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Sheep Pneumonia Final Project

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Pneumonia in Bighorn Sheep (*Ovis canadensis*)

Listed on the U.S. Fish and Wildlife Service's endangered species list, bighorn sheep (*Ovis canadensis*) face many issues surrounding habitat loss and destruction as well as disease. Bighorn sheep are greatly valued by Indigenous peoples and are often an excellent source of wildlife viewing, proving to be very important socially to people in the western United States ("Pneumonia and bighorn sheep" n.d.). Focusing on disease, bighorn sheep are negatively impacted by pneumonia. This pneumonia is caused primarily by *Mycoplasma ovipneumoniae*, an infectious agent affecting the lungs of bighorn sheep (Plowright et al. 2017). This disease has proven to be a population-limiting disease among bighorn sheep in the west, giving it importance in the field of wildlife management (Besser et al. 2012). This disease has hindered the success and contributed to a drastic decline in wild bighorn sheep populations ever since European settlement in the western United States, another concern for wildlife managers (Besser et al. 2021).

The transmission of *M. ovipneumoniae* to bighorn sheep is highly dependent upon populations of domestic sheep (*Ovis aries*). Although domestic sheep populations do not directly co-exist with bighorn sheep populations, the interaction between the two species is nearly impossible to avoid. *M. ovipneumoniae* is transmitted from these domestic populations to bighorn populations through various direct interactions the two groups have. Often, domestic populations are not heavily impacted by the infection of *M. ovipneumoniae*, and instead act as carriers and also as natural reservoirs for the disease. These domestic sheep harbor and grow the pathogen and assist in transmitting it to other sheep in their herd as well as other populations. Upon interacting with bighorn populations, domestic sheep transmit the disease through direct contact, specifically nose to nose contact. *M. ovipneumoniae* proves to be a very fatal infection for bighorn sheep (Sells et al. 2015). About 50-80% of the individuals of an affected herd will die from an infection of *M. ovipneumoniae*, causing pneumonia in sheep ("Bighorn Sheep Pneumonia | U.S. Geological Survey" n.d.).

There are many causes of pneumonia in bighorn sheep, however, it has been discovered that *M. ovipneumoniae* is more than often the primary infecting agent. Although this pathogen acts as the primary infectant, it is not the only factor into the complex nature of pneumonia in bighorn sheep. However, for research purposes, *M. ovipneumoniae* is most deeply studied, as it is the most common and uniform cause for pneumonia in bighorn populations, and its transmission is more easily followed (Cassirer et al. 2018). It should also be noted that *M. ovipneumoniae* is not at risk of transmission to humans, posing no threat to the health of ranchers and handlers of domestic sheep, and wildlife game managers of bighorn sheep populations ("Pneumonia in bighorn sheep" n.d.).

The signs of infection among bighorn sheep are quite apparent, with symptoms including fever, nasal discharge, and difficulty breathing. That being said, the levels of infection can also range quite drastically. The most severe cases of *M. ovipneumoniae* infection occur when the pathogen degrades the cilia in the bronchi and trachea of bighorn sheep. This then opens the lungs up to a secondary

infection cased by otherwise harmless bacteria and even dust particles (Cassirer et al. 2018). Other factors contributing to pneumonia in sheep include poor nutrition, hot weather, and overall unclean environmental and living conditions (Department of Jobs 2021). Infections of the lungs are not uncommon among any organism due to the organs' increased contact with the aggressions of the environment, especially the environment of farm animals. After exposure and infection of *M. ovipneumoniae*, sheep become increasingly sensitive to extra infection (Mekibib et al. 2019). Unfortunately, this infection may occur many days and even weeks before symptoms begin to appear. Seemingly healthy sheep may be infected, and fall gravely ill within days of infection, having poor effects on conservation efforts, as disease can spread widely in a very quick manner (Cassirer et al. 2018). This infection pattern is apparent in bighorn sheep, however, in domestic populations, infection appears to be quite different. While domestic sheep can suffer severe infection, many have a built-up immunity to *M. ovipneumoniae* from a young age. Because of this, domestic populations harbor *M. ovipneumoniae* as well as many other strains and bacteria (Cassirer et al. 2018). This resilience allows for easy transmission to bighorn sheep upon contact, as ranchers are often never aware of the infections their sheep possess.

Pneumonia rarely affects one individual in a population. Unfortunately, M. ovipneumoniae infections often result in mass die-off events among bighorn populations. This is because as populations of bighorn sheep become heavily infected, M. ovipneumoniae can spread not only by direct contact, but may also become slightly airborne. Because of this, many individuals of a population, if not the whole population become infected (Cassirer et al. 2018). As previously mentioned, bighorn sheep are more often than not severely impacted by *M. ovipneumoniae*, and often develop severe pneumonia. These infections are often deadly, and result in mass die-offs of a population within a relatively short period of time.

As with any disease or infection, there is great variability within populations in the immunity against infection. For example, some members of a population will be severely impacted, while others show little to now sign of severe or chronic infection. Normally, these differences in immunity are population based, with most members of a certain population facing similar immunities. Differences in immunity are often caused by differences in exposure. Those populations that have been exposed to *M. ovipneumoniae* from a young age develop a higher immunity than those who are exposed only in adulthood. Not only is this still somewhat misunderstood, the concept of re-infection is also one that is not entirely understood. Although many individuals have built up immunity to *M. ovipneumoniae*, re-infection is not a rare occurrence. Both domestic and bighorn sheep are susceptible to becoming infected more than once by *M. ovipneumoniae*, a phenomena that is still not entirely understood (Cassirer et al. 2013).

