The ecology of tularaemia

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Summary: Tularaemia, a zoonotic disease caused by the bacterium Francisella tularensis McCoy, 1912, is reported from North America, Europe and northern parts of Asia, but not from the Southern Hemisphere. Two subspecies of F. tularensis are recognised: the highly virulent type A and the milder type B, with additional subdivisions reported.

Tularaemia has been reported in more than 250 animal species including man, other mammals, birds, fish, amphibians, arthropods and protozoa.

Type A is reported to have a terrestrial cycle with the main reservoirs being cottontail rabbits (Sylvilagus spp.) and ticks. Type B is reported to have a mainly water-borne cycle with aquatic rodents as reservoirs, e.g. muskrats (Ondatra zibethicus) and beaver (Castor canadensis) in North America, and ground voles (Arvicola terrestris) in the former Soviet Union.

In Europe, tularaemia is most frequently seen in hares (Lepus spp.) although hares probably do not constitute a reservoir for the disease.

Tularaemia is transmitted by direct contact with infected animals, through contaminated water or food, or by vectors such as mosquitoes or ticks.

The disease normally occurs as an epidemic, both in man and in animals, depending on the types of reservoir involved and the means of transmission at different times of the year.


INTRODUCTION

Tularaemia was first reported as a new plague-like disease of California ground squirrels (Citellus spp.) by McCoy in 1911 (13) and the bacterium Francisella tularensis was isolated in 1912 (14). The disease was probably present in the Old World much earlier (26), and it is believed that the "lemming-fever" in Norway reported by Horne in 1911 (6) was tularaemia.

Natural infections with F. tularensis have been found in 145 species of vertebrates including lagomorphs, rodents, insectivores, carnivores, ungulates, marsupials, birds, amphibians and fish, and in 111 species of invertebrates (24).

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Tularaemia is a zoonosis which can be transmitted to man in several different ways, causing four clinically different types of disease, depending on the means of transmission (10).

**BACTERIA**

Two subspecies of *F. tularensis* are recognised – the virulent *F. t. biovar tularensis* (type A), which is found only in North America and is fatal for man, and the less pathogenic *F. t. biovar palaearctica* (type B), which is not fatal for man and is found throughout the Northern Hemisphere (7). Two additional subdivisions of type B can be identified, namely *F. t. p. biovar japonica*, and *F. t. p. biovar mediasiatica* (23).

The identified biovars can be differentiated by biochemical tests, such as the ability to ferment glycerol, the possession of the enzyme citrulline ureidase, and antibiotic sensitivity patterns (27). The different biovars of *F. tularensis* have similar antigenic composition and cannot be differentiated by ordinary serology (2). Recently, deoxyribonucleic acid (DNA) hybridisation has been demonstrated to provide a sure means of differentiating types A and B (5).

No virulence factors of *F. tularensis* have yet been identified, although differences in virulence within a single strain have been observed (20).

*F. tularensis* is a facultative intracellular parasite (27). The defence mechanism in the host is cell-mediated and the humoral system is of less importance (3).

Outside the host, the bacteria can survive for a long time (up to ten months) under low temperatures (24), and the ability of *Francisella* to survive in water is well documented (7).

**EPIDEMIOLOGY**

Different “cycles” of tularaemia are reported from different countries depending on the type of bacteria, the reservoir and the means of transmission or vector. Jellison (7) describes tularaemia as a disease of “higher” animals naturally transmitted to other animals. However, despite many studies which report vertebrates as reservoirs of tularaemia, invertebrates such as ticks also act as reservoirs for the disease (24).

In North America, two main epidemiological systems are identified, namely tick-borne tularaemia of rabbits (Lagomorpha) and water-borne tularaemia of true rodents (Rodentia) (7). Ninety percent of the human cases of tularaemia in the United States of America are tick-borne. At least 70% of these cases are infected with *F. t. tularensis* (type A) related to contact with cottontail rabbits (*Sylvilagus* spp.) (10). Olsufjev and colleagues (25) state that the evolution of the genus *Francisella* has followed the evolution of the family *Leporidae*, in that *F. t. tularensis* has developed together with *Sylvilagus* spp. and *F. t. palaearctica* together with *Lepus* spp.

