



PESTS

That Affect Human Health



Mosquitoes and West Nile Virus

West Nile virus (WNV) continues to spread west. In summer 2002, WNV was detected for the first time in Kansas. Since the first U.S. case in New York in 1999, West Nile virus has been reported in 45 U.S. states and four Canadian provinces (Figure 1). The virus had reached California by September 2002. The Kansas report included 793 cases in horses, 170 cases in wild birds, and 21 pools of 50 mosquitoes. Twenty-two people were infected, and all recovered. The nationwide database reports 3,775 people infected, and 216 deaths in 2002.

Virus Ecology

Birds and Mosquitoes

WNV typically circulates between birds and mosquitoes. The female mosquito feeds on the blood of an infected bird. The virus multiplies in the mosquito gut and then travels to the salivary glands. When an infected mosquito bites or feeds on a non-infected bird, it injects virus-containing saliva into the new host (Figure 2). In some bird species, primarily crows, blue jays, and ravens, the virus can cause infection of kidney and brain, often leading to death. Mosquitoes do not feed on dead birds. But more than 110 species of birds, including chickens, can be infected and carry the virus without becoming sick.

Figure 2. Transmission cycle of West Nile virus

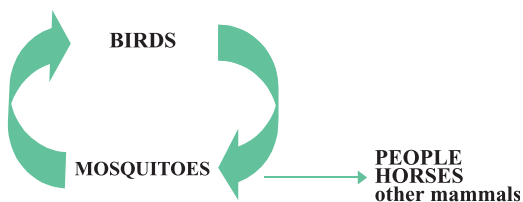
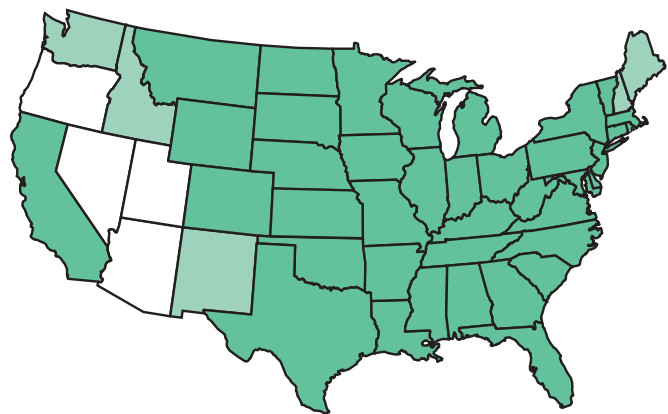


Figure 1. West Nile virus in the United States, 2002



- Indicates human cases verified as of Dec. 11, 2002.
- Verified avian, animal, and mosquito infections during 2002, as of Dec. 11, 2002.

Bird-to-bird transmission is possible because predatory birds feeding on infected birds can become infected. Migratory birds and the movement of goods contaminated with mosquitoes are the two most likely ways the virus is transported to new areas. Infected ticks have been found in Asia and Africa, but there is no evidence that ticks play a role in WNV transmission in the United States.

At least 26 mosquito species can transmit WNV. In Kansas, the primary mosquito species detected to carry the WNV belong to the genus *Culex* (*Cx. tarsalis*, *Cx. salinarius*, *Cx. restuans*, *Cx. pipiens*, *Cx. erraticus*).

Mammals

The common way mammals, including horses and people, are infected with the virus is a bite from an infected mosquito. Infections from organ transplants, blood transfusions or breastfeeding have been reported, but these are extremely rare.

WNV symptoms in horses include lack of coordination, difficulty walking, muscle twitching, head tilting, weakness and paralysis of limbs, blindness, lip droop, and in some cases, death. These symptoms are also typical of other infections such as eastern and western equine encephalitis and rabies. A horse vaccine for WNV is available, but it takes about six weeks for the vaccine to become effective. (A booster is effective in three weeks.) Vaccines for other types of encephalitis do not protect horses from WNV. Contact your veterinarian or local K-State Research and Extension agent for more information on the vaccine.

