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Introduction

Our western rangelands support a wide variety of species including ruminants that are exquisitely suited to make use of these renewable resources. Domestic ruminants utilizing these rangelands include cattle, domestic sheep, and less frequently, at least in the northern Great Plains and intermountain west, domestic goats. Wild ruminants, in numbers, variety, and quality not found anywhere else in North America, include mule deer, pronghorn, and elk. White-tailed deer frequent the riparian areas, moose are found in low numbers in forest lands, bighorn sheep inhabit rough breaks and the higher altitudes, and free-ranging bison are found around the national parks in Wyoming and Montana. Domestic and wild ruminants have many biological, physiologic, and behavioral similarities, as well as considerable differences. These ruminants consume similar forages, share salt licks and blocks, and seek out the same sources of water in our desert/semidesert region. Thus it is not surprising that they may share diseases. The purpose of this paper is to review what we know about some of the diseases that domestic and wild ruminants may exchange and to put the potential for sharing diseases into perspective.

Bovine Virus Diarrhea

Bovine virus diarrhea (BVD) is caused by a *Pestivirus* called bovine virus diarrhea virus. There are many strains of BVD virus and virologists have been isolating and characterizing many of them over the last few years. It is a common cause of disease in beef cattle and most producers vaccinate for this disease. BVD infection results in several disease manifestations in cattle - the most important being infection of the fetus. Depending on many factors, but especially the age of the fetus when infected, the fetus may die and be aborted, may suffer in utero illness and be born with congenital defects, or it may become infected and remain a carrier of the virus for life. These animals are called "persistently infected" or "PI" animals and they are the most significant carriers of the virus which may then infect other members of the herd. If a cow becomes infected as an adult they typically do not become clinically ill, but if the cow is pregnant she may pass the virus through the placenta to the fetus. If an animal is already infected by BVD virus and is then infected with a different BVD virus, a severe form of BVD may occur which is caused "mucosal disease". To make things worse, in the last several years a particularly virulent strain of the BVD Type 2 virus has been causing death in adult cattle in northeastern and northern midwest North America.

Until fairly recently there has been relatively little interest in the possible occurrence of BVD virus in wild ruminants. With the exception of bison and some experimental infections of caribou in the laboratory, BVD virus doesn’t appear to cause significant illness in wild

ruminants; however, because little research attention has been directed at the question of the effects of BVD in these animals that view may change. Van Campen and colleagues reviewed what is currently known (Van Campen and Williams, 1996; Van Campen et al., 2000). Surveys of wild ruminant using blood tests (serology) to detect antibodies have been conducted in many wild ruminant species over the years and these studies have found that pestiviruses are present in some wild herds. One significant problem in understanding the relationship of the pestiviruses that occur in wild ruminants and those that occur in cattle is that there have been few isolates of viruses from wild ruminants. This is a problem because the blood tests only indicate there has been exposure to closely related viruses (there are significant cross-reactions on these tests). To really know what is going on it is necessary to isolate the virus in culture so that there can be direct comparison of various pestivirus isolates.

Based on serologic surveys, a few virus isolations, and limited experimental studies in wild ruminants it is apparent that at least bison, elk, mule deer, white-tailed deer, pronghorn, and caribou among North American wild ruminants may serve as hosts for pestiviruses, including BVD virus. It is not known how these viruses may be maintained in herds of wild ruminants. We do not know if persistently infected individuals may occur. Because of the biological similarities of bison and cattle, it is likely that bison may become persistently infected, though this has never been documented. It is less clear if this could occur in members of the deer family. Given the rigors of life of free-ranging wild ruminants, and the generally poor growth and vigor of persistently infected carriers of BVD virus, even if they should occur they probably would not survive for long.

Because the pestiviruses are quite delicate in the environment, transmission from one animal to another requires fairly close contact (for example by aerosol or nose-to-nose contact) between the animal shedding the virus and the susceptible animal. This close direct contact could occur between cattle and wild ruminants on range but is probably not a very common event. We know persistently infected cattle can shed the virus, thus wild ruminants could become infected by contact with one of these animals. Persistently infected wild ruminants have never been identified (but are possible), thus transmission of the virus from wild ruminants to cattle is less likely. Because information on the dynamics of BVD virus and other pestiviruses in wild ruminants is scant, more research is needed.

