

## RESIDUAL EFFECTS OF PNEUMONIA ON THE BIGHORN SHEEP OF WHISKEY MOUNTAIN, WYOMING

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**Abstract.** During the winter of 1990, approximately 25% of bighorn sheep (*Ovis canadensis canadensis*) in the Whiskey Mountain herd died during a major pneumonia epizootic. Lamb production declined below average levels the following 2 years, resulting in sub-normal yearling recruitment in 1992 and 1993. Low recruitment, coupled with harvest and trap removals of approximately 190 sheep since the die-off, further reduced the herd to an estimated 1,000 animals in 1993. Concurrent with declining population size, utilization of herbaceous forage on crucial wintering sites declined from pre die-off levels of 75% to 59% and 60% in 1992 and 1993, respectively. *Pasteurella haemolytica* and *Moraxella* spp. were isolated from the pharynges of several animals trapped in 1993 and 1994 and seroprevalence to respiratory syncytial virus, parainfluenza 3, and chlamydia remained high. However, seroprevalence was essentially the same as 1991 and years prior to the 1990 epizootic.

The Whiskey Mountain area in west-central Wyoming supports one of the largest wintering concentrations of Rocky Mountain bighorn sheep in North America. Bighorns from this area have been used as transplant stock for the past 50 years, being released throughout Wyoming and 5 other western states. The herd also is becoming increasingly important as a source of economic revenue to businesses in nearby cities and counties of Wyoming due to its accