DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA7060

Developing a Community Mosquito Abatement Program

John D. Hopkins
Associate Professor and
Extension Entomologist

Max V. Meisch
University Professor
(Retired)

Mosquitoes are among the most common pests of people, and their biting habits can cause them to be an extreme nuisance. Mosquitoes can also carry (vector) numerous diseases that affect humans and their pets or livestock. In Arkansas, transmission of disease to humans has occurred at a very low level. Five types of encephalitis – St. Louis encephalitis (SLE), eastern equine encephalitis (EEE), West Nile virus (WNV), Venezuelan equine encephalitis (VEE) and western equine encephalitis (WEE) – have occurred in the state and can be transmitted by mosquitoes to humans. In addition, a threadlike parasitic filarial worm (heartworm) can be transmitted by mosquitoes to dogs and cats. Anaplasmosis is also vectored by mosquitoes.

Although disease transmission is the most commonly cited reason for considering mosquitoes to be a public health problem, the presence of large numbers of biting pests will influence the physical and mental well-being of most people. Mosquitoes also cause economic loss to livestock as a result of blood loss and irritation. In addition, mosquitoes can reduce recreation activities that can result in a loss of tourist income and can depress property values on land adjacent to areas where they breed.

Communities can best address mosquito problems when an organized, tax-supported abatement program is established. In an area without a current mosquito abatement program, local community leaders must direct and implement the program themselves; successful programs should have persons who are qualified to direct effective mosquito control operations. Contract mosquito control companies are successfully used by some Arkansas communities. This fact sheet is intended to assist communities that are not part of an established abatement program.

Effective mosquito control requires advanced planning and preparation at the county, municipal or district level. General guidelines for program development follow.

Funding, Management and Personnel Requirements

Funding

For the most part, control programs are funded locally through the city and county budgets. Some state aid may be available; amounts might vary depending on the size of the program and the area served. Federal funds may be available as disaster relief.

Management

Mosquito control programs are usually operated through either local public works programs or county health departments. About a dozen cities in Arkansas use contract mosquito control companies.

Personnel Requirements

Staffing will depend on the level of service your local area requires. If your program will include application of pesticides, personnel will need to be trained and possibly licensed through the state, depending on the label requirements of the pesticides used. Check with the Arkansas State Plant Board (501-225-1598). There are no special licensing requirements for programs that will focus on education and container clean-up.

Identifying Your Target

Knowledge of Arkansas mosquitoes, specifically the mosquitoes in your area, will enable you to optimize your program while keeping expenditures to a minimum. To be effective, you must know which types of mosquitoes you are trying to control and which species are a problem in your area. Knowledge of the biology of these species will enable you to tailor your program for optimum control.

Mosquito Life History

Mosquitoes have four distinct stages in their life cycle: egg, larva, pupa and adult. Only the larvae must have water to develop, while the adult is free-flying. The length of time it takes a mosquito to complete its life cycle varies according to food availability, weather conditions and the species of mosquito. Under favorable conditions, mosquitoes can pass from egg to adult in as little as three and a half days, but usually one to two weeks is required.

Egg – Different species of mosquitoes use different sites for egg laying. Some mosquitoes lay their eggs in clusters called rafts on the water surface. Other species lay their eggs singly on the water surface, while others place eggs in dry areas that are flooded periodically. When first laid, mosquito eggs are white but become dark brown to black after a few hours. The shape and size of mosquito eggs vary, with most being football- or boat-shaped and 0.02 to 0.04 inch long. In warm water, the eggs may hatch in two to three days. Some mosquito eggs can remain dormant in dry conditions for many months.

Larva – Mosquito eggs hatch into worm-like larvae called wigglers and are seldom over 1/2 inch long. Wigglers have three body sections: a small head, an enlarged thorax (the middle section) and a long, cylinder-shaped abdomen. Wigglers live only in water. Most of them feed on microscopic plants, animals and organic debris suspended in the water by filtering out the food particles with their brush-like mouthparts. The larvae of some mosquito species are predators that feed on other mosquito larvae. Most mosquito larvae mature in three and a half to ten days, passing through four instars (growth stages). After the final larval stage, mosquitoes transform into the pupal stage. Larval development time depends on food, temperature and species. While feeding or breathing, mosquito larvae assume distinctive positions in the water. For most species, the larva breathes through an air tube located near the end of the abdomen. It projects the air tube to the water surface and hangs head down at an angle to the water surface, with only the tip of the breathing tube coming into contact with the surface of the water. An exception is the larvae of *Anopheles* mosquitoes. They lack air tubes and tend to lie flat against the water surface. One species actually respires by piercing the hollow stems of aquatic plants.

