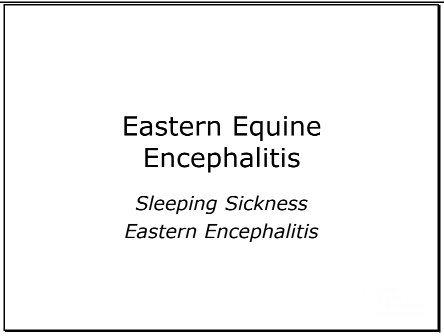
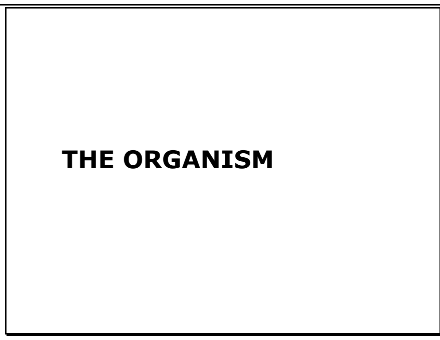
Slide 1



Slide 2

In today’s presentation we will cover information regarding the agent that causes eastern equine encephalomyelitis and its epidemiology. We will also talk about the history of this diseases, how it is transmitted, species that it affects, and clinical signs seen in humans and animals. Finally, we will address prevention and control measures, as well as actions to take if eastern equine encephalomyelitis is suspected. [Photo: Horses in a field. Source: U.S. Department of Agriculture]

Slide 3



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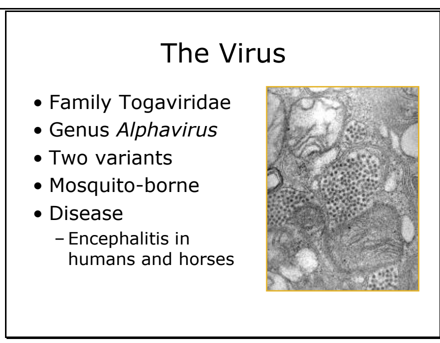


Eastern equine encephalomyelitis (EEE) results from infection by the respectively named virus in the genus *Alphavirus* (family Togaviridae). The numerous isolates of the Eastern equine encephalomyelitis virus (EEEV) can be grouped into two variants. The variant found in North America is more pathogenic than the variant that occurs in South and Central America. EEE is a mosquito-borne, viral infection that can cause severe encephalitis in horses and humans. [Photo: Electron micrograph of the Eastern equine encephalitis virus. Source: Dr. Fred Murphy and Sylvia Whitfield/CDC Public Health Image Library]

Slide 5

Slide 6

EEE History

- 1831:
  - Unknown encephalomyelitis virus affects horses in Massachusetts
- 1933
  - EEE first isolated from a horse
- 1937
  - EEE identified in ring-necked pheasants
- 1938
  - EEE first isolated from human brain

EEE was first isolated from a horse with encephalomyelitis in 1933, but it is thought that the disease dates back to 1831 to horses in Massachusetts. Birds are also susceptible to EEE as was discovered in ring-necked pheasants in 1937 in Connecticut. Since then the disease has been found to affect sparrows, pigeons, Peking ducks, Chukar partridges, emus, and ostriches, illustrating that species not indigenous to North America are susceptible. In 1938, EEE was first isolated from a human brain.

Slide 7

EEE History

- 1942-1943
  - Michigan epidemic
- 1947
  - Southern Louisiana and Texas
  - 14,000 cases
  - 83% case fatality rate
- 1951
  - Isolated from *Culiseta melanura*

Most epidemics since then tend to occur along the eastern seaboard, from New Hampshire along the Atlantic Coast to the Gulf of Mexico states. However, Michigan had an epidemic in 1942 and 1943, demonstrating that the vector is not restricted to the east coast states. The largest known epidemic occurred in 1947 in southern Louisiana and Texas. Fourteen thousand horses and mules were affected, and nearly 12,000 died. This 83% case fatality rate reflects the typical disease in horses in North America. The disease was first thought to be transmitted by an *Aedes* species mosquito, but in 1951 EEE was isolated from *Culiseta melanura*. [Photo: Horses in field. Source: public-domain-image.com]

