

The Role of Wildlife in Spreading Diseases

Introduction

Wildlife host many different diseases, some of which may infect humans. In recent years there has been heightened public awareness of zoonotic wildlife diseases (those transmitted from animals to humans; e.g., West Nile virus, avian influenza H5N1, and hantavirus). In response to emerging disease threats, USDA/APHIS/Wildlife Services has established a National Wildlife Disease Surveillance and Emergency Response System ([SERS](#)). The goal of SERS is to develop and implement a nationally coordinated disease monitoring system aimed at safeguarding wildlife populations, agriculture, and human health and safety from disease threats. In California, the Vector-Borne Disease Section ([VBDS](#)) and the Veterinary Public Health Section ([VPHS](#)) of the California Department of Public Health ([CDPH](#)) is responsible for protecting Californians from diseases transmitted by vectors (insects and vertebrate pests) and other animal-borne diseases. Primary vector-borne diseases in California include diseases transmitted by mosquitoes (e.g., West Nile virus), fleas (e.g., plague), ticks (e.g., Lyme disease), and rodents (e.g., hantavirus). Important zoonotic diseases carried by wildlife in California include rabies and raccoon roundworm. The following chapter provides an overview of some important diseases that represent a potential health threat to persons coming in contact with wildlife, particularly in the western U.S. Persons who enter wildlife habitats or otherwise contact wildlife or their secretions should always take appropriate health precautions. The degree of risk depends on many factors, including geographical location and type of wildlife exposure. Local health departments and other public health officials should be consulted for recommendations for risk reduction specific to the activity involved.

Certain communicable diseases with public health significance are monitored at the federal (Centers for Disease Control and Prevention; CDC) and state (CDPH in partnership with local health departments) levels. These diseases are called notifiable or reportable diseases. Diseases reportable in California are listed in [Title 17 of the California Code of Regulations](#). In California, vector-borne reportable diseases associated with wildlife pests include West Nile virus, plague, Lyme disease, relapsing fever, Rocky Mountain spotted fever, babesiosis, Q-fever, hantavirus, and tularemia. Rabies is reportable when it occurs in humans or animals. Further information on all the diseases in this chapter is available at the [CDC](#) website.

The following terms are used frequently in this chapter; their meanings are defined in this section:

Accidental host: A host that harbors an infectious agent and does not ordinarily serve as a source of infection in nature.

Endemic: The constant presence of a disease or infectious agent within a given geographic area or population group.

Enzootic: Referring to animals specifically, the constant presence of a disease or infectious agent within a given geographic area or population group.

Epidemic: A disease attacking greater than expected numbers of people in a region at the same time.

Epizootic: A disease attacking many animals in a region at the same time at higher frequency than expected.

Host: The animal, including birds and arthropods, or human that harbors an infectious agent under natural conditions.

Incubation period: The time interval between invasion of an infectious agent and the first appearance of disease.

Infection: The entry and development or multiplication of an infectious agent in the body.

Infectious agent: An organism that causes infection (e.g., bacteria, viruses, parasites, fungi).

Reservoir: The animal in which the infectious agent completes its cycle of infection in nature and which serves as a source of infection for other species.

Serology: Blood tests that detect antibodies to obtain evidence of a previous or current infection.

Sporadic: A disease that occurs occasionally or irregularly.

Vector: A living carrier (usually an invertebrate) that transports an infectious agent from an infected individual or its wastes to a susceptible individual or its food or immediate surroundings.

Zoonosis: Infection which is transmitted from animals to humans.

Common diseases associated with some vertebrate pests

Arboviral encephalitis: Arboviruses are infectious viruses that cause encephalitis and are transmitted by mosquitoes and other arthropods. In the western U.S., the most significant viruses of this group are West Nile virus (WNV; see "West Nile virus" below), western equine encephalitis virus (WEE) and St. Louis encephalitis virus (SLE). The occurrence of arboviral encephalitis in people may be sporadic, or in some cases epidemic, if there are



a large number of infected mosquitoes in an area. The disease is usually seen in the summer and early fall months when mosquitoes are most abundant. WNV, WEE, and SLE infection is only spread by certain species of mosquitoes, primarily of the *Culex* species. The reservoirs of WEE and SLE are wild birds. Most infected bird species do not become sick, but some types of birds may cause a large increase (amplification) of virus in nature. As virus transmission amplifies and some mosquitoes shift their feeding preference from birds to mammals later in the summer, the virus may "spill over" to accidental hosts, such as humans and horses. There is no person-to-person or horse-to-person transmission.

Anyone can potentially be infected with arboviral encephalitis, but children infected with WEE or elderly persons infected with WNV or SLE viruses are more apt to have severe illness. The incubation period is approximately 5 to 15 days. Most infected persons do not become sick or only develop a mild flu-like illness. Some persons become more severely ill with symptoms of meningitis or encephalitis (inflammation of the brain). Symptoms include a sudden onset of fever, headache, disorientation, convulsions, coma, and sometimes death. Approximately 7% of severe cases are fatal. Arboviral encephalitis is typically diagnosed by serology. There is no specific treatment or human vaccine to protect against WNV, WEE or SLE infections.

To prevent infection, people should avoid outdoor activity when mosquitoes are biting, typically at dusk and dawn. Screens should be used to prevent mosquitoes from entering dwellings. While outdoors, protective clothing should be worn and insect repellent used in mosquito-infested areas. Some regions have surveillance and control programs to measure mosquito populations, detect arboviral encephalitis virus activity in nature, and initiate appropriate control measures. Further information is available at the [CDPH](#) or [CDC](#) websites.

Avian influenza virus H5N1 (bird flu): Avian influenza is an infection caused by avian (bird) influenza (flu) viruses. These influenza viruses occur naturally among birds. Wild birds worldwide carry the viruses in their intestines, but usually do not get sick from them. However, avian influenza is very contagious among birds and can make some domesticated birds, including chickens, ducks, and turkeys, very sick and may kill them.

Of the few avian influenza viruses that have crossed the species barrier to infect humans, H5N1 has caused the largest number of detected cases of severe disease and death in humans. For the most current information about avian influenza and cumulative case numbers, see the [World Health Organization \(WHO\) avian influenza](#) website.



Of the human cases associated with the ongoing H5N1 outbreaks in poultry and wild birds in Asia and parts of Europe, the Near East, and Africa, more than half of those people reported infected with the virus have died. In general, H5N1 remains a very rare disease in people. The H5N1 virus does not infect humans easily, and if a person is infected, it is very difficult for the virus to spread to another person.

Nevertheless, because all influenza viruses have the ability to change, scientists are concerned that H5N1 virus could, one day, be able to infect humans more readily and spread easily from one person to another. Presently, because these viruses do not commonly infect humans, there is little or no immune protection against them in the human population. If H5N1 virus were to gain the capacity to spread easily from person to person, an influenza pandemic (worldwide outbreak) could begin. For more information about influenza pandemics, see the [U.S. government pandemic flu](#) website. Further information is also available at the [CDC](#) website.

Babesiosis: Human babesiosis is caused by *Babesia microti*, a small parasite that infects red blood cells. Other *Babesia* spp. may also cause human illness. In the U.S., babesiosis is a rare disease in humans and most cases are reported from the East Coast or upper Midwest in areas where the disease is endemic. The distribution of babesiosis may actually be more widespread, and travel or transfusion related cases have also been reported from western states. The reservoirs of *B. microti* are wild rodents. In the Northeast, *B. microti* shares the same mouse reservoir (*Peromyscus leucopus*) and tick vector (*Ixodes scapularis*) as Lyme disease. There is limited information on the nature of the disease in the western U.S. Similar to other tick-borne diseases, babesiosis is seen mostly in the spring, summer, and fall months when the tick vector is most active. The parasite is transmitted by the bite of an infected tick. The parasite may be transmitted perinatally from mother to offspring or by blood transfusion.



The incubation period ranges from one week to one year. Persons who have had their spleen removed are more susceptible to infection. The disease is characterized by a gradual onset of fever, fatigue, and anemia (blood loss). The illness may linger for several months. Babesiosis is diagnosed by identification of the parasite in blood cells, PCR, or by serology. There is no specific vaccine. Atovaquone and azithromycin or clindamycin and quinine are used to treat infections. To prevent infection, efforts should be made to avoid tick bites (see Lyme disease). Further information is available at the [CDPH](#) and [CDC](#) websites.

Brucellosis: Brucellosis is a bacterial disease caused by infection with *Brucella* spp. and is primarily associated with domestic animals, particularly cattle, goats, swine, and dogs. However, there is evidence that wildlife, especially wild pigs, may also be infected. Brucellosis is transmitted to humans by consumption of milk from infected animals or via direct contact with tissues or body fluids from infected animals. Airborne transmission is also possible, particularly in laboratory settings.

The incubation period ranges from one week to two months. The disease is characterized by an illness that may reoccur for months or years after the first episode; thus it is sometimes called "undulant fever". The symptoms include fever, headache, weakness, profuse sweating, chills, and joint pain. The illness may be complicated by infections of the bones, joints, and testes. Brucellosis is not usually fatal, but may cause disability. Diagnosis is made by isolation of the bacteria or by serological tests. Brucellosis can be treated with antibiotics, but relapses still occur about 5% of the time. There is no vaccine available for humans.

Pasteurization of milk and milk products prevents *Brucella* transmission; other prevention approaches include avoiding contact with tissues and body fluids from infected animals. Cuts and abrasions, as well as mucus membranes, are areas where the bacteria can enter your body (wear protective clothing, gloves, etc., to minimize exposure). Foods of animal origin should never be eaten raw or undercooked because they may be contaminated with disease-causing organisms such as *Brucella*. Further information is available at the [CDPH](#) and [CDC](#) websites.



Colorado tick fever: Colorado tick fever is a rare tick-borne virus that occurs in mountainous regions of the western United States, including California. Wild rodents (e.g., ground squirrels, chipmunks, wood rats, mice, etc.) are the reservoirs of the virus. Colorado tick fever is transmitted by the bite of an infected tick, primarily the Rocky Mountain wood tick (*Dermacentor andersoni*). There is no person-to-person transmission except by blood transfusion.



Persons entering tick-infested habitat in endemic areas are at an increased risk of exposure to Colorado tick fever. The incubation period is usually less than one week. Symptoms are fever, chills, headache, muscle pain, and sometimes a rash. The symptoms may resolve and reappear several times, but the disease is rarely fatal. Diagnosis of Colorado tick fever is made by isolation of the virus from the blood or by serological tests. There is no specific treatment or vaccine. Colorado tick fever is prevented by avoiding tick bites (see Lyme disease). Further information is available at the [CDPH](#) and [CDC](#) websites.