Pupa – The pupal stage is the transitional stage between the water-inhabiting mosquito larvae and the free-living adults. Mosquito pupae do not eat and spend most of their time at the water surface, tending to move only when disturbed. Mosquito pupae are sometimes called tumblers because, when disturbed, they exhibit a tumbling motion in water. Mosquito pupae are comma-shaped and, like the larvae, breathe through air tubes at the water surface. The front region of the pupa's body is greatly enlarged, consisting of a fused head and thorax. A pair of respiratory tubes called trumpets extend from the back of the thorax and are used to breathe. The pupal abdomen or tail consists of several segments that move freely. The pupal stage may last from one to ten days or even more, depending on temperature and mosquito species.

Adult – Adult mosquitoes have a single pair of wings. Male mosquitoes usually emerge a few hours up to a few days before females emerge. Males rest in vegetation surrounding the emergence site, waiting for female emergence. Male and female mosquitoes feed on nectar, plant juices and other sources of liquid carbohydrates. Males do not take blood meals. However, females of most species must have a blood meal as a source of protein before they can produce viable eggs. Mating occurs quickly in the air, usually near the emergence site. Female mosquitoes can fertilize all of their eggs after a single mating because they can store sperm internally. Male mosquitoes usually die shortly after the mating period. Adult female

Table 1. Common Mosquitoes of Arkansas: larval habitats, biting times, adult flight range and disease relationship.

Mosquito Species	Larval Habitat(s)[a]	Biting Time[b]	Flight Range[c]	Disease Agent[d]
Aedes aegypti	AC	C, D	<1/2 mile	DG, YF
Aedes albopictus	AC, TH	D	<1/2 mile	DG, YF, (CE), (WNV)
Aedes vexans	FW, GP, IP	C, N	1->5 miles	CE, EEE, DHW, (WNV)
Anopheles crucians	SM, FS, LM	C	1-2 miles	(M), (VEE), (EEE)
Anopheles punctipennis	WP	C, D	>1 mile	M
Anopheles quadrimaculatus	FW, GP, LM, RF	C, N	1/2-1 mile	M, DHW
Coquillettidia perturbans	DD, FS, GP, LM, RE	C, N	1-5 miles	EEE, (VEE), (WNV)
Culex erraticus	WP, RF	N	0-1/4 mile	(WNV)
Culex nigripalpus	GP, FW, DD	C	1/2-1 mile	SLE, (WNV)
Culex pipiens	AC, SCB, GRP	C, N	1/4-1/2 mile	SLE, WEE, WNV, DHW
Culex quinquefasciatus	AC, SCB, CRP	C, N	1/4-1/2 mile	SLE, (WEE), (VEE), WNV, DHW
Culex restuans	WP, GRP, DD	C, N	1-2 miles	(EEE), (WEE), WNV
Culex salinarius	GP, LM, FS, RF	C, N	1/4-5 miles	(EEE), WNV
Culex tarsalis	IP, RF, GRP	C, N	1-2 miles	WEE, SLE, WNV
Culiseta inornata	GRP, DD	C, N	1-2 miles	(WEE), (CE)
Culiseta melanura	FS, WP	C, N	1/2-1 mile	EEE, (WNV)
Mansonia titillans	FS, GP, LM	C, N	1/4-5 miles	(VEE)
Ochlerotatus atlanticus/tormentor	WP	C, D	1/4-1/2 mile	
Ochlerotatus canadensis	WP, DD, FS	C, D	0-1/4 mile	CE
Ochlerotatus fulvus pallens	WP	C, N, D	2-5 miles	
Ochlerotatus infirmatus	WP, GP, LM, FS	C, D	1/4-1 mile	
Ochlerotatus mitchellae	GP, FW	D	1/2-1 mile	(EEE)
Ochlerotatus nigromaculis	IP, FW	C, D	1-2 miles	(WEE), (CE)
Ochlerotatus sollicitans	SM	C, D	5-40 miles	EEE, (WNV)
Ochlerotatus taeniorhynchus	SM	C, N, D	5-40 miles	SLE, VEE, (CE)
Ochlerotatus triseriatus	TH, AC	D	1/2-1 mile	CE, (WNV)
Ochlerotatus trivittatus	GP, WP, FW	C, N	1/2-1 mile	CE, (WNV)
Psorophora ciliata	WP	C, N	1-2 miles	
Psorophora columbiae	IP, RF, GRP, GP	C, N	5-10 miles	VEE
Psorophora discolor	IP, RF, GRP	C, N	1-5 miles	VEE
Psorophora ferox	WP	C, N	1-2 miles	
Psorophora horrida	GP, GRP, IP, WP	C, N	1-2 miles	
Psorophora howardii	GP, GRP, IP, WP	C, N	1-2 miles	

[a]AC = artificial containers; DD = drainage ditches; FS = freshwater swamps; FW = flood waters; GP = grassland pools; GRP = ground pools; IP = irrigated pastures; LM = lake margins; RE = rooted emerged vegetation; RF = rice fields; SCB = sewer catch basins; SM = salt marshes; TH = tree holes; WP = woodland pools.

