Category K: Public Health Pest Control

Public Health Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

After studying this section, you should be able to:

- ✓ **Describe the concepts and significance of host, reservoir and vector in public health pest control.**
- ✓ **Explain management methods used to control and prevent diseases.**
- ✓ **List the common public health pests.**
- ✓ **Describe how disease is transmitted from arthropods to humans.**

Category K, Public Health Pest Control

Public health pest control involves the management of insects and other animals that transmit diseases to humans. It also includes arthropod pests such as bed bugs and cockroaches. It is important to understand a few terms and concepts.

Arthropods: This is the group of invertebrate animals that includes insects and arachnids, such as spiders, ticks and lice.

Arboviruses: These are the viruses transmitted by arthropods, including ticks or mosquitoes. The word is derived from "arthropod-borne viruses." Examples of arboviruses are the West Nile virus (mosquito vector) and Colorado tick fever (tick vector).

Epizootic: An epidemic that caused a die-off in a wild animal population. Epizootics from plague periodically occur in rodent populations, such as the California ground squirrel.

Category K, Public Health Pest Control, involves the management of insects and other animals that transmit diseases to humans.

Arthropods are the group of invertebrates that include insects and arachnids.

Arthropods can be vectors of disease between one animal and another, including humans.

Arboviruses are those viruses transmitted by arthropods.

Vectors are living creatures that transmit disease or pathogens from one animal to another animal.

Just like all other pests, it is important to understand the life cycle of these public health pests in order to control them.

Host: A living animal that provides sustenance to a parasite. For example, California ground squirrels are hosts for rodent fleas.

Pathogen: A microscopic organism that causes disease in living things. Examples of pathogens in humans include bacteria, viruses, fungi, protozoa and rickettsiae.

Reservoirs: A host animal that can harbor a disease-causing organism over an extended period of time without showing symptoms of the disease. The disease is spread when an insect feeds on the reservoir animal and then feeds on another animal later. Insects that spread diseases but are not affected by the disease are termed vectors. For example, birds are a reservoir for West Nile virus. West Nile virus is spread from the reservoir birds to horses and humans by mosquito vectors. Horses and humans become hosts, falling ill from the virus.

Vector: Generally, an insect, such as a flea, mosquito or fly, or an arachnid, such as a tick, that transmits the disease or pathogen from one animal to another. Vectors may infect hosts directly or indirectly.

Indirect transmission is also referred to as mechanical transmission: the insect transports disease organisms on its body surfaces from one host, area or reservoir to another host. An example is dysentery bacteria transmitted on the feet, body hairs or other body surfaces of a fly to a human. In mechanical transmission, the insect vector is a passive or accidental transmitter of disease. The disease does not require the vector for development, just for transportation.

Another method of transmission is biological. Disease organisms need assistance moving from one host to another. Biological transmission occurs when the vectors acquire the disease organisms, the disease organism develops in the insect or arachnid vector's body, and then is transmitted to a host. Within the vector, the disease may remain as it was, may further develop or may reproduce.

Some diseases require time within a specific vector to develop. These insects or arachnids are termed "obligatory vectors." Malaria is an example of a disease that requires an obligatory vector. The malaria organism develops within the mosquito before being transferred to humans via the mosquito bite or sting. Without the mosquito vector, the malaria organism would die.

Just like all other pests, it is important to understand the life cycle of these public health pests. In the malaria example above, understanding the life cycle of the malaria organism has helped control spread of the disease. We recognize that we must control the mosquito vector to reduce or eradicate malaria.

Zoonotic diseases: These are infections caused by pathogens that are transmitted from animals to humans. The transmission can be direct, such as rabies, which is transmitted from one mammal to another. It may also be indirect, spread by an insect or arachnid vector from one vertebrate animal to another. Examples of indirect zoonotic transmissions include malaria from mosquitoes or rodent fleas that transmit plague.

Specific Diseases Transmitted by Vertebrates

Hantavirus is a zoonotic disease that was first identified in the Southwest in 1993. The strain of virus that causes disease in the West and Southwest is known as "**Sin Nombre**." The primary reservoir for Sin Nombre virus is the deer mouse. The deer mouse remains unaffected by the virus, which is passed in its saliva, droppings and urine. People primarily become infected by inhaling the virus when entering or stirring up dust in a closed structure that contains infected mouse droppings and urine. Rarely, infection occurs through a mouse bite. Mortality rates for Sin Nombre virus remain high at about 40%. Since the discovery of Sin Nombre virus, other disease-causing strains of hantavirus have been found in New World rats and mice. For this reason, all rodent droppings should be considered potentially infectious.

