EXPERIMENTAL TREATMENT OF LUNGWORM IN WILD BIGHORN SHEEP USING FENBENDAZOLE AVAILABLE AT FREE-CHOICE TREATMENT STATIONS

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We provided fenbendazole treated pelleted feed and salt blocks to lungworm infected bighorn sheep on winter range near Melrose Montana. Between seven and nine treatment stations were maintained and available to approximately 35 bighorn sheep during the winters of 1994-95 and 1995-96. These sheep were the remaining survivors of a recent pneumonia epizootic that removed 87% of a population of approximately 400 sheep. Three of the surviving sheep were radio collared. Treatment stations were visited weekly during two winters to collect fecal samples and evaluate visitation. Sheep found the stations more quickly during the second winter, presumably due to familiarity with sites. Larval output as measured in larvae per gram and prevalence of the parasite declined during the first winter of treatment and remained low through the following winter of treatment. We believe that the free-choice treatment applied in this study reduced the lungworm load and relative infection rate of free ranging bighorn sheep on this winter range. The management implications and potential future of similar treatment protocols are discussed.

Introduction

Bighorn sheep across North America commonly host parasitic lungworm (*Protostrongylus stilesi* and *Protostrongylus rushi*) infections. Many dramatic pneumonia epizootics have implicated lungworms as the predisposing factor contributing to respiratory disease (Marsh 1938, Buechner 1960, Forrester 1971). An additional concern for bighorn sheep is the transplacental migration of Protostrongylus *stilesi* which can produce lambs predisposed to pneumonia and result in what is termed "summer lamb mortality" (Thorne et al. 1982). For sheep populations at very low numbers this lamb mortality may severely hamper recovery and growth of populations to more suitable levels (Jones and Worley 1994).

Most Montana bighorn sheep populations are infected to some degree with *Protostrongylus* spp. (Forrester and Senger 1964, Beckland and Senger 1967, Worley and Seesee 1992). There is considerable variation in the prevalence and parasite load reported depending upon season and geographic location of the herd unit. Lungworm has been implicated in several pneumonia epizootics in Montana (Forrester and Senger 1964, Couey 1950, Rush 1927). Other parasites have been identified and described for various bighorn sheep herds in Montana (Worley and Seesee 1992, Hoar et al.1996)

Lungworm infections have been adequately treated in captive or transplanted bighorn sheep on several occasions with the application of suitable anthelmintics (Layne and McCabe 1986, Miller 1988, Worley and Seesee 1990, Foreyt and Johnson 1980). Several experiments to treat wild bighorns with free-choice treated feeds and/or medicated salt have been successful in reducing larval output (Easterly et al. 1992, Jones and Worley 1997). The most elaborate experiments in treating wild bighorns with free-choice feeds and medicated salt, to date, were conducted in Colorado (Miller et al. 1996). Although successful in treating the parasite the Colorado experiments did not result in improved population performance for the four-year period of the study.

Native populations of bighorn sheep were extirpated from the Highland-Pioneer Mountains in the early 1900's. Sheep were reintroduced to the area in 1967 when 27 sheep were transplanted from the Sun River. The initial transplant population was supplemented with 31 sheep in 1969. The population expanded in size and range up through the mid 1990's so that sheep today extend across the Bighole River and into the foothills of the Pioneer Mountains. The number of males in the population grew and the herd became well known for it large trophy quality rams. The number of sheep was estimated between 350-400 (Wiegand 1994, Semmens 1996). Harvests were increased in 1992 and 1993 to 39 and 40 sheep. In addition, 35 sheep were captured and transplanted from the population in 1992 to reduce sheep numbers. In 1993 the population was at an all time high. Hoar et al. (1996) found that the Highlands-Pioneers bighorn sheep population was infected with lungworms and a wide variety of other gastrointestinal parasites. In addition to mild lungworm loads, gastrointestinal parasite loads were suggestive of clinical parasitism and the combined effects of mixed endoparasites could produce a recognizable stress factor. In late November 1994 sheep hunters reported observing the clinical signs of pneumonia in many sheep. An all age die-off proceeded through the late fall and winter, reducing the population by 87%.

As a result of the severity of this pneumonia epizootic and the known parasite history of this herd unit, a program was initiated to treat the population of bighorns frequenting the critical winter range in the Maiden Rock area. Our objectives were to mitigate the mortality that the herd experienced and to enhance the recovery of the survivors of this pneumonia epizootic. We designed and implemented the treatment to, at the very least, do no harm to the surviving bighorn sheep.

Study Area

The study area included the critical winter habitats along the Bighole River near the Maiden Rock Mine, West of Interstate 15, in southwestern Montana. The elevations range from 1593 m along the Big Hole River to 3108 m on Table Mountain in the Highlands range (Wiegand 1994). Land ownership is a combination of private, Bureau of Land Management, Beaverhead National Forest and Montana Department of Natural Resources and Conservation. Major land use activities are mining, recreation and livestock production. Two domestic sheep producers operate along the lower edges of critical bighorn sheep winter range. Domestic sheep have been husbanded in this area for more than 20 years as the introduced bighorn sheep population flourished. A railroad line follows the river course through the center of the winter range.

Methods

All bighorn sheep mortalities were investigated as opportunity and logistics allowed. Specimens were collected from fresh carcasses during a field necropsy, from hunters and biologists, or by transporting whole carcasses to the laboratory for necropsy. Sheep that could not be transported immediately were occasionally frozen whole in regional freezers for later transport. Individual sheep were necropsied at the MDFWP Wildlife Laboratory or the Department of Livestock State Diagnostic Laboratory to determine cause of mortality. Gross lesions were submitted for histopathologic examination, routine bacteriologic culture and virus isolation. Histopathology was performed by board certified pathologists from the State Diagnostic Laboratory.

Herd health monitoring was performed when animals were captured for translocation or field research in 1992-1994. Blood was drawn from the jugular vein, a pharyngeal swab from the tonsilar crypt was taken and fecal samples collected. Each animal was inspected for external parasites or other indicators of health problems.

Blood samples were transported to the MDFWP laboratory and centrifuged to extract serum. Whole blood samples were submitted to the State Diagnostic Laboratory for hematology. Standard large animal serum chemistries were performed. Standard approved serum tests were performed to determine antibodies for *Brucella abortus*, *Brucella ovina*, Bluetongue, IBR, BVD, PI3, Ovine Progressive Pneumonia, and Leptospirosis (eight serovars). Excess blood serum was archived for future testing.

Following diagnosis of serious lungworm loads in Highland-Pioneers sheep, a strategy was developed to treat surviving animals with fenbendazole treated feed and salt. During the winters of 1994-95 and 1995-96, between 6 and 9 stations were widely distributed across the sheep winter range near Maiden Rock west of I-15. Attempts to treat sheep east of I-15 were unsuccessful due to limited manpower and complex logistics. Each station consisted of a single medicated salt block in a rubber feed tub surrounded with light amounts of weed free alfalfa hay to draw the sheep to treated feed and salt. Small 1 lb. portions of SafeGuard pelleted feed were placed on the hay, salt and inside the tub. Portions were spread for best access by multiple sheep. Sheep use of each station was monitored in weekly field observation sessions and by monitoring tracks in the snow. Cameras triggered by passive infrared sensors were used to monitor some sites until one of the systems was stolen.

Routine fecal collections from sheep bedding areas near treatment stations or from radio monitored study sheep for specific herd units were conducted to monitor trends in parasite loads. Fecal samples were refrigerated and transported to the MDFWP laboratory. A modified Baerman procedure was used to determine the number and relative concentrations of lungworm larvae shed by each animal (Dinaburg 1942, Beane and Hobbs 1983). The modified Lane fecal flotation procedure was used to recover ova and oocysts from feces (Dewhirst and Hansen 1961). Coverslips from each tube were examined with a light microscope to determine the number and type of ova and oocysts present.