[b]C = crepuscular (dusk and dawn); D = day, N = night.

[c]Values given are estimates of normal flight ranges. For some species, seasonal migratory flights may be 10 times these values.

[d]Parentheses indicate secondary or suspected vectors, otherwise, primary vectors. CE = California group encephalitis; DG = dengue; DHW = dog heartworm; EEE = eastern equine encephalitis, M = malaria; SLE = St. Louis encephalitis; VEE = Venezuelan equine encephalitis; WEE = western equine encephalitis; WNV = West Nile virus; YF = yellow fever.

mosquitoes typically live for about one to six weeks, but this can vary depending on several environmental factors. Some species overwinter as blood-engorged, mated females that may live up to six months or more (some mosquito species overwinter as eggs and others as larvae). When female mosquitoes are inactive, they rest in protected areas that are typically dark or shaded, humid and cool in the summer or warm in the winter. The mouthparts of female mosquitoes are complex and form a prominent beak or proboscis. When a mosquito takes a blood meal, it uses its mouthparts to puncture the skin of the host and take blood directly from small capillaries. A small amount of saliva is injected into the wound before drawing blood, preventing the blood from clotting during feeding. In most cases, itching and swelling caused by the saliva subside within a few hours.

Mosquito Identification

All mosquitoes are classified in the order Diptera (true flies) and in the family Culicidae, which has more than 2,500 recognized species in the world. Adult mosquitoes are small, long-legged flies that have two wings. There are three characteristics **in combination** which separate adult mosquitoes from all other flies: 1) long, many-segmented antennae, 2) piercing and sucking mouthparts in females that are elongated into a distinctive beak or proboscis and 3) scales on the wing veins and margins.

The adult mosquitoes around your home may have come from a breeding site near or far away, depending on the species, wind patterns and the flight habits of the females. *Aedes aegypti* breed primarily in and around human habitations and fly short distances (200 to 300 yards). The flight ranges of *Culex* species vary (<1/2 mile up to about 5 miles) depending on the species. Most *Anopheles* mosquitoes have a flight range of at least 1 mile. *Psorophora* species have flight ranges of at least 8 miles. Some salt-marsh and floodwater mosquitoes in the genera *Aedes* and *Ochlerotatus* can disperse with the prevailing winds for 20 to 40 miles or more away from their larval development sites. You need to recognize these flight distances in order to find the source of mosquito problems and choose the appropriate management strategies. If the source of the mosquitoes is not on your property, you may need to cooperate with others to be able to control them.

To control mosquitoes in your area, you need to know what kinds are living there. There are at least 55 species of mosquitoes that are known to occur in Arkansas, many of which are not significant pests of man. These species have considerable variation in their larval breeding sites, time of day when they bite and adult flight distances. Table 1 provides a summary of this information for some common species in Arkansas.

Identification of larvae or adult mosquitoes to species is complicated and generally requires considerable expertise and training. If there is a question about the species involved, it is best to send samples to an identification lab. A mosquito control district, county health department, university or a pest control operator should be able to help.

Mosquito Grouping

Mosquito species are often divided into groups based on where the females lay their eggs and where the larvae develop (Table 2). There are different control strategies for each group. The Centers for Disease Control and Prevention (CDC) has developed a convenient grouping of four mosquito types according to the habitats in which the larvae generally develop.

- Permanent pool group
- Transient water group
- Floodwater group
- Artificial container and tree-hole group

Understanding these groups will aid in determining the source of the mosquito problem and what control measures are likely to help.

Know Your Area

To optimize your resources, it is necessary to have comprehensive and detailed knowledge of the immediate and surrounding area. This requires locating and prioritizing the treatment areas (mapping). Therefore, your plan should include the following:

- Defining the treatment areas
- Prioritizing the potential treatment areas
- Locating productive mosquito habitat within the protected areas
- Evaluating the mosquito production adjacent to the protected areas
- Timing the work (build maps over time)
- Choosing equipment and chemicals
- Training personnel
- Planning and coordinating with other mosquito programs

Table 2. Mosquito groups, their breeding sites and management suggestions for each group.