Hantaviruses are maintained in nature by a reservoir species, usually a rodent, that carries the virus but does not contract the disease. Once infected, the reservoir species probably carries the virus for the rest of its life and sheds it in feces, urine and saliva. This appears to be the case for deer mice (*Peromyscus maniculatus*), the reservoir species for the Sin Nombre hantavirus. There have been thousands of deer mice trapped and tested for hantavirus in the United States. since the 1993 outbreak. As the age of the deer mice increases, as indicated by body weight, the percent found positive for hantavirus also increases. Non-reservoir species may carry the virus to a lesser extent and for shorter periods.

There are four rodents that carry different strains of hantavirus in the United States that can affect humans:

- The deer mouse (*Peromyscus maniculatus*) is the reservoir species for the Sin Nombre strain of hantavirus. The deer mouse is a small rodent, 2 to 3 inches in body length and another 2 to 3 inches of tail, with large eyes and ears. While the body color can vary from gray to reddish-brown, the underbelly and feet are always white. The tail is fur-covered and white on the underside. The deer mouse is found throughout North America.
  Deer mice and house mice (*Mus musculus*) are similar looking but have characteristics that enable them to be differentiated. Deer mice have

Hantavirus is a zoonotic disease that can cause illness and death in humans. The reservoir of hantavirus is the deer mouse.

Deer mice have white bellies and feet. Their tails are furred, and the underside of the tail is white also.

House mice have scaly, non-furred tails and do not have white bellies or feet.

Deer mice also have larger eyes and ears than house mice.

Deer mice have white hair on their belly, legs and feet. The tail has short hair that is bicolored: dark on the top and white on the sides and bottom

Deer mice have larger ears and eyes than house mice.

The oral history of the Navajo Indians suggests that deer mice and people should not be together because deer mice cause sickness.

white hair on their belly, legs and feet. The tail has short hair that is bicolored: dark on the top and white on the sides and bottom. The house mouse has a tail that is scaly, with few hairs. The belly of a house mouse is lighter than its back and sides, but a house mouse does not have a white belly, feet and legs. Deer mice have no odor, whereas house mice have a musty odor. Deer mice have larger ears and eyes than house mice.

- The cotton rat (*Sigmodon hispidus*) is the reservoir species for the Black Creek Canal strain of hantavirus. The head and body of the cotton rat measure 5 to 7 inches long, with another 3 to 4 inches of tail. The fur is long and coarse and can be grayish brown to grayish-black. The cotton rat is native to the southeastern United States, Central America and South America. It generally inhabits overgrown areas with shrubs and tall grasses.
- The rice rat (*Oryzomys palustris*) is the reservoir species for the Bayou strain of the hantavirus. The head and body measure 5 to 6 inches long, with a very long 4 to 7 inch tail. The fur is short and soft and grayish-brown in color. The underbelly is gray or tawny brown. The feet are whitish colored. The rice rat is native to the southeastern United States and Central America. It generally inhabits marshy areas and is semi-aquatic.
- The white-footed mouse is the reservoir of the New York strain of the hantavirus. The head and body measure 4 inches long. The tail is shorter than the body length, generally 2 to 4 inches long. The body fur is pale to reddish brown. The underbelly and feet are white, as the name implies. The tail is furred. It resembles the deer mouse, but generally the tail is shorter than the body length. The white-footed mouse is native to southern New England, the mid-Atlantic, midwestern and western United States, and Mexico. It generally inhabits wooded and brushy areas, but will inhabit more open ground.

Another strain, the Prospect Hill strain, of the hantavirus was identified in meadow voles in the northeastern United States but has not been shown to cause disease in humans.

The oral history of the Navajo Indians suggests that deer mice and people should not be together because deer mice cause sickness. They further say that in 1918, 1933 and 1934, rain provided for large pine nut crops that resulted in high populations of deer mice, causing deaths in young healthy Navajo Indians.

Since the 1993 outbreak, the State and County Health agencies in Nevada have conducted state surveys to gather information about hantavirus in

Nevada. In 2010, 80 blood samples from rodents were sent in for testing by the Southern Nevada Health District; all 80 samples tested negative for Hantavirus. Testing done by the Southern Nevada Health District from 2001 to 2010 found 19 positive tests out of 824 test submissions, with the last positive test occurring in 2008. The Washoe County Health District also routinely tests rodents for hantavirus. The average rate of infection is 15%, although the rate of infection fluctuates. Test results in Washoe County have been as low as 5% and as high as 50% of the rodents trapped testing positive for hantavirus. Hantavirus can be found to some extent in deer mice populations throughout most of Nevada, regardless of elevation.

