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**PROBLEMS WITH "MULTIPLE LAND USE" DEALING WITH BIGHORN SHEEP AND DOMESTIC LIVESTOCK**

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Abstract: Under the multiple land-use concept, the interaction of bighorn sheep (*Ovis canadensis*) with domestic livestock has produced 4 problems. These problems are utilization of range resources by domestic livestock, displacement of sheep from valuable range, interbreeding, and disease. These 4 problems with emphasis on the transmission of diseases are discussed. Viral, chlamydial, rickettsial, mycoplasma, bacterial and parasitic diseases that are potential hazards to bighorn sheep are described.

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The first documented problem associated with intermixing of domestic animals with bighorns was the transmission of infectious diseases. These diseases including anthrax, *Pasteurella* sp. and scabies were devastating to bighorn sheep populations in the late 1800s and early 1900s (Buechner 1960). In recent years there has been increased awareness of the problem of domestic animal and bighorn sheep interactions. The concept that has been promoted for years, "Multiple Land Use," in regard to grazing different species of ruminants on the same range needs reevaluation. Grazing and/or intermixing of domestic sheep, cattle and exotic ruminants with bighorn sheep may not be an acceptable management strategy.

Four problems affecting bighorn sheep that share range with domestic sheep and cattle have been observed. The first is utilization of forage by cattle, domestic sheep and exotic ruminants. Some ranges used by cattle and domestic sheep, referred to as "high summer ranges" are critical winter ranges for bighorn sheep. When bighorn sheep arrive on these critical winter ranges, they may find them overgrazed by domestic animals. This can significantly reduce winter nutrition for bighorn sheep.

Another problem is displacement of bighorns. When domestic sheep and cattle occupy a bighorn range, bighorn sheep may abandon that part of their original range occupied by the domestic animals. If this occurs over an extended period of time these bighorn sheep may permanently lose some of their range. This problem with range occupancy can also be secondary to utilization by other wildlife such as elk and deer, and human activity. McCollough (1982) found that only 4-5% of the preferred range of the Trickle Mountain herd of bighorn sheep was used by cattle, but in my opinion this is a real problem that needing further investigation.

A third problem is interbreeding. Occasionally, bighorn rams, especially young rams, will leave their herds and travel long distances. These rams will occasionally intermix with domestic sheep and breed receptive ewes. These rams can easily contract diseases and bring these diseases back to their original herds or to other bighorn herds. These young rams may also transmit endemic diseases between bighorn sheep herds. On the other hand, stray bands of domestic sheep may run with bighorns and not only introduce diseases but introduce their genes into the bighorns.

Lastly, there is the generic problem of transmission of diseases from domestic and exotic ruminants to bighorn sheep. Viral, chlamydial, rickettsial, bacterial and parasitic diseases that potentially can be transmitted between domestic sheep and cattle and bighorns will be described. The following is not a complete list, but includes the more common diseases found in domestic sheep and cattle.

Viral diseases of domestic sheep and cattle that may be transmitted to bighorn sheep include bluetongue (BT), contagious ecthyma (CE), bovine respiratory syncytial virus (BRSV), parainfluenza type-3 (PI-3), ovine progressive pneumonia (OPP), caprine arthritis/encephalitis (CAE), scrapie, bovine virus diarrhea (BVD), and ulcerative dermatosis (UD). Of these BT, CE, BRSV, and PI-3 have been diagnosed in bighorn sheep.

Bluetongue is a noncontagious, infectious, orbivirus of ruminants that is spread by Culicoides. BT is primarily a disease of domestic sheep. Cattle appear to be the reservoir host but rarely suffer illness from the virus. Four serotypes of BT are present in the United States (Barker and Van Dreumel 1985). It is not certain which serotypes infect bighorn sheep. BT appears to be pathogenic in desert bighorn lambs and is believed to predispose lambs to pneumonia (Jessup and DeForge, pers. commun.). BT has been seen on 2 occasions in captive bighorn sheep that were penned within 1 to 2 miles of domestic sheep in Colorado. The disease caused an acute hemorrhagic enterocolitis in these 2 Rocky Mountain bighorn sheep (Spraker unpubl. data). BT has not been diagnosed as a cause of mortality in free-ranging Rocky Mountain bighorn sheep in Colorado.

