Tularemia

Iowa State University Center for Food Security and Public Health

Follow this and additional works at: http://lib.dr.iastate.edu/cfsph_factsheets

Part of the Animal Diseases Commons, and the Veterinary Infectious Diseases Commons

Recommended Citation

http://lib.dr.iastate.edu/cfsph_factsheets/140
Tularemia

Rabbit Fever, Deer Fly Fever, Meat-Cutter’s Disease Ohara Disease, Francis Disease

Importance

Tularemia is a zoonotic bacterial disease that can affect many mammals. It is most prevalent among wild animals, but clinical cases occur regularly in cats, and outbreaks have been reported among sheep, captive prairie dogs and ranched mink. A variety of syndromes can be seen, but fatal septicemia is common in some animal species. In humans, the disease varies from a localized illness to fulminant, life-threatening pneumonia or septicemia. Tularemia has recently emerged in some areas. It was recognized for the first time in Spain in 1997-1998, when two outbreaks, one associated with hares and the other linked to crayfish, affected more than 500 people. In 2000, a human epidemic in Kosovo was associated with a population explosion and epizootic among rodents, which occurred after large numbers of people had been displaced from their homes by the conflict. In 2002, an unexpected outbreak was seen among captive prairie dogs in the U.S., and the disease entered the Czech Republic in a shipment of these animals. Tularemia was detected for the first time in the Southern Hemisphere the same year, when a case caused by Francisella tularensis subsp. novicida was identified in Australia. In addition, tularemia is considered to be a potential bioterrorism agent.

Etiology

Tularemia results from infection by Francisella tularensis (formerly known as Pasteurella tularensis), a Gram negative coccobacillus in the family Francisellaceae. Four subspecies are currently recognized. Although all four cause tularemia, they tend to be associated with different animal hosts, and their propensity to cause severe disease varies. F. tularensis subsp. tularensis (also known as type A) has been found almost exclusively in North America. It is the most virulent species, particularly in humans. F. tularensis subsp. holarctica (type B) is much more widely distributed in the Northern Hemisphere, but it is less virulent. The two remaining species, F. tularensis subsp. mediasiatica and F. tularensis subsp. novicida, have been recognized in limited geographical regions, are rarely found in people, and seem to cause relatively mild disease when they occur. Additional subspecies have also been proposed.

Geographic Distribution

With rare exceptions, tularemia occurs only in the Northern Hemisphere. This disease has been reported from North America, Europe, parts of Asia and the Middle East, and northern Africa. A single human case, caused by F. tularensis novicida, was acquired in Australia.

F. tularensis tularensis is seen almost exclusively in North America, and has very rarely been isolated in Europe. F. tularensis holarctica is widely distributed in the Northern Hemisphere. This species is responsible for nearly all cases of tularemia outside North America. It co-exists with F. tularensis tularensis in North America. F. tularensis mediasiatica occurs in a limited area of Central Asia, and F. tularensis novicida has been reported from North America, Australia and Spain.

Francisella tularensis persists in some locations without outbreaks being reported, and the distribution of clinical cases among humans is patchy. In the U.S., Missouri, Arkansas, Oklahoma, Massachusetts and South Dakota accounted for 58% of the human cases from 2000 to 2005. Parts of Europe such as Finland and Sweden, and foci in northern Asia, also seem to be disproportionately affected.

