day incubation period in the mosquito before it becomes infective. The mosquito will then remain infective for the rest of its life.

Symptoms include sudden onset of high fever, severe headache, backache, and joint pains. The disease is so painful it is sometimes referred to as "breakbone fever." A skin rash may also appear. Infection may be very mild or completely without symptoms. In some areas, however, a complication called "dengue hemorrhagic fever" or "dengue shock syndrome" causes a high fatality rate, especially among children.

The disease has been raging in Mexico and Central and South America for the last 10 years. It is literally "knocking at the door," with cases frequently occurring along the U.S. - Mexican border.

The yellow fever mosquito, *Aedes aegypti*, can transmit both yellow fever and dengue, while the Asian tiger mosquito, *Ae. albopictus*, an introduced species into the Americas, is a carrier of dengue in Asia and possibly in South America. Both species are present in the southeastern states (although some have suggested that the Asian tiger mosquito has displaced *A. aegypti* from this area), but they have not been strongly implicated as potential carriers of the encephalitic viruses, such as WNV or SLE. Instead, a number of mosquito species in the genus *Culex* have been shown to be carriers for these viruses, and the mosquito species varies from region to region. *Culex* species that are likely carriers in Mississippi are *Culex quinquefasciatus* (Southern house mosquito, shown on the front of this publication) and *C. restuans* (to birds only). Other species that may play a role are *C. salinarius* and *C. nigripalpus.*

Most mosquitoes follow the same general pattern of development, with some variation in different genera. The following discussion of mosquito biology centers on species within the genus *Culex*.

Biology

All mosquitoes have a four-stage life cycle that includes egg, larva, pupa, and adult (Fig. 2 A, B, C, D and cover drawing). *Culex* females deposit from 50 to 400 eggs in clusters, or "rafts," on water surfaces that range from relatively clear water to very polluted water, depending upon species (Table 1). This might include artificial containers, storm sewer catch basins, clogged street drains, water accumulations in low areas, open or leaking septic tanks, and drains from sewage disposal plants or lagoon systems. In most cases, clear water that doesn't have organic matter or algae growth is not attractive to female mosquitoes.

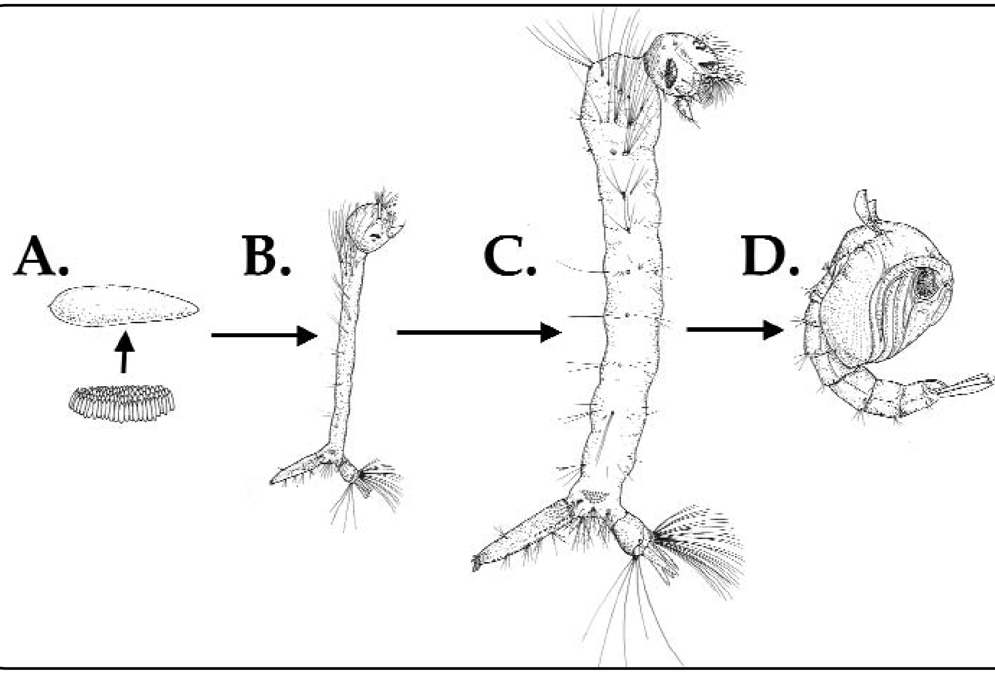


Figure 2.
Life stages of Culex quinquefasciatus Say, the southern house mosquito.

