

# Respiratory Disease in Bighorn Sheep

Studies of *Pasteurella Haemolytica* at Washington State University

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Washington is the home of two subspecies of bighorn sheep, the Rocky Mountain bighorn (*Ovis canadensis canadensis*) and the California bighorn sheep (*O. c. californiana*). Prior to 1940, both subspecies were extirpated from the state, probably as a direct result of over hunting, habitat loss, and diseases. Because the timing of the extirpation was coincident with the introduction of large numbers of domestic sheep into the state, some people believe the diseases that potentially caused the demise of the bighorn sheep may have been transmitted from domestic sheep. Since 1957, both subspecies have been reintroduced to Washington, and there currently are approximately 1,000 bighorn sheep in the state.

At Washington State University, Pullman, Washington, we have

determine the effects of specific diseases on the well-being of the sheep, and evaluate methods to prevent or ameliorate effects of disease. Respiratory disease is the major mortality factor in wild bighorn sheep populations, and can be caused by several factors including bacteria, viruses, lung worms, and stress. However, we have focused our effort studying the major respiratory pathogen in bighorns, a bacterium taxonomically called *Pasteurella haemolytica*. Major die-offs of wild bighorn sheep due to *P. haemolytica* are devastating, and lamb survival from ewes that survive these pneumonia outbreaks is very low for several years after the initial pneumonia episode. Our pneumonia research involves four specific areas including: (1) the disease transmission potential

strains of *P. haemolytica*, (4) development of standardized test to evaluate toxins from different strains of *P. Haemolytica*.