The symptoms of Hantavirus Pulmonary Syndrome are not specific to HPS. However, there are some characteristic patterns to look for and be aware of:

- Fever, fatigue and muscle ache of large muscle groups (thighs, hips, back and sometimes shoulders) occur in all cases.
- Headaches, dizziness and chills occur in about half the cases.
- Abdominal pain, nausea, vomiting and/or diarrhea occur in about half of the cases.
- Late symptoms include coughing and shortness of breath.
- Earaches, rashes and sore throat are VERY UNCOMMON in HPS.

Symptoms do not appear for one to three weeks. Occasionally symptoms may take up to six weeks to appear. Shortness of breath is a symptom that appears later as the lungs fill with fluid, leading to frequent misdiagnoses of pneumonia. Abdominal pain and bilateral filling of the lungs in HPS help to differentiate HPS from pneumonia.

Fortunately, HPS is very difficult to contract. Since the disease was discovered in 1993, the Centers for Disease Control have tracked hantavirus cases. From 1993 to January 2017, a total of 697 cases of hantavirus have been reported in the United States. This includes people with laboratory-confirmed hantavirus infection who have either hantavirus pulmonary syndrome (HPS) or non-pulmonary hantavirus infection. More than 96% of reported cases occurred in states west of the Mississippi River; 36% of the cases have resulted in death.

The greatest risk of transmission is from rodent infestations in or around the home. Any activity that results in contact with rodent droppings, urine, saliva, or nesting materials can put you at risk. The virus is spread when dust particles containing rodent urine, droppings or saliva are stirred into the air and then inhaled. It is very important to avoid stirring up dust when dealing with rodent infestations to avoid risk of hantavirus infection.

Person-to-person transmission has not been observed, and health care

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Rodent-proofing and sanitation are the best ways to eliminate deer mice and minimize the chances of contracting hantavirus.

workers who have cared for HPS patients have not become infected. Pine nuts have been mentioned as a possible source of Sin Nombre virus. This is incorrect. While increases in pine nut harvests contribute to increases in deer mouse populations, pine nuts do not carry the HPS virus!

None of the hantaviruses identified in the United States are transmitted by any animals other than the rodents previously mentioned. Guinea pigs, hamsters, gerbils and domestic rats and mice are not known to carry hantavirus. Dogs and cats are not known to carry hantavirus, but they may bring infected rodents into contact with humans if they catch and bring rodents back to their human owners. As with all rodents, use caution when handling injured or dead rodents.

Rodent Control Strategies

Rodent-proofing and sanitation are the best ways to eliminate deer mice and minimize the chances of contracting hantavirus. To keep deer mice out of a building, seal all openings over ¼-inch in size. Openings can be sealed with steel wool, cement, lath metal, hardware cloth, sheet metal or caulk. Do not seal with materials that can be easily chewed through by rodents. Entrance routes include:

- Holes around doors, windows, closet floors, cupboard floors, fireplaces, etc.
- Gaps around holes cut into walls or floors for gas pipes, vents, electrical lines, plumbing, etc.
- Gaps in rafters, gables, eaves, foundations or basement walls.
- Gaps in attic or crawl space access routes.
- Gaps in seals placed around door, garage doors and windows.
- Disintegrating caulking or rubber seals.

Remove trash, brush and debris from around the outside of structures. Use rodent-proof containers for storing food and trash, both inside and outside the home. Keep pet food in sealed containers when not being used. Do not consume food or use animal feed that you suspect may be contaminated with rodent droppings, urine or saliva.

Eliminating an Infestation Safely: Before cleanup can begin, all rodents should be trapped. Deer mice can be trapped using snap traps (mouse traps). Baits for trapping include peanut butter plus oatmeal, bacon, gumdrops or other candy, sardines, nutmeats, dried fruit or anything oily. Trapped deer mice can be buried or placed in a bag or container and then into the trash. Continue trapping for a minimum of one week. To prevent re-infestation, seal all potential entry points. To reduce the risk of contracting HPS, wear rubber gloves when handling deer mice.

If possible, allow the infested area to remain undisturbed for four to five

days after the rodents have been removed. Research indicates that the virus does not remain viable after about three to four days. Before beginning to clean an infested area, open the windows and doors and allow the room to air out for 30 minutes. Try to establish cross-ventilation, and exit the area while it is airing out. If dusty areas must be entered, wear a respirator or dust mask with a HEPA filter to remove viruses.

Next, spray any urine, droppings and nesting materials with disinfectant or a solution of one part bleach to nine parts water. Soak urine, droppings and nesting materials with the disinfectant or bleach solution and allow them to remain undisturbed for five to ten minutes before wiping up the droppings or nesting materials with paper towels. Try to limit disturbance that raises dust, as this will increase the levels of airborne virus. Avoiding sweeping or vacuuming the materials, especially fresh materials.