Mosquito Group	Genera and/or Species	Breeding Sites	General Management Approaches
Permanent pool	*Anopheles*, some *Culex*	Standing water that seldom dries, edges of ponds, lakes and small impoundments	Biological control – mosquito fish, *Bacillus thuringiensis israeliensis* toxin and *Bacillus sphaericus* Habitat disruption – draining the water or removing plants
Transient water	*Culiseta*, some *Culex*, occasionally *Anopheles*	Roadside ditches, excavations, canals, ground pools, catch basins, storm sewers, clogged streams, irrigated land (rice fields)	Biological control – *Bacillus thuringiensis israeliensis* toxin and *Bacillus sphaericus* Habitat disruption – removing water and vegetation or draining water where mosquitoes breed Chemical suppression – using insecticides against adults and/or larvae
Floodwater	*Aedes*, *Ochlerotatus*, *Psorophora*	rice fields, flood plains, salt marshes, small sites, including animal footprints	
Artificial container and tree hole	Mostly *Aedes*, especially *Aedes aegypti*, *Aedes albopictus*, *Culex quinquefasciatus* and *Ochlerotatus triseriatus*	Artificial containers, discarded tires, tin cans, flower pots, cemetery vases, roof gutters, tree holes, water caught in bromeliads, orchids and other plants	Sanitation – removing food, water and shelter Habitat disruption – draining the water in small containers

Mosquito Surveillance and Monitoring

Surveillance and monitoring of mosquito populations are essential components of any proactive mosquito control program. Surveillance involves identifying likely problem areas within your local area. Monitoring involves routine and regular assessment of what is occurring in those specific areas.

No one method alone can provide enough information to assess the risks of disease transmission in an area. Instead, it is necessary to rely on a combination of methods. In addition to surveillance and monitoring of adult and larval mosquito populations, it is also necessary to survey and monitor for evidence of viral agents when specific disease threats are present. This monitoring is conducted by the Arkansas Department of Health through the use of sentinel flocks, bird bleeding and testing of suspected infected wild birds.

Population Monitoring

Potential problem areas can be identified early through careful monitoring of the numbers and species of mosquito adults and larvae. Monitoring efforts need to take into account the geography of the area as well as local conditions; they may need to be adjusted seasonally as well as intensified after a natural disaster.

Adults – Adult mosquitoes can be monitored in two ways. Both methods sample the population of female mosquitoes in the area.

- **Light Traps With CO_2** – These specially designed and baited traps capitalize on the female mosquitoes' attraction to CO_2. Some species of *Aedes* and *Anopheles* are poorly attracted to light, and because of this, CDC light traps are sometimes used with CO_2 but without the light source. Mosquitoes are trapped over a 24-hour period to estimate species distribution within an area. Traps are placed in the survey area, and trapped adults are classified, counted and may be analyzed for the presence of disease pathogens. Using the trap data, an adult mosquito index is usually calculated by averaging several collection

sites or traps to provide a composite index for a particular area. One index commonly used is females per trap per collection period. The equation is:

$$\text{Adult Female Mosquito Index} = \frac{\text{Number of Female Mosquitoes}}{\text{Number of Traps} \times \text{Number of Collection Periods}}$$

Data can be plotted to help visualize changes in the mosquito population and detect long-term trends. This information can help show the effect of rainfall and temperature on mosquito populations and the effectiveness of pesticide applications.

- **Landing Count Surveys** – A count is taken of the number of mosquitoes that land on the surveyor within a specified time period (usually one minute from the time of the first landing). Landing counts of 20 mosquitoes per minute may indicate a severe mosquito problem. Regular stations should be sampled weekly. Collections for each station should be made at the same time of day or night depending upon the biting habits of the species involved. In some cases, particularly with day-biting salt-marsh or pasture mosquitoes, the index may be obtained from the numbers alighting upon one's clothing rather than those actually in biting position. This method is also useful for a rapid check of mosquito abundance before and after treatment when populations are very high.

Larvae – Aquatic habitats should be routinely sampled for mosquito larvae, with counts taken of the number and species present. Larval surveys are used to determine the locations and seasons that mosquitoes use specific aquatic habitats and, when specimens are identified and counted, the information can be used to determine species composition and population densities. The information can be used to determine optimal times for application of larval control measures, including chemicals, biologicals, draining or impounding. It can also be used to help forecast the need for adult mosquito control and to help assess the effectiveness of both chemical and biological control measures.