A. egg raft and single egg
B. second instar larva
C. fourth instar larva
D. pupa

Table 1. Possible larval developmental sites and host animals used by adult females as a source of a blood meal.

Mosquito Sp.	Quality of Water Used for Larval Development			Adults Females Feed Primarily on		
	Clear	**Nearly Clear**	**Polluted**	**Birds**	**Mammals**	**Humans**
C. restuans		x	x	mostly	occasionally	rarely
C. salinarius	x	x		occasionally	mostly	readily
C. nigripalpus		x		readily	readily	occasionally
C. quinquefasciatus		x	x	mostly	occasionally	readily

Data taken from the Center for Disease Control (CDC) web page and several scientific papers.

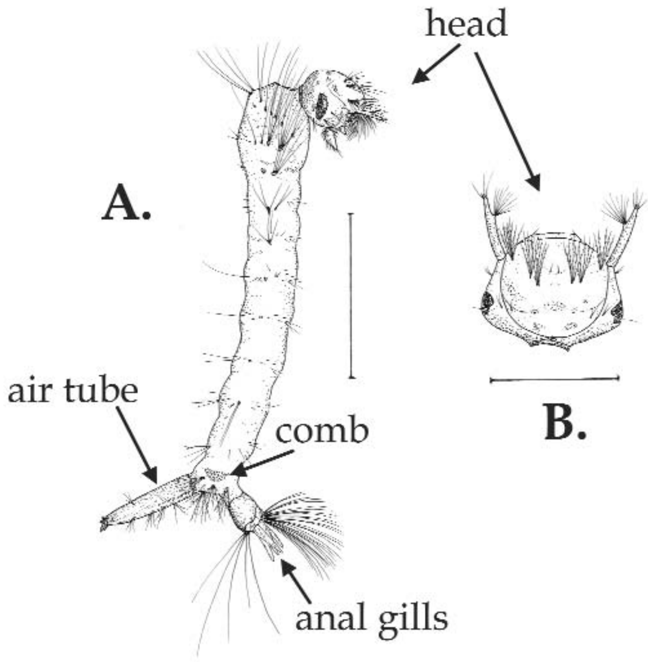


Figure 3. Culex quinquefasciatus Say, the southern house mosquito. A. profile view of fourth instar larva (scale bar =2 mm) and B. dorsal view of head of fourth instar larva (scale bar = 1 mm)

Eggs hatch in 24 to 48 hours. Hatched larvae, known as "wigglers," use algae or decaying organic matter for food and, if conditions are good, the larvae will pass through four larval instars in 5 to 7 days. First instar larvae are very small and require magnification just to determine they are mosquito larvae. First, second, and third instar larvae will actively feed, but the fourth instar is a nonfeeding stage (Fig. 3).

Following larval development, a nonfeeding pupal stage forms that lasts one to two days before adult emergence. Thus, development from egg to adult may occur in 8 to 10 days in warm weather. Adult mosquitoes may live from 3 to 6 weeks or more. When not actively searching for food, adults may rest in protected sites such as animal burrows, buildings, shrubs, other low growing vegetation, dense forested areas, culverts, and/or similar cool shaded areas.

Adult Culex mosquitoes are medium-sized, brownish gray, with some white markings on the thorax and abdomen. Separating adult Culex species using quick or field identification guides is difficult, but species identification is sometimes critical in disease control. If this is the case, you can collect specimens and submit them to appropriate authorities for identification. A number of larval mosquitoes can be identified using a number of characteristics that may be located on the body or the head of the larva (Fig.3A, 3B).

Culex mosquitoes may feed at sunset, or shortly before, and for one or two hours thereafter, or in the early morning hours before sunrise and for a short period thereafter. If mosquitoes are disturbed during periods of rest by a suitable host, mosquitoes may feed, regardless of the time. Hosts will vary (Table 1) between birds, humans, and other mammals, and host selection may also vary, depending on a number of factors, including adult habitat or time of year. Mosquitoes' association with birds makes them good carriers for most encephalitic viruses.

Mosquito Management Guidelines

When dealing with a "vectored disease," it is desirable to control the vector. If the disease cannot move from its reservoir in nature to other host animals, the cycle is interrupted and the disease cycle ends. Mosquito control would appear to be in the best interest of all concerned, but not everyone may accept this plan. To be as widely accepted as possible, mosquito programs should follow a sound set of principles. Consider the following:

- An established organized program is more efficient than one started under an emergency situation.
- Control programs should be started when there are sufficient data to support the various options that are available. Support data might include, but are not limited to, 1) the presence of mosquito-borne diseases in the area, 2) high numbers of mosquitoes in traps, or 3) citizen complaints of mosquitoes' biting.
- You should evaluate control options or combinations after considering the effectiveness, health effects, ecological effects, and cost-versus-benefits of the various options. Control options might include educational programs, eliminating breeding sites, biological controls, and/or applying pesticides.
- If you use pesticides, personnel should be trained in the safe and effective use of the materials that are selected, and applications should be made in accordance with any existing local, state, or federal laws governing use of the materials.
- Personnel involved in vector control programs should be familiar with the application equipment and trained in its proper use.
- Have a "route chart" available for interested residents.

Surveillance Techniques/ Treatment Indicator

Mosquito surveillance should be a routine part of any mosquito control program. A good surveillance program provides two types of information: 1) a list of local mosquitoes (including distribution and population size estimates) and 2) effectiveness of the control strategies being used.

Routine surveillance can keep control personnel informed about locations of major breeding areas, helping to identify problem sites where control should be concentrated. Carefully interpreted survey data can provide vital information. For instance,

Figure 4. CDC light trap with dry ice as a carbon dioxide source.

Figure 5. Gravid trap used to trap *Culex* species.

large numbers of Culex egg rafts around the edges of ditches or *Aedes* eggs on egg-laying (oviposition) strips indicate you should watch these breeding sites closely for the next few days. Treatment should be timed to catch the heavy crop of resulting larvae during the period of their life cycle when they are active feeders. Heavy adult catches in light traps stationed near treated areas may indicate an important breeding site has been overlooked in the survey or that mosquitoes are migrating in from other areas, depending upon the species captured.

Surveillance can be as simple as larval sampling with a "dipper." Counts of numbers of larvae per dip are important and help predict adult mosquito emergence a few days later. For catching adult mosquitoes, CDC light traps (Fig. 4) are often used along with a CO_2 source, such as dry ice. CDC light traps are easy to use, since they are portable and battery-powered. Not all adult mosquitoes are easily attracted to CDC traps. *Culex* species seem to avoid CDC traps, so numbers of *Culex* collected in the traps may not represent the true mosquito situation. For this reason, more specific trapping for *Culex* mosquitoes is often done using a "gravid" trap (Fig. 5), where pans of stinky water are set out, along with a battery-powered trap above them to collect incoming mosquitoes.

Control Options

Historically, mosquito control tactics have included four parts. In the early years, the parts would have been adult control, aquatic habitat reduction (removal of standing water, permanent or temporary), larval control by water additives (larviciding), and personal protection. These components are still valid, but emphasis has changed over the years. Here's the order in which the components might be implemented today: personal protection, aquatic habitat reduction, larvaciding, adulticiding.