Transmission

F. tularensis can be transmitted by ingestion, inhalation, arthropod–borne transfer, or direct contact with mucous membranes and broken skin. This organism is found in the blood and tissues of infected animals, and it can survive for long periods on fomites including food and water. Aquatic animals may develop tularemia after being immersed in contaminated water, and some human outbreaks have been linked to drinking from natural springs and wells. Carnivores can be infected by ingesting carcasses, and cannibalism seemed to be the primary route of transmission during an outbreak in captive prairie dogs.
A variety of arthropods can transmit *F. tularensis*. Ixodid ticks are biological vectors; species that are important in transmission include *Dermacentor andersoni*, *D. variabilis* and *Amblyomma americanum* in North America, and *Haemaphysalis flava* and *Ixodes japonesi* in Japan. *F. tularensis* is transmitted transstadially, and ticks can remain infected throughout their lifetimes; however, the occurrence of transovarial transmission is controversial. Biting flies in the family Tabanidae (particularly the deer fly, *Chrysops discalis*) can act as mechanical vectors. Individual flies can carry the organism for two weeks. Mosquitoes can also be vectors. The arthropods that are most important in transmission vary with the geographical area. For example, tabanid flies have been implicated as vectors in both the western U.S. and northern Europe, while mosquitoes can spread the organism in northern Europe. *F. tularensis* also occurs in other arthropods, although their role in transmission is speculative in many cases. In Europe, *F. tularensis holarctica* has been isolated from mites (family Gamasidae) collected from rodents. Mites can also transmit tularemia between rodents in the laboratory. Fleas are thought to be of little importance as vectors. Although they can remain infected for weeks, they do not transmit the organism readily between animals. Ceratopogonids (biting midges) and Simulidae (blackflies) have been proposed as potential vectors. Fruit flies (*Drosophila melanogaster*) can be infected in the laboratory, and bedbugs are reported to harbor the organism for 136 days. *F. tularensis holarctica* seems to be associated with lakes, streams and aquatic animals in some areas, and it might also be maintained in aquatic protozoans.

*F. tularensis* can survive for long periods in the environment. Viable bacteria can be found for weeks to months in the carcasses and hides of infected animals, and in fomites including grain dust, straw, water and soil. This organism is highly resistant to freezing; live bacteria have been found after 3 years in rabbit meat stored at -15°C.

Humans acquire *F. tularensis* from various sources including lakes and streams, food contaminated by the carcasses of infected animals or their excretions, laboratory cultures or clinical samples, and tissues from infected animals. Hunting or skinning animals, or contact with meat when preparing food, are important routes of exposure. Respiratory infections sometimes occur in farmers who are exposed through activities such as piling hay. Cases have been reported after mowing lawns, possibly from running over an animal carcass. Human infections have also been linked to handling infected animals or being bitten by them. Person-to-person transmission has not been reported.

### Disinfection

*F. tularensis* can be killed by variety of disinfectants including 1% hypochlorite, 70% ethanol, glutaraldehyde and formaldehyde. It can also be inactivated by moist heat (121°C for at least 15 min) and dry heat (160–170°C for at least 1 hour).

---

**Tularemia**

**Infections in Humans**

**Incubation Period**

The incubation period in humans can be 3 to 15 days; most often, clinical signs appear after 3 to 5 days.

**Clinical Signs**

Six forms of tularemia are seen in humans: ulceroglandular, glandular, oculoglandular, oropharyngeal, respiratory and typhoidal. The form of the disease depends on the inoculation site.

Ulceroglandular tularemia, the most common form, occurs after infection through the skin or mucous membranes. The initial clinical signs are nonspecific and may include fever, chills, headache, body aches and malaise. An inflamed papule usually develops where the bacteria entered the body. This papule turns into a pustule that ulcerates. In some cases, the skin lesion may heal by the time the patient seeks medical care; in others, it persists. The regional lymph nodes become enlarged and painful, and may suppurate and drain profusely. Unusual cases with a vesicular skin rash have also been reported. The vesicles contain clear fluid that becomes turbid with time. Vesicles may also be found around an ulcerated eschar. Glandular tularemia is identical to the ulceroglandular form, but there is no lesion to indicate where the organism might have been inoculated.

Inoculation of the conjunctiva, often by touching the eye with contaminated fingers, results in oculoglandular tularemia; this form is characterized by unilateral, painful, purulent conjunctivitis with preauricular and/or cervical lymphadenopathy. In some cases, there may be chemosis, periorbital edema and multiple small nodules or ulcerations on the conjunctiva. Corneal perforation and iris prolapse are possible complications.

