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Management of Bighorn Sheep due to Pneumonia Causing Population Decline

In western North America and throughout the Rocky Mountains, bighorn sheep (*Ovis canadensis)* populations are on the decline and have been listed by the US Fish and Wildlife service as a species of least concern due to its fairly stable populations. Like many species in North America, the populations used to be much higher than they are today. Bighorn sheep had been estimated from 1.5 to 2 million individuals in the 19th century. Now, they are at a fraction of that sitting under 70,000 mature specimens (Bighorn Institute, 2020). These populations are being threatened by habitat loss, human disturbance, and most dangerously, they are being affected by the spread of triggers for pneumonia from domestic sheep (*Ovis aries*) (Cassier et al. 2017). Some of the many causes can be attributed to a bacterium called *Mycoplasma ovipneumoniae* along with multiple types of parasitic lung worms, all causing pneumonia in wild populations of bighorn sheep (Cassier et al. 2017)(Besser et al. 2013). The use of public land for grazing of domestic sheep brings the triggers into contact with *O. canadensis* and introduces the illness to the wild populations. There is obviously a greater difficulty in managing the wild populations of bighorn sheep as the sickness is difficult to prevent, and the spread is hard to treat in the affected populations. Although the threat of this has been documented for over 80 years, there is still much to learn about the causes for the multifactorial respiratory disease complex and how to combat it (Besser et al. 2013).

Of the many reasons why bighorn sheep are especially being affected by bacterium *Mycoplasma ovipneumoniae*, the pathogen that triggers pneumonia, is due to their lack of genetic resistance. Sheep were domesticated 8,000-10,000 years ago in the Near East (Cao et al. 2021). The domestication of sheep into *O. aries* was the product of selective breeding of the Asian mouflon (*Ovis orientalis*) and have since have been used all over the world as livestock (Cao et al. 2021). Some of these breeds of *O. aries* have been shown to have a genetic resistance to

pneumonia in the PADI2 gene (Cao et al. 2021). The bighorn sheep in the new world, while still in the same genus as some of the innately bacterially resistant sheep, do not possess those same beneficial qualities. The spread and effects of pneumonia between the wild and domestic sheep are still being studied and can shed light on how to combat it.

What we call pneumonia is a secondary effect of an injury in the lungs that can be caused by bacteria, virus, parasites and even fungi (Baque-Juston et al. 2014). When an irritant injuries a lung during the healing process, the avalor epithelium produces tissues and if there are debris in the way, it can lead to blockage of the alveoli, their ducts as well as the terminal bronchioles causing a greater inflammatory response in the lungs (Baque-Juston et al. 2014). Some of the symptoms of pneumonia in sheep are fever, coughing, reduced activity, labored breathing, and thick white nasal discharge to name a few (OSU Sheep Team, 2018). Both wild and domestic sheep suffering from this exhibit similar symptoms, but domestic sheep do not have as fierce competition as the wild bighorn sheep, and thus have a lower mortality rate. That being said, pneumonia outbreaks in livestock populations cause huge losses to the global sheep industry (Cao et al. 2021). Unfortunately, the wild populations do not get the care that the domestic ones do so when they are less active while fighting this infection, they lose out on potential food sources, mating opportunities, and/or fall victim to the predators of bighorn sheep. The predators like gray wolves (*Canis lupus)*, mountain lions/cougars (*Puma concolor),* and coyotes (*Canis latrans)* pick out the weaker members of the herd (usually the sick) and chose them as their desired prey (Sawyer & Lindzey, 2002). Once pneumonia triggers like *Mycoplasma ovipneumoniae* get introduced to a population, it can be devastating for many of the bighorn sheep attempting to survive.