THE BOTTOM LINE. The most significant source of BVD virus for range cattle is the persistently infected bovine carrier within the herd and not wild ruminants.

Leptospirosis

Leptospirosis is a bacterial infection of many domestic and wild animals caused by various serovars of *Leptospira interrogans*. There are hundreds of different serovars of this bacterium and only a few seem to cause disease in ruminants. In cattle, serovars *pomona* and *harjo* are among the most common pathogenic serovars. A problem with serologic surveys for evidence of infection by *Leptospira* is the degree of cross-reactivity among the various serovars. This makes determination of the actual infecting serovar difficult without isolation of the bacterium, which is very tricky and time consuming.

Leptospirosis in cattle is typically characterized by abortion. It may be significant in particular herds or areas, but in general is not a major cause of beef cattle abortion in our area. Where it is significant, vaccines are used. Transmission of this bacterium is thought to be primarily through contamination of water because the bacterium is shed in the urine. Small mammals are important carriers of some serovars. Our dry environment may reduce the importance of leptospirosis in our region. However, concentration of wild and domestic animals around a water hole could potentially facilitate transmission of the bacterium.

Surveys of wild ruminants for antibodies against *Leptospira* have been conducted for many years and seropositive deer, elk, bison, and pronghorn are occasionally found (Thorne et al., 1982). Rarely are wild ruminants found to have antibodies against serovar *pomona* in the western range states and provinces. Studies of pronghorn in the early 1980s in Colorado showed a moderate prevalence of antibodies against *Leptospira interrogans* serovar *harjo*. After several years of monitoring, the prevalence declined. There was no indication that this infection caused illness in wild pronghorn or cattle sharing range, though experimental infection demonstrated that this bacterium could infect the fetus resulting in death of fawns. These studies also showed that pronghorn could shed the bacterium in the urine for long periods of time, thus potentially serving as a source for this serovar. Occasionally bison have been identified with antibodies against *Leptospira* and in one herd high antibodies against serovar *pomona* were found along with relatively poor reproduction. It was not determined if leptospirosis was responsible for this problem.

THE BOTTOM LINE. While both cattle and wild ruminants may become infected with *Leptospira interrogans* with few exceptions the serovars they maintain are different and interspecies transmission is not significant.

Brucellosis

Brucellosis is a bacterial infection caused by *Brucella abortus*. This disease is nearly eradicated in cattle in the United States thanks to the successful State-Federal Brucellosis Eradication program that has been ongoing for about 60 years. Colorado, Wyoming, and Nebraska are considered brucellosis free. An infected privately owned bison herd is present in South Dakota. Unfortunately, brucellosis is harbored by free-ranging elk and bison in the Greater Yellowstone Area (including northwestern Wyoming, parts of southern Montana, and parts of eastern Idaho). Brucellosis does not occur in free-ranging elk, bison, deer, or pronghorn outside the Greater Yellowstone Area.

The presence of brucellosis in elk and bison has generated considerable controversy involving many perspectives on management of wildlife, livestock grazing, and use of public lands (Thorne et al., 1991; Cheville et al., 1998). The brucellosis problem in wildlife is not easily resolved either biologically or politically. The Greater Yellowstone Interagency Brucellosis Committee was formed of state and federal agencies with the goal of eradicating the disease in wildlife by the 2010. A recent National Academy of Science/National Research Council study reviewed the biology and controversy surrounding this issue (Cheville et al., 1998).