Personal Protection – Mosquito management personnel and municipal or county employees involved in mosquito control should encourage people within their districts to use personal protection during periods of peak mosquito activity and/or disease outbreaks. This will have direct benefits to everyone within their areas. The following points may or may not apply in all situations, but where applicable, they should be followed:

- Limit outdoor activities during peak mosquito activity. This might include late afternoon, night, and at or just after sunrise.
- If outside, wear long-sleeved shirts and long pants. The tighter the weave of fabric, the better.
- Use an approved insect repellent. Products containing DEET have proven to give longer periods of protection than most others. Be sure to follow label directions when applying products containing DEET, especially on children.
- Screens and door fitness should be in a good state of repair to keep mosquitoes from entering homes.
- Do not leave doors open while bringing items into the home. It may be inconvenient, but close doors between trips.
- If mosquitoes do enter the home, you can use a pyrethrin plus piperonyl butoxide aerosol spray to control these insects. Grocery stores and other outlets sell a number of sprays containing these materials, and the label will usually state, "for flying insect control." Be sure to follow label directions for use.

Aquatic Habitat Reduction – In early mosquito control efforts, aquatic habitat reduction probably referred to "draining the swamp." This had some benefits, but with today's wetlands protection, drainage programs are much harder to implement, and they may not be necessary.

Culex mosquitoes use a variety of temporary water sources, as we said earlier, and these can be drained without any problems. People should be encouraged to check their property for any water serving as mosquito breeding sites and to drain this water or change it every four to five days. Remember, breeding sites could be birdbaths, wading pools, pet watering containers, aquatic gardens, used tires, improperly maintained swimming pools, improper maintained sewage lagoons, standing water caused by overuse of irrigation systems, and any other container or site that could hold water for 8 to 10 days. You should also monitor city- and county-owned property for potential breeding sites you can modify or drain.

Larviciding – You can use this method to control mosquito larvae in situations where you cannot drain, fill, or otherwise modify low areas (Table 2). Or, this method can work in standing water after extremely wet periods, such as above average rainfall or the heavy rainfall during and after hurricanes. Biological materials or physical agents available for larviciding are insect growth regulators, bacterial formulations, and molecular films. You can also use two chemical insecticides, temephos (Abate) and malathion, in larval control programs.

Table 2. Biologicals, insect growth regulators, and physical agents used to control mosquito larva.

Active Ingredient	Trade Name	Amount To Apply per Acre or per Sq Ft	Comments
Bacillus thuringiensis israelensis	VectoBac® 12 AS	0.25 to 32 oz	Use 16 to 32 oz in highly polluted water.
	With ground equipment, apply the specified amount in 5 to 100 gallons of water per acre. Aerial applications may be applied diluted or undiluted.		
	Aquabacxt®	0.25 to 32 oz	Use 16 to 32 oz in highly polluted water. For dilution see above.
	Aquabac® (200G)	2.5 to 20 lbs	Use 10 to 20 lb in highly polluted water
	Bactimos® Pellets	1.25 to 8 lbs	
	Use 1.25 to 5 lbs in pools, ponds, pastures, ditches, etc. with light to moderate populations. 5-8 lbs may be used in catch basins, tidal water, lagoons etc. with moderate organic content or pollution.		
Bacillus sphaericus Serotype H5a5b	Vectolex® WDG	0.5 to 1.5 lbs	Use 1.0 to 1.5 lbs for extended residual control or in areas with dense surface cover.
	For ground equipment, apply the specified amount in 5 to 100 gallons of water per acre. Use 0.5 to 10 gallons of water for aerial applications.		
S-Methoprene	Altosid® Briquets	1 Briquet/100 sq ft	The listed rate is for use in shallow water with little flow and up to 2 ft deep. For deeper water with flow, consult label.
	Altosid® Pellets	2.5 to 10.0 lbs	Use site will dictate the specific amount to use. Consult label.
	Altosid® XR Briquets	1 Briquet/100 sq ft	See Altosid Briquets above and label for additional application rates.
	Altosid® Liquid Larvicide 5.0%	3 to 4 fl oz	
	For ground equipment, apply specified rate in 0.5 to 5 gallons of water per acre. For aerial application, use 0.5 to 5 gallons of water per acre.		
	Altosid® Liquid Larvicide 20.0%	0.75 to 1 fl oz	See A.L.L. 5.0% above.
Monomolecular film	Agnique MMF	0.2 to 1.0 gallons	
	May be use undiluted or diluted. Use 0.35 to 1.0 gallon in polluted water. Winds at or greater than 10 miles per hour for extended periods may affect control.		
Aliphatic petroleum hydrocarbons	Mosquito Larvicide GB-1111	3 to 5 gallons	
	Use higher rates for polluted water or on water with dense foliage. Oil may produce an unsightly appearance on the water – you should consider this.		