Contagious Ecthyma is an important disease in bighorn sheep. CE is common in domestic sheep and goats and is caused by a parapoxvirus. CE is characterized by proliferative lesions around the margins of the lips, muzzle and teats (Yager and Scott, 1985). Domestic sheep are routinely vaccinated for CE. CE has been diagnosed in desert and Rocky Mountain bighorn sheep (Samuel 1975). CE causes a severe proliferation dermatitis around the nose, lips and teats in bighorns. CE may be severe in young lambs and can result in mortality. Although CE can cause lesions in adults, it usually does not result in mortality. However, if animals are on poor range or if CE affects them during the winter, apprehension of food can be difficult. As a result, adult animals could starve. CE is transmitted among animals by direct contact, especially from dam to neonate via nursing, by contamination of the environment and by contact with dogs. The virus that is shed from scabs of infected animals can persist on the ground up to 10 years.

Bovine Respiratory Syncytial Virus is a common disease of cattle (Dungworth 1985) and has been found in desert and Rocky Mountain bighorn sheep throughout the western United States (Dunbar et al. 1985). A respiratory syncytial virus (BHS-RSV) has been isolated in a bighorn lamb with pneumonia from a herd suffering from a all-age die-off in Ouray, Colorado. Pasteurella haemolytica biotype T was also isolated from this

lamb (Spraker et al. 1986). The virulence of this virus is not known and the role it plays in all-age die-offs is not understood. However, BRS-RSV and Pasteurella haemolytica biotype T were isolated from bighorn sheep lungs in 2 herds suffering from a respiratory disease in Colorado during the winter of 1989-1990. In one herd (Estes Park), the sheep only manifested mild clinical signs characterized by coughing and serous nasal discharge. Mortality was not observed in this herd. On the other hand, the Powderhorn Canyon herd suffered extensive mortality. One major difference between these two herds is that the Estes Park herd is treated for Protostrongylus and has a extremely low lungworm burden, whereas, the Powderhorn Canyon herd has a relative high lungworm load. The importance of Protostrongylus in the mortality suffered by the Powderhorn Canyon herd is not known, but in the authors opinion probably plays an important role (Spraker unpubl. data).

Parainfluenza type-3 is an important virus in cattle and domestic sheep (Dungworth 1985). PI-3 titers have been found in numerous Rocky Mountain and desert bighorn herds throughout the western United States (Howe 1966). PI-3 may be an important viral agent predisposing bighorns to bacterial pneumonias. Viral infection leading to bacterial pneumonia has been documented in domestic sheep, cattle and pigs (Dungworth 1985). Therefore, this pathogenesis may occur in bighorn sheep.

Ovine progressive pneumonia is a lentivirus disease that causing chronic interstitial pneumonia in domestic sheep (Dungworth 1985). This disease is transmitted among domestic sheep by close contact, to lambs during the first days of life, and is transplacentally transmitted. Animals affected with OPP usually do not manifest clinical signs until they are 3 to 4 years old. In Colorado, approximately 225 free-ranging bighorn sheep from the Estes Park and Georgetown herds have been tested for OPP, but antibodies have not been found (Spraker unpubl. data).

Caprine arthritis encephalitis is a retroviral infection (similar to OPP) characterized by neurological, respiratory and arthritic lesions in domestic goats. CAE is transmitted via carrier animals and milk and is common in domestic goats (Jubb et al. 1985). Titers to CAE have not been found in free-ranging bighorn sheep. However, 2 desert bighorn lambs that were seronegative to OPP/CAE were fed goat colostrum and both converted to seropositive. These 2 animals were released in the wild, but died due to encephalitis at approximately 18 months of age (D. Jessup pers. commun.).

Scrapie is a chronic infectious disease affecting the central nervous system of domestic sheep and is present throughout the western United States (Sullivan 1985). Six cases of scrapie were diagnosed in Colorado in 1989. A scrapie-like disease has also been found in 3 free-ranging mule deer and a free-ranging elk in Colorado (Spraker unpubl. data). This disease usually is transmitted to the newborn lamb. Clinical signs in affected animals do not appear until the animal is 2 to 4 years old. Free-ranging bighorns are probably susceptible to scrapie, although none have been diagnosed.

Bovine Virus Diarrhea is primarily a disease of cattle. A virus similar to BVD causes border disease or "hairy shakers" in domestic sheep (Barker and Van Dreumel 1985). Titers to BVD have occasionally been found in free-ranging bighorns in Colorado. The importance of BVD in bighorn sheep is unknown.

Ulcerative dermatosis is an uncommon disease of domestic sheep characterized by ulcerative lesions of the lips, face, legs, feet, vulva, prepuce and penis. UD is caused by an unclassified poxvirus. Transmission

is by direct contact and coitus. This disease is potentially transmissible to free-ranging bighorns especially at common water holes and by interbreeding with domestic sheep (Yager and Scott 1985).