Slide 8

EPIDEMIOLOGY

Slide 9

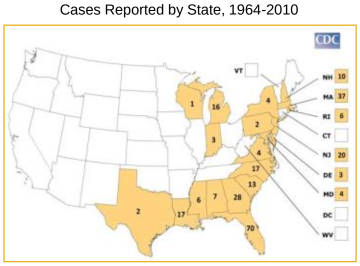
EEE Epidemiology

- 1964-2010
  - 270 cases total
  - Average 6 cases each year
  - Average 1 to 2 deaths each year
- Case-fatality rates
  - Human: 30 to 70%
  - Equine: 90%
- Equine cases usually appear first
  - Serve as sentinels for human disease

Since 1964, there have been a reported 270 cases of human EEE, averaging 6 cases per year, which is much smaller than the number of equine cases. The fatality rate is 30 to 70%, which is 1 to 2 human deaths annually, whereas horse mortality rates can be 90% or higher, with death occurring rapidly. EEE is a seasonal disease in most of North America, with outbreaks occurring in the late summer and early fall, reflecting the activity of the mosquito vector. Horses are usually the sentinel indicator of human disease.

Slide 10

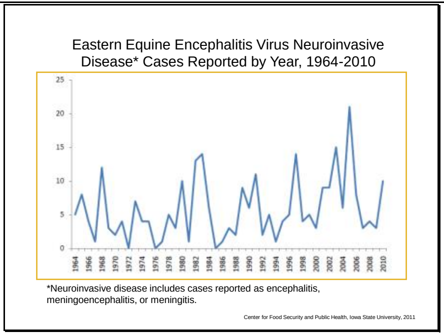
Eastern Equine Encephalitis Virus Neuroinvasive Disease Cases Reported by State, 1964-2010



Center for Food Security and Public Health, Iowa State University, 2011

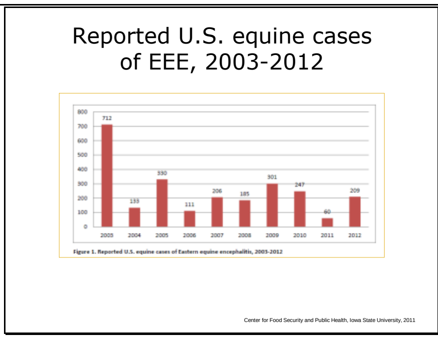
From 1964 through 2010, EEEV neuroinvasive disease cases were reported in Alabama (7), Delaware (3), Florida (70), Georgia (28), Indiana (3), Louisiana (17), Maryland (4), Massachusetts (37), Michigan (16), Mississippi (6), New Hampshire (10), New Jersey (20), New York (4), North Carolina (17), Pennsylvania (2), Rhode Island (6), South Carolina (13), Texas (2), Virginia (4), and Wisconsin (1).[Photo: Map reflecting the number of human cases of Eastern equine encephalitis virus neuroinvasive disease in the United States – reported by state, 1964-2010. Source: Centers for Disease Control and Prevention at http://www.cdc.gov/EasternEquineEncephalitis/tech/epi.html]

Slide 11



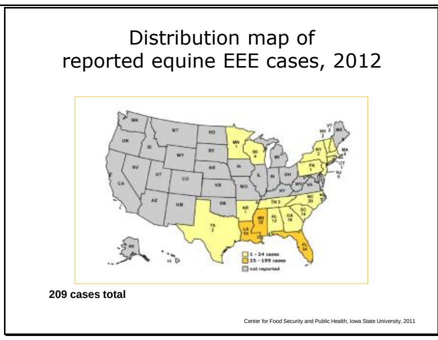
Data Table: In the United States, the annual number of reported Eastern equine encephalitis virus neuroinvasive disease cases reported varies. From 1964 through 2010, an average of 6 cases were reported annually (range 0-21). This graph demonstrates how the number of cases can vary markedly from year to year. Note the cyclic, seasonal nature of the reported cases related to the summertime activity of the vector.[Photo: Human Cases of Eastern Equine Encephalitis virus neuroinvasive disease in the United States – reported by year, 1964-2010. Source: Centers for Disease Control and Prevention at http://www.cdc.gov/EasternEquineEncephalitis/tech/epi.html]

Slide 12



This graph shows the reported U.S. equine cases of Eastern equine encephalitis from 2003-2012. Source: U.S. Department of Agriculture, 2012 Summary of Eastern Equine Encephalitis Cases in the United States at http://www.aphis.usda.gov/vs/nahss/equine/ee/

