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MYCOBACTERIAL DISEASES IN WILDLIFE

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Abstract: *Mycobacterium* infections occur in numerous wildlife species worldwide and this bacterial genus can also cause disease in humans and livestock. Two *Mycobacterium* species and one subspecies that infect wildlife are important from a wildlife damage management perspective. *Mycobacterium avium*, avian tuberculosis, is a ubiquitous and cosmopolitan disease of wild and domestic birds. Wild and domestic ruminants are host to *M. avium paratuberculosis,* also known as Johne's disease. Finally, *Mycobaterium bovis*, bovine tuberculosis, is primarily associated with domestic and wild bovines and ungulates, but also infects many other species of mammals. Eradicating these diseases from wildlife populations is very difficult if not impossible. Preventing spill-over into domestic livestock herds is also problematic. We review the *Mycobacterial* diseases in wildlife and discuss their implications to livestock and human health. Our emphasis is on bovine tuberculosis and the current outbreak in northern Michigan, USA.

Key words: Avian tuberculosis, bovine tuberculosis, Johne's disease, livestock disease, *Mycobacterium*, wildlife damage management, wildlife disease

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INTRODUCTION

Wildlife diseases continue to be a major concern worldwide, especially as they affect human and livestock health and highly-valued wildlife populations. Some are "newly arrived or discovered" such as hantavirus and West Nile Virus, while others have been around a long time (e.g., plague, tuberculosis). With extensive, frequent, and increasing worldwide travel and commerce, there is a continuing concern that new diseases will arrive in the USA. Diseases such as smallpox, foot-and-mouth disease, swine cholera, or mad cow disease could be economically devastating should they enter the country.

We review the group of diseases caused by *Mycobacterium* species. This bacterial genus comprises some 72 species and several subspecies. At least 32 of the species and subspecies can cause disease in humans, livestock, or wildlife. In most cases, these diseases are contagious, cause chronic infection, and have a wide host range. The three main groups of serious disease concern are *Mycobacterium leprae*, the *Mycobacterium avium* complex, and the *Mycobacterium tuberculosis* complex. Several of the diseases are well established in North America and cause health, economic,

and wildlife population management concerns. In particular, we will emphasize the bovine tuberculosis outbreak in northern Michigan. In our overview, we have used reviews on human tuberculosis and leprosy (Benenson 1995, Williams 2001), avian tuberculosis (Friend 1999, Lamberski 1999, Williams 2001), paratuberculosis (Johne's disease, Jessup and Williams 1999, Williams 2001), and bovine tuberculosis (O'Reilly and Daborn 1995, Bengis 1999, Whipple and Palmer 2000, Clifton-Hadley et al. 2001). Lamberski (1999) also reviewed the zoonotic implications of other, nontuberculous members of the genus *Mycobacterium*. A large body of literature on *Mycobacterium* exists and readers are referred to those reviews for additional references.

MYCOBACTERIUM LEPRAE

This organism causes leprosy (Hansen's disease) in humans. Leprosy is a very slow-growing bacterium and is not highly contagious. There are both cutaneous and neural forms. It occurs mostly in the topics and subtropics, but the incidence in most parts of the world is low. The disease was formerly endemic to parts of Florida, Louisiana, Texas, and Hawaii. Patients in the USA were mostly treated at a facility in Louisiana. The disease has not been considered important in wildlife populations, but has occurred in free-ranging armadillos (*Dasypus novemcinctus*) in Texas and Louisiana at least since the early 1980s (Williams 2001). The source of the infection in armadillos has not been determined.