Water-borne tularaemia of true rodents, which also affects other animals, is the source of 5-10% of human infections in North America (10) and is caused by *F. t. palaearctica* (type B). In North America, this cycle involves beavers (*Castor canadensis*) and muskrats (*Ondatra zibethicus*) (7).
In the Old World, where only type B is found, several different cycles exist. In the former Soviet Union, tularaemia in man has been linked to the presence of epizootics among ground voles (*Arvicola terrestris*), domestic mice (*Mus musculus*) and voles (*Microtus* spp., *Clethrionomys* spp.) (26).

In Central Europe, tularaemia is most often observed in hares (*Lepus europaeus, L. timidus*) and small rodents (11).

In Scandinavia as well, tularaemia is most frequently found in the mountain hare (*L. timidus*) (1) but is also reported in several different species of rodents and birds (17). It has never been diagnosed in European brown hares in Sweden, despite the fact that this species is common (19).

The animal reservoir for tularaemia in Europe has not been established, although the disease in man is most frequently observed at the same time as epizootics in animals, mainly hares (11, 17). In Sweden, there is a clear correspondence between the number of cases of tularaemia in animals and in humans (Fig. 1).

Tularaemia can be transmitted between animals and from animals to man in several different ways. In North America, direct contact with infected animals is responsible for the majority of cases (7), although transmission by vectors such as deer flies (*Chrysops* spp.) or ticks (*Dermacentor* spp., *Haemaphysalis* spp.) occurs frequently. Contamination of water with *F. tularensis* and subsequent infections in animals (beavers, muskrats) and man is also a common feature (8, 9).

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**FIG. 1**

Cases of tularaemia in mountain hares (*Lepus timidus*) investigated at the National Veterinary Institute and human cases of tularaemia reported to the National Bacteriological Laboratory in Sweden from 1973 to 1985.
In the former Soviet Union, tularaemia is reported to be transmitted by vectors such as ticks (*Ixodes* spp.) or mosquitoes (*Aedes, Culex, Anopheles* spp.) (24), by direct contact with infected animals or by contaminated water (24, 26).

In Central and Western Europe, the disease in man is normally linked to direct contact with sick or dead hares (11) during epizootics in these species, although epidemics of water-borne tularaemia are also reported (15).

In Sweden, tularaemia in both man and mountain hares is most often transmitted by mosquitoes (4, 19, 22). Tick-borne (18) and air-borne tularaemia (4, 28) is also reported in Scandinavia.

**PATHOLOGY AND DIAGNOSIS**

The diagnosis of tularaemia is difficult for a number of reasons, and the disease is probably often overlooked at necropsy in several animal species.

The pathology of tularaemia differs between species depending on the susceptibility to infection with *F. tularensis* (24). In sensitive species, such as the mountain hare, tularaemia is an acute infectious disease with coagulation necrosis in liver, spleen and bone marrow (2, 19) (Fig. 2). In less sensitive species, the disease causes chronic inflammatory changes with proliferative reactions composed of vacuolated macrophages, epitheloid and giant cells in lymph nodes (28). In most species, the general picture is that of acute disease, although sometimes no visible lesions are observed upon macroscopic examination (19).

**FIG. 2**

Pinpoint-sized necrotic foci in liver, spleen and bone marrow of a mountain hare (*Lepus timidus*) which died from acute tularaemia
The diagnosis of tularemia cannot be based exclusively on pathology, since other infectious diseases can cause similar lesions (2). Post-mortem findings must be verified by laboratory findings (21). It is normally very difficult to grow *F. tularensis* from carcasses sent for examination (19). The most reliable way to establish diagnosis is to use immunological methods, such as fluorescent antibody technique, either on fresh imprints (12) or on paraffin-embedded material (16).

