

Crop Profile for Public Health in North Carolina

Prepared: March, 2004



General Information

A variety of animals can be considered public health pests in North Carolina. The largest group is the insects and other arthropods. They include mosquitoes, ticks, mites, bed bugs, lice, fleas, cockroaches, flies, bees, wasps, ants, urticating caterpillars, spiders, centipedes, and scorpions. Mosquitoes, ticks, mites, bed bugs, lice, fleas, cockroaches and flies are nuisances and, more importantly, can transmit diseases to humans and domestic animals (e.g., eastern equine encephalitis, La Crosse encephalitis, West Nile virus, Lyme disease, Southern tick associated rash illness (STARI), ehrlichiosis, and Rocky Mountain spotted fever). Venomous arthropods such as bees, wasps, ants, urticating caterpillars, spiders, centipedes, and scorpions are most often considered domestic pests; however, can sometimes create public health problems.

Vertebrate animals also comprise a significant group of public health pests. Rodents (domestic and wild species), birds, bats, deer, raccoons, skunks and opossums can become nuisances, cause structural damage, infect humans directly with diseases (e.g., rabies), and/or serve as reservoirs for diseases transmitted by ectoparasitic arthropods (e.g., Lyme disease, STARI, ehrlichiosis, and Rocky Mountain spotted fever).

In North Carolina, the State's Department of Environment and Natural Resources' Public Health Pest Management Section provides financial and technical assistance to local (county, city, etc.) health departments to develop and implement mosquito control programs across the state. The management of mosquitoes for nuisance and vector-borne disease control in North Carolina is addressed in this document.

The management of other arthropods (i.e., mites, ticks, lice, fleas, cockroaches, flies, and venomous arthropods) and vertebrate animals (i.e., birds, rodents and other mammals) is generally handled by homeowners in North Carolina. Where local health departments are involved in the management of the aforementioned pests, they may contract with pest control companies to perform these activities. Therefore, the management of these arthropod and vertebrate pests in North Carolina is not addressed in this document, but is more appropriately covered in the North Carolina Residential and Industrial Pests Crop Profile (<http://pestdata.ncsu.edu/cropprofiles/docs/ncresidentialandindustrial.html>).

Worker Activities

Ultra low volume (ULV) adulticides are generally used as concentrates without dilution or mixing, thus limiting worker exposure. Exposure to pesticide when loading the ULV spray tank is minimal. Some products are used directly from the original container to which the pump hose is connected, thus requiring no loading into ULV spray tanks. Some exposure may take place during machine operation, but most ULV machines are completely operable from the cab of the vehicle on which it is mounted.

Exposure of the public may take place while adulticides are being applied. The level of exposure from a moving ULV sprayer is considered to be minimal. ULV application is typically conducted in the early morning or late evening, which helps to avoid human exposure. Spray vehicles are usually equipped with warning signs and flashing lights. Operators are instructed to cut off insecticide flow when nearing pedestrians. Most ULV machines are equipped with synchronous flow equipment that regulates the insecticide pump according to vehicle speed and automatically cuts insecticide flow when the vehicle is stopped. In addition, spray routes are made available to the public in a variety of ways including publication in local newspapers and on municipal websites. Many programs maintain a no-spray list that includes beekeepers and others who wish not to be sprayed. Machines are shut down when passing these locations.

Larvicides used in North Carolina are primarily biological and/or growth regulators with low toxicity to those handling product. Normal pesticide safety precautions are used when applying larvicides. These

products are applied directly to mosquito breeding habitats; any exposure to the public from larvicidal products is unlikely.

Mosquitoes

General Biology

There are approximately 175 species of mosquitoes in the United States. Most mosquitoes bite and take a meal of blood. Some mosquitoes only feed on a very narrow range of hosts, such as birds, while other species exhibit broader feeding habits and will take a blood meal from any animal that is readily accessible. Only about 100 or so species are pestiferous to people. When mosquitoes feed, pathogens, such as West Nile virus, that cause illnesses in humans, domestic or wild animals may be transmitted. Mosquito abatement programs exist to address the transmission of illness as well as the nuisance caused by mosquitoes.