Brucellosis is maintained in elk of the Greater Yellowstone Area because they are concentrated during the winter period by artificial feeding. Winter feeding was started early in the 1900s by an act of congress and by the state of Wyoming due to starvation of large numbers of elk associated with loss of natural winter range in the Jackson Hole area because of development and ranches. The practice has been maintained to the present time to reduce damage to domestic hay stacks, to keep hungry elk off of cattle feedlines in this deep snow area, and to stabilize numbers of elk in northwestern Wyoming. Bison can maintain brucellosis in their populations because behaviorally they calve in herds which facilitates transmission of brucellosis; feeding is not required for bison to maintain the infection.

The most important sign of brucellosis in cattle, bison, and elk is abortion of the first calf following infection. After this the cows typically carry calves to term. Transmission from one animal to another most often occurs at the time of abortion or when and infected calf is born; huge numbers of bacteria are expelled with the fetus or calf, placenta, and associated fluids. Bulls are not significant in transmission of brucellosis. The *B. abortus* found in elk and bison is the same organism that causes brucellosis in cattle, under experimental conditions it has been transmitted from elk and bison to cattle, and while transmission from the wild ruminants to cattle in the wild is extremely unlikely, it remains a remote possibility. The controversy surrounding this disease is due to the probability of transmission, which is low, but should it occur would seriously impact the cattle industries in the region and possibly the country. Various management options to eradicate this disease in bison and elk have been proposed including vaccination, habitat management, buffer zones, test-and-slaughter, and combinations of the above. Solving this problem will undoubtedly be a long-term process.

THE BOTTOM LINE. Brucellosis occurs in bison and elk of the Greater Yellowstone Area; the likelihood of transmission to cattle is extremely low, but possible, and the consequences would be great. Brucellosis does not occur in free-ranging wild ruminants outside of this area.

Paratuberculosis (Johne's Disease)

Paratuberculosis, also called Johne's disease, is caused by a bacterium *Mycobacterium avium* subspecies *paratuberculosis*. In cattle, this disease is of greatest concern in the dairy industry and, while beef cattle are susceptible, it seems to cause much less of a problem in beef herds. This is likely due to management differences and, in our region, because the environment probably is not very suitable for maintenance of the bacterium. It causes chronic infection of the intestine, with resulting diarrhea, and loss of condition and poor production. Over the last few years there has been growing concern about paratuberculosis with recognition that infected animals, even if they appear healthy, do not perform as well as uninfected animals; thus there is a significant economic impact to infection. Paratuberculosis is not a major problem in our area.

The bacterium is shed in the feces of affected animals and transmission is "fecal-oral". Calves appear to be more susceptible to infection than adults, however, the incubation periods are long and clinical signs are typically only seen in adult cattle. Considerable exposure to the bacterium is likely needed for infection to take place. The bacterium is relatively resistant in the environment, but it is susceptible to drying and ultraviolet radiation in sunlight which probably

reduces survival of the bacterium in much of the west.

Paratuberculosis is insignificant in free-ranging wild ruminants in the west with the exception of a few herds of bighorn sheep and mountain goats in Colorado and a herd of tule elk in California. (Jessup and Williams, 1999). However, it is being identified with increasing frequency in privately owned bison and elk.

THE BOTTOM LINE. Paratuberculosis is not common in beef cattle or wild ruminants in our area and interspecies transmission among these species is not likely.

Respiratory Viruses

The most important respiratory viruses of beef cattle, bovine respiratory syncytial virus and parainfluenza 3 virus, are common and may cause disease alone or in combination with bacteria resulting in pneumonia. These viruses are delicate and are transmitted among cattle by aerosol and "nose-to-nose" contact. Most producers vaccinate for these viruses.

Serologic surveys have shown that many wild ruminants carry antibodies against both of these viruses though clinical disease is probably not common. However, some researchers feel that parainfluenza 3 virus may occasionally cause serious disease in bighorn sheep. High serologic prevalences in many herds of wild ruminants (bison, bighorn sheep, pronghorn) suggest that these viruses are probably maintained and transmitted within these herds.

The viruses carried by wild ruminants have not been compared to those of beef cattle using modern molecular techniques but it is likely they are similar enough so that they could infect any of these ruminant species. However, because transmission requires close contact between animals during the time when they are actively shedding the virus, interaction among animals within a herd maintains the virus. Transmission between wild ruminants and beef cattle probably is rare.