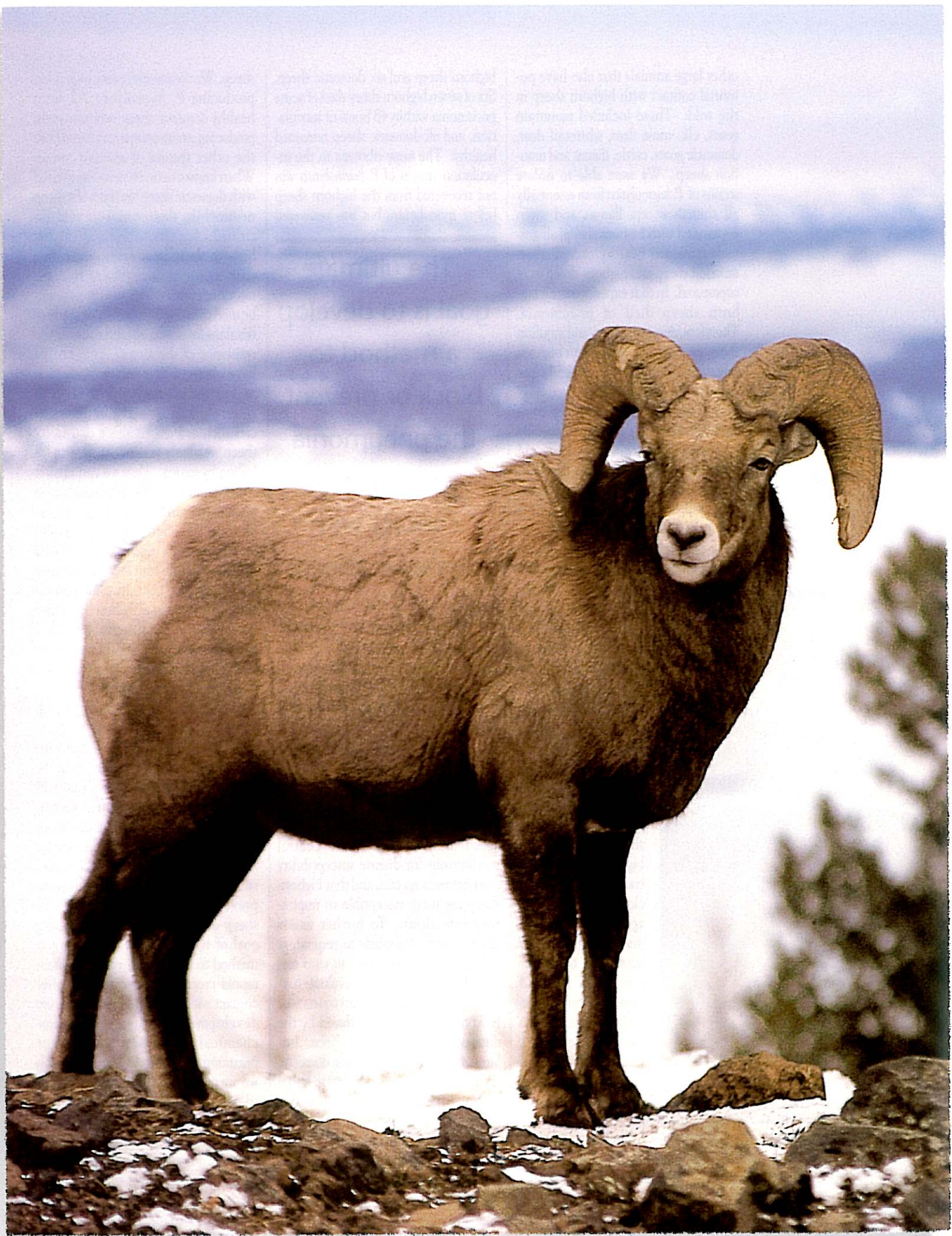
Our involvement in this research began by accident in 1979 when we copastured 14 bighorn sheep and 10 domestic sheep in a five acre outdoor pen. The domestic sheep remained healthy, but 13 of 14 of the bighorn sheep died from pneumonia. Based on those results, we speculated that an infectious organism was transmitted from the domestic sheep to the bighorn sheep and resulted in the death of bighorns. To determine whether a cause-effect relationship existed, we then repeated the experiment under carefully controlled conditions at Washington State University. We introduced 6 healthy domestic sheep into a pen that contained 6 healthy bighorn sheep after evaluating all animals for potential disease organisms. Based on nasal swab analysis, *P. haemolytica* was detected in all domestic sheep, and none of the bighorn sheep prior to mixing the animals. All six bighorn sheep died from pneumonia between days 3 and 71 after domestic sheep contact, and *P. haemolytica* was the main pathogen isolated from the lungs and tissues of all dead bighorns. None of the domestic sheep developed disease. We repeated the above experiment three more times, and in all experiments, all bighorn sheep died from pneumonia and all domestic sheep remained healthy. The conclusion of these experiments was that bighorn sheep and domestic sheep should not share common grazing areas or it is likely the bighorn sheep will die from pneumonia. We also evaluated the compatibility of



PART OF THE STUDY INVOLVED GROUPING BIGHORN SHEEP WITH MOUNTAIN GOATS IN COMMON GRAZING AREAS.

been working with bighorn sheep diseases for about 15 years and currently have a captive herd of bighorn sheep divided among three pens on the campus. The goal of the research is to

when bighorn sheep share common grazing areas with other ungulates, (2) effects of strains of *P. haemolytica* on the health of sheep, (3) susceptibility of specific herds of bighorn sheep to



other large animals that also have potential contact with bighorn sheep in the wild. These included mountain goats, elk, mule deer, whitetail deer, domestic goats, cattle, llamas and mouflon sheep. We were able to isolate strains of *P. haemolytica* from essentially all animals except llamas, and when copastured with bighorn sheep, all animals remained healthy except when mouflon sheep and bighorn sheep were copastured. In that experiment, all bighorn sheep died of pneumonia. Therefore, domestic sheep and mouflon sheep are not compatible with bighorn sheep, and should not be allowed close contact with bighorn sheep.