MYCOBACTERIUM AVIUM COMPLEX

There are three important subspecies in this group: *M. a. avium*, *M. a. sylvaticum*, and *M. a. paratuberculosis*. The first of these, also known as avian tuberculosis, is ubiquitous and causes disease in birds. The disease is most often found in wild birds that live in close association with humans and domestic stock (e.g., sparrows, *Passer* spp.; starlings, *Sturnus* spp.) or in avian scavengers (e.g., crows, *Corvus* spp.; gulls, *Larus* spp.)(Friend 1999). When a captive flock of birds becomes infected, it is best to destroy the flock because treatment is ineffective and not all infected birds will be detected; unfortunately, the site can remain contaminated for many months (Friend 1999). Exposure to a contaminated environment (water, food, soil) is thought to be the main route of transmission. Avian tuberculosis can be a significant disease in chickens (Lamberski 1999), but is normally avirulent to humans unless they are immuno-compromised. Wild mammals are commonly exposed to the disease, but clinical disease is rare. Mink, *Mustela vison*, various species of rabbits, pigs, and nonhuman primates may be exceptions and anorexia, diarrhea, emaciation, and weight loss may occur (Friend 1999, Williams 2001). Unfortunately, exposure in humans and mammals can cause cross-reactions and confusion when skin testing for bovine tuberculosis or human tuberculosis.

The situation with *M. a. sylvaticum* is somewhat similar to avian tuberculosis. The organism is ubiquitous and can cause disease in birds and mammals, notably, wood pigeons (*Columba palumbus*) in Eurasia (Williams 2001). It is thought to rarely cause clinical disease in wildlife, but does affect skin-testing for other tubercular diseases.

The third disease in this group, Johne's disease, is caused by *M. a. paratuberculosis*. This is primarily a disease of both domestic (including farmed elk, *Cervus elaphus*) and wild ruminants, including camelids (Williams 2001). While clinical disease has been found in many species of wild ungulates, it is rarely reported. It is occasionally found in rabbits and nonhuman primates. The disease affects the gastro-intestinal tract and infected animals may exhibit a gradual loss of body condition, poor hair coat, intermittent diarrhea, and

anorexia (Williams 2001). In general, young animals are the most susceptible. Infected animals eventually shed the bacteria in their feces, often long before showing clinical disease. Ingestion of the organism by susceptible animals is the typical route of transmission. The organism can persist in the environment for at least one year. Diagnosis is problematic in live animals, requiring fecal culture.

The control of Johne's disease in free-ranging and captive populations of wildlife is very difficult (Jessup and Williams 1999). Prevention of infection is preferable, but veterinary oversight of herd health and management is essential. Practices can include quarantine, testing, and culling of test-positive animals. Sanitation of facilities and pastures is also very important. Control methods for the disease in free-ranging populations are impractical or impossible, although increased culling and hunter harvest have been used in some cases. Unfortunately, with 20 years of effort, the disease has not been eliminated in populations of tule elk (*Cervus elaphus nannodes*) and Bighorn sheep (*Ovis Canadensis*)(Williams 2001). To protect livestock herds, it is important to prevent contact with free-ranging ruminants and to only purchase or move animals between paratuberculosis-free herds (Jessup and Williams 1999).

There continues to be a concern that there may be a relationship between Johne's disease and Crohn's disease, a chronic inflammatory bowel disease of humans (Lamberski 1999, Williams 2001). This controversial issue continues to be studied.

MYCOBACTERIUM TUBERCULOSIS COMPLEX

There are four species involved in this group: *M. tuberculosis*, *M. africanum*, *M. microti*, and *M. bovis* (Whipple and Palmer 2000). The first of these, human tuberculosis, is primarily a disease of humans although nonhuman primates and elephants are very susceptible. Individuals of other species (e.g., cats, dogs, birds, horses) are occasionally found to be infected, but the disease is not considered important to other species (Williams 2001). Tuberculosis is a very serious human disease worldwide, and is the leading cause of death from a single infectious agent; it is estimated that about 1/3 of the Earth's human population is infected with tuberculosis (Whipple and Palmer 2001). Small outbreaks of the disease occasionally occur in the USA when infected individuals arrive from other countries. A major concern with human tuberculosis is that multiple-antibiotic-resistant strains are becoming more common and are very difficult to treat (Navin et al. 2002). The disease is also a serious problem in many zoos where various animals have become infected and can transmit the disease to zookeepers (Williams 2001). *M. africanum* is a similar disease of humans, although rarer, that was first isolated in Africa (Clifton-Hadley 2001).