The most commonly used larval collection method is the standard white dipper (pint- to quart-sized scoop-on-a-handle). Sample slowly and carefully to avoid disturbing larvae at the water's surface. Vibrations from heavy footsteps, casting a shadow or moving vegetation that contacts the water may be enough to cause larvae to dive to the bottom.

Mosquito larvae of most genera, particularly the common *Culex*, *Aedes* and *Anopheles*, are usually found at the water's surface and frequently next to vegetation or surface debris. In larger pools and ponds, they are usually near the margins, not in open, deep water. Dipping should be concentrated around floating debris and aquatic and emergent vegetation. If there is a strong wind, dipping should be done on the windward side of the habitat where larvae and pupae will be most heavily concentrated. Look for larvae and pupae before beginning to dip, if possible.

Each water body may contain a number of different microhabitats that could contain different mosquito species. Microhabitats are such places as under tree roots, within clumps of emergent vegetation, under floating or overhanging vegetation and in open water. Learn to recognize different microhabitats within an area, and sample as many as possible in order to obtain an accurate picture of the area's species composition.

Know Your Management Options

To control mosquitoes effectively long term, an abatement program should use several complementary management techniques, including:

- **Sanitation** – Removing food, water and shelter.
- **Habitat disruption** – Draining the water where mosquitoes breed.
- **Biological control** – Using mosquito fish, *Bacillus thuringiensis israeliensis* toxin and *Bacillus sphaericus*.
- **Mechanical control** – Maintaining window screens and altering building designs.
- **Personal protection** – Wearing protective, light-colored, loose-fitting clothing; using repellents; and avoiding activities in areas when mosquitoes are active.
- **Chemical suppression** – Using insecticides against adults and/or larvae.

Homeowners can be valuable assets in managing mosquito problems. Homeowners should be educated as to their responsibilities for mosquito control and should be encouraged to:

- Dispose of plastic containers, ceramic pots, tin cans or similar water-holding containers.
- Remove and properly discard old tires from their property.
- Drill holes in bottoms of recycling containers kept outdoors.
- Ensure roof gutters drain properly, and clean clogged gutters in the spring and fall.
- Fill tree holes with sand or drill and drain.
- Turn over plastic wading pools and wheelbarrows when not in use.
- Change the water in birdbaths at least once a week.
- Clean excess vegetation and debris from around the edges of ponds.
- Clean and chlorinate swimming pools, outdoor saunas and hot tubs.
- Drain water from pool covers.
- Use landscaping to eliminate stagnant water that collects on the homeowner's property.
- Avoid over-irrigation of lawns.

Additional control information can be obtained from FSA7059, *Mosquito Control Around the Home and in Communities*.

Define Operational Strategies

At the outset, it is necessary to develop a strategy in order to direct control efforts toward each mosquito population affecting the citizens of your county. Central to this goal are the following issues:

Survey

Develop and maintain a map system that includes the following information:

- The area under your protection
- Access routes into the area
- Mosquito production zones

Monitoring Procedures

- Initiate routine monitoring procedures that include larval and adult counts identified to species.
- Define thresholds – the acceptable landing counts in your area.
- Develop procedures to receive and respond to mosquito complaints.

Develop and Plan Control Strategies for Each Type of Production Zone

- Analyze each zone individually to determine which control strategy will provide the most sound and effective control – prevention, larvicide or adulticide controls.
- Plan ground treatment routes that are based on providing service to the citizens of the community while incorporating mosquito hot spots.

Evaluate and Refine Your Plan

Take the following into consideration:

- Available equipment
- Availability of experienced operators
- Surveillance history of the area
- Surrounding habitat and environmental limitations/hazards

Record Keeping and Program Review

Future prioritizing will be greatly facilitated by accurate and complete surveillance histories and pesticide application records.

Precautions

KEEP THE PUBLIC INFORMED about mosquito control operations. Whenever possible, notify the public of the date and time of applications before any applications for larval or adult mosquito control are made.

In the case of applications directed to control adult mosquitoes, individuals with severe allergy conditions and persons with asthmatic problems may wish to stay indoors or plan to be away from the community during the treatment hours.

Car finishes may be spotted with certain adulticidal insecticide sprays, and owners may wish to house them in the garage during the treatment hours.

The understanding and cooperation of the general public is necessary if the program is to be successful.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

DR. JOHN D. HOPKINS is associate professor and Extension entomologist with the University of Arkansas Division of Agriculture, Little Rock. **DR. MAX V. MEISCH** is university professor (retired), Department of Entomology, University of Arkansas, Fayetteville.

FSA7060-PD-3-13RWC