Slide 13

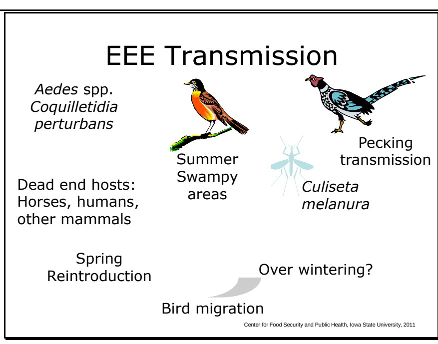


This map shows the distributio of the reported equine Eastern equine encephalitis cases reported in 2012 in the U.S. (209 cases total). Source: U.S. Department of Agriculture, 2012 Summary of Eastern Equine Encephalitis Cases in the United States at http://www.aphis.usda.gov/vs/nahss/equine/ee/

Slide 14

TRANSMISSION

Slide 15



Transmission of EEE occurs via a mosquito-vertebrate-mosquito cycle, with *Culiseta (Cs.) melanura* (an ornithophilic [“bird-loving”] mosquito feeding almost exclusively on songbirds) as the asymptomatic reservoir host. Birds are also able to spread the disease if they peck or eat diseased pen mates in captivity. *Cs. melanura* does not generally feed on mammals and requires secondary mosquitoes to transmit disease to humans and horses. *Cs. melanura* lives and breeds in freshwater and swamp areas during the summer, and feeds most actively 2 hours after sunset to sunrise. In late summer and early fall they can be found in drier uplands. The epidemic vector (“bridge vector”) that spreads disease to mammals and exotic birds varies for different regions of EEE prevalence, but *Coquilletidia (Cq.) perturbans* and several *Aedes* species are often involved. Horses and humans are considered dead-end hosts of EEE virus because neither reaches a high enough level of viremia to infect mosquito vectors. How EEE survives over winter is still unknown but *Cs. melanura* overwinter as larvae.

Slide 16

EEE Vectors

- *Culiseta melanura*
  - Most important vector for enzootic cycle
- Bridge vectors
  - *Coquilletidia* spp.
  - *Aedes* spp.
  - *Ochlerotatus* spp.
  - *Culex (Cx.) nigrapalpus*

The most important vector in the enzootic cycle is *Culiseta melanura*, a mosquito that primarily feeds on birds. During some years, EEEV is transmitted to mammalian hosts by bridge vectors, mosquitoes that feed on both birds and mammals. Bridge vectors for EEEV include *Coquilletidia perturbans* and members of the genera *Aedes, Ochlerotatus* and *Culex*. EEEV can also be found in the introduced species *Aedes albopictus* (the Asian tiger mosquito), and limited evidence suggests this mosquito might be a particularly efficient vector.

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DISEASE IN HUMANS

Slide 18

EEE in Humans

- Incubation period: 4 to 10 days
  - Mild disease uncommon
  - Fever, myalgia, headache, nausea, vomiting, abdominal pain, and photophobia
  - Seizure and coma in severe cases
- Longer fever and flu-like symptoms before CNS signs results in a better outcome

The incubation period of EEE in humans is anywhere from 4 to 10 days following the bite from an infected mosquito. Milder disease is uncommon with EEE, and the time of onset of signs often indicates severity. Generally symptoms begin with a sudden fever, myalgia, headache, nausea, vomiting, abdominal pain, and photophobia. Severely affected individuals progress to seizure and coma. A long onset of fever and flu-like symptoms without CNS signs generally indicates a better prognosis.

Slide 19

EEE in Humans

- Survival rates associated with age
  - Highest in young adults: 70%
  - Lower in children: 60%
  - Lowest in elderly: 30%
- Recovery can result in permanent brain damage
- Diagnosis by serology
- Treatment is supportive care

Outcome and quality of life following survival are also age-related, with survival rates being 70% in young adults, 60% in children, and lowest in the elderly at 30%. Those who recover may suffer permanent brain damage and require permanent institutional care. Diagnosis is often based on clinical signs, but is definitively made serologically with IgM capture ELISA. Seroprevalence at any titer, along with signs of a CNS infection is considered diagnostic because antibody levels in endemic areas are naturally low. Treatment is generally supportive and includes ventilation, minimizing cerebral edema, and maintaining electrolyte balance. There is no commercially available vaccine for humans.