M. microti is a disease of voles and other rodent species in Europe (Clifton-Hadley 2001). Little is reported on this disease, and it is considered of little importance to humans, livestock and wildlife populations.

Bovine tuberculosis, *M. bovis*, is the most significant disease in this group for wildlife and for having significant implications for livestock and humans. This disease has a wide host range worldwide and is a serious disease of cattle (Whipple and Palmer 2000). It is a common disease in humans where un-pasteurized milk is consumed. In most species, the disease causes a slow debilitation of health, although it may remain non-clinical for many years in infected animals (Clifton-Hadley 2001). The disease can be transmitted by inhalation or by ingestion of contaminated materials. The organism can persist for months in the environment, especially under cool, moist

conditions.

Bovine tuberculosis causes large economic losses to the cattle industry worldwide and intensive efforts to eradicate the disease have occurred and are on-going. Unfortunately, where the disease occurs in free-ranging wildlife populations, it has not been possible to eliminate the infection from domestic herds (O'Reilly and Daborn 1995). The wildlife host varies by country (O'Reilly and Daborn 1995, Clifton-Hadley 2001). In the United Kingdom, the European badger (*Meles meles*) is the primary host, while in South Africa it is the African buffalo (*Syncerus caffer*). In New Zealand, the primary hosts are non-native and include brush-tailed possum (*Trichosurus vulpecula*) and ferret (*Mustelo putorius*), although a large portion of red deer/elk (*Cervus elaphas*) are also infected. In some parts of Canada, infected, free-ranging bison (*Bison bison*), elk, and mule deer (*Odocoileus hemionus*) have been a chronic problem.

BOVINE TUBERCULOSIS IN THE USA

In the USA, bovine tuberculosis is one of several livestock diseases programmed for elimination in the country (USDA 2000). The USDA Animal and Plant Health Inspection Service (APHIS) made major progress in eliminating this disease in livestock over the past decades. This eradication program largely involves nationwide surveillance of cattle at slaughter plants and a test-and-cull program of cattle herds in areas where the disease is known to occur (Whipple and Palmer 2000). When an infected animal is found, a Atrace-back@ and "trace-forward" system is used to locate any potentially-infected herds which are then quarantined and tested for bovine tuberculosis. Infected animals are destroyed or the entire herd may be destroyed. By the mid-1990s, only a few known infected herds remained and it looked like the eradication of the disease in domestic livestock in the U.S. was within sight. However, the final instances of a disease are often the most difficult to find and eliminate. The levels of surveillance conducted by USDA have been low in some years, but there are now efforts to vastly expand surveillance where there has been reoccurring infection (USDA 2000).

In recent years, there have been tuberculosis outbreaks or infected cattle herds in four states: Michigan, Texas, New Mexico, and Hawaii (Whipple and Palmer 2000) It now appears that captive cervid populations and free-ranging wildlife may be hindering efforts to eradicate the disease in at least two of those states. Although infection rates are low, white-tailed deer (*Odocoileus virginianus*), elk, and several species of carnivores have tested positive in Michigan (Schmitt et al. 2002). Infected axis deer (*Cervus axis*), feral swine (*Sus scofa*), and mongoose (*Herpestes auropunctatus*) have been found in Hawaii. The source of the problem in Texas and New Mexico has not been determined, although it has been speculated that wildlife (perhaps avian species or carnivores) coming into contact with infected cattle herds in Mexico may be responsible. It is also possible that the movement of infected cattle from Mexico to adjacent areas of the U.S. is responsible in some cases.

Large economic costs are incurred by a state and the livestock industry when the state loses its bovine tuberculosis-free status (USDA 2000). It is estimated that Michigan will incur losses of $22-74 million over a 5-year period. In Texas, the losses could be between $260 million and $1.1 billion over a 5-year period.