Most people infected with WNV show no signs of the disease, and it is assumed that they develop lifelong immunity. Symptoms of WNV infection in people include fever, headache, muscle weakness, and in some cases, skin rash and swollen lymph glands. Most infections are mild and last a few days. More severe symptoms can last several weeks and include high fever, neck stiffness, disorientation, nausea, tremors and convulsions. In rare cases, infection leads to inflammation of the brain (encephalitis) and death. The incubation period is three to 14 days after infection.

People 50 and older are considered the highest risk group, although people as young as 3 years old have been infected. If you develop the severe symptoms listed above, contact a physician immediately. Keep in mind that *most mosquito bites will not result in WNV infection*. And less than 1 per-cent of people infected with West Nile virus develop severe illness.

Other mammals can be infected with WNV, but show no signs of infection. These include, for example, black bears, white-tailed deer, cats, dogs, bats, chipmunks, skunks, squirrels and domestic rabbits. All mammals, including people and horses, are “dead-end hosts” because the virus does not multiply in their bodies at levels high enough to be infectious to other organisms, including mosquitoes. For example, the virus is detectable in horse blood for just a few days, and a mosquito feeding on the blood of an infected horse cannot transmit the virus.

Animal-to-person and animal-to-animal infections do not occur, with the exception of predatory birds feeding on infected birds. There is no reason

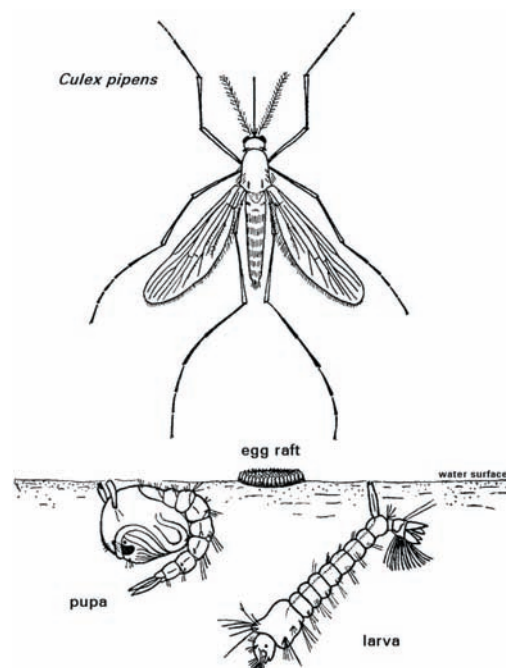
to destroy a domestic animal because it is infected with WNV. Recovery from the infection is likely.

Mosquito Biology

There are four developmental stages of mosquitoes: egg, larva, pupa and adult (*Figure 3*). *Culex* mosquitoes are the most important vectors of WNV. Adult females lay eggs every third night during their life span in a raft of 100 to 300 eggs on the surface of standing water. Eggs hatch into larvae that feed on aquatic microorganisms. They must frequently come to the surface to breathe. The pupa is a non-feeding, but mobile stage from which an adult emerges. The length of time for the development from egg to adult varies depending on the water temperature and mosquito species. It can take from seven to 10 days, but sometimes up to several weeks.

The adult life span is usually several weeks and depends on environmental conditions such as temperature and food supply. Adults have two wings and can fly, although most *Culex* species usually do not travel long distances. Both sexes feed on nectar to gain energy; only female mosquitoes bite and ingest blood, which is necessary for egg production. Females are attracted to the host by sensing carbon dioxide (CO₂) from breath and skin as well as host odor, temperature, color, and movement.

Figure 3. Developmental stages of mosquitoes



Culex pipiens (Figure 4) and *Culex restuans* prefer to bite or feed on birds, but if their breeding sites are close to homes, they may bite people and domestic animals. Both species breed in standing water, especially water polluted with organic matter.



Robert Novak, Illinois Natural History Survey

Figure 4. *Culex pipiens*

They are weak fliers and are most active at dawn and dusk.