Clothing, bedding and other fabric-based materials can be laundered in hot water and detergent and then dried in a machine dryer set on high heat. Detergent breaks down the virus's lipid envelope, rendering it harmless. The virus is also inactivated at a temperature of about 115 F. Unfortunately, not all dryers reach this temperature, even on a high or hot setting. Use both detergent and the dryer heat to inactivate the virus. Fabric materials that can't be washed and dried in conventional machines, such as carpeting, rugs or upholstered furniture, can be disinfected with a commercial-grade steam cleaner or shampoo machine and detergent or disinfectant.

Plastic, glass or metal utensils or items can be disinfected by washing in hot water and soap or detergent. Papers, books and other items that can't be cleaned with liquids can be sanitized by direct sunlight. Research indicates that ultraviolet light can inactivate the virus, so placing contaminated items in direct sunlight for several hours can help render the virus inactive. Use caution when handling contaminated items. Wear rubber, latex or vinyl gloves and respiratory protection when handling these items. Change clothes and wash before eating, drinking, smoking or touching your face. Wash the clothing you wore in hot water and detergent.

Rabies is a zoonotic disease of public health concern in Nevada, primarily associated with bats and wild carnivores, such as skunks, foxes, coyotes and feral dogs. The most recent domestic animal rabies case in Nevada is thought to have been a cow in Elko County that died of a bat strain of rabies in 1990. Daytime activity, weakness and inability to fly can be signs of rabies in bats. Rabies is almost always fatal in humans but can easily be prevented if an exposure is followed with post-exposure prophylactic shots (PEP). The rabies virus is slow growing, with symptoms typically developing one to three months after exposure. However, the time to develop symptoms can vary

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Spray any urine, droppings and nesting materials with disinfectant or a solution of one part bleach to nine parts water and leave undisturbed for five to ten minutes before wiping up.

Try to limit disturbance that raises dust, as this will increase the levels of airborne virus.

Avoiding sweeping or vacuuming the materials, especially fresh materials.

Rabies is a zoonotic disease that passes from mammal to mammal, including humans. It is most commonly found in bats in Nevada, but has also been identified in skunks, raccoons and foxes.

from less than one week to over one year. Since bats have very small teeth, a bite can be invisible. A victim is often unaware of being bitten and fails to seek PEP. By the time a victim displays symptoms of rabies, PEP is no longer effective.

Exclusion from buildings is the best method of **bat control**. Excluding bats must be done in accordance with federal law, as some species of bat are protected. Young bats must be able to fly before an exclusion strategy will work. If you seal entry/exit points while young are present, they will die inside the building, resulting in additional problems. Make sure the bats have departed for the evening and then seal up all openings greater than 1/4 inch. This includes vents, chimneys and other openings in the roof, eves or soffits, gaps around windows or doors, gaps around conduit or pipes, and holes or gaps in window screens. For migratory species, the best time to implement exclusion measures is the fall or winter. No pesticides are registered for bat control.

Most bat bites occur when people handle or provoke them. Anyone doing work, such as bat removal and exclusion, should consider pre-exposure rabies vaccinations as a measure of personal protection. As with all animals, use caution and common sense when handling dead bats.

Vaccination of domestic animals and control of stray and feral animals by animal control agencies since 1950 have resulted in reduced rabies in domestic animals in the United States. However, wild animal rabies remains a threat and is spreading in some areas.

Specific Diseases Transmitted by Arthropods

Plaque is a bacterial infection vectored to humans by rodent fleas.

Plague is caused by a bacterial infection vectored to humans by rodent fleas. The bacterium involved is called *Yersinia pestis* and is easily treated with antibiotics if diagnosed early. There are three main forms of plague infection in humans:

- **Bubonic plague** is infection of the lymphatic system. It results from a flea bite. It is the most common form, characterized by rapid onset of fever and painful swollen lymph glands. Mortality often exceeds 50% in untreated cases of bubonic plague.
- **Septicemic plague** is infection of the bloodstream. It is usually fatal if not treated.
- **Pneumonic plague** is infection of the lungs. It results in a pneumonia that is associated with the highest mortality and is very contagious. It requires that the victim be isolated because of easy person-to-person transmission

by droplet inhalation. Domestic cats are susceptible to pneumonic plague and can transmit it to humans.

Plague is characterized by continuing cycles of infection in native rodent species, with rodent fleas serving as vectors. Reservoir rodent species in Nevada may include deer mice, meadow voles and some species of wood rats. The reservoir species are thought to be the source of plague-infected fleas that transfer the infection to more susceptible host species, such as ground squirrels, chipmunks, marmots and wild rabbits. Plague epizootics among susceptible species leave infected vector fleas seeking new hosts, providing potential risk to humans and domestic animals.