Oropharyngeal tularemia occurs after eating or drinking the bacteria. In addition to nonspecific symptoms such as fever and malaise, patients develop exudative stomatitis and pharyngitis with pustules and ulcers. In some cases, the tonsils may also be inflamed. The lymph nodes in the neck are usually enlarged and tender, and abscesses may develop in these nodes. Lymph node enlargement often occurs on only one side. Gastrointestinal signs such as abdominal pain from mesenteric lymphadenopathy, as well as vomiting, diarrhea and gastrointestinal bleeding, are occasionally reported.

Respiratory (pneumonic) tularemia occurs after inhalation. The outcome varies with the organism. Inhalation of *F. tularensis holarctica* does not usually cause fulminating disease or pneumonia, and cases are not generally fatal; however, *F. tularensis tularensis* is more likely to cause serious disease. Sometimes, the only signs of respiratory tularemia are a cough, decreased breath sounds and substernal discomfort. In other cases, there may be a high fever, chills, malaise, coughing, chest pain,
dyspnea and other signs of pneumonia. Patients may be weak, and in some cases, delirious. Some patients have severe systemic signs such as high fever, nausea and vomiting, without obvious signs of respiratory disease. Unless treated promptly, the more severe forms of respiratory tularemia, especially those caused by *F. tularensis tularensis*, have a high case fatality rate. Pulmonary signs can also occur with any other form of tularemia, when the lungs are affected via hematogenous spread.

Typhoidal tularemia is the term used for severe cases without an obvious route of exposure. Most cases are probably the result of inhalation, but this form can also develop after skin inoculation or ingestion. The symptoms may include nonspecific signs such as fever, prostration, headache, nausea and weight loss. Some patients become extremely weak and develop recurring chills and drenching sweats. A nonspecific rash may be seen, but lymphadenopathy is usually absent. Pneumonia is particularly common in the typhoidal form and can be severe.

Complications of tularemia may include meningitis, endocarditis, osteomyelitis, kidney failure, hepatitis, disseminated intravascular coagulation and acute respiratory distress. People who have recovered from tularemia can develop localized papules without generalization of the lesions, if they are later exposed to large amounts of the bacterium.

**Communicability**

Person-to-person transmission has not been reported; however, infectious organisms can be found in the blood, lesions and tissues.

**Diagnostic Tests**

In humans, tularemia is often diagnosed by serology. Commonly used serological tests include tube agglutination, microagglutination and enzyme–linked immunosorbent assays (ELISA). Significant, detectable titers begin to appear at the end of the second week of infection, although some specific antibodies may be present within the first 7 days. Cross–reactions can occur with *Brucella* spp., *Legionella* sp., *Proteus* OX19, and *Yersinia* spp., usually at low titers.

Tularemia can also be diagnosed by isolating *F. tularensis* from blood or affected tissues/ exudates such as sputum, pharyngeal or conjunctival exudates, ulcers, lymph nodes and gastric washings. *F. tularensis* subsp. *novicida* can be isolated on standard media such as blood agar; however, *F. tularensis tularensis* and *F. tularensis holarctica* are fastidious and require thiol compounds such as cysteine. The latter two organisms can be isolated on cysteine heart agar with 9% chocolatized blood (CHAB), buffered charcoal yeast extract (BYCE), McCoy and Chapin medium, modified Thayer/Martin agar and other specialized media. On CHAB, *F. tularensis* colonies are distinctive and appear green, opalescent, raised and shiny after 24 to 48 hours. Some bacteria appear to inhibit the growth of *F. tularensis*, a problem in contaminated samples. An antibiotic supplemented CHAB medium (CHAB-A) can be helpful. *F. tularensis* from tissues may also form colonies on sheep blood agar, but it will not grow well on this medium after subculture. *F. tularensis* colonies can be identified using slide agglutination, immunofluorescence or polymerase chain reaction (PCR) assays. This organism is a non–motile, Gram negative coccobacillus, with bipolar staining in young cultures. Because it is very small and stains faintly with conventional stains such as Gram stain, it can be difficult to detect. *F. tularensis tularensis* can be distinguished from *F. tularensis holarctica* by glycerol fermentation and molecular methods including PCR. Culture and identification of the organism can take from 2 days to more than 2 weeks. Because it must be done at biosafety level 3 (BSL-3), this test not available in all diagnostic laboratories.