Consult the label of the product of choice for a complete guide to the safe and effective use of these materials.

Table 3. Some insecticides for use in cold foggers/ULV applicators to control adult mosquitoes

Insecticide	Trade Name	Application Method	Flow Rate at 10 MPH in fl oz/min	Pounds, a.i./Acre
malathion ULV 96.5%				
	Fyfanon U.L.V.	Undiluted	2.0 – 4.3	
	Drexel Malathion U.L.V.	Undiluted	2.0 – 4.3	
	Terra Malathion U.L.V.	Undiluted	2.0 – 4.3	
	Atrapa VCP	Undiluted	2.0 – 4.3	
sumithrin + PBO				
sumethrin —— 10.0%	Anvil® 10 + 10 ULV	Undiluted	1.3 to 3.8	0.0012 to 0.0036
piperonyl butoxide - 10.0%				0.0012 to 0.0036
permethrin + PBO				
permethrin —— 30.0%	Permanone® 30-30	Undiluted	1.0	0.003
piperonyl butoxide - 30.0%				0.003
permethrin —— 3.98%	Permanone® Ready-to-Use	Undiluted	12.0	0.0045
piperonyl butoxide - 8.48%				0.009
permethrin —— 20.0%	Aqua-Reslin®	Undiluted	0.46 – 3.25	0.0010 – 0.007
piperonyl butoxide - 20.0%				0.0010 – 0.007
permethrin —— 30.0%	Masterline Kontrol 30 - 30	Undiluted	1.0	0.003
piperonyl butoxide - 30.0%				0.003
permethrin—— 31.28%	Biomist® 31+66 ULV	Undiluted	1.0 to 6.0	0.0035 to 0.021
piperonyl butoxide–66.0%				0.0075 to 0.047
permethrin—— 30.0%	Biomist® 30 + 30 ULV	Undiluted	1.0 to 6.0	0.0031 to 0.0185
piperonyl butoxide–30.0%				0.0031 to 0.0185
resmethrin + PBO				
resmethrin —— 4.14%	Scourge® Insecticide	Undiluted	3.0 – 18.0	0.00117 – 0.007
piperonyl butoxide – 12.42%				0.00351 – 0.021
resmethrin —— 18.0%	Scourge® Insecticide	Dilute with refined soybean oil, light mineral oil of 54-second viscosity, or other suitable solvent. Flow rates and dilution ratios are based on pounds of active ingredient desired per acre.		
piperonyl butoxide –54.0%				

Products such as Permanone® 30-30 or Biomist® 30 + 30 ULV may be diluted with mineral oil or other suitable solvent. Ratios (product: solvent) are 1:2, 1:4 or 1:8. If you use one of these dilution ratios, change the flow rate to reflect the appropriate dilution and the corresponding amount needed per acre. Check label for flow rates. Other products may also have dilutions that may be used. Concentrations and subsequently flow rates are based on a treated acre. A treated acre is 43,560 square feet (for example, 300 feet by 145.2).