Chlamydia is a common infectious agent of domestic sheep and cattle. Chlamydia can cause upper respiratory disease, keratoconjunctivitis, arthritis, and abortion in these animals (Dungworth 1985, Jubb et al. 1985). It is a common cause of abortion in domestic sheep in Colorado. Chlamydia have been isolated from bighorn sheep (Pearson and England 1979) and appear to be able to cause an upper respiratory infection, keratoconjunctivitis, and arthritis in these animals. Abortion associated with chlamydia in bighorn sheep has not been documented. Since chlamydia is common in domestic sheep and cattle, it should be monitored in bighorn sheep populations. Chlamydia has been isolated from 3 bighorn sheep herds in Colorado, including Almont Triangle, Trickle Mountain and Grant. Ocular lesions and upper respiratory signs were associated with this chlamydial infection in 1 herd (Grant) after it was placed in captivity (Spraker unpubl. data).

Anaplasma ovis is a tick-transmitted rickettsial organism occurring in domestic sheep. The organism affects erythrocytes and causes anemia (Valli 1985). Anaplasmosis has been diagnosed in desert bighorns in Mexico. It is not known if this disease can be transmitted from domestic sheep to bighorn sheep, or if the organism of domestic sheep is the same agent described in Mexican bighorns. Caution should be taken if Mexican bighorns are transplanted into the United States. Titer to A. ovis has been detected in desert bighorn sheep in southern California (D. Jessup pers. commun.).

A mycoplasma agent (Mycoplasma arginini) has been isolated from bighorn lambs with pneumonia in 1970 from Pike's Peak, Colorado (Spraker 1979). The organism has also been isolated from captive bighorns (Al-Aubaidi et al. 1972). Mycoplasma pneumonia caused by Mycoplasma ovipneumoniae is present in domestic sheep (Dungworth 1985). Mycoplasma pneumonia may be transmitted from domestic sheep to bighorn sheep, but there has been no evidence to directly implicate domestic sheep for transmitting this disease.

Numerous bacterial diseases affect both domestic and bighorn sheep. Anthrax transmitted from domestic sheep was believed to have killed numerous bighorn sheep in the late 1800's (Buechner 1960). Anthrax is an acute bacteremia caused by Bacillus anthracis that produces postmortem lesions similar to those observed in acute septicemic pasteurellosis (Valli 1985).

Pasteurellosis is a common disease causing septicemia/bronchopneumia in bighorn and domestic sheep. Pasteurellosis was blamed for the death of bighorn sheep in the early 1900's. It was believed to have been transmitted from domestic sheep (Buechner 1960). Several types of Pasteurella, including Pasteurella multocida and Pasteurella haemolytica biotypes A and T, have been found within the nasal cavity, tonsil and lung of domestic and bighorn sheep. These organisms have been isolated from both sick and healthy bighorns. Species of Pasteurella isolated from domestic sheep can potentially cause an acute fulminating pneumonia in bighorn sheep (Foreyt and Jessup 1982, Onderka and Wishart 1988, Foreyt 1989). Circumstantial evidence suggest that some of the Pasteurella spp. of domestic sheep are highly pathogenic to bighorn sheep; conversely Pasteurella spp. of bighorn sheep are probably not pathogenic to domestic sheep (Onderka and Wishart 1988). Pasteurella play a major role in the

pathogenesis of all-age die-offs and lamb mortality of bighorn sheep. Of all the bacterial species that affect bighorn sheep, Pasteurella is probably the most important.

Johne's disease or paratuberculosis is an important bacterial disease caused by Mycobacterium paratuberculosis and occurs in domestic sheep, cattle, goats, bighorns, Rocky Mountain goats and most exotic ruminants (Williams and Hibler 1982, Barker and Van Dreumel 1985). Bighorn sheep and Rocky Mountain goats in the Mount Evans/Grant herds west of Denver, Colorado are infected with paratuberculosis. This disease causes a chronic granulomatous enteritis. Clinical signs include intermittent diarrhea and emaciation. Animals contract the disease in the first 3 to 4 months of life and usually do not manifest clinical signs until 2 to 4 years of age. Johne's disease can be transmitted transplacentally. In an infected domestic bovine, ovine, or caprine herd the disease kills approximately 5-10% of the animals in the herd each year (Barker and Van Dreumel 1985). Paratuberculosis is an extremely important disease that should be guarded against to avoid transmission to other bighorn herds. If Johne's disease is diagnosed, the infected herd is not a suitable source for transplants.