Farmers who have sheep as livestock bring their sheep out to graze on public land. This land has no fencing. When the sheep are done grazing for the day, the farmers bring them back to their enclosures. Unfortunately, if any of the sheep have an ailment that contributes to pneumonia, they can leave it behind in their waste in the fields. As the wild bighorn sheep come to find food on the same lands, they are at risk of catching the bacterium, virus or parasite and spreading it through the rest of the wild population. After the introduction of pneumonia triggers, healthy populations of *O. canadensis* have experienced a mortality rate of 30%-90% for all age classes (Besser et al. 2013). Mortality can be so elevated because the bighorn sheep historically haven't been exposed to this disease and now are being introduced to it at a far greater rate than

what would occur naturally. As mentioned earlier, the *O. canadensis* does not have the naturally resilient genes that the domesticated sheep have. These two factors combined lead to the major effects on the population.

Large outbreak events causing massive mortality in populations of *O. canadensis* make managing this species difficult. To learn more about the management of this species and how pneumonia affects them, we interviewed Dr. Frances Cassirer. Dr. Cassirer is a senior wildlife biologist at the Idaho Department of Fish and Game. She works to restore bighorn sheep in the Hells Canyon region of Idaho, Washington, and Oregon, as well as manage *O. canadensis* throughout North America. According to this expert, preventing the spread of the bacterium *M. ovipneumoniae* from domestic livestock to wild populations is the key to restoring a healthy population of bighorn sheep in North America.

Currently, both governmental and private organizations are attempting to restore the wild populations by implementing different management strategies. These approaches include making vaccines, building double fenced exclosures, using guard dogs, culling infected individuals in wild populations, and changing regulations regarding livestock use on public lands (Garwood et al. 2020) (Cassier et al. 2017). Not all of these tactics work and each has their own pros and cons.

While in theory a vaccine to protect against this disease sounds great, it's not as practical as we imagined. In the Cassirer interview, we learned just a few reasons why vaccines are not the answer to the problems *O. canadensis* are facing. Pneumonia causing pathogens like *M. ovipneumoniae* have many variants among domestic sheep and a vaccine only protects against one strain. She stated that there would be multiple vaccines needed to immunize the domestic populations before it would be worth using on the wild bighorns. This would be very expensive. Another problem with vaccines is the vaccinated sheep do not pass complete immunity to their offspring, meaning that with each generation more doses would have to be administered for the prolonged effect wildlife managers are looking for. Moreover, if the lambs cannot survive their youth and make their way to adulthood and produce the next generation of bighorn sheep, then the population will have an even harder time recovering.

Some of the strategies to grow the bighorn population sound counterintuitive at first. There has been successful work done showing that the culling of infected individuals in wild populations greatly reduces the diseases that result in pneumonia (Garwood et al. 2020). When

the carriers of *M. ovipneumoniae* have been removed from the population of bighorn sheep in South Dakota, there was less mortality from both lambs and adults and there was no longer pneoumia or *M. ovipneumoniae* detected in the populations (Garwood et al. 2020). While knowing that this works is great, it can be tricky to implement. The interview with Dr. Cassirer showed that detecting pneumonia is not the easiest process. Nasal swabs need to be taken and analyzed much like a COVID detection test. This process is costly and can take a lot of time, which can slow the recovery operation. Regardless of the poor detection problems, it seems like it can be a great solution to the sickness in big horn populations. Unfortunately, this method only acts as a band-aid for the true problem. If domestic sheep keep spreading pneumonia causing triggers to the bighorn sheep, then culling will continue to occur. In order to make real progress to end this problem, wildlife managers not only will remove the sick from the wild, but also reduce the interaction of infected livestock with wild populations.