Flea-borne typhus: Flea-borne typhus is a disease caused by the bacteria (*Rickettsia typhi*) and is transmitted through the feces of an infected flea. The disease is endemic in certain regions of the western U.S. Human cases are usually sporadic and occur in late summer and fall. Rodents and opossums are the common reservoirs of *R. typhi*, and domestic cats have been implicated as reservoirs. *R. typhi* is shed in the feces of certain flea species that infest the reservoir animals. Typhus is transmitted to humans by feces from an infected flea that contaminates the flea-bite site or other wounds. Less commonly, the disease is transmitted by inhalation of aerosols contaminated with feces from infected fleas. Person-to-person transmission is not recognized.



The incubation period is one to two weeks. The symptoms are fever, chills, and headache which may be followed in five to six days by a rash. Flea-borne typhus is not usually fatal. The diagnosis is made by serology, and antibiotics are used to treat the infection. There is no vaccine available to protect against flea-borne typhus. For prevention, insecticides are used to control wild and domestic animal fleas. Where flea-borne typhus is suspected in the area, flea control should always precede rodent control measures. Further information is available at the [CDPH](#) and [CDC](#) websites.

Giardiasis (backpacker's disease): Giardiasis is an infection caused by a small protozoan parasite (*Giardia lamblia*). It is one of the most commonly identified parasitic causes of diarrhea in the U.S. Humans are the reservoir, but wild and domestic animals may also be infected and shed the parasite in their feces. Person-to-person transmission by the fecal-oral route is the usual mode of spread, such as may occur with inadequate hygiene in day care centers. Drinking untreated water is another common source of infection. Stream and lake waters may be contaminated with human or animal feces and serve as a source for human infections.



The incubation period ranges from one to four weeks. The infection may be unapparent, mild, or severe. Symptoms are diarrhea, abdominal cramps, bloating, weight loss, and fatigue; the diarrhea may last for several months. Diagnosis is made by visualizing the parasite in the feces under a microscope, but it is not always shed in the feces every day. Therefore, to diagnosis giardiasis, fecal specimens may need to be collected and examined several times. Antiprotozoals are used to treat the infection. Similar to most parasitic infections, there is no vaccine available to protect against giardiasis. To prevent giardiasis, follow good hygiene practices, including thorough hand washing, and never drink untreated water such as from streams and lakes. Further information is available at the [CDPH](#) and [CDC](#) websites.

Hantavirus Pulmonary Syndrome: Hantavirus Pulmonary Syndrome (HPS) is a severe and sometimes fatal disease caused by infection with the hantavirus. HPS was first recognized in an outbreak in the Four Corners area (Arizona, New Mexico, Colorado, and Utah) in 1993, and has since been identified in many areas of the U.S., including California. The primary reservoir of the virus in California is the deer mouse (*Peromyscus maniculatus*). Hantavirus is shed in the urine, feces, and saliva of infected rodents but does not cause apparent illness in these hosts. The disease is transmitted to humans by inhalation of aerosolized rodent urine, feces, or saliva containing the virus. There is no evidence of person-to-person transmission of hantaviruses found in the U.S.



Persons engaged in activities that bring them into contact with rodents or into infested structures, especially in a rural setting, are at increased risk of exposure to the disease. To date, the average age of the HPS cases is 38 years (range from 12 to 69 years). There are slightly more cases in males compared with females. The incubation period is generally one to two weeks, but may be as long as six weeks. Initially, the symptoms are flu-like with fever, chills, muscle aches, cough, headache, and sometimes abdominal pain being the most frequently reported symptoms. The illness may quickly progress to signs of lung disease similar to adult respiratory distress syndrome (ARDS). ARDS is a life-threatening condition of the lungs that can lead to respiratory failure and death. The mortality

of HPS is approximately 35%. HPS is diagnosed by serology and other special tests. There is no specific treatment or vaccine.

To prevent HPS, avoid contact with rodents and rodent urine or droppings and exclude rodents from structures. Vector-control personnel, researchers, mammalogists, and any others who work with rodents should consult local or state health officials for specific recommendations for risk reduction before handling live wild rodents (e.g., live-trapping, processing, etc.). General precautions include eliminating and preventing rodent infestation of human dwellings or other structures. Special precautions apply for cleaning buildings with heavy rodent infestations. Details on cleaning can be found in the [deer mouse chapter](#). Further information is available at the [CDPH](#) and [CDC](#) websites.

Leptospirosis (Weil's disease): Leptospirosis is caused by the bacteria (*Leptospira interrogans*). The disease occurs worldwide. Human cases of leptospirosis occur sporadically in the western U.S. Wild and domestic animals are reservoirs including cattle, horses, pigs, dogs, raccoons, rats, mice, badgers, squirrels, deer, foxes, skunks, opossums, and marine mammals. Wild rodents are well-adapted to the bacteria and many rodent species maintain the organism within their populations with no apparent illness.



L. interrogans is shed in infected animal urine and may contaminate water and moist environments. Transmission to humans occurs by direct contact of the skin (especially if abraded or cut) or mucous membranes with urine, placental fluids, or milk of infected animals. Less commonly, the route of transmission is by ingestion or inhalation of contaminated water or aerosols, respectively. Person-to-person transmission is very rare.