Slide 20

DISEASE IN ANIMALS

Slide 21

EEE in Horses

- Incubation period: 5 to 14 days
- Clinical signs in horses
  - Fever, anorexia, depression
  - CNS signs
    - Hypersensitivity, aimless wandering, head pressing, circling, ataxia, paresis, paralysis
- Death may occur within days
- Asymptomatic or mild infections
- Equine vaccine available

The incubation period for EEE is five to 14 days. The initial clinical signs include fever, anorexia and depression. In severe cases, this prodromal stage is followed by encephalitis; altered mentation, hypersensitivity to stimuli, involuntary muscle movements, impaired vision, aimless wandering, head pressing, circling, an inability to swallow, ataxia, paresis, paralysis and convulsions may be seen. Periods of excitement or intense pruritus can also occur. Laterally recumbent animals sometimes have a characteristic "paddling" motion. In addition, some animals may develop diarrhea or constipation, or have significant weight loss. Some affected horses die, particularly when infected with EEE, within a few days. Asymptomatic infections or mild disease without neurologic signs may also occur. Equine vaccines are available for EEE.

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EEE in Birds

- Asymptomatic in most bird species
- Clinical signs
  - Depression, tremors, leg paralysis, somnolence
  - Emus, ostriches
    - Hemorrhagic enteritis, emesis
  - Death 24 hours after onset
- Vaccination
  - Some birds are vaccinated for EEE

EEE virus infections are asymptomatic in most species of birds, but serious or fatal infections can occur in some species. Birds infected with EEE exhibit depression, tremors, leg paralysis, and somnolence, resulting in death after 24 hours. Emus and ostriches may only present with hemorrhagic enteritis and emesis. In some areas, some bird species may be vaccinated for EEE. [Photo: Ring-necked pheasant flying. Source: U.S. Fish and Wildlife Service.]

Slide 23

Diagnosis

- Ante mortem: serology
  - Virus neutralization
  - Hemagglutination inhibition
  - ELISA
  - Complement fixation
  - Virus isolation
- Post mortem
  - Virus identified in tissues (brain)
  - Immunohistochemistry, ELISA, RT-PCR

In horses, EEE can be diagnosed by serology. Commonly used tests include virus neutralization (the plaque reduction neutralization or PRN test), hemagglutination inhibition, ELISA and complement fixation. A definitive diagnosis usually requires a fourfold rise in titer in paired samples. The identification of specific IgM in the ELISA is also useful; a presumptive diagnosis may be obtained with a single sample, particularly when a combination of serologic tests is used. In horses, EEE may also be diagnosed by virus isolation. At necropsy, EEE virus may be found in tissues, particularly the brain, with immunohistochemistry, ELISA or RT-PCR.

Slide 24

PREVENTION AND CONTROL

Slide 25

Management of Mosquito-Borne Diseases

- Source reduction
- Surveillance
- Biological control
- Chemical control
  - Larvicide
  - Adulticide
- Educating the public
  - How to protect themselves

Prevention and control of mosquito-borne diseases involves source reduction, surveillance, biological control, chemical control (larvicides and adulticides), and educating the public on how to protect themselves.

[Photo: *Culeseta* mosquito. Source: Wikimedia Commons]

Slide 26

Source Reduction

- Mosquito habitats
  - Make unavailable or unsuitable for egg laying and larval development
- Minimize irrigation and lawn watering
- Punch holes in old tires
- Fill tree holes with cement
- Clean bird baths, outside waterers, fountains

By trying to eliminate the source of mosquitoes, humans and animals can decrease their risk of exposure. Efforts should be concentrated on making habitats for egg laying and larval development unsuitable. Less irrigation should be utilized or ditches managed so that water does not sit undisturbed for more than 2 days. Other actions include punching holes in old tires to encourage drainage, filling tree holes with cement, and cleaning bird baths and outside animal waterers at least once a week. [Photo: Domestic mosquitoes are often found breeding in old discarded tires. Source: CDC Public Health Image Library]

Slide 27

Source Reduction Cont'd

- Drain or fill temporary pools with dirt
- Keep swimming pools treated and circulating
  - Avoid stagnant water
- Open marsh water management
  - Connect to deep water habitats and flood occasionally
  - Fish access

Further source reductions include draining or filling temporary pools with dirt and keeping swimming pools treated and circulating to avoid stagnant water; eliminating puddles in gutters, around faucets, air conditioners, and septic tanks; and managing open marshes by connecting mosquito areas and shallow ditches to deep water habitats that allow drainage or fish access.