THE BOTTOM LINE. While the respiratory viruses, particularly parainfluenza 3 virus, are found in beef cattle and wild ruminants, they are probably are self-maintained within herds, and interspecies transmission, while possible, is probably rare.

Bluetongue and Epizootic Hemorrhagic Disease

These disease are caused by similar orbiviruses and are "arthropod-borne" viruses which require a vector (*Culicoides variipenis*, midges, no-see-ums) for transmission. These blood sucking insects take in the virus from the blood of an infected animal, the virus replicates in the midge, and then when they subsequently feed, the virus is injected into another host. Beef cattle are susceptible to infection by these viruses but they seldom have overt clinical disease. However, they may develop antibodies which may interfere with the ability to export, because some jurisdictions do not allow entry of seropositive cattle. In contrast to the relatively mild to nonexistent diseases caused by these viruses in cattle, bluetongue and epizootic hemorrhagic disease may kill large numbers of white-tailed deer, mule deer, and pronghorn. There are many

questions about the natural history and dynamics of these viruses, especially in the western United States. For example, it is not known how these viruses are maintained in our area over the winter. Environmental conditions which favor the midge vectors, such as increased rainfall and late frosts, may increase the likelihood that outbreaks of bluetongue and epizootic hemorrhagic disease will occur. Because a vector is involved, transmission is not directly between beef cattle and wild ruminants.

THE BOTTOM LINE. Bluetongue and epizootic hemorrhagic disease may cause significant mortality of deer and pronghorn but seldom causes significant illness in cattle. These viruses require an insect vector and transmission is not directly between cattle and wild ruminants.

Chronic Wasting Disease

Chronic wasting disease (CWD) is a disease of mule deer, white-tailed deer, and elk (Williams and Young, 1992) which is related to bovine spongiform encephalopathy (BSE) of cattle, scrapie of domestic sheep and goats, and Creutzfeldt-Jakob disease of humans. Cattle producers are most familiar with BSE, which was devastating to the cattle industries of the United Kingdom and from which they are only now beginning to recover. Bovine spongiform encephalopathy is considered to be an exotic disease in North America and extensive surveillance by USDA and state diagnostic laboratories has been uniformly negative.

Chronic wasting disease and the other diseases listed above are grouped together and referred to as the transmissible spongiform encephalopathies. Though the actual cause of these infections is not known, many researchers feel that infectious proteins or "prions" are the agents responsible. In free-ranging deer and elk, CWD only occurs in the southeastern corner of Wyoming and the northcentral and northeastern portion of Colorado. Since 1996 it has been found in privately owned elk on game farms in Saskatchewan, South Dakota, Oklahoma, Nebraska, Colorado, and Montana.

There is no evidence that CWD naturally affects cattle but because of the similarities of this disease to BSE there is concern that cattle might be susceptible. Thus integrated studies are underway to test the possibility that transmission from deer and elk to cattle might be possible. One ongoing study is determining if beef cattle are susceptible to CWD by intracerebral inoculation. This obviously is nothing that could ever occur in the real world and is an extreme challenge, but if cattle develop CWD it would provide researchers with information on what the clinical signs are and what the lesions would look like. More realistic exposure studies are being conducted by giving cattle the CWD agent by mouth in a one-time feeding. Oral exposure was chosen because this is the most likely naturally route of transmission. Other ongoing studies include housing cattle with deer and elk in wildlife research facilities where CWD naturally occurs. The goal of these studies is to determine if transmission between the species could occur by contact. And finally, both Wyoming and Colorado have been actively involved in the national surveillance program for BSE or other spongiform encephalopathies in cattle, especially in the CWD endemic areas. To date, there is no evidence that CWD is transmissible to cattle.

THE BOTTOM LINE. Chronic wasting disease occurs in deer and elk in localized areas of

Colorado and Wyoming. To date there is no evidence that CWD is naturally transmissible to cattle.

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