Plague prevention involves a comprehensive approach using habitat modification, sanitation, rodent proofing, trapping, toxic baits and public education. Precede rodent removal by flea control using an insecticide dust in the burrows to reduce populations of potentially infected host-seeking fleas. Follow label directions, including wearing the proper Personal Protective Equipment (PPE). For further information on controlling ground squirrels and other rodents, consult the General Knowledge: General Pest Problems chapter of this manual.

Tick-borne Diseases can be transmitted to humans by two types of ticks in Nevada and surrounding states. Hard ticks (ixodids) can vector several types of pathogens including viruses (Colorado tick fever), rickettsiae (Rocky Mountain spotted fever), and bacteria (Lyme disease). Soft ticks (argasids) are known to vector the bacteria that cause relapsing fever in humans. Both types of ticks become infected when taking blood meals from diseased hosts.

Hard ticks quest for new hosts from vegetation. They quickly transfer to animal or human hosts that brush against the vegetation. These ticks are slow-feeding and can take days to complete taking a blood meal from a host. In Lyme disease, both the adult and the nymph form, which is about the size of a pinhead, are capable of transmitting disease.

Hard tick control: In endemic areas, removal of leaf litter and clearing tall grass and brush around houses and at the edge of gardens may reduce the numbers of ticks. Applying acaracides at the edge of woodlands near homes can be very effective in controlling ticks. Personal protection, including wearing long-sleeved shirts and long pants, and prompt tick removal reduces the infection rate.

Soft ticks capable of vectoring relapsing fever are found in the nests of rodents, such as squirrels and chipmunks. If the nests are in the home and the rodents become scarce, the ticks will take a meal from other nearby

Precede rodent removal by flea control using an insecticide dust in the burrows to reduce populations of potentially infected host-seeking fleas.

Diseases vectored by ticks include:

- **Colorado tick fever**
- **Rocky Mountain spotted fever**
- **Lyme disease**
- **Relapsing fever**

Removal of leaf litter and clearing tall grass and brush around houses and at the edge of gardens may reduce the numbers of ticks.

warm-blooded animals, including humans. Soft ticks feed for only about 20 minutes while the unsuspecting host is sleeping.

Soft tick control: The key to prevention is to rodent-proof buildings in areas where tick-borne relapsing fever is known to occur. Once an infestation has occurred, rodent nesting material should be removed. A crack-and-crevice pesticide treatment should also be performed in the nesting area to kill any remaining ticks.

Mosquitos: Mosquitoes are flies, members of the order Diptera. They are pests to humans and other animals. They act as vectors of several diseases worldwide, including malaria, filariasis, yellow fever, dengue fever, West Nile virus, St. Louis encephalitis, Western equine encephalitis, Eastern equine encephalitis and dog heartworm. In addition to being the vector of many diseases, they are annoying and can reduce property values.

Mosquito-borne viruses known to cause disease in humans and domestic animals in Nevada include **St. Louis encephalitis virus (SLE), Western equine encephalomyelitis virus (WEE),** and **West Nile virus (WNV)**. These viruses cycle in nature between mosquitoes and birds. Humans and domestic animals such as horses are incidental hosts that are accidentally infected but have no role in the spread of the disease. Although it is rare, humans can suffer severe permanent neurologic disability or even death from these arboviruses. Even milder forms of these arboviral illnesses can be quite debilitating and can result in extended loss of work time.

Mosquitoes undergo complete metamorphosis: egg to larva to pupa to adult.

Mosquitoes undergo complete metamorphosis. The female lays eggs on or near water. Eggs of mosquitoes may be laid singly on water or in mud, in rafts on the water surface, or attached to aquatic plants. The incubation period varies among species and is detailed later in the individual species discussion. In general, the incubation period lasts 16 to 24 hours. The eggs hatch and the mosquito larvae are aquatic, living in water and breathing by surfacing or via a breathing tube or siphon. The larvae, also called wrigglers, do not depend on the oxygen in the water. Large numbers of larvae can survive in a small amount of water, even stagnant water. The larvae feed on algae and other organic material in the water. Controlling mosquitoes is most effective in the early life stages.

Mosquito larvae are called "wrigglers."

Mosquito pupae are called "tumblers."

Mosquito larvae go through four instars or molts. After the fourth molt, the larvae pupate. The adult mosquito develops within the pupa case. The pupal stage varies among species and varies with water temperature, but it is usually between two and four days. The pupae, also called tumblers, are comma-shaped and breathe through a pair of siphon tubes located on the sides of the thorax. The pupae do not feed but do remain active and will avoid predators by tumbling through the water, similar to larvae.