One of the newer strategies used to help prevent the spread of disease from livestock here in North America is one of humans early accomplishments. During the paleolithic period, around 35,000 years ago, humans began the domestication of wolves into the dogs we know today (Galibert et al. 2011). True domesticated dogs (*Canis familiaris)* are officially recognized to have been distinguishable from their wild counterparts around 14,000 BC (Galibert et al. 2011). They are great companions but also provide humans with valuable services. They have been used as hunting partners, personal protection and in the care of livestock (Gehring et al. 2010). Work dogs have been instrumental in reducing predation on livestock, but they also are used to control the herds and deter other non predatory wildlife from coming into contact (Gehring et al. 2010). By reducing the wild ungulates from coming into contact with the domestic herd, the domesticated dogs reduce the spread of any diseases they may possess (Gehring et al. 2010). When North America was first settled, the use of work dogs for livestock was not as popular as it was in Europe and Asia, where it first originated. It wasn't until the 1970's that there was a resurgence of the use of these guarding dogs (Gehring et al. 2010). That being said, indigonous people, specifically the Navajo Indians, had used dogs for this before the Europeans came and brought their farming methods (Gehring et al. 2010). In the past, these working dogs have been used to prevent infected deer (*Odocoileus spp.)* from spreading bovine tuberculosis to livestock (Gehring et al. 2010). This same strategy can prevent the triggers that cause pneumonia from spreading to wild populations from livestock.

The use of dogs isn't the only way to keep wild bighorns from interacting with the domesticated sheep. Restricting the land that domestic sheep are allowed to graze on has been an effective way to reduce the interaction between livestock and bighorn sheep. As of now, farmers are allowed to bring their livestock on public land to graze. Regardless of direct or indirect interaction between bighorn sheep and the domesticated sheep, the pneumonia triggers make it into the wild. After sheep feed they leave their droppings in the fields and as bighorns come to graze in that area later on, they come in contact with the fecal matter that carries the same diseases that the livestock does, and thus can indirectly affect the wild populations. In order to combat this issue, new regulations need to be ratified to either restrict the use of public lands for domesticated sheep, or more tests need to be done on the livestock to ensure that they are not carriers of potentially devastating diseases. A study was done in Payette National Forest in western Idaho to predict the likelihood of disease transmission with different grazing plants for domestic sheep (Carpenter at al. 2014). Carpenter and their colleagues determined that if nothing was granted in the grazing practices there was a high chance, 20% to 100%, that the seven wild bighorn herds would be extirpated from on or around the Payette National Forest region. This shows that new laws need to be produced to reduce the public land that is allocated for grazing in order to help protect wild populations.

Double fencing has been a very effective way at preventing the spread of livestock born diseases from making it out into the wild (Cassier et al. 2017) (Henise et al. 2016). The reason why the second fence is needed to reduce disease transmission is because as male bighorn sheep roam in search of mates they can walk right up to the fence and directly touch the livestock, a second fence makes that problem go away. While this method of building exclosures is very effective, it has gotten pushback for being feasibly impractical. Building these double fences costs a lot of money and farmers aren't willing to shell out that much money for something they do not necessarily care much about. Wildlife management agencies have used their resources to lesson some of the financial burden, but the amount of fencing it takes to go around the perimeter costs far too much

money to be reasonably implemented.

With all of the complications in managing wildlife, it's hard to be optimistic. There are many reasons why it seems like a losing battle, but every day scientists and managers are working tirelessly to save the bighorn sheep. No one method will end the problem, but by

incorporating the different plans together, serious progress can be made to help save this once plentiful animal.

Bighorn sheep are an important part of the ecosystem as well as important for the many stakeholders who care about them. They are prey for predators and human hunters and thus have the potential to generate money for conservation. There are over 15 million hunters in the United States and Canada. While most focus on deer hunting, if there was a larger sustained population of bighorn sheep, that number could increase (Arnett & Southwick, 2015). From Mexico to Canada, some bighorn hunts can cost at least $4,500 (BookYourHunt, 2022). This shows how economically profitable a sustainable population of this species can be.

Pneumonia is still being studied. It is a major hindrance to the recovery of the native bighorn sheep populations being devastated by the spread of this high mortality disease. Different strategies used to fight the disease have their specific benefits and costs, and only by implementing a mixture of these strategies is there hope for a recovery. People care for these animals, but there still is not much public education for bighorn sheep and efforts tend to go unnoticed. Whether its double fencing, vaccines or culling the sick, stronger efforts need to be made to help revive the wild populations of *O. canadensis.* With support and cooperation from the public and wildlife agencies we hope to see bighorn sheep closer to their historic population sizes.

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