All mosquitoes regardless of species share some features of their biology. For example, all mosquitoes need water to complete their life cycle. Consequently, rainfall or other flood events (e.g., high tides) significantly increases mosquito production. There are four stages in the life cycle of all mosquitoes: eggs; larvae; pupae and; adults. The length of the life cycle from the egg to the adult stage varies considerably between species, but it can be completed in as little as 5 to 7 days under optimal conditions during the mosquito season. Local weather conditions, in particular temperature, have significant impacts on the length of the life cycle and the abundance of mosquitoes.

Adults are terrestrial, while larvae and pupae are aquatic. Some mosquito species lay their eggs directly on the surface of the water. *Culex* mosquitoes group their eggs into rafts that float on the surface of the water, while *Anopheles* mosquitoes lay single eggs that float on the surface of the water. The eggs of these "permanent water" mosquitoes generally hatch within 24 to 36 hours of being laid. Other "floodwater" species lay desiccation-resistant eggs in depressions in the ground in woodlands, roadside ditches, salt and fresh water marshes, etc. After they are flooded by rainfall or high marine tides, these eggs hatch synchronously ultimately producing large "broods" of mosquito adults. Examples of these mosquito species include the salt marsh mosquitoes *Ochlerotatus sollicitans* and *Oc. taeniorhynchus*, or the freshwater species *Oc. canadensis*. Other mosquitoes lay single eggs that are glued to the sides of natural or man-made containers just above the water line. The eggs of these species exhibit "installment hatching"; in other words, a portion of the viable eggs hatch after each flooding, drying and re-flooding event. *Aedes albopictus* and *Ae. aegypti* are examples of mosquitoes that inhabit man-made containers, such as tires and discarded buckets. *Ochlerotatus triseriatus* occupies natural tree holes as well as man-made containers.

In general, males live for one to two weeks and females for several weeks up to a month, depending on local air temperature and humidity. Only female mosquitoes bite and take a meal of blood. Mosquitoes lay 50 to 200 eggs depending on the species and the size of the blood meal. Most mosquitoes die before

biting and taking a blood meal. In general, those mosquitoes that do feed are only able to take one blood meal. Both male and female mosquitoes use plant sugars as a source of energy for flight.

The carbon dioxide exhaled by humans activates the mosquitoes' search for a host from which to take a blood meal. Mosquitoes use other chemicals in breath and body odor to locate a host. Females use the proteins in the blood meal to develop eggs. When females bite they salivate into the wound. Proteins in the saliva facilitate the taking of the blood meal by preventing the blood platelets from coagulating and by dilating blood vessels. When mosquitoes bite, people and other animals may become infected with disease agents. Mosquitoes secrete viruses in their saliva when they feed. The impact of viruses on mosquitoes has not been extensively studied, but it is likely that the life span of mosquitoes is shortened if they are heavily infected.

Mosquitoes pass through harsh winter months as hibernating females, larvae, or as eggs in an arrested state of development called *diapause*. As weather conditions improve in the spring, adults become active and overwintering larvae pupate and emerge as adults. Females seek hosts for a blood meal, and eggs hatch when flooded by rainfall or high tides. Mosquitoes may have one to many generations per season.

Disease Transmission

Mosquitoes may carry malaria, dengue fever, yellow fever and encephalitis diseases and are responsible for more human fatalities worldwide than any other insect. North Carolina is most at risk for the eastern equine encephalomyelitis (EEE) and La Crosse encephalitis (LACE). In recent years, the migration of West Nile virus has become a pressing concern to the state.

Eastern equine encephalomyelitis (EEE)

Eastern equine encephalomyelitis is a rare disease, but can surface in both humans and horses. The virus normally occurs in bird populations and, if mosquito populations grow very large, may be transmitted to other species. North Carolina averages about one human case each year. About fifty percent of human EEE cases are fatal, with young children and the elderly most at risk. In North Carolina, this disease is more likely to occur in the coastal or eastern Piedmont areas and late in the summer or early fall.

Symptoms can develop from a few days to two weeks after being bitten by an infected mosquito. They include rapid onset of fever and headache and can resemble a case of the flu. Survivors of EEE infections may suffer from long-term effects to the nervous system. Therapy is limited to treating the symptoms of the disease, because there is no specific cure. There is no vaccine available for humans currently, although a horse vaccine is available.

La Crosse Encephalitis (LACE)

La Crosse encephalitis is a disease associated with small mammals such as squirrels and chipmunks. In North Carolina, the disease occurs mainly in the western part of the state.