Controlling mosquitoes is most effective in the early life stages.

Because they are active feeders and their development is sensitive to water chemistry, larvae are easy to control using biological or chemical methods. Because pupae do not feed, control at this stage is limited to disrupting the surface tension of the water where pupae raise to the surface to breath. This is generally less effective than controlling larval populations.

The adult mosquito emerges and rests on the water surface until its exoskeleton hardens and its wings dry. At this point it can fly and will disperse. Male and female mosquitoes may feed on the nectar of flowers after emerging from the water surface, depending on the species. Females typically require a blood meal as a protein source before they can develop eggs.

The length of the metamorphosis cycle and the overwintering life stage varies from species to species. Aedes species generally overwinter as eggs on the soil surface. Anopheles, Culex and Culiseta species typically overwinter as adults. During the active season, generation times can vary from five days to several weeks, depending on both the species and average daily temperatures.

Species of Mosquito in Nevada: There are 37 species of mosquito in Nevada. The most important species are:

- *Aedes dorsalis*: a major pest mosquito often produced through flood irrigation; feeds anytime but mainly during the day and early evening; females live up to three months; over-winters as eggs.
- *Aedes melanimon*: another major pest mosquito; six- to seven-day larval period during warm days; also associated with irrigated pastures and fields.
- *Aedes nigromaculis*: daytime biter; will not enter houses; can vector encephalitis; very tolerant to alkaline water; five-day larval period.
- *Aedes sierrensis*: western treehole mosquito; carries dog heartworm; occurs up to 6000 feet along the Sierras (both sides); one brood/year. In areas where this is a problem, the release of sterile males can aid in control.
- *Aedes vexans*: day and evening biter; does not enter houses; found in swamps, stream overflows and borrow pits. Occasionally breeds in open pastures.
- *Anopheles freeborni*: main vector of malaria; night biter; enters houses; found in permanent open water.
- *Culex pipiens quinquefasciatus* (the southern house mosquito): southern Nevada species; birds are the principal hosts, but they do attack humans and readily invades homes; breeds in artificial pools and ponds, catch basins, waste treatment ponds and roadside ditches.

There are 37 species of mosquito found in Nevada.

The primary goal of mosquito control is the elimination or treatment of the water source or breeding area.

Chemical controls that target adult mosquitoes are called adulticides.

Chemical controls that target mosquito larvae are called larvicides.

- *Culex pipiens pipiens* is ecologically very similar to the southern house mosquito but occurs in northern regions.
- *Culex tarsalis*: evening and night biter; enters houses; principal vector of encephalitis; prefers birds; migrates readily; found in pastures and flood waters, rain pools, ornamental pools/ponds, roadside ditches and dairy drains.
- *Culiseta inomata*: primarily feeds on cattle; they are large; survive well in cool weather; found in duck clubs, pastures and ditches.

Mosquito Control: The primary goal of mosquito control is the elimination or treatment of the water source where larvae develop. First, determine the primary species. Next, sources must be determined, mapped and monitored regularly. This should first be attempted using cultural controls (source reduction) or biological controls. Cultural controls may include draining, filling, flushing and lining swamps, ponds and ditches. In general, source reduction should eliminate the water source or alter the habitat by improving water flow and making the habitat less conducive to mosquito development.

Biological controls include *Gambusia affinis* (mosquito fish) and some biological insecticides, such as *Bacillus thuringiensis* var. *israelensis* (Bti) or *Bacillus sphaericus*.

Mosquito fish have been used very successfully in a wide variety of sources, from large ponds to small urban water features. When relocating mosquito fish, you must use locally adapted stock and notify the Nevada Department of Wildlife before moving the fish.

Bacillus thuringiensis var. *israelensis* (Bti) and *Bacillus sphaericus* are bacterial biological control products. They can provide excellent control if applied from the first to early fourth instar. This timing is very critical.

Once these methods have been exhausted, chemical controls can be used to control both adults and larvae. It is best if control measures for both are undertaken, but the primary goal should always be control of the larvae.

Chemical controls that target adult mosquitoes are called adulticides. Adulticides are usually applied as fogs, sprays, and as sprays from ULV (UltraLow Volume) sprayers.

Chemical controls that target mosquito larvae are called larvicides. Larvicides can be applied as liquids, granules or pellets. The granular and pellet formulations are best for areas with thick vegetation cover. The granules readily settle through vegetation, whereas liquids will not.

Pesticide formulations change often. Consult your local dealer for the latest pesticide formulations that will control the species of mosquito on the specific site. Given the history of pesticide resistance developing in mosquitoes, alternating chemicals throughout the season is always advisable.