Culex salinarius feeds indiscriminately on birds and mammals, and it readily bites people. It is found in fresh and saltwater marshes, lakes, ponds and man-made containers around homes. It is a good flier and active from sunset to sunrise.

Culex tarsalis is one of the most abundant mosquitoes in Kansas. It breeds primarily in rural areas in temporary to semipermanent depressions in pastures, ditches and springs. It is a good flier, it is most active at dusk, and it feeds most frequently on cattle, chickens and people. This mosquito is the main vector of western equine encephalitis.

Culex erraticus is present in forested areas. It is a weak flier and feeds on forest animals.

The primary mosquito season in Kansas is May through mid-September, although in some years, several species can be seen as early as February and as late as November. The main season for *Culex* species in Kansas is July, August and September. *Culex* species survive the winter as adults.

Control

Personal protection

- When outdoors, apply insect repellent containing DEET (N,N-diethyl-meta-toluamide). The more DEET the repellent contains *the longer*, not better, it will protect you. However, the use of products containing more than 33 percent DEET is not recommended. Pay close attention to the product label, especially regarding the use for children. There are many products on the market, but some provide little protection (*Tables 1 and 2*).
- Wear long-sleeved shirts and long pants treated with repellents containing DEET or permethrin. Keep in mind mosquitoes can bite through thin clothing. Do not apply *permethrin* directly on your skin.
- Avoid being outdoors at dusk and dawn, which are the periods when mosquitoes are most active.
- When outdoors, place netting over infant carriers.
- Mosquito traps based on release of CO₂ do not reduce the mosquito population to the level where there is a noticeable decline in mosquito numbers. (*Table 2*)
- Traps based on ultrasound technology are not effective for reducing the nuisance level. (*Table 2*)
- Make sure that screens on doors and windows are tight and without holes.

Important Facts About West Nile Virus

- Most mosquito bites do not lead to WNV infection.
- Less than 1 percent of people infected with WNV develop severe illness.
- Only mosquitoes transmit WNV in the United States.
- WNV cannot be transmitted from person-to-person or animal-to-person.
- Children are not more or less susceptible to WNV infection than adults.
- Follow the guidelines for personal protection and minimize mosquito breeding sites on your property.

Reducing mosquito breeding sites at home

The most effective method of controlling mosquito populations is targeting the larval stage and the sites where they can develop. Once mosquitoes become flying adults, control is more difficult and expensive.

- Eliminate artificial water-holding containers. If that is not possible, empty buckets, cans, bottles, used tires and other containers at least once a week.
- Clean birdbaths and water bowls for animals at least once a week.
- Fill or drain tree holes, stumps and puddles.
- Irrigate gardens and lawns carefully to prevent water standing for more than a few days.
- Check for water trapped in plastic covers on boats and swimming pools.
- Make sure rain gutters are clean and do not hold water.
- Stock garden ponds with mosquito-eating fish, such as minnows and goldfish.
- Aerate ponds and swimming pools.
- Eliminate aquatic vegetation around the edges of garden ponds, which allow predatory fish and beneficial predatory insects to reach the mosquito larvae.
- When feasible, raise and lower the water level to allow predatory fish to reach the mosquito larvae.
- Before considering chemical control, make sure mosquito larvae are present. Use a white container attached to a long pole to scoop a water sample. Wigglers (larvae) and tumblers (pupae) are easy to spot. Always read and follow the instructions on the product label.

Table 1. Summary of effectiveness of mosquito repellents

Product	Active Ingredient	Minutes of Complete Protection
Off! Deep Woods	23.8% Deet	302
Sawyer Controlled Release	20% Deet	234
Off! Skintastic	6.7% Deet	112
Bite Blocker for Kids	2% Soy oil	95
Skin-So-Soft Bug Guard Plus	7.5% IR3535	23
Natrapel	10% citronella	20
Herbal Armor	12% citronella 2.5% peppermint oil 2% cedar oil 1% lemongrass oil 0.05% geranium oil	19
Green Ban for People	10% citronella 2% peppermint oil	14
Buzz Away	5% citronella	14
Skin-So-Soft Bug Guard	0.1% citronella	10
Skin-So-Soft Moisturizing Sun Care	0.05% citronella	3
Gone Original Wristband	9.5% Deet	0.3
Repello Wristband	9.5% Deet	0.2
Gone Plus Repelling Wristband	25% citronella	0.2

Modified from: Fradin, M. S. and J. F. Day. 2002. Comparative efficacy of insect repellents against mosquito bites. *New England Journal of Medicine* 347: 13 - 18.