Symptoms occur from a few days to a couple of weeks after being bitten by an infected mosquito. These symptoms include fever, headache, nausea, and vomiting. In more severe cases, convulsions, tremors and coma can occur. Young children and the elderly are the most susceptible to the disease. LACE is rarely fatal in humans. Previously approximately five cases of LACE are reported each year in North Carolina, but in recent years annual case rates have increased to more than 20. The incidence of LACE may be underestimated because the disease is often misdiagnosed or cases not reported to the state health department.

West Nile Virus (WNV)

West Nile virus is a disease that is normally found in Africa, West Asia, and the Middle East. Its occurrence has been documented in the United States in recent years, however. This virus is associated with birds and can be transmitted to human populations through mosquito bites.

Symptoms occur five to fifteen days after infection and may include fever, headache and body aches, which may be accompanied by skin rashes and swollen lymph glands. In more severe cases, disorientation, coma, tremors and paralysis can occur. This disease has a low fatality rate, however, the elderly are most at risk with a fatality rate of approximately 10%. There is no vaccine for West Nile virus for humans, although a horse vaccine is available.

Integrated Mosquito Management

The diverse biology of mosquitoes means that no single common tactic can be used to control all pestiferous species. Instead, mosquito abatement programs use an integrated management approach in which several control procedures are selectively combined based on the species targeted for suppression. In this way, higher levels of mosquito reductions can be achieved than by using any single method. These tactics can be grouped into environmental management, insecticide use, and biological control.

Environmental management involves the manipulation of mosquito habitat to disrupt the mosquito's life cycle. An example would be the use of Open Marsh Water Management, which is a selective ditching technique, used for controlling salt marsh mosquitoes. Another example would be the removal from backyard environments of discarded water-holding containers that are used as mosquito production sites. Removing blockages from roadside ditches that impound water is another example of source reduction achieved through environmental management.

Use of insecticides is a main component of most mosquito control programs. Surveys are commonly conducted to locate mosquito habitat. Routine sampling is then used to target areas and mosquito species for larviciding. In this way, mosquitoes are suppressed before adults emerge and disperse into

communities. However, storm events may produce mosquito populations that are too large to be treated with larvicides before adults emerge. In such cases, insecticides are applied as aerosol sprays in communities to control adult mosquitoes. As with the management of immature mosquitoes, application of adulticides is based on measuring adult mosquito activity.

The principal form of biological control for controlling mosquitoes is the use of mosquito-eating fish, such as the common mosquito fish (*Gambusia affinis*). Mosquito fish are usually introduced into permanent bodies of water that are known to produce nuisance mosquitoes.

Other forms of control include legal actions to reduce public nuisances. An example would be the creation of public ordinances to forbid the accumulation of tires on private or public properties. Public education is an integral component of most publicly funded mosquito control programs. A public that is informed about the biology of mosquitoes and the dangers of mosquito transmitted illnesses is more likely to eliminate water-holding containers and other sources of mosquito production.

Mosquito Control Programs in North Carolina

There are currently 61 species of mosquitoes recorded from North Carolina, of which approximately 40 are considered to be of public health importance. At any one time during the mosquito season one or more of those 40 species exist in sufficient abundance and public health importance to initiate mosquito control practices. Ninety-eight local mosquito control programs in North Carolina that received state aid for mosquito control provided information regarding their estimated usage of larval and adult mosquito control products in 2003, which is summarized below. Mosquito management practices by approximately ten to fifteen small programs not receiving state aid are not included in this summary.

Larval Mosquito Control

Sixty-six of 98 local mosquito control programs planned to use larvicides as part of their mosquito control program in 2003. A program may employ more than one type of larvicide depending upon circumstances. For example, surface oils or monomolecular films (MMF) may be used on pupal or late instar larval mosquitoes because *Bacillus thuringensis* var. *israelensis* (Bti) and methoprene are less effective at that point in mosquito development. Table 1 contains the number of programs planning to use mosquito larvicides in 2003.

Table 1. Number of local mosquito control programs planning to use mosquito larvicides in 2003 (98 programs reporting).