PCR can also identify *F. tularensis* in clinical samples. Some PCR tests can distinguish the subtype. Other molecular techniques such as restriction fragment linked polymorphism (RFLP) Southern blot, pulsed-field gel electrophoresis (PFGE) and multi-locus variable number tandem repeat assays (MLVA) can be used to identify strains for epidemiological studies. 16S rDNA sequencing can be helpful in areas where *F. tularensis* has not been reported before.

Immunohistochemical staining is also used in diagnosis. Histopathology can be helpful. ELISAs are occasionally used to detect antigens in tissues and secretions, but this technique is not used routinely to diagnose tularemia in humans.

**Treatment**

*F. tularensis* is susceptible to a number of antibiotics such as tetracyclines and quinolones. Early treatment avoids complications such as suppuration of the lymph nodes.

**Prevention**

Tularemia can be acquired in bites from arthropods, through contaminated food and water, or by direct contact with infected animals, their tissues or excretions.

Long pants, shirts with long sleeves, and long socks can reduce bites from a variety of insects including ticks, tabanid flies and mosquitoes. Any attached ticks should be removed promptly. Insect repellents that contain chemicals such as DEET can fend off ticks and mosquitoes. They are not effective against deer flies and horse flies. Because deer flies and horse flies are attracted to dark, moving objects, wearing light colors and a light colored baseball cap can be helpful, especially when it is warm and the insects are active. Additional methods of control include deer fly patches that attach to the backs of caps, and deer fly traps.

Hunters and others who handle wildlife and their carcasses should use gloves, and make sure that any breaks in the skin are covered. This precaution is particularly
important with rabbits, hares, beavers, muskrats, prairie dogs and other rodents. The hands should be washed with soap and water after handling the animal, and any equipment should be cleaned well. Game meat should be cooked completely. Veterinarians and their staff, as well as sheep ranchers, should use good infection control procedures and precautions when working with animals that may be infected. Particular care should be taken to avoid bites and scratches. Die-offs of rodents and lagomorphs should be reported. In endemic areas, dust masks may be helpful during activities such as piling hay or mowing the lawn. Water should be filtered or treated before drinking.

Precautions have also been published for laboratories that work with F. tularensis. At one time, a live attenuated vaccine was used in the U.S. to protect laboratory workers. This vaccine is under review by the US Food and Drug Administration and it is no longer available.

Controlling a tularemia outbreak relies on finding the source of the organism and applying specific measures to stop transmission. In the former USSR, widespread outbreaks after WWII were controlled by massive vaccination campaigns, aided by improvements in sanitary conditions after the war.

**Morbidity and Mortality**

Tularemia is an occupational hazard for hunters, butchers, farmers, fur/wool handlers, veterinarians, laboratory workers and others who come in contact with infected animals. In most countries, tularemia outbreaks are interspersed with periods during which only a few sporadic cases occur. Some outbreaks in humans have been linked to epizootics among animals. Epidemics can be seen during or after wars, when population explosions occur among rodents that have access to unharvested grain and other food sources, and these animals contaminate human food. One outbreak occurred in a sugar plant, and may have been caused by sugar beets contaminated with rodent excretions or carcasses. Other epidemics have been reported in people who hunted lagomorphs, hamsters or other species during epizootics in these animals, or who drank contaminated water. Human cases have also been associated with outbreaks in sheep. One unusual outbreak occurred among people who had been exposed to contaminated freshwater crayfish while fishing.