To reduce the mosquito population around homes and other structures:

- Repair window screens if needed, and make sure window and door screens remain closed.
- Change water every few days in bird baths, pet water bowls and water troughs for large animals.
- Mosquito fish or goldfish can be put in large water troughs to eliminate mosquitoes.
- Clean clogged roof gutters on an annual basis. Roof gutters are easily overlooked and can be ideal mosquito breeding sources.
- Aerate ornamental pools or stock them with fish. Water gardens are major mosquito producers if allowed to stagnate.
- Dispose of tin cans, ceramic pots or similar water-holding containers on your property.

West Nile virus (WNV) infection is a mosquito-borne virus and is closely related to St. Louis encephalitis (SLE) virus. In 1999, the first confirmed cases in the United States were all recorded in New York City. Since then, confirmed cases of WNV in animals and humans have spread across the continental United States.

Mosquitoes that feed on infected birds pass WNV to other birds, animals and people. West Nile virus (WNV) is not spread by person-to-person contact. Healthy people of any age can become ill with the disease. It can be fatal or permanently disabling, although most people who are bitten by a mosquito with WNV never develop symptoms.

Common symptoms of mild infections include fever, headache, body ache, skin rash and swollen lymph glands. Those with a more severe infection may experience high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, paralysis and death. In humans, the virus has an incubation period of three to 10 days.

There is no human vaccine or treatment for the WNV infection. Most people fully recover from the viral infection, but those with severe symptoms may have to be hospitalized to receive supportive care.

There is no vaccine for dogs or cats. However, horse owners should ensure their horses are vaccinated against WNV, Eastern Equine Encephalitis (EEE),

West Nile virus (WNV) infection is a mosquito-borne virus and is closely related to St. Louis encephalitis (SLE) virus.

WNV is passed by mosquitos from infected birds to other birds, animals and humans.

There is no human vaccine for WNV, nor is there a vaccine for dogs or cats. There is a vaccine for horses.

Unexplained bird deaths may indicate the presence of West Nile virus.

If dead birds of a susceptible species such as crows or jays are found, contact the county health department.

and Western Equine Encephalitis (WEE). Consult a veterinarian for more information.

Unexplained bird deaths may indicate the presence of West Nile virus. If dead birds of a susceptible species such as crows or jays are found, contact the county health department. The bird must have died within 24 hours. If maggots are present or the body is stiff, the carcass is unacceptable. Decomposed or scavenged carcasses cannot be tested. DO NOT touch the carcass with bare hands. Wear rubber or latex gloves when picking it up and handling it. If gloves are not available, use a plastic bag turned inside out to pick up the bird. Place each bird carcass into a plastic bag and secure it inside a second zip-top plastic bag and zip lock it shut. Double bagging prevents cross-contamination and leakage.

If a carcass is not testable, collect the bird and dispose of it by placing it inside a double bag and putting it in a secure garbage can or dumpster.

While there is no recommendation to limit outdoor activity, there are certain precautions to take in areas where WNV is found.

- Limit outdoor activity when mosquitoes are most active in the evening.
- When outdoors, wear mosquito repellant.
- Repellants containing 20% to 30% DEET for adults and no more than 10% for children are effective. Do not use repellant containing DEET on children under 3 years of age. Non-DEET based products have also become widely available and effective.
- Spray repellant on the hands and then apply to the face. Only adults should apply repellant on a child.
- Apply repellant to exposed skin and clothing only. Do not use repellant under clothing or apply on cuts, wounds, or sunburned or irritated skin.
- Wash treated clothes before wearing them again.
- Wear long-sleeved shirts and pants when outdoors for long periods of time.
- Avoid perfumes and colognes when outdoors for extended periods of time.
- Repair window screens if needed, and make sure window and door screens remain closed.

Endangered Species If you are conducting pest control activities in eastern Clark County, be aware that there are several endangered species in this county. There may be restrictions on the chemicals that can be used and where they can be sprayed. This information can be obtained from the pesticide label.

Additional Pest Arthropods

Bed bugs, members of the Hemiptera (true bugs) order, are not associated with disease transmission in the United States. These insects are considered a public health concern because they can be a terrible nuisance and are difficult to eradicate.

Bed bugs are small insects that range from a poppy seed to an apple seed in size. They are commonly brown in color and have a flat, oval shape when unfed. When not feeding, they can hide in several places, including the piping, seams and other areas of the mattress and box spring, in cracks of the bed frame and headboard, in clutter near the bed, under baseboards, in curtains and under loose wallpaper.