Differences in exposure also explain the differences between bighorn populations compared to domestic populations. Domestic populations are exposed to *M. ovipneumoniae* starting at a much younger age than bighorn sheep populations. Because of this, domestic sheep are more prone to becoming carriers of the disease as opposed to actually presenting severe symptoms (Cassirer et al. 2013). Transmission rates also depend heavily on the rates of interaction between populations of domestic and bighorn sheep populations as well. The exposure of populations to *M. ovipneumoniae* is reliant upon how large their roaming range is. The further the range, the more likely that a bighorn population is exposed to *M. ovipneumoniae*, resulting in the infection of a population (Cassirer et al. 2018). Exposure occurs when bighorn sheep populations come into contact with domestic sheep

populations. This often happens on public lands where ranchers bring their sheep to graze. Because the lands are public, they are not blocked off, leaving the areas open and clear for bighorn sheep to also graze. These two groups then come into close physical contact, transmitting a plethora of infections, notably *M. ovipneumoniae* (Cassirer et al. 2018).

When it comes to testing for pneumonia in bighorn sheep, testing is often not done until it is too late. Many cases of *M. ovipneumoniae* infection are not discovered until after the death of an individual. Infection can be determined through a necropsy and laboratory testing (Cassirer et al. 2018). However, testing can be done while an individual is still alive. Nasal swabs and polymerase chain reaction (PCR) testing can be done to determine whether an individual is infected with *M. ovipneumoniae*. Testing is important in protecting against the spread of pneumonia in both bighorn and domestic sheep populations. If caught and treated in domestic populations, transmission rates may be lowered, and bighorn sheep may not be exposed as often (Cassirer et al. 2018).

So far, there have been very few effective management methods of pneumonia in bighorn sheep caused by *M. ovipneumoniae*. Wildlife managers as well as veterinarians have implemented multiple techniques to help prevent the spread on a medicinal level. These include vaccinations, antibiotics, and even mineral supplements (Cassirer et al. 2018). Vaccinations, however, bring forth many issues. Issues include the idea that there are many different strains of *M. ovipneumoniae*. Because of this, a vaccine would be difficult to develop and implement. Not only this, but immunity would also not be carried from generation to generation, and therefore would need to be administered for every new generation. On top of all else, administering a vaccine to sheep both bighorn and domestic, would prove to be quite challenging. There is also little to no economic market for sheep vaccinations and would be difficult to provide funding for (Cassirer 2022).

Management techniques also include those that are not medicinal. For example, selective culling and separation techniques have also been implemented (Cassirer et al. 2018). Separation techniques involved include double fencing to help in separating bighorn and domestic sheep populations in order to minimize the occurrence of interactions between bighorn and domestic sheep populations. Other techniques include managing the population densities, so as to not allow for populations to be too crowded, therefore decreasing the risk of transmission between individuals within a population. Methods of reduced contact have proven to be the most effective form of disease prevention so far (Cassirer et al. 2018). State and federal agencies have developed models that outline high and low contact areas between domestic and bighorn sheep populations. From these models, actions can be taken to reduce contact between populations in high contact areas. Sometimes this may include eliminating certain grazing lands, or even just changing their allocation from sheep grazing (Cassirer et al. 2018).

Regarding the management of sheep pneumonia in domestic sheep specifically, there is an overall misunderstanding of information regarding the illness (Cassirer et al. 2017). With little understanding of the modes of transmission and even the science behind the disease, it is quite apparent that this greatly hinders management techniques. This misunderstanding comes from not only people in the conservation field, but also the general public, as well as ranchers. The less that is understood regarding the concept, the less likely individuals are to accept any change regarding the topic. For example, in telling ranchers they need to change the patterns of their grazing sheep on public lands, wildlife and land managers are often met with pushback to a general lack in understanding from

the public. This also proves to be an issue when it comes to implementing the use of vaccines and antibiotics. Understandably, if knowledge regarding *M. ovipneumoniae* is not widely known, putting vaccine and antibiotics to use in domestic populations would prove to be quite difficult given pushback from ranchers. As previously mentioned, if the disease is not controlled in these domestic sheep populations, it certainly will continue to negatively impact wild bighorn sheep populations that domestic populations come into contact with (Cassirer et al. 2017). Another difficulty in the management of this specific infection is the uncertainties that accompany the occurrence of the disease. Most often, the location of a *M. ovipneumoniae* outbreak cannot be easily predicted nor avoided. Not only this, the long-term impacts on populations are also not fully understood, and prove to cause issues for populations down the road (Sells et al. 2016).

Overall, management techniques for controlling pneumonia in bighorn sheep have proven to be time consuming, costly, and somewhat ineffective. *M. ovipneumoniae* infection continues to be an issue in wild bighorn sheep populations due to inevitable contact between bighorn and domestic sheep populations. However, ongoing research continues to move forward in both the science and management of the disease. Advances in the understanding of the disease itself as well as its transmission continue to make way in the field. Not only this, conservation efforts and management techniques are ever evolving, and the outlooks of this issue are not always dismal, regardless of the many issues faced.

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