Table 2. Effectiveness of mosquito-control products

Treatment	Rank (1 = most effective)
Experiment 1	
Flowtron U-V Insect Killer with Octenol	4.1
Off! Mosquito Coils (allethrin insecticide)	2.7
Mosquito Contro Portable Mosquito Repeller (ultrasonic)	3.4
No treatment	3.7
Cutter Unscented Backwoods (22% deet)	1.1
Experiment 2	
Skeeter Beater 3% Citronella Candles	3.1
Mosquito plant, <i>Pelargonium citrosum</i> var. 'Van Leeni'	3.4
No treatment	2.6
Cutter Unscented Backwoods (22% deet)	1.0

Modified from from Jensen, T., R. Lampman, M. C. Slamecka and R. J. Novak. 2000. Field efficacy of commercial antimosquito products in Illinois. *Journal of the American Mosquito Control Association* 16: 148 - 52.

Products. There are several types of products available for control around homes, which are listed in *Table 3* on page 6. Products based on the bacterium *Bacillus thuringiensis* subs. *israelensis* (*B.t.i.*) and *Bacillus sphaericus* are selectively pathogenic to mosquito and blackfly larvae. There are also products based on the organophosphate Temephos and the chemical Methoprene, which kill mosquito larvae by disrupting their development. (*Table 3*)

Reducing mosquito breeding sites on farms

Animal waste lagoons. Water in animal waste lagoons is usually saturated with organic matter that might affect larval development. In some situations, mosquito and midge larvae can develop in great numbers. It is important to determine whether or not mosquito larvae are present before starting a control program.

Usually, the appropriate use of insecticides will bring an infestation under control in one to three days. Because mosquito breeding occurs in a zone about 10 feet wide from the shoreline outward, it is

not necessary to treat the entire surface area of the lagoon. Calculate needs based on a 10-foot-wide band around the circumference of the lagoon.

Products. There are five types of products for farm and rural area mosquito control.

- *Bacillus sphaericus*, a biological larvicide
- *Bacillus thuringiensis* subs. *israelensis*, a biological larvicide
- Insect growth regulator *Methoprene*, which kills mosquito larvae by disrupting their development. This product comes in a variety of formulations, but pellets and briquets are best suited for farm lagoons.
- Organophosphate compound Temephos is an effective mosquito larvicide. However, this product is not specific to mosquito larvae and will affect other insects and invertebrates in the water.
- Specially formulated mineral oils, Napthenic oil, distilled petroleum oil and monomolecular surface films may be applied to lagoon surfaces to smother mosquito larvae and pupae.

Used tires. No matter how a tire is oriented, it always collects water and becomes an ideal breeding site for several mosquito species. *Culex pipiens*, *Cx. restuans* and *Aedes albopictus*, the Asian tiger mosquito, colonize the aquatic habitat offered by tires. The outdoor storage of tires by businesses is regulated by Kansas Department of Health and Environment statutes, but the storage and utilization of used tires in agricultural facilities are exempted from the regulations. In some states, tires used in agricultural facilities must be either have holes punched in them or cut in half to prevent water accumulation and subsequent mosquito breeding. If the control of mosquito breeding in tires has to be implemented using chemicals, there are various larvicides available, which are listed in Table 3.