Infections caused by *F. tularensis tularensis* are more virulent than those caused by *F. tularensis holarctica*; the course is more likely to be fulminating and deaths are more common. Estimates vary, but before antibiotics, the overall case fatality rate for tularemia caused by *F. tularensis tularensis* was 5-15%, or possibly as high as 30%. Far fewer deaths were caused by *F. tularensis holarctica*. Antibiotics have reduced the overall case fatality rate from tularemia to 1-3%.

Ulcerglandular and glandular tularemia are the most common forms of disease caused by both organisms, occurring in at least 75 to 85% of cases. The case fatality rate for ulcerglandular tularemia is estimated to be 5% if it is untreated. The oculoglandular form is uncommon, and the prevalence of the oropharyngeal form varies with the region. The respiratory form of tularemia is often linked to farming activities. The case fatality rate varies widely for this form, depending on the subspecies of the organism, but it can be greater than 50% for untreated, severe cases. The typhoidal form may occur in 5 to 15% of cases. It is most often caused by *F. tularensis tularensis* and has the highest case fatality rate. Typhoidal tularemia would be expected to be the predominant form after an attack that used aerosolized *F. tularensis* in a biological weapon.

**Infections in Animals**

**Species Affected**

Nearly two hundred species of animals can be infected with *F. tularensis*. Common wild animal hosts include lagomorphs (cottontail rabbits, jack rabbits and hares), muskrats, beavers, and a variety of rodents including voles, field mice, vole rats, squirrels and lemmings. Among domesticated animals, sheep and cats seem to be particularly susceptible to clinical disease. Tularemia has also been seen in dogs, pigs, horses, nonhuman primates, ranched mink and captive prairie dogs; cattle seem to be relatively resistant. Infections have been reported occasionally in birds, reptiles, amphibians, crayfish, mollusks and fish; it is not known whether some of these cases were true infections or if the organism was acquired only temporarily from contaminated water.

Each subspecies of *F. tularensis* tends to be associated with certain host species. Lagomorphs are important hosts for *F. tularensis tularensis* in North America. *F. tularensis holarctica* is linked to muskrats (*Ondatra zibethicus*), American beavers (*Castor canadensis*) and voles (*Microtus spp.*) in North America, and to hares (*Lepus spp.*) and rodents in Europe. Little is known about the preferred hosts for *F. tularensis mediastatica*, which has been detected in hares and Gerbillinae (gerbils and their relatives), or *F. tularensis* subsp. novicida.

**Incubation Period**

The incubation period is 1 to 10 days.

**Clinical Signs**

The full spectrum of clinical signs is not known in animals, but syndromes corresponding to the typhoidal, respiratory, ulcerglandular and oropharyngeal forms have been reported. Septicemia is often reported in susceptible animals, but asymptomatic infections also seem to be common, especially in resistant species such as dogs and cattle.

Signs of septicemia may occur in wild mammals, domesticated rabbits and pet rodents, but many animals are found dead. Rabbits and rodents may be depressed, with anorexia and ataxia, a roughened coat and a tendency to
Tularemia

huddle. In an outbreak among captive prairie dogs, which probably spread by cannibalism, all of the animals had signs of the oropharyngeal form. The clinical signs also included emaciation, dehydration and lethargy.

In cats, infections often begin with the sudden onset of fever, lethargy, anorexia, and regional or generalized lymphadenopathy. The lymph nodes may suppurate and drain. The submandibular lymph nodes are often affected, and oral lesions including white patches or ulcers may be found. Pneumonia, icterus, hepatomegaly, splenomegaly, weight loss and vomiting have also been reported. Other syndromes can be seen. One infected cat had a chronic draining cutaneous lesion and swelling of the mandibular lymph nodes, but no systemic signs, for about a year before tularemia was diagnosed. In general, the case fatality rate seems to be high.