Bed bugs spread readily, moving from infested furniture, bedding, baggage, boxes and clothing to new sites. While they typically feed on blood every five to 10 days, they can go for 20 to 400 days without feeding, depending on the temperature and humidity. The ease with which they spread and their ability to live without food for long periods of time makes them difficult to eradicate once an infestation has occurred. **Control of bedbugs** requires that all bedding and clothing be removed and washed in hot water. Clutter that may provide additional hiding places for bed bugs should be removed. Thorough cleaning of infested areas is required to control an infestation. Commercial heating services are available for bed bug infestations. The current recommendation for effective commercial heating services calls for a temperature of at least 140 F for two hours or 130 F for three hours (the minimum lethal temperature is 113 F), which will kill most bed bugs and eggs. Chilling to a temperature of 32 F or lower and maintaining this temperature for several days will also kill bed bugs. Insecticide sprays and/or dusts are used for control, but READ THE LABEL. Make sure the pesticide product you choose is labeled for indoor use and labeled for use on bed bugs. Applications should be made to cracks, crevices and other places where bed bugs hide. Do not overlook mattress seams and tufts, cracks along baseboards and moldings, loose carpet edges, loose wallpaper, and hollows in bed frames or other furniture. For the most up-to-date information on bed bugs, go to the Western IPM Center bed bug working group website at https://westernbedbugipm.ucanr.edu/.

Cockroaches are nuisance insects that may cause rare, isolated cases of food-borne illness and asthma. **Cockroach control** depends on maintaining strict cleanliness. Remove any crumbs, dirty dishes or food and drink spills, and fix leaking pipes or faucets to eliminate food and water sources for cockroaches. Use insecticide applications with products that are labeled for

Bed bugs are not associated with disease, but they are an insect of concern throughout the United States.

Bed bugs spread easily and are difficult to eradicate once an infestation has occurred.

For the most up-to-date information on bed bugs, go to the Western IPM Center bed bug working group website at https://westernbedbugipm.ucanr.edu/.

Cockroach control depends on maintaining strict cleanliness. Remove any crumbs, dirty dishes and food and drink spills to eliminate food sources for cockroaches.

Clockwise from top left: German, brown banded, American, and Oriental cockroaches.

Art Cushman, USDA, Smithsonian Institution, Department of Entomology, Bugwood.org

German, American and Oriental cockroaches will enter premises in search of moisture.

use inside a dwelling or kitchen to get rid of a cockroach infestation. Follow-up treatments may be needed as cockroaches continue to hatch after the initial treatment. If more than one application of a pesticide is required, use pesticides with different mechanisms of action to prevent development of resistance in cockroaches.

There are four species of importance.

- The German cockroach is the most common in Nevada. It is a small cockroach, generally about ½ inch long, tan to almost black. While this species has wings, it can't fly well. Usually found outdoors, these cockroaches enter the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. The German cockroach has developed resistance to chlorinated hydrocarbons, so use one of the newer insecticides developed for cockroach control. Contact your local dealer for specific insecticides to control German cockroaches.
- The American cockroach is large (1.5 inches long) and red. Like the German cockroach, the American cockroach is usually found outdoors and enters the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific recommendations.
- The Oriental cockroach is black, shiny and up to 1 inch long. Usually outside, these cockroaches also enter premises in search of moisture, like the German and American cockroaches. Limit food and water sources and eliminate access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific insecticides.
- The brown banded cockroach is very common in certain areas. Unlike the other three species mentioned, brown banded cockroaches prefer warm and dry locations. Brown banded cockroaches are tan to light brown and ½ inch or less in length. They are found in structures generally away from water sources. Good sanitation is important. Eliminate food sources. Block entry points by filling in cracks, crevices and other entry sites at ducts, moldings or other openings. Baits and traps are used to control these pests, along with quick knockdown residual insecticides. Contact your local dealer for specific recommendations.

Conclusion

Category K, Public Health Pest Control, involves the management of insects and other animals that transmit diseases to humans. Cleanliness and good

sanitation are very important in preventing or at least limiting infestations. Prevention and exclusion are the best methods of control for many of these public health pests.

For more information go to the following websites:

- American Mosquito Control Association: https://www.mosquito.org/Nevada
- Centers for Disease Control and Prevention, http://www.cdc.gov
- Nevada Department of Agriculture, Division of Animal Industry: https://agri.nv.gov/Animals/Animal_Home/
- Nevada Department of Health and Human Services: https://dhhs.nv.gov/
- Southern Nevada Health District Vector Borne and Zoonotic Diseases, http://www.southernnevadahealthdistrict.org/stats-reports/zoonotic-diseases.php
- Washoe County Health District Vector Borne Disease Prevention Program, https://www.washoecounty.us/health/programs-and-services/vector-borne-diseases/index.php

Prevention and exclusion are the best methods of control for many of these public health pests.

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