- If there is a small number of used tires, common rock salt can be as effective as any commercial pesticide. A handful of salt per tire should last for an entire season.
- Methoprene, an insect growth regulator, is highly effective and has a very low mammalian toxicity.
- Temephos, an organophosphate, is as effective as pellets in these habitats at a rate as low as one pellet per tire.
- *Bacillus thuringiensis* subs. *israelensis* and *Bacillus sphaericus* are based on toxins from these bacteria. These chemicals are highly specific and have very low mammalian toxicity. These are generally sold as pellets, granules or “donuts.” The chemical must get into every individual tire for proper application. Improper and incomplete coverage will result in ineffective mosquito control.

Livestock drinking tanks.

Watering tanks can become habitats for mosquito larvae. If the water surface in the tank can be aggressively agitated, larvae will not be able to suspend themselves from the water surface for breathing. This method will damage larval development, but it doesn't offer complete control. If mosquito larvae are breeding in a water tank, there are several possible methods of control.

Stocking the drinking container with mosquito-eating fish can be effective. Products based on *Bacillus thuringiensis* var. *israelensis* are useful.

Briquets and donuts have to be enclosed in metal screens so horses or other domestic animals do not consume them. The products are safe for animals, but will not be effective if they are eaten (Table 3).

Road ditches and depressions in pastures.

Before you treat make sure these sites are holding water for more than four days and, if so, that they contain mosquito larvae. If you find mosquito larvae, drain or fill up these sites with soil. *Bacillus thuringiensis* var. *israelensis* products are suitable for control in this environment (Table 3). Always be sure to follow the label instructions.

Web sites on mosquitoes and WNV

- www.cdc.gov/
- www.oznet.ksu.edu/westnilevirus/
- www.epa.gov/pesticides/factsheets/
- www.kdhe.state.ks.us/health-info/#Mcindi.usgs.gov/hazard/event/west_nile/west_nile.html
- www.mosquito.com/
- whyfiles.org/016skeeter/index.html
- www.cfe.cornell.edu/erap/WNV/default.cfm#mosquitohygiene

Suppliers and manufacturers of mosquito-control products

- Adapco (distributor) www.adapcoinc.com
- Clarke Environmental Mosquito Management Inc. (distributor) www.emosquito.com
- Henkel Chemical (Agnique Monomolecular Film) www.mosquitommf.com
- Summit Chemical (Bti Briquets, Mosquito Bits, Mosquito Dunks) www.summitchemical.com/mos_ctrl/default.htm
- Valent Biosciences (Bactimos, Spherimos, Vectobac, Vectolex) www.valentbiosciences.com
- Wellmark International (Altosid and Zodiak) www.wellmarkinternational.com/mosquito.htm
- Van Diest Supply Co. (larvicides and adulticides) www.vdsc.com/

Table 3. Summary of active ingredients approved for control of mosquito larvae.

Commercial Names	Action	Application Sites	Restrictions and Hazards
<u>Bacillus thuringiensis israelensis (Bti)</u>			
Aquabac, Bactimos, Bti Briquets, Mosquito Dunks, Mosquito Bits, Teknar, Vectobac	Kills larvae	Flood water, standing water, pastures, etc.	Less effective against larger larvae and in presence of heavy pollution or algae.
<u>Bacillus sphaericus</u>			
Spherimos, Vectolex	Kills larvae	Most noncrop and crop mosquito habitats	More effective than Bti in highly polluted environments.
<u>Larviciding Oils (highly refined, petroleum based oils)</u>			
GB-1111, BVA 2	Smother larvae and pupae	Borders and shallow areas of mosquito habitats	Toxic to fish and other aquatic organisms, consult with fish and wildlife authorities before use.
<u>Methoprene</u>			
Altosid, Zodiac Preventive Mosquito Control	Prevents pupation	Standing water of many types, including agricultural sites and manmade containers.	Toxic to aquatic dipterans (midges, flies, etc.).
<u>Monomolecular Surface Film</u>			
Agnique	Smother larvae and pupae	Semipermanent and permanent fresh or brackish standing water	May be ineffective where there are persistent unidirectional winds.
<u>Temephos</u>			
Abate, Skeeter	OP insecticide kills larvae	Standing water. Not for food, forage or pasture crops.	Toxic to birds and fish. Consult with fish and wildlife authorities before use.

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