Persons in certain occupations (e.g., farmers, sewer workers, miners, veterinarians) are at a higher risk of exposure to the disease. The illness ranges from no symptoms to severe illness. The incubation period is approximately one to two weeks. Symptoms can include fever, chills, headache, vomiting, jaundice (yellowness of the skin and mucous membranes), anemia, and sometimes a rash. Leptospirosis can cause damage to the kidneys, liver, brain, lungs, or heart, but the disease is not usually fatal. Leptospirosis is diagnosed by serological tests, and antibiotics are used to treat the infection. No vaccine is available.

To prevent leptospirosis, workers should have good personal hygiene and wear protective clothing when working in potentially contaminated areas, particularly around water and moist soil or vegetation. Direct contact with wild rodents and their secretions should be avoided. Further information is available at the [CDPH](#) and [CDC](#) websites.

Lyme disease: Lyme disease is a tick-borne disease caused by spiral-shaped bacteria called *Borrelia burgdorferi*. Lyme disease is currently the most commonly reported vector-borne disease in the U.S. Since 2002, over 20,000 human cases are reported each year to the CDC; in California about 100 cases are reported each year. Most of the human cases are reported from the East Coast, parts of the Midwest, and Northern California. On the East Coast, Lyme disease is maintained in nature by a tick-rodent cycle of transmission involving the white-footed mouse (*Peromyscus leucopus*) and the deer tick (*Ixodes scapularis*). In the western U.S., rodents such as the dusky-footed woodrat (*Neotoma fuscipes*), deer mouse (*Peromyscus maniculatus*), and western gray squirrel (*Sciurus griseus*) are reservoirs of the spirochete; the western black-legged tick (*Ixodes pacificus*)



transmits the organism to people. Transmission to humans occurs through the bite of an infected tick. Lyme disease is not transmitted person-to-person.

The incubation period is three to thirty days after the tick bite. The illness may start as a characteristic rash (large red circle that sometimes clears in the center like a "bull's-eye"). Flu-like symptoms such as fever, headache, fatigue, stiff neck, and muscle and joint pain may accompany the rash or may occur without a rash. If Lyme disease is not recognized and treated in its early stage, it may progress to a more severe illness involving the nervous system, heart, or joints. Lyme disease is diagnosed by clinical signs combined with serological tests. During early stages of the disease (<15 days after infection), a person may test negative. Properly performed serological tests, combined with clinical symptoms and appropriate exposure history, help a physician make the diagnosis. Antibiotics are used to treat Lyme disease, and treatment is most expedient if initiated early in the course of the illness. There is no vaccine available for humans.

To prevent Lyme disease and other tick-borne diseases, efforts should be made to prevent exposure to tick bites. Guidelines for avoiding tick bites and for removing attached ticks include:

How to avoid tick bites:

- Apply insect repellent containing DEET on exposed skin. Use an insect repellent containing permethrin on pants, socks, and shoes. Use insect repellent registered for use against ticks
- Check yourself for ticks frequently.
- Tuck pants into boots or socks, and shirt into pants.
- Shower as soon as possible after being in areas where ticks are found.
- Avoid trail margins, brush, and grassy areas when in tick country.
- Check bedding for several days after exposure to tick-infested habitats to see if engorged ticks have dropped off.

How to remove attached ticks:

- Remove an attached tick as soon as possible.
- Use tweezers or forceps rather than your fingers, if they are readily available.
- Grasp the tick's head as close to the skin as possible, preferably at the mouthparts if possible.
- Gently pull the tick straight out, steadily and firmly. Do not twist or jerk the tick as these methods are ineffective.
- Wash hands and bite site with soap and water. Apply antiseptic to bite site.
- If mouthparts of the tick break off and remain in your skin, consult your physician.
- Dispose of tick in alcohol (if you would like it identified later, submit it to your local vector control agency) or by flushing it down the toilet.

Further information can be found at the [CDPH](#) and [CDC](#) websites.

Lymphocytic choriomeningitis: Lymphocytic choriomeningitis (LCM) is a viral disease carried by animals, especially mice. The disease in humans is rare, but there have been outbreaks associated with pet and laboratory rodents. The reservoir of LCM is the house mouse (*Mus musculus*). The virus is excreted in the urine, feces, and saliva of infected rodents. Transmission to humans occurs by inhalation of contaminated aerosols or by ingestion of contaminated food. Person-to-person spread is not known to occur.

After an incubation period of approximately ten days, the illness begins with flu-like symptoms. The signs may disappear or progress to involve the nervous system. Recovery is usually rapid and deaths from the disease are rare. Diagnosis is made by isolation of the virus from body fluids or by serological tests. There is no specific treatment or vaccine. To prevent LCM, avoid contact with rodents and their excretions and secretions and follow good personal hygiene practices. Further information is available at the [CDC](http://www.cdc.gov) website.



Plague: Plague is a disease caused by infection with the bacteria *Yersinia pestis*. Plague was first recognized in the U.S. in San Francisco in 1900. The disease was detected in other west coast cities (Los Angeles and Seattle) in the early 1900's and has since become established in wild rodent populations of many western states where it is maintained in nature by wild rodent reservoirs. Certain rodent species are very susceptible to the disease, while others are infected but show no symptoms.