Brucellosis, both Brucella abortus and B. ovis, occur in the western United States and affect both domestic sheep and cattle. B. abortus causes abortion in cattle and has a potential of being transmitted to bighorns in areas where cattle and bighorn ranges overlap. Approximately 350 bighorn sheep sera from 4 herds (Estes Park, Georgetown, Sugarloaf/Terryalls, and Cottonwood Canyon) in Colorado have been tested for B. abortus and all were negative (Spraker unpubl. data). B. ovis is common in domestic rams in Colorado. This disease is spread primarily through breeding. A bighorn ram entering into a domestic sheep herd and breeding with estrus ewes could acquire this organism and transmit it to other wild sheep. This organism causes little to no harm to ewes but causes an chronic suppurative epididymitis in rams and reduces fertility. Titers to B. ovis have been found in free-ranging bighorn sheep throughout Colorado (Severin unpubl. data).

Bacterial diseases of domestic sheep and cattle that have not been diagnosed in bighorn sheep include Campylobacter intestinalis, leptospirosis, and Foot Rot. C. intestinalis is a common cause of abortion in domestic sheep in the western United States. Leptospirosis is a disease of cattle and sheep and has the potential of being transmitted to bighorn sheep. The primary agent of foot rot is Bacteroides nodosa. This is a chronic infection of the interdigital area and hoof and leads to lameness. This disease has not been found in bighorn sheep. Caseous lymphadenitis, Corynebacterium ovis, is an important disease of domestic sheep in the western United States. This disease is caused by Corynebacterium ovis. This bacteria is a wound contaminant and probably not a significant disease that would be transmitted to bighorn sheep.

Numerous parasitic diseases may be transmitted to bighorn sheep. Probably most important is scabies. Older literature suggests that scabies of domestic sheep is transmissible to bighorn sheep. However, documentation has not been made. Recent work suggests a difference between the scabies mite from domestic sheep compared to the mite of bighorn sheep and cattle. Until it is determined if the scabies of domestic cattle or sheep is transmissible to bighorns, precautionary measures should be taken to avoid contact between infected animals.

Oestrus ovis is a

parasitic larva of a fly that lives in the frontal sinuses of domestic sheep. This parasite has been found in desert and Rocky Mountain bighorn sheep (Capelle 1966). This organism appears to be more of a problem in desert bighorns than in Rocky Mountain bighorns. O. ovis maybe responsible for, or at least associated with, a condition called chronic frontal sinusitis which can be fatal to desert bighorn sheep.

Demodex is a mite found in domestic sheep and cattle. A case of demodectic mange in Rocky Mountain bighorn sheep has recently been found (Spraker unpubl. data). The Rocky Mountain sheep with Demodex sp. did not have clinical signs of dermatitis. The significance of this finding and the possibility of transmission between domestic sheep and cattle to bighorn sheep has not been determined.

Bighorn sheep are susceptible to at least 2 species of lungworms, Protostrongylus and Muellerius. Muellerius is transmissible between domestic sheep and bighorn sheep; Protostrongylus is not. Muellerius occurs in a few domestic sheep populations in the western United States. Muellerius capillaris was involved in a die-off of captive bighorn sheep (DeMartini and Davis 1977). Muellerius has only been found in free-ranging bighorns from South Dakota (Spraker unpubl. data).

The lungworm, Protostrongylus, of bighorn sheep is not transmissible to domestic sheep. There are 2 species of Protostrongylus, P. stilesi and P. rushi. P. rushi lives in the bronchi and bronchioles of the lung, whereas P. stilesi lives in the alveolar spaces. Experimental transmission of these parasites to domestic sheep have failed (R. Lange pers. commun.). Protostrongylus appears to be associated with Pasteurella in causing all-age die-offs and lamb mortality in bighorns (Marsh 1938).

Elaeophora schneideri is a filarial nematode that inhabits the carotid arteries of mule deer. It is transmitted by horseflies (Hybomitra and Tabanus). Horsefly activity is primarily in June/July. Domestic sheep, goats, elk, and moose are susceptible and infection may be fatal (Hibler and Adcock 1971). There is no reason why bighorn sheep should have a natural resistance. Under normal conditions, bighorns are not in ideal horsefly/mule deer habitat in June/July; but with some recent bighorn sheep transplants, this natural protection may be eliminated. This indiscrete transplanting of bighorns may place them on ranges of endemic diseases of other wildlife. Bighorns should not be transplanted into areas of known endemic elaeophorosis.

The above list of disease is not complete. Many known and unknown diseases pose a threat to bighorn sheep populations. If bighorn sheep, domestic sheep, cattle, and exotic ruminants are allowed close contact due to multiple land use, many diseases may be transmitted to the bighorn sheep.

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