[Photo: Domestic mosquitoes are seen here breeding in jars of rainwater. Source: CDC Public Health Image Library]

Slide 28

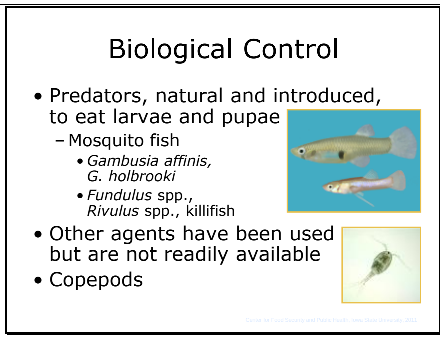
Surveillance

- Mosquito trapping and testing for viral presence
- Record keeping
  - Weather data, mosquito larval populations, adult flight patterns
- Sentinel chicken flocks
  - Blood test and ELISA to monitor seroconversion

Many states and local governments utilize surveillance programs when there are established risk factors for human disease present. This may include mosquito trapping and testing for viral presence in a given area. When established mosquito larval and adult threshold populations are exceeded, control activities can be initiated. For example, heavy winter snow fall followed by heavy spring rains can lead to flooding and more standing water for mosquitoes to lay eggs upon. Seasonal weather patterns and historical records are kept to predict mosquito larval occurrence and adult flights. Instituting surveillance programs using sentinel chicken flocks and mosquito trapping and testing are ways to monitor disease prevalence in a given area. Blood testing birds, either wild or young, unexposed chickens, and monitoring viral seroconversion or antibody titer allows authorities time to alert the general public if there is concern. These are common practices for EEE.

[Photo: Sentinel chicken flock. Source: Danelle Bickett-Weddle/CFSPH]

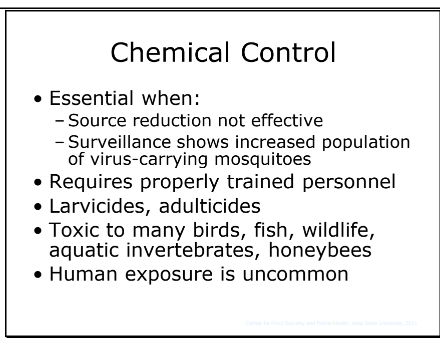
Slide 29



Biological control involves using different predators that eat mosquito larvae and pupae. The mosquito fish, *Gambusia affinis* and *G. holbrooki* are the most commonly used supplemental control because they are easily reared. They are indiscriminate feeders, though, and may eat other things, such as tadpoles, zooplankton, aquatic insects and other fish eggs. Some naturally occurring fish, such as *Fundulus* spp., *Rivulus* spp., and killifish, play an important role in controlling mosquitoes in open marsh water and rotational impoundment management. There are other agents, such as fungi, protozoa, and nematodes, that have been tried but are not readily available. A predacious copepod, *Mesocyclops longisetus,* preys on mosquito larvae and is a candidate for local rearing with *Paramecium* spp. for food. [Note: Copepods are tiny aquatic crustaceans (shrimp, crabs lobster, and relatives) that are widespread in both fresh and salt water habitats.]

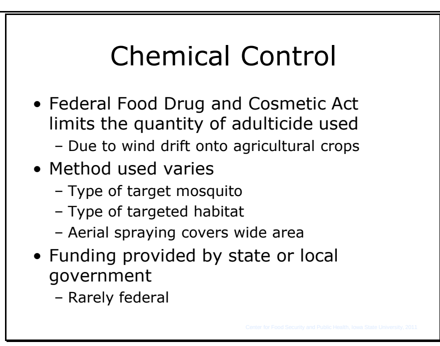
[Photo: (Top) *Gambusia holbrooki* (Eastern mosquitofish). Source: Wikimedia Commons; (Bottom) Adult copepod. Source: University of Florida Extension at http://edis.ifas.ufl.edu/in490]

Slide 30



Chemical control is often warranted when source reduction is not enough and surveillance shows an increased population of virus-carrying mosquitoes. All insecticide use requires proper training by the personnel applying it, and can be targeted at the immature (larvicides) or adult (adulticides) mosquitoes. While it is limited, there is a risk of toxic effects on nontarget organisms, such as birds, fish, wildlife, aquatic vertebrates, and honeybees, so low levels of pesticide and proper training of applicators are used. Humans are often concerned with the use of chemicals, but low application rates, ultra low volume (ULV) methods, spraying at night while people are indoors, and notifying the public prior to application all decrease exposure risks.

Slide 31



To further prevent human exposure, the Federal Food Drug and Cosmetic Act (FFDCA) limits the quantity of poisonous or deleterious substances added to food, specifically adulticides carried by wind drift over agricultural crops. The method selected depends on the type of mosquitoes that need to be controlled and the targeted habitat. Aerial spraying can cover a wide geographic area to control nuisance mosquitoes in emergency situations. Costs for such application are often covered by state or local emergency funds, and rarely by federal funds unless a natural disaster has occurred.