In contrast, dogs appear to be relatively resistant and may recover spontaneously. Clinical signs that have been reported in this species include anorexia, depression, mild fever, lymphadenopathy (which may be mild), draining abscesses, and mucoid ocular discharge or conjunctivitis. Experimentally infected dogs that were fed *F. tularensis* developed a self-limited illness with fever and mucopurulent discharge from the nose and eyes. Dogs that were inoculated intradermally had pustules at the inoculation site and regional lymphadenopathy.

Outbreaks in sheep are usually characterized by late term abortions in ewes, and illness and deaths among lambs. Fever, listlessness, regional lymphadenopathy and diarrhea may be seen. Adult sheep can have systemic signs, but this is uncommon. Although serological evidence suggests that infections are fairly common in cattle, a specific syndrome has not been described, and many cases may be asymptomatic. Tularemia has been diagnosed rarely in sick calves.

Nonspecific signs including lethargy, anorexia, vomiting, diarrhea, generalized lymphadenopathy, pale mucous membranes and cutaneous petechiae have been reported in nonhuman primates. Some animals have died acutely.

Communicability

*F. tularensis* occurs in blood and tissues. This organism has also been reported in the feces and urine of some animals. Infected animals can transmit tularemia to arthropod vectors. In an outbreak among prairie dogs, *F. tularensis* was probably transmitted between the animals by cannibalism. Outbreaks in sheep might follow epizootics among lagomorphs or rodents, and infections appear to be acquired via ticks.

Human cases have been associated with cats, pet rodents, dogs, prairie dogs and sheep, as well as wild animals. Tularemia has been transmitted to people in bites from cats, a pet hamster and a dormouse, as well as in a scratch by a buzzard. In some cases, cats that transmitted the bacterium were not ill, and may have been colonized temporarily after contact with a rodent. Human infections linked to dogs include a case of typhoidal tularemia in a child who had probably been infected via saliva from a sick puppy, and seven cases of respiratory tularemia in people who had been exposed to dogs that hunted rabbits. In the latter case, people were apparently infected when the wet dogs shook themselves.

Post Mortem Lesions

Animals with acute tularemia are often in good body condition, but they may also be dehydrated, thin or emaciated. Oral lesions can occur in animals that were infected by ingestion. The liver, spleen and lymph nodes are frequently enlarged, and the affected lymph nodes may contain areas of caseous necrosis. Miliary, grayish–white, white or light yellow necrotic foci are often noted in the liver, spleen, bone marrow, lungs and/or lymph nodes. Some of these foci may be barely visible. In rabbits, the pale necrotic foci on a dark, congested liver and spleen have been compared to the Milky Way. The lungs are often congested and edematous, and they may contain areas of consolidation and fibrinous pneumonia or pleuritis. Ulcerative enteritis, associated with necrosis of Peyer’s patches, can also be seen, and icterus occurs in some cats. More resistant species may have chronic granulomas that resemble tuberculosis lesions.

Diagnostic Tests

*F. tularensis* is zoonotic, and samples must be collected, handled and shipped with care. The receiving laboratory should be consulted before collecting or shipping samples.

Impression smears of the liver, spleen, bone marrow, kidney, lung or blood may be helpful for a presumptive diagnosis; small Gram negative coccobacilli can sometimes be found inside cells and scattered among tissue debris. *F. tularensis* is very small (0.2–0.7 µm) and easy to miss, it stains faintly with conventional stains such as Gram stain, and it can look like stain precipitates. Organisms are more likely to be found in impression smears with immunofluorescence. Immunohistochemistry can detect antigens in tissue sections, and ELISAs have been used to find antigens in tissues and secretions from animals, or in environmental samples such as water and mud.