**CONCLUSIONS**

Tularemia is a disease with an extremely complex epizootiology and little is known about the wide range of factors regulating the appearance of the disease in nature and the impact of the disease on population ecology.

*F. tularensis* can infect a great variety of animal species in different ways, ranging from fatal infections causing mass mortality to subclinical infections. It has been reported that *F. tularensis* can circulate in human populations for a long time before severe disease is recognised (28).

Factors influencing the ecology of tularemia are the virulence of *F. tularensis*, climate, accessibility of suitable hosts and vectors, density of animal populations and host resistance to infection.

To improve knowledge on the ecology of tularemia, there is a need for long-term studies on the appearance of the disease in different animal species and for studies on antibody levels to *F. tularensis* in different species.

*ÉCOLOGIE DE LA TULARÉMIE. – T. Mörner.*

**Résumé :** La tularémie est une affection zoonotique due à une bactérie, *Francisella tularensis* McCoy, 1912. Elle est présente en Amérique du Nord, en Europe et dans le nord de l'Asie mais elle est absente de l'hémisphère Sud. Deux sous-espèces de *F. tularensis* sont connues : le type A qui est hautement virulent et le type B qui l'est moins. Des subdivisions supplémentaires ont été décrites.

La tularémie a été signalée chez plus de 250 espèces dont l'Homme, les autres mammifères, les oiseaux, les poissons, les batraciens, les arthropodes et les protozoaires.

Le type *A* est connu pour son cycle terrestre, les principaux réservoirs étant les lapins du genre *Sylvilagus* et les tiques. Le type *B* a un cycle essentiellement aquatique avec, pour réservoirs, des rongeurs aquatiques tels que le rat musqué (*Ondatra zibethicus*) ou le castor (*Castor canadensis*) en Amérique du Nord et le campagnol terrestre (*Arvicola terrestris*) dans l'ex-Union Soviétique.

En Europe, la tularémie est surtout fréquente chez les lièvres (*Lepus* spp.) mais ces animaux ne constituent probablement pas un réservoir de la maladie.

La tularémie se transmet par contact direct avec les animaux infectés, par l'eau ou la nourriture infectée ou par des vecteurs tels que les moustiques et les tiques.
La maladie revêt en principe les caractères d'une épidémie, aussi bien chez l'Homme que chez l'animal, et dépend des types de réservoirs en cause et des modes de transmission caractéristiques des différentes époques de l'année.


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ECOLOGÍA DE LA TULAREMIA. – T. Mörner.

Resumen: La tularemia es una afección zoonótica provocada por la bacteria Francisella tularensis McCoy, 1912. Es señalada en América del Norte, Europa y el norte de Asia, pero no en el hemisferio sur. Se conocen dos subespecies de F. tularensis: el tipo A, de gran virulencia, y el tipo B, de virulencia menor. Se han descrito también subdivisiones suplementarias.

Se señaló tularemia en más de 250 especies, entre las cuales el hombre y otros mamíferos, aves, peces, artrópodos y protozoarios.

El tipo A se conoce por su ciclo terrestre, siendo sus principales reservorios los conejos del género Sylvilagus y las garrapatas. El tipo B tiene un ciclo fundamentalmente acuático y son sus reservorios los roedores acuáticos como la rata almizclera (Ondatra zibethicus) o el castor (Castor canadensis) en América del Norte o el topo de monte (Arvicola terrestris) en la ex Unión Soviética.

En Europa, la tularemia es frecuente sobre todo en las liebres (Lepus spp.), pero es probable que estos animales no sean un reservorio de la enfermedad.

La tularemia se transmite por contacto directo con los animales infectados, por el agua o los alimentos infectados o por vectores tales como mosquitos o garrapatas. Tiene en principio las características de una epidemia, tanto en el hombre como en los animales, y depende del tipo de reservorios involucrados y de los modos de transmisión según las diferentes épocas del año.


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REFERENCES