The bovine tuberculosis prevalence rates in infected free-ranging cervid populations are often reported to be about 1-5%, although the rates can be much higher in captive cervid herds (O'Reilly and Daborn 1995). These rates, however, are usually based on the detection of gross lesions and

many animals may be infected, but not show gross lesions or the lesions are so small as to be overlooked. Because of the low prevalence rates in deer, it is thought that deer populations alone may not be able to maintain the disease. Hence, some other wildlife reservoirs may be involved or the passage of the disease back and forth between cattle and free-ranging deer may be involved.

Bovine tuberculosis may be sub-acute or chronic in deer and most infected deer appear healthy (Clifton-Hadley 2001). All ages of deer may be infected and prevalence rates increase with age. Some deer show clinical signs within 6 months of being infected, while others may survive for years with no evidence of infection. Coughing or obvious respiratory problems are rarely observed in deer. In advanced stages, some deer may appear emaciated and some may die suddenly with no clinical signs evident. There are no reliable, practical methods of testing deer for infection. Instead, animal health personnel rely upon the culturing of bovine tuberculosis bacteria from post-mortem tissues of lesions or lymph nodes. When an infected deer is processed by a hunter or meat processor, it is rarely obvious that the deer they are processing is infected. Fortunately, it appears that the risk of human infection from this activity is very low.

In Michigan, the original focal point of the disease outbreak in cattle has expanded considerably in area. Various measures are being, or have been, implemented in an interagency attempt to slow the spread of the disease. These include more testing of cattle herds, destruction of infected cattle herds, liberal hunting seasons to reduce deer density, and restrictions on the artificial feeding of deer to avoid concentrating deer in small areas where disease transmission is more likely (Schmitt et al. 2002). Much of the property in the outbreak area is under the ownership of private deer hunting clubs with greatly restricted access to the general public or governmental personnel, making sampling and deer population management very difficult. Additionally, deer hunting in Michigan is a highly valued industry, providing the State=s economy with an estimated $1 billion per year. Michigan serves as a good example of the challenges and controversy surrounding disease management when a highly valued public resource, wildlife, is involved.

Despite a large, interagency effort in northern Michigan, the disease persists in the deer population, new farms continue to become infected, and there has been re-infection of some farms after cattle removal and clean-up operations. The deer density has been substantially reduced and the prevalence rate of the disease in deer has dropped to about 2%, but it has leveled off there. Studies have revealed a very low number of direct (<5 m) interactions between deer and cattle, but a large number of indirect (>5 m) interactions. A large number of wildlife species occur at various times near these farms, including activity within barns. Studies and management efforts to reduce proximity of wildlife to livestock and their feed on farms are underway. Studies are also being conducted to identify sentinel species of wildlife (e.g., coyote, *Canis latrans*; raccoon, *Procyon lotor*; opossum, *Didelphis virginianus*) that might be more effective and cost-efficient than deer in monitoring the presence of bovine tuberculosis in the region. It will also be important to identify farm risk factors and to determine farm management methods to reduce the risk of bovine tuberculosis infection to farms in the region (e.g., Kaneene et al. 2002).

CONCLUSIONS

Mycobacterial diseases occur worldwide and cause significant impacts to wildlife, livestock, and humans. Clearly, the reduction of threats posed by *Mycobacterial* infections to livestock pose significant

challenges to the health care profession and to livestock and natural resource managers. Increased surveillance along with a better understanding of their transmission routes, environmental persistence, and associated risk factors are needed if we are to effectively prevent, control or eradicate these diseases (Wobeser 1994). Strategies to better protect farms and captive wildlife populations are needed. It would also be helpful to have validated ante-mortem tests for wildlife. Current research efforts in wildlife management methods (e.g., fertility control, vaccines and effective delivery systems) could, potentially, greatly aid in the establishment and maintenance of disease-free wildlife populations.

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