- Insect Growth Regulators (IGR's). Active ingredients in this group disrupt the normal growth patters in an immature insect (in this case a mosquito larva) as it molts. This interruption causes the insect to retain its juvenile or immature characteristics, preventing adult emergence. The larva eventually dies. IGR's may be used to control second, third and fourth instar larvae. Materials in this group affect only systems found in insects and closely related arthropods and have very little, if any, toxicity to mammals and fish.
- Bacterial Formulations. Two bacterial related formulations are available for larviciding programs: *Bacillus thuringiensis var. israelensis* (B.t.i.) and *Bacillus sphaericus*. B.t.i. attacks cells of the intestinal tract, and within a few hours affected larvae cannot absorb food. The larvae die within 8 to 12 hours. These products must be ingested by actively feeding mosquito larvae. Both products are sensitive to ultraviolet light and break down fairly quickly, but they work well in clear to polluted water. B.t.i. probably has a broader spectrum of activity than *B. sphaericus*. At operational concentrations, these products have very little, if any, toxicity to mammals or fish.
- Monomolecular Films. Products in this class reduce surface tension of the water, making it difficult for larvae, pupae, and emerging adults to attach to the surface, causing them to drown. The product may also clog larval and pupal breathing tubes, which again interferes with air exchange. Wave action will cause the product to mix with the underlying water, thereby reducing its effectiveness. Concentrations of this film are not toxic to mammals or fish.
- Petroleum Hydrocarbons. After they are applied, hydrocarbons rest on the surface of the water and will enter breathing tubes of mosquitoes as they approach the surface to collect oxygen.
- Abate (temephos) and malathion. These materials are organophosphate insecticides. You must follow label directions for mixing and application. Nontarget organisms may be affected if you don't follow these procedures. If there is interest in these products, consult the label of choice for information relative to site use, mixing, and application.

Adulticides (Table 3) – Adult mosquito control programs are defined as much by the application equipment as by the pesticide. You can buy equipment that will apply thermally produced fogs or ultra low volume applications (ULV). In both instances, the insecticide plus carriers, if applicable, are broken into very small droplets. These droplets move in the direction of the prevailing wind (wind speed should be no more than 2 to 3 miles per hour), with movement between structures but with very little or no movement into structures. You must apply in periods of peak mosquito activity, which is generally late evening or at night. The small droplets remain suspended for a short time, and you get control as mosquitoes fly through the suspended droplets. There is no residual control associated with these applications. Although small, the droplets will eventually settle, or they may be moved greater distances from the point of application by wind and be diluted.

Thermal applications produce a consistent droplet size that is slightly smaller than ULV droplets as long as the flow rate is not greater than the vaporization capacity of the applicator. Fogs of this nature are termed "dry fogs." Larger droplets will be produced if the flow rate becomes too great or the heat is reduced. Additionally, the smaller droplets may penetrate dense foliage better than the larger droplets produced by ULV applicators. The results of a correctly produced thermal fog are easily visible. The public may perceive it as being more beneficial, but this may or may not be true.

Cold or ULV applicators (Fig. 6) reduce the need for large volumes of number two diesel or other lightweight petroleum distillate, thus reducing cost of the application and overall size of the machine. For example, with ULV applications, a concentrate is used, and the rate is measured in ounces. With a thermal machine, you might use 4 to 5 gallons of insecticide and 94 to 96 gallons of diesel. The rate might be as high as 30 to 40 gallons per acre. The mist produced by ULV machines is nearly invisible, which improves visibility in and around the applicator. A number of ULV applicators, such as Leco, Clarke, Micro-Gen, Hudson, London Fog, and Beecomist are sold commercially.

Performance requirements for ULV machines are as follows:

- ULV applicators should be able to produce droplets in the 5 to 30μ range. In some cases, larger droplets may permanently damage automobile paint. You can measure droplets by collecting a sample from the applicator onto a coated microscope slide. Then measure droplets under a microscope with the aide of an ocular micrometer.
- Tank pressure may vary, depending on flow rates and speed of the vehicle, but consider using 2 to 3 pounds, with a psi of no more than 6 pounds.
- Flow rate must be regulated by an accurate flow meter. Flow meter data should be recorded at the end of each day's operation.