Mosquito Larvicide	Number of Programs Planning to Use Larvicide
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<i>Bacillus thuringensis</i> var. <i>israelensis</i> (Bti)	51
<i>Bacillus sphaericus</i>	10
Methoprene	25
Surface Oils	6
Monomolecular films (MSF)	13
Temephos	1

Bacillus thuringensis var. *israelensis* (Bti) is being used in three different formulations: 30-day briquets, granules, and liquid. The estimated quantity to be used was reported as 71,315 briquettes (31 programs), 12,990 pounds of granules (10 programs), and 4,925 gallons of liquid (4 programs). It was estimated that 538 pounds of *B. sphaericus* would be used in 2003. Methoprene, the second most commonly used larvicidal product, is applied in briquette and granular formulations. An estimated 55,920 briquettes (16 programs) and 1,041 pounds of granules (5 programs) were expected to be used in 2003. It was estimated that 466 gallons of surface oil would be used.

Adult Mosquito Control

Eighty-two of 98 local mosquito control programs reported plans to conduct adult mosquito control. Applications are made with truck-mounted ultra low volume (ULV) equipment, using one of several ULV adulticides. Table 2 contains the number of programs planning to use mosquito adulticides in 2003.

Table 2. Number of local mosquito control programs planning to use mosquito adulticides in 2003 (98 programs reporting).

Mosquito Adulticide	Number of Programs Planning to Use Adulticide	Gallons of Product
Permethrin	52	20,497
Malathion	13	4,716
Pyrethrins	6	210

Sumethrin	4	470
Resmethrin	1	--
Naled	1	810

Emergency Adult Mosquito Control

At times, emergency adult mosquito aerial control has been necessary following some hurricanes. The product of choice for adult mosquito aerial applications is naled. Following Hurricane Isabel in 2003, 1,839 gallons of 87.4% naled were aerially applied at the rate of 0.67 fluid ounces per acre to 351,262 acres.

IPM and Mosquito Control

In addition to control of adult and larval mosquitoes with insecticides, local mosquito control programs are encouraged to use an integrated pest management (IPM) approach to mosquito control that incorporates surveillance, identification, response levels, and integration of non-chemical approaches to mosquito control such as source reduction. Table 3 contains the number of mosquito control programs planning to use IPM practices in 2003.

Table 3. Number of local mosquito control programs planning to use integrated pest management practices (IPM) in 2003 (98 programs reporting).

IPM Practice	Number of Programs Planning to Use IPM Practice
Clean up campaigns	85
Ditch cleaning	79
Use of mosquito fish	39
Public education program	76
Larval surveys	72
Adult trapping	40

Monitor complaints	73
Adult landing counts	59

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References

1. Public Health Pest Control. Public-Health Pesticide Training Manual for the USA and Its Territories. (<http://vector.ifas.ufl.edu>)
2. Apperson, C. S. and M. G. Waldvogel. 2002. Mosquito Control Around the Home and in Communities. Residential, Structural and Community Pests Insect Note No. 6. Department of Entomology, North Carolina State University, Raleigh. (<http://www.ces.ncsu.edu/depts/ent/notes/Urban/mosquito.htm>)
3. Apperson, C. S. and M. G. Waldvogel. 1999. Biting Flies and Their Control. Residential, Structural and Community Pests Insect Note No. 17. Department of Entomology, North Carolina State University, Raleigh. (<http://www.ces.ncsu.edu/depts/ent/notes/Urban/b-midge.htm>)
4. Apperson, C. S. and M. G. Waldvogel. 1999. Black Flies and Their Control. Residential, Structural and Community Pests Insect Note No. 16. Department of Entomology, North Carolina State University, Raleigh. (<http://www.ces.ncsu.edu/depts/ent/notes/Urban/blackfly.htm>)
5. Apperson, C. S., B. Engber, and M. G. Waldvogel. 2003. Tick and Tick-Borne Diseases in North Carolina. Residential, Structural and Community Pests Insect Note AG-426. Department of Entomology, North Carolina State University, Raleigh. (<http://www.ces.ncsu.edu/depts/ent/notes/Urban/ticks.htm>)
6. Apperson, C. S., L. Garcia, and M. G. Waldvogel. 2003. Control of the Red Imported Fire Ant. Residential, Structural and Community Pests Insect Note AG-486. Department of Entomology, North Carolina State University, Raleigh. (<http://www.ces.ncsu.edu/depts/ent/notes/Urban/ifa.htm>)
7. Apperson, C. S., J. J. Arends, J. R. Baker, C. C. Carter, C. S. Payne, and D. L. Stephan. 1986. Insect and Related Pests of Man and Animals. Publication AG-369. North Carolina Cooperative Extension Service, Raleigh. (<http://ipm.ncsu.edu/AG369/>)

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