Results

Mortality Patterns

Most of the bighorn mortality occurred between January 1 and February 30,1995 (Table 1) during a period of severe cold weather. Sheep continued to die through March and continued to exhibit clinical signs of pneumonia. One hundred and twenty-six carcasses were located in random searches of the critical winter ranges. When discovered, fresh carcasses were collected and decomposed carcasses were flagged or spray painted to avoid duplication in carcass surveys. Most carcasses located were not suitable for tissue sampling. Total mortality exceeded 87% of the populations.

Table 1. The cumulative bighorn sheep carcass count during the Highlands-Pioneers pneumonia epizootic, 1994-95.

	Carcass Counts	Marked Sheep Alive
Dec. 15, 1994	2	29
Jan. 1, 1995	8	
Jan. 15, 1995	27	17
Feb. 1, 1995	49	
Feb. 15, 1995	71	
Mar. 1, 1995	89	
Mar. 15, 1995	94	4
Apr. 1,1995	117	
Apr. 15,1995	120	4
Apr. 30, 1995	126	2

Diagnostic Evaluations

Diagnostic necropsies were performed on 12 sheep. Histopathology indicated numerous nematode cross sections within thick caseated lesions pervasive throughout the lungs.

Bacteriology isolated *Pasteurella haemolytica* from 6 of 12 samples. Bio and serotypes isolated included T-3, T-3,15, T-4, T-4,10, T-4,10,15 and A-2. Other isolates included Streptococcus and *Pasteurella multocida*. Virus isolation attempts were negative for 9 attempts. Although isolation attempts were negative prior serologic evidence indicated antibody prevalence for PI3 and BVD for 90% and 45% of the sheep herd, respectively. Lungworm loads based on larval shedding in 10 fecal samples ranged from 1-164 LPG. Average lungworm larval shedding from 35 bighorn sheep captured for transplant programs two years prior to the pneumonia epizootic was 21.8 ± 74.1 LPG. Average lungworm load just prior to the die-off was 116.6 (Hoar et al, 1996).

Experimental Treatment

In 1994-95 stations became available to bighorn sheep on January 13, 1994 and were first utilized by January 27. In the first winter sheep utilized all 9 stations. In 1995-96 only 6 stations were established due to the limited distribution of sheep on winter ranges. Sheep visited each of the six stations in 1995-96. The proportion of stations visited was higher in the second year of treatment indicating sheep became familiar with the sites and treatment protocol (Table 2).

Table 2. The percent of treatment stations visited by bighorn sheep during time periods of approximately one week for two winter periods, 1994-95 and 1995-96.

Sample Period	1994-95	1995-96
1	25.0	40.0
2	37.5	100.0
3	75.0	100.0
4	77.7	100.0
5	71.4	100.0
6	50.0	100.0
7	62.5	66.6
8	85.7	-----

Field problems encountered included interference with deer, elk and domestic horses at treatment stations. In 1994-95 several sites were rendered inoperable due to visits by free-ranging horses on leased pastures. Human intrusions were also recorded. An initial plan to utilize infrared triggered cameras to monitor stations was discontinued after several stations were sabotoged and one camera was stolen.