Slide 32

Larvicides

- Use when source reduction and biological control not feasible
- More effective and target-specific
- Less controversial than adulticides
- Applied to smaller geographic areas
  - Larvae concentrate in specific locations

Larvicides are used when immature mosquito populations become larger than source reduction can manage or biological control can handle. They are often more effective and target-specific than adulticides, making them less controversial. They can be applied to smaller geographic areas than adulticides because larvae are often concentrated in specific locations, such as standing water.

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Larvicides

Name	Product (Larvae, Pupae, Adult)
Temephos	Abate (L)
Methoprene	Altosid (L)
Oils	BVA, Golden Bear (L, P)
Monomolecular film	Agnique (L, P)
Bacillus thuringiensis israelensis (BTI)	Aquabac, Bactimos, LarvX, Teknar, Dunks (L)
Bacillus sphaericus	VectoLex (L)
Pyrethrins	Pyrenone, Pyronyl (A, L)

This chart depicts the various types of larvicides used in the United States, with their chemical or biological name, as well as the commercial product name. There may be others on the market that this chart does not cover.

Slide 34

Adulticides

- Necessary when other control measures unsuccessful
- Least efficient
- Proper type and time of application helps efficacy
  - Ultra low volume (ULV) foggers
    - 1 ounce per acre
  - Small droplets contact and kill adults

Despite the efforts listed in previous slides, there are times when the environment prevails or humans are unable to prevent large swarms of mosquitoes. Adulticide use then becomes necessary. It is often the least efficient control program, but ultra low volume spray either on the ground or aerially can reduce the population when the proper type and time of application is followed. Effective adult mosquito control with adulticides requires small droplets that drift through mosquito areas and come in contact with adults to kill them. Large droplets that settle on the ground or vegetation do not contact mosquitoes and may cause undesirable effects on nontargeted organisms. Insecticides are applied in a concentrated form at very low volumes, such as 1 oz (29.6 mL) per acre. Excessive wind and updrafts reduce control, but light wind is necessary for drifting spray droplets.

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Adulticides

Chemical Name	Product
Malathion	Fyfanon, Atrapa, Prentox
Naled	Dibrom, Trumpet
Fenthion	Batex
Permethrin	Permanone, AquaResilin, Biomist, Mosquito Beater
Resmethrin	Scourge
Sumithrin	Anvil

This chart displays the various types of chemicals used as adulticides, namely the organophosphates, malathion, and naled. Natural pyrethrins, fenthion, and synthetic pyrethroids, such as permethrin, resmethrin, and sumithrin, and their product names are also listed.

Slide 36

Personal Protection

- Stay inside during the evening when mosquitoes are most active
- Wear long pants and sleeves
- Use mosquito repellent when necessary
  - Follow label directions
  - DEET
    - Do not use on pets

Humans can protect themselves in two ways: reduce contact with mosquitoes and reduce the population of infected mosquitoes in the environment. Personal protection involves reducing time outdoors in the early evening hours when mosquitoes are most active, wearing long pants and long sleeved shirts, and applying mosquito repellent containing DEET to exposed skin areas. DEET can be sprayed on clothing, but this is unnecessary because the underlying skin is protected from insect bites by the clothing. **DEET should not be used on pets.** [Photo: Applying mosquito repellant. Source: Radford Davis/CFSPH]

Slide 37

Personal Protection

- Make sure window and door screens are "bug tight"
- Replace your outdoor lights with yellow "bug" lights
  - Bug zappers are not very effective
- ULV foggers for backyard use
- Keep vegetation and standing water in check around the dwelling

It is important to protect yourself by making sure mosquitoes cannot enter your home. Check window screens for holes and make sure they are bug tight so as not to allow entry. Replacing your outdoor lights with yellow bulbs decreases the attractiveness of many bugs to entry ways. Bug zappers are not specific to mosquitoes and are not much help with control. Ultra low volume foggers can be purchased for backyard use to decrease the mosquito population in the event that people will be outdoors during mosquito feeding hours. Keep vegetation and standing water in check around the dwelling to avoid larval habitats.

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Internet Resources

- Centers for Disease Control and Prevention
  - http://www.cdc.gov/EasternEquineEncephalitis/index.html
- U.S. Department of Agriculture
  - http://www.aphis.usda.gov/vs/nahss/equine/ee/

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Acknowledgments

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