Figure 6. ULV applicator showing the fine mist as it leaves the nozzle.

- In general, the nozzle should be in the rear of the truck and pointed upward at an angle of 45°.
- Vehicle speeds may vary from 5 to 20 miles per hour, depending on product used (check label).

Aerial Applications

Ground applications can achieve a certain level of control, based on the availability of roads. If you need a greater degree of coverage, consider aerial applications. Aerial applications may be applied with fixed wing or rotary aircraft, depending on the site being targeted. In general, aerial applications should be made only under these conditions:

*When temperatures are below 80 °F, or before any temperature inversions occur.

*With droplets averaging 50 to 60 microns MMD, and at least 20 percent of the droplets should not exceed 100 microns. In some areas, damage to car paint has occurred when larger droplets were dispersed or more than 10 percent of the droplets exceeded 100 microns.

*By multi-engine aircraft flying at a height of 100-150 feet, at speeds of about 150 miles per hour, with a swath widths of 300-1000 feet, and with particle sizes of 50-60 microns. Multi-engine aircraft must be used when treating populated areas. Single-engine fixed wing and rotary wing aircraft are undesirable for this technique because of their slow air speed and problems with droplet break-up, but these aircraft types can be used in treating unpopulated areas.

Precautions

It is important for those who work in mosquito control to have a working knowledge of pesticides, pesticide label information, and application mechanics. This will help ensure a safe application as well as control of the target pest. A trained person familiar with pesticide applications can anticipate potential problems and avoid consequences of a wrong application. Always keep pesticides in original, labeled containers.

Some aquatic sites and apiaries are sensitive areas that mosquito control personal should recognize and take special precautions to avoid. When dealing with aquatic sites, observe precautions on the pesticide label of choice for information regarding these sites, especially where fish, shrimp, or crabs are important resources. Also, pesticides should not be applied to potable water supplies.

An apiary or "bee yard" might include one or two hives or fifty hives and be located in town or in the country. Whatever the case, bees are an important resource, and you should avoid accidents around these sites. In general, bees forage for nectar and pollen during the day and have quit foraging by the time most mosquito control applications are made. This lessens direct contact between bees and the pesticide. Education also plays a role in protecting apiary sites – make sure owners know when applications are planned. At this point, the bees might be moved or other protective precautions taken.

Larvicides or Larviciding – The immature form of the mosquito is a larva, and a material used to control the larva is termed a "larvicide." A program directed at controlling the larva is termed "larviciding."

Adulticide or Adulticiding – An insecticide or other material used to control adult mosquitoes. Adulticiding programs aim at controlling adult mosquitoes.

Growth Regulator – These products mimic effects of natural insect hormones. Once they are absorbed into the body of the mosquito, they interfere with molting, or they may cause abnormalities in egg hatching or maturation. These products are sometimes referred to as IGR's.

Micron – A term used to characterize the droplet size various adult mosquito control machines created. One micron (μ) is 1/1,000 of a millimeter or about 1/25,000 of an inch; a human hair is approximately 100 μ in diameter.

Mass Median Diameter (MMD) – The average size of spray droplets emerging from a spray machine. Spray droplets coming from the applicator head are spherical. As they are collected on coated microscope slides for measurement, they spread or flatten out. MMD is a measurement using a spread factor to calculate droplet size, once it is flattened.

Thermal Fog – A "fog" created when an insecticide formulation plus carrier are injected into a heated chamber or onto a hot plate that is hot enough to cause an immediate vaporization of the formulation and carriers. Droplet size for fogs range between 0.1 to 5.0 μ, and some probably fall within the range of 0.001 to 0.1 μ. The latter size range characterizes "smokes."

ULV Application – Applications of this type are created mechanically. In some cases, the formulation is propelled into spinning discs and rotors. Some applicators use extremely fine nozzles combined with high pressure. Droplet size is in the 1 to 30 μ range.

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Publication 2336

Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. JOE H. MCGILBERRY, Director (1M-08-04)