*Pasteurella haemolytica* is a common organism that is carried naturally by many different hosts in tonsils and nasal secretions, and often does not cause clinical disease. This is a complex group of bacteria, and at least 2 biotypes (A and T), and 16 known serotypes (1 through 16) have been identified. Several additional strains do

not fit into the traditional taxonomy system because they crossreact between or among the known serotypes, or do not identify with any of the known types. However, based on our work, it appeared that some strains of *P. haemolytica* from healthy domestic sheep was lethal in bighorn sheep when transfer occurred after close contact. It also appeared that the main strain of *P. haemolytica* that is often found in dead bighorns after contact with domestic sheep is biotype A, serotype 2 (A2). This strain is

rare in bighorn sheep (bighorns usually carry the T biotype), but is the most common strain in domestic sheep. We isolated the A2 strain from a healthy domestic sheep, and subjected it to a DNA fingerprinting technique called ribotyping. In three independent experiments, we then inoculated the A2 strains from domestic sheep into seven

bighorn sheep and six domestic sheep. Six of seven bighorn sheep died of acute pneumonia within 48 hours of inoculation, and all domestic sheep remained healthy. The same ribotype in the inoculation strains of *P. haemolytica* was not recovered from the bighorn sheep before inoculation, but was recovered

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## The ultimate goal is to develop a method to block or prevent the pneumonia process after contact with domestic sheep.

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from the lungs and tissues of all dead bighorns. The conclusion of the experiment was that some strains of *P. haemolytica* from domestic sheep are lethal in bighorn sheep.

Additional research at the cellular level involved understanding mechanisms of the disease process in bighorn sheep. Studies on metabolism of arachidonic acid in lung macrophages indicated that different control mechanisms for disease susceptibility exist between species, and that bighorn sheep are more susceptible to respiratory infections. To further assess susceptibility of animals to respiratory disease, we developed an *in vitro* test using blood neutrophils to evaluate toxins (also called cytotoxins or leukotoxins) that are produced by the different strains of *P. haemolytica*. Isolates of *P. haemolytica* A2 from domestic sheep produced toxins that were lethal to blood neutrophils, whereas, toxins produced by most of the serotypes of the T biotype of *P. haemolytica* did not kill neutrophils. If the high toxin producing bacteria were given to bighorn sheep, death occurred within 24 to 72 hours, whereas, the low toxin producing bacteria did not kill the bighorn

sheep. We commonly isolate high toxin producing *P. haemolytica* A2 from healthy domestic sheep; whereas toxin producing strains were not isolated from the other species of animals tested. When known toxin bacteria were tested with domestic sheep and bighorn sheep neutrophils, there was a six-fold increased susceptibility observed with the bighorn sheep neutrophils, indicating their increased susceptibility to respiratory infection. This *in vitro* test can be used to assess the potency of the bacterial toxins produced, and to assess the resistance of the animal species. We have observed that wild animals such as deer and elk are highly resistant to neutrophil killing toxins, but other species such as bighorn sheep and Dall's sheep are highly sensitive to neutrophil killing by toxins. Thus we can predict which animals are the most sensitive to pneumonia caused by toxin producing bacteria. We currently plan to evaluate susceptibility of different wild herds of bighorn sheep with this test. If there are free-ranging herds that are most resistant to neutrophil killing by toxins, these would be the sheep that are ideal for transplanting to new areas, especially in areas where potential domestic sheep contact could occur.

Based on our research and all published data, we strongly recommend that bighorn sheep contact with domestic sheep or mouflon sheep be prevented or the bighorn sheep will likely die. Two management recommendations are (1) that bighorn sheep should not be transplanted into areas where domestic sheep contact is possible, and (2) that domestic sheep be prevented from using areas where sheep currently exist. The ultimate goal of the research is to develop a method to block or prevent the pneumonia process in bighorn sheep after contact with domestic sheep. Vaccine development or alteration of biochemical pathways to prevent pneumonia are two areas of research we are currently investigating, but until new methods for the prevention of pneumonia in bighorn sheep are available, physical separation of bighorn sheep and domestic sheep to prevent nose to nose contact is the only viable management technique to prevent domestic sheep induced fatal pneumonia in bighorn sheep.



AUTHOR, BILL FOREYT, AT THE RESEARCH AREA IN PULLMAN, WAHSINGTON, WITH A NEWLY BORN BIGHORN LAMB.