The infection may cause epizootics characterized by readily observable "die-offs" in susceptible rodent populations, such as prairie dogs and ground squirrels. In other cases, epizootic plague activity may be less apparent. Plague is most commonly transmitted between rodents by flea bites. The most frequent route of transmission to humans is also by the bite of an infected flea. In addition, humans may be infected by direct contact with the tissues or bodily fluids of rodents, rabbits, and other wildlife or domestic animals, especially cats, infected with plague. Person-to-person transmission can occur, particularly if the person has pneumonic plague where the bacteria can spread by aerosol. Sputum from an infected person is also very contagious. Outbreaks or epidemics of human plague can be devastating and were responsible for the Black Death epidemic in the middle ages. The last known instance of human-to-human plague transmission in the United States occurred in Los Angeles in 1924. Although human outbreaks of plague are rare today, the potential for person-to-person transmission makes recognition and control of this disease a high priority for public health officials.

The incubation period for plague is short, usually only two to six days. There are three clinical forms of plague in humans. Bubonic plague is the most common form and is characterized by fever, chills, headache, muscle aches, and swollen and painful lymph nodes, called "buboes." Septicemic plague is caused by the bacteria spreading into the bloodstream. Pneumonic plague occurs when plague bacilli spread to the lungs and is potentially the most deadly form of the disease. Untreated plague is often fatal. Prompt diagnosis by identification and isolation of the bacteria or by serological tests is very important to facilitate early treatment with antibiotics. No commercial vaccine is currently available.

To prevent plague, avoid contact with rodents and their fleas and never touch sick or dead rodents. Signs of a rodent "die-off" should be reported to public health officials immediately. Flea control should always precede any rodent control efforts in areas of suspected plague infestations. For personal protection, use insect repellent and wear long pants tucked into socks to reduce flea exposure.

Plague is maintained in the wild by moderately disease-resistant sylvatic rodents such as deer mice, meadow voles, and chipmunks. When conditions exist such that fleas from the resistant rodents infest and bite more susceptible rodents such as ground squirrels, the bacteria may spread rapidly through the squirrel populations, resulting in depopulation of the squirrels and active, infective, host-seeking fleas. If an infective flea bites another animal or human, it will inject some bacteria as

part of the feeding process. Ground squirrels are often found in close proximity to offices, family housing, or recreation areas, and plague transmission to humans by flea bites may occur. Further information is available at the [CDPH](#) and [CDC](#) websites.

Psittacosis: Psittacosis is a bacterial disease of wild and domestic birds caused by *Chlamydophila psittaci* (formerly *Chlamydia psittaci*). The disease is distributed worldwide, and human cases are usually sporadic. Outbreaks have been linked to pet shops, aviaries, and pigeon lofts. The reservoirs are psittacine birds (e.g., parrots, macaws, cockatoos, and parakeets), pigeons, domestic fowl, and other birds. Infected birds shed *C. psittaci* in their droppings. Transmission to humans is usually by inhalation of aerosols contaminated with droppings from infected birds. Pet birds are the most common source of infection. Transmission from person-to-person is rare.



The incubation period is approximately ten days. Symptoms are fever, chills, headache, muscle aches, and respiratory signs, such as coughing. Occasionally the disease is more severe and relapses may occur. Diagnosis is made by serological tests. There is no vaccine, but the disease is treatable with antibiotics.

Precautions should be taken to avoid inhaling contaminated aerosols where birds are kept, particularly in enclosed spaces. To control psittacosis, some states regulate the importation and sale of pet birds. Further information is available at the [CDPH](#) and [CDC](#) websites.

Q fever: Q fever is a disease caused by bacteria (*Coxiella burnetii*). The disease is endemic in many areas, including parts of the western U.S. A number of wild and domestic animals can be infected with Q fever, but livestock are the usual source of human infections. There are two possible transmission cycles: the most common one involves domestic animals (e.g., cattle, sheep, and goats) and the other less common cycle is between wildlife (e.g., rodents, marsupials, and lagomorphs) and ticks in nature. Many species of soft (Argasid) and hard (Ixodid) ticks may be infected with Q fever. *C. burnetii* is found in the afterbirth and other body fluids, including milk, of infected animals. *C. burnetii* can live in the environment for a long time and continue to serve as a source of infection to livestock and humans. Inhalation of contaminated aerosols is the usual mode of transmission to humans. Transmission by the bite of an infected tick is less common and person-to-person transmission is very rare.



Persons at a higher risk of exposure to Q fever include veterinarians, farmers, slaughterhouse workers, researchers, and others who handle livestock, especially sheep. Persons entering wildlife habitat in endemic areas may also be at an increased risk of infection. The incubation period is two to three weeks. Symptoms are fever, chills, headache, weakness, profuse sweating, and sometimes pneumonia. Complications may include damage to the heart, lungs, liver, or other organs. If treated, the disease is not usually fatal. Q fever is diagnosed by serological tests and antibiotics are used to treat the infection. A vaccine is available for persons at a high risk of exposure to the disease. Q fever is prevented by practicing good hygiene while working with livestock, pasteurizing milk, and preventing tick bites (see Lyme disease). Further information is available at the [CDPH](#) and [CDC](#) websites.

Rabies: Rabies is caused by a virus that attacks the nervous system. The disease is widely distributed in animals throughout much of the U.S., but human rabies is rare in this country. Wild animals account for over 90% of all rabid animals identified. The principal rabies reservoirs today are wild carnivores and bats. The wild animals most frequently reported rabid are skunks, raccoons, bats, coyotes, and foxes. In California, skunks and bats are the most common wildlife reservoir. However, any mammalian species may theoretically contract rabies. Some animals, such as rodents, are very resistant to infection. In the past, rabies in dogs was reported more frequently than in wild animals. Statutes mandating rabies vaccination and licensing of dogs resulted in a substantial drop in the number of dog rabies cases since that time.



The rabies virus is shed in the saliva of infected animals and is usually transmitted by bites. Scratches or contamination of wounds, abrasions, or mucous membranes with saliva or nervous system tissue from an infected animal are other documented routes of transmission. Airborne transmission of rabies has occurred in humans entering caves with roosting bats.

In contrast to many of the diseases described in this chapter, infection with rabies in susceptible animals always results in clinical disease. Rabies often causes abnormal behavior in wildlife and it should be suspected in any wild animal showing a lack of fear around humans, activity of nocturnal animals during the day, or aggression and unprovoked attacks. Other signs of rabies in animals include weakness, paralysis, and increased excitability.

The incubation period in humans may be as short as ten days or as long as one year. Symptoms include a sense of apprehension, headache, fever, and unexplained sensations, usually at the site of the bite. The disease may progress to severe weakness or paralysis, delirium, convulsions, and death. Spasms in the throat make swallowing very difficult; this sign has been described as a fear of water or hydrophobia. The course of illness is usually less than one week. Diagnosis is made by special tests of the brain tissue. Rabies is almost always fatal once clinical signs begin.

A pre-exposure rabies vaccine is available and strongly recommended for persons at risk for rabies exposure (e.g., veterinarians and their staff, wildlife rehabilitators, and animal control officers). More information regarding the pre-exposure vaccine and its availability can be found at the [CDC](#) website. To prevent exposure to rabies, direct contact with wildlife should be avoided. If an animal is behaving strangely or appears to be sick, the local health department or animal control agency should be notified. Further information is available at the [CDPH](#) and [CDC](#) websites.

What to do if bitten by an animal: All animal bites should be treated seriously because of the potential for exposure to rabies and other diseases (e.g., pasteurellosis, tularemia, rat-bite fever, and tetanus).

- Always clean bite wounds thoroughly with soap and water as soon as possible after the bite. This is one of the most important steps to prevent infection.
- A physician should be consulted immediately after any animal bite. There is a specific treatment available for rabies prevention after an exposure incident.
- If the biting animal is available, the local animal control agency should be contacted. Wild animals are sacrificed and the brain submitted to a public health laboratory for rabies testing.

Raccoon roundworm infection: Roundworms of the species *Baylisascaris procyonis* are parasites that live in the intestine of raccoons. Parasite eggs are shed in the feces of infected animals. The eggs can survive in the environment for long periods of time. The parasite is transmitted to humans by ingestion of infective eggs, either directly from the feces or from a feces-contaminated environment. The disease occurs sporadically and is usually seen in children. Badgers, skunks, fishers, martens, bears, and other wildlife species also carry *Baylisascaris* spp. that may infect humans. The disease is called larva migrans. Because humans are accidental hosts of these parasites, after ingestion, the egg hatches and the parasite larvae migrate aberrantly to organs and tissues, potentially causing severe damage.



The infection is usually unapparent or mild, but sometimes symptoms persist for many years. Children are more commonly infected with larva migrans, probably because of poor hygiene and a tendency to eat contaminated soil. The incubation period is weeks to months; symptoms occur more rapidly if large numbers of eggs are ingested. The symptoms depend on the location and migration path of the larvae and can be severe if the brain or eyes are infected. The disease may manifest as fever, fatigue, loss of coordination, stupor, coma, or loss of vision. Infection is sometimes fatal. Diagnosis of *Baylisascaris* larva migrans is difficult and depends on a history of exposure to raccoons, clinical signs, and a serological test. There is no vaccine or effective treatment, although if larvae are located in the eye, they can sometimes be removed.

To prevent infection, contact with raccoon feces or areas contaminated with animal feces should be avoided. Persons working with raccoons or other wildlife should follow good hygiene practices, including careful hand washing. Further information is available at the [CDPH](#) and [CDC](#) websites.

Rat-bite fever: Rat-bite fever is a bacterial disease caused by *Streptobacillus moniliformis*. The disease has a widespread distribution, but human cases are rare. The bacteria that cause rat-bite fever are part of the normal flora of the mouth of many rodents, especially rats. Animals that eat rodents may also become infected and transmit the disease to humans. Rat-bite fever is usually transmitted by animal bites or by direct contact with the secretions of infected animals. Persons have also become infected by eating infected rodents or food contaminated by infected rodents.



The incubation period is ten days or less and symptoms include an abrupt onset of high fever, headache, vomiting, muscle pains, swollen joints, and a rash on the arms and legs. Some people develop complications including damage to the joints, heart, liver, lungs, or brain. Without treatment, the disease is fatal 10 to 12% of the time. Diagnosis of rat-bite fever is made by isolation of the bacteria or by serological tests. There is no vaccine, but the infection can be treated with antibiotics. To prevent this disease, precautions should be taken to avoid animal bites, and human dwellings should be rodent-proofed. Further information is available at the [CDC](#) website.

Rocky Mountain spotted fever: Rocky Mountain spotted fever (RMSF) is a tick-borne disease caused by the bacteria *Rickettsia rickettsii*. RMSF is one of the most frequently reported vector-borne diseases in the U.S. The main tick vectors are the Rocky Mountain wood tick (*Dermacentor andersoni*), the American dog tick (*D. variabilis*), and the brown dog tick (*Rhipicephalus sanguineus*). The incidence of human disease is greatest between April and August, which can coincide with the increased activity of adult ticks. The reservoirs of RMSF are wild rodents, rabbits, domestic dogs, and the ticks themselves. RMSF is transmitted by the bite of an infected tick or by contamination of the skin (especially if wounded or abraded) with the body fluids or feces of infected ticks.



Persons who enter tick-infested areas where RMSF is endemic are at an increased risk of exposure to the disease. Recent outbreaks in the southwestern U.S. were associated with many stray dogs infested with brown dog ticks. Symptoms begin within two weeks after the tick bite and include fever, chills, headache, fatigue, muscle pain, and a characteristic rash. The rash usually starts on the legs or arms and may spread to the feet, hands, and rest of the body. Some people do not develop the rash. The disease can be very severe and is fatal 15 to 20% of the time if untreated and 4 to 6% of the time if treated. RMSF is diagnosed by clinical presentation and history. Serological tests are used to confirm the diagnosis but treatment with antibiotics should begin as soon as possible, often before serology results can be obtained. There is no vaccine for RMSF. Tick bites should be avoided to prevent RMSF (see Lyme disease). Further information is available at the [CDPH](#) and [CDC](#) websites.

Salmonellosis: Salmonellosis is caused by bacteria in the *Salmonella* genus. The disease is a common cause of "food poisoning" worldwide. *Salmonella* spp. are found in many animals, including wildlife. Ectothermic animals (those that rely on behavior to maintain their body temperature; e.g., reptiles such as snakes, tortoises, and turtles) often carry the bacteria without any signs of illness. Salmonellosis is the most frequent zoonotic disease transmitted by reptiles. *Salmonella* spp. are shed in the feces of infected animals and humans. Humans acquire the infection by ingestion of the bacteria directly from the infected animal, feces-contaminated environment, or contaminated food. Persons with salmonellosis can transmit the disease to other persons by the fecal-oral route of transmission.



Anyone can be infected with *Salmonella* spp., but the very young, very old, and immunosuppressed are at the greatest risk of serious illness. The incubation period is approximately 12 to 36 hours. Symptoms are fever, abdominal cramps, diarrhea, nausea, loss of appetite, and sometimes vomiting. The illness may be mild to very severe, even fatal. Salmonellosis is diagnosed by isolation of the bacteria from feces. Treatment depends on the severity of the illness, but preventing dehydration from fluid loss is very important. There is no vaccine for humans.

To prevent salmonellosis, persons in contact with animals should practice good personal hygiene, including thorough hand washing after handling animals or working in their environment. Salmonellosis is also prevented by properly storing, handling, and cooking food. Further information is available at the [CDPH](#) and [CDC](#) websites.

Tick-borne relapsing fever: Tick-borne relapsing fever (TBRF) is caused by spiral-shaped bacteria in the *Borrelia* genus, most commonly *Borrelia hermsii*. Natural foci of this disease exist in high elevation areas of the western U.S., including California. Human cases are sporadic, but outbreaks are occasionally reported. The disease has a seasonal occurrence with most cases seen in the summer and early fall. Wild rodents and ticks are the reservoirs.



The disease is transmitted by the bite of the soft tick (*Ornithodoros* spp.) or by contamination of a wound with the body fluids of an infected tick, for example if it is crushed or squeezed. TBRF is distinct from louse-borne relapsing fever, a disease with similar signs but which has not been reported in the U.S. for many years.

Human cases of TBRF have been associated with the occupation of rodent-infested homes in endemic areas. The *Ornithodoros* spp. tick normally resides in rodent nests; however if rodent removal from human habitations is conducted without nest removal, the *Ornithodoros* tick will leave the nests to search out an alternative host, such as a human. Unlike hard (Ixodid) ticks, soft ticks feed quickly and return to a dark, protected location. It is likely a person fed on by a soft tick will not know they have been bitten.

The incubation period for TBRF is approximately one week. The illness is characterized by fever for three to four days and a brief recovery. This is followed by multiple episodes of fever, chills, profuse sweating, headache, and muscle pains, thus the name "relapsing fever." The disease is fatal in 2 to 5% of the cases. TBRF is diagnosed by detection of the bacteria on a blood smear during a febrile episode. There is no vaccine, but antibiotics can be used to treat the infection.

TBRF can be prevented by excluding rodent infestation of human dwellings. If a building is rodent infested, in addition to rodent control and exclusion, rodent nests should be removed from in and around buildings. To reduce the risk for soft tick bites, beds should be pulled away from the walls and bedding should not be in contact with the walls or floor. People should avoid sleeping on the floor. Further information is available at the [CDPH](#) or [CDC](#) websites.

Tick paralysis: Tick paralysis is a clinical syndrome described in humans and animals caused by a toxin (poison) secreted in the saliva of certain female ticks (*Dermacentor* spp.). Children appear to be more commonly affected than adults. Dogs can also be affected. Most cases occur in the Pacific Northwest and Rocky Mountain states in the spring and summer months. The symptoms usually begin after the tick has been attached for four to seven days. Symptoms are weakness and in coordination in the legs which may progress to paralysis (ascending paralysis). Removal of the tick usually results in recovery; often these ticks attach on the head just at the hairline. Tick paralysis is prevented by avoiding tick bites and promptly removing attached ticks (see Lyme disease). Further information is available at the [CDPH](#) and [CDC](#) websites.

Tularemia (rabbit fever): Tularemia is a bacterial disease caused by *Francisella tularensis*. The disease occurs sporadically in the western U.S. More cases are seen in the summer during tick season and the winter during rabbit hunting season. The reservoirs of tularemia are ticks, primarily of the genus *Dermacentor*, and wildlife, especially rabbits, hares, and rats. There are many possible routes of transmission to humans including: 1) direct contact with the tissues or body fluids of infected animals, ticks, or deer flies, 2) the bite of an infected tick, 3) the



consumption of undercooked meat from an infected animal, 4) swimming in or drinking water contaminated by infected animals, and 5) inhaling dust contaminated by infected animals.

Rabbit hunters and persons visiting tick-infested areas are at a higher risk of exposure to tularemia. There is a short incubation period, usually three days. The most common symptoms are swollen glands and an ulcer, often on the hand. Tularemia can cause other clinical signs including pneumonia, diarrhea, vomiting, or eye infections, but the disease is not usually fatal. Tularemia is diagnosed by isolation of the bacteria or by serological tests, and antibiotics are used to treat the infection. A vaccine is available to certain individuals in high-risk groups.

Precautions should be taken to avoid contact with the tissues and body fluids of animals, flies, and ticks. Tick and fly bites should be prevented (see Lyme disease). Other precautions include avoiding swimming in or drinking untreated water and thoroughly cooking meat. Further information is available at the [CDPH](#) and [CDC](#) websites.

West Nile virus: West Nile virus (WNV) is a mosquito-transmitted viral infection of birds that historically was distributed throughout Africa, Middle East, Europe, and western Asia. The virus was responsible for human epidemics within its historical range, but the virus strains there did not typically cause noticeable mortality in native birds. WNV was introduced into the U.S. in 1999 via the Middle East (likely Israel where an identical WNV strain was circulating the previous year), however the exact source of introduction is unknown. WNV is maintained in nature in a mosquito-bird cycle. People and other mammals become infected when they are bitten by an infectious mosquito, but they are “dead-end” hosts, meaning they do not develop enough virus in their blood to infect additional mosquitoes. Bird species in the U.S. show a wide variability in their response to WNV infection. House finches and sparrows are important reservoirs; they can maintain sufficient virus levels in their blood for several days and infect feeding mosquitoes. In contrast, birds in the Corvid family (crows, jays, magpies, etc.) exhibit high mortalities and die soon after infection. The American crow was a valuable indicator of the disease’s spread throughout the U.S., and dead crows (and other species) are still used as sentinel indicators of local WNV activity. WNV is now a widely disseminated enzootic disease throughout North America. Targeted mosquito control is at present the only method available to suppress local virus transmission, which reduces human risk for WNV infection. Equine vaccinations reduce the risk for disease in horses. National surveillance indicators are posted on the [USGS disease map](#). In California, local information is available at the [California West Nile Virus](#) website. Further information is available at the [CDC](#) website.



REFERENCES AND ADDITIONAL READING

- Borchert, J.N. 2002. Current control strategies to combat Lyme disease in the North-Central and Eastern U.S. *Proceedings of the Vertebrate Pest Conference* 20:244–248.
- Childs, J.E., J.W. Krebs, and C.E. Rupprecht. 1998. Mammalian reservoirs and the changing epidemiology of rabies in the United States. *Proceedings of the Vertebrate Pest Conference* 18:77–81.
- Faine, S., B. Adier, C. Bolin, and P. Perolat. 1999. *Leptospira and Leptospirosis*. Second edition. Medisci Press, Melbourne, Australia.
- Fritz, C.L., and V.L. Kramer. 1998. Surveillance for Sin Nombre Virus and Hantavirus Pulmonary Syndrome in California, 1993 to 1997. *Proceedings of the Vertebrate Pest Conference* 18:208–212.

- Kjemtrup, A. 2006. Surveillance of vector-borne disease in California. Proceedings of the Vertebrate Pest Conference 22:304–307.
- Lane, R.S. 2006. Lyme disease in California: ecology and epidemiology. Proceedings of the Vertebrate Pest Conference 22:308–310.
- McLean, R.G. 2006. West Nile virus in North American wildlife. Proceedings of the Vertebrate Pest Conference 22:308–310.
- Townzen, K.R., M.A. Thompson, and C.R. Smith. 1996. Investigations and management of epizootic plague at Ice House Reservoir, Eldorado National Forest, California, 1994 and 1995. Proceedings of the Vertebrate Pest Conference 17:68–74.
- Williams, E.S., and I.K. Barker. 2001. Infectious diseases of wild mammals. Third edition. Blackwell Publishing, Ames, Iowa.
- Witmer, G.W. 2004. Leptospirosis in the Azores: the rodent connection. Proceedings of the Vertebrate Pest Conference 21:217–220.

*Chapter last updated: 28 October, 2015***

Suggested citation:

Baldwin, R.A., and R. Meinerz. 2015. The role of wildlife in spreading diseases. Pages 91–105 *in* Vertebrate Pest Control Handbook, R.A. Baldwin, editor. Sixth edition. California Department of Food and Agriculture, Sacramento, CA. <http://www.vpcrac.org/about/vertebrate-pest-handbook/>

**Adapted from several previous editions authored by D.O. Clark, J.P. Clark, and T.P. Salmon, among others.