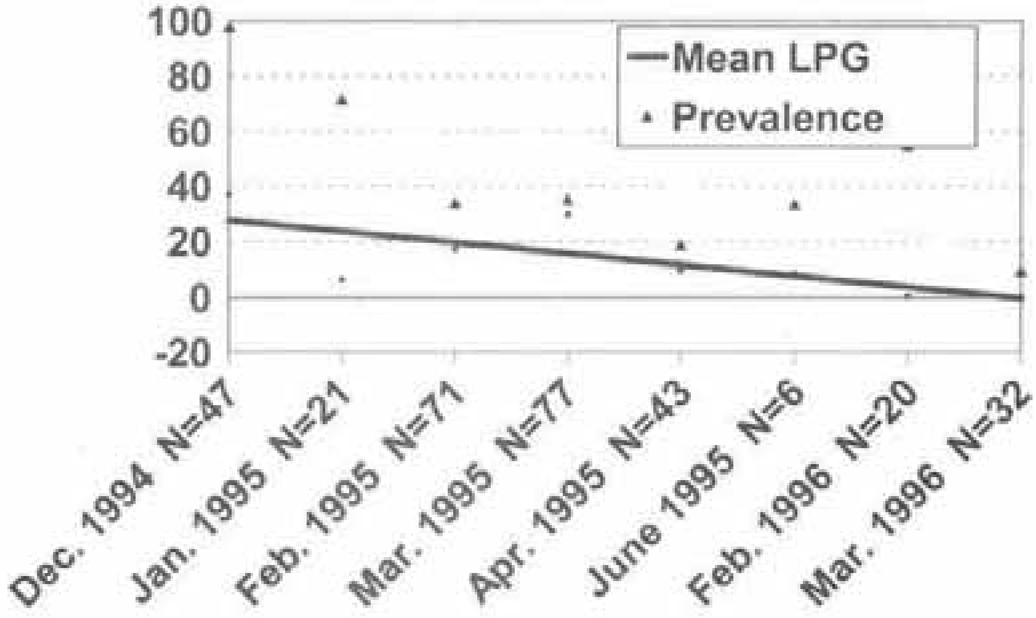
Larval Shedding

Larvae samples collected just prior to the 1994-95 epizootic indicated increasing larval loads and over 30 % of the sheep in the study area were shedding more than 100 larvae per gram (Table 3). During the treatment period the mean LPG and the prevalence of infection dropped substantially (Figure 1).

Table 3. Trend in bighorn sheep larval shedding during experimental treatment with fenbendazole in the Highlands-Pioneers herd unit 1993-1998

	N	Mean LPG	%LPG's > 100	Sheep Population Size
1993-94 (Prior)	78	116.6	31.6	380
1994-95 (During)	212	19.2	4.7	50
1995-96 (After)	68	1.2	0.0	32
1998	17	1.2	0.0	>35

Figure 1. Trend lines for prevalence and mean LPG for Protostrongylus in bighorn sheep from the Highlands-Pioneers herd unit during experimental treatment, 1994-95.



Bighorn sheep in the study area readily found all treatment stations and visited them regularly consuming most of the pelleted feed and hay. Moderate use of the medicated salt block was observed at many stations. Bighorn sheep found the treatment stations more quickly the second year of treatment and visited them regularly indicating the sheep had became familiar with the treatment protocol. We could not determine what proportion of the population received treatment during the experiment. However, there was only a small remnant of about 35 sheep remaining in the population after the pneumonia epizootic subsided. A survey of the remaining sheep population counted 23 sheep within the treatment area.

Two years of treatment with fenbendazol reduced larval shedding in surviving sheep following a significant pneumonia epidemic. The shedding of larvae had not increased substantially for 20 months following the treatment program. Worley and Seesee (1990) demonstrated that fenbendazole successfully reduced larval shedding for 5 months following treatment and they considered the animals cured. Schmidt et al. (1979) reported no recurrence of lungworm larval excretion in bighorn sheep up to 6 months after treatment. The reduced larval output we observed in bighorn sheep for prolonged periods may indicate that adult lungworms were successfully killed in treated animals.

Miller et al. (1996) has shown that several anthelmintic treatment protocols applied in Colorado did not improve population performance or improve lamb survival. Layne and McCabe (1986) found that ivermectin treatment improved lamb survival in Custer State Park. Schmidt et al (1979) observed increased lamb survival in Colorado where several anthelmintics were applied. Foreyt et al (1990) reported increased lamb production when comparing fenbendazole treated and untreated controls. We did not measure lambing success in detail from this population following treatment. However, we have observed lambs in both years following treatment. The long term benefits of treating bighorn sheep populations with fenbendazole remains in question.

The treatment protocol applied to the Highlands-Pioneers demonstrates that intense short-term anthelmintic treatment of wild bighorn sheep is feasible and can reduce parasite loads. The immediate benefits of reducing larval output and perhaps killing adult lungworms are assumed to be beneficial. However, we do not recommend long term application of anthelmintics as a treatment option based on this study. Long term application of anthelmintics may lead to drug resistent parasites and may not be economically or logistically applicable to many situations in Montana.

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