*F. tularensis* can be isolated from enlarged lymph nodes, blood, and tissues including liver, spleen and bone marrow; the overgrowth of other bacteria may prevent recovery from animals that are found dead. *F. tularensis* subsp. novicida can be isolated on standard media such as blood agar; however, *F. tularensis* tularensis and *F. tularensis* holarctica are fastidious and require thiol compounds such as cysteine. The latter two organisms can be isolated on cysteine heart agar with 9% chocolate medium, modified Thayer/Martin agar and other specialized media. On CHAB, *F. tularensis*
colonies are distinctive and appear green, opalescent, raised and shiny after 24–48 hours. On McCoy and Chapin medium, the colonies are small, prominent, round and transparent. Confluent, milky, mucoid colonies develop on Francis medium and modified Thayer/Martin agar. Organisms from tissues may also form colonies on sheep blood agar, but they will not grow well on this medium after subculture. Some bacteria seem to inhibit the growth of *F. tularensis*, a problem in contaminated samples. An antibiotic supplemented CHAB medium (CHAB-A) can be helpful in this situation. *F. tularensis* colonies can be identified using slide agglutination, immunofluorescence or PCR. The organism is a Gram negative coccobacillus with bipolar staining in young cultures, but bacteria from older cultures may be pleomorphic. *F. tularensis tularensis* can be distinguished from *F. tularensis holarctica* by glycerol fermentation and molecular methods including PCR. Culture and identification of the organism can take from 2 days to more than 2 weeks. Because it must be done at biosafety level 3 (BSL-3), this test is not available in all diagnostic laboratories.

PCR can also identify *F. tularensis* in clinical samples. Some PCR tests can distinguish the subtype. Other molecular techniques such as RFLP Southern blot, PFGE and MLVA can be used to identify strains for epidemiological studies. 16S rDNA sequencing can be helpful in areas where *F. tularensis* has not been reported before.

Serology is occasionally useful in animals. Species sensitive to tularemia typically die before specific antibodies develop; however, significant titers may be found in more resistant animals such as sheep, cattle, pigs and dogs. Serological tests include tube agglutination, microagglutination and ELISA. A rising titer should be seen. Cross-reactions may occur with other bacteria including *Yersinia* spp., *Brucella* spp. and *Legionella* spp.

### Morbidity and Mortality

Tularemia is relatively common and highly fatal in some species of wild animals; epizootics occur regularly among rabbits and rodents. Susceptibility varies among domesticated animals. Epizootics of tularemia were once common among range sheep in Idaho, Montana and Wyoming, and occasional outbreaks can still occur. The morbidity rate/abortion rate in this species can be as high as 50%. Mortality rates up to 10-15% are seen in untreated lambs, but adult sheep do not usually develop systemic signs. Cats seem to be relatively susceptible to tularemia. Sick cats often have severe clinical signs, and the mortality rate is high if the disease is not treated early. However, milder cases are reported occasionally, and some cats with no history of disease are seropositive. Dogs, cattle and some other species seem to be relatively resistant, and may have milder clinical signs.

### Internet Resources

- Centers for Disease Control and Prevention (CDC). Tularemia
  - [Tularemia](http://www.cdc.gov/Tularemia/)
- CDC. Emergency Preparedness and Response. Tularemia
- Public Health Agency of Canada. Material Safety Data Sheets
- Medical Microbiology
- The Merck Manual
- The Merck Veterinary Manual
  - [http://www.merckvetmanual.com/mvm/index.jsp](http://www.merckvetmanual.com/mvm/index.jsp)
- University of Rhode Island. Deer and horse flies.
  - [http://www.uri.edu/ce/factsheets/sheets/deerhorseflies.html](http://www.uri.edu/ce/factsheets/sheets/deerhorseflies.html)
- World Organization for Animal Health (OIE)
  - [http://www.oie.int](http://www.oie.int)
- OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
  - [http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/](http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/)
- OIE Terrestrial Animal Health Code
  - [http://www.oie.int/international-standard-setting/terrestrial-code/](http://www.oie.int/international-standard-setting/terrestrial-code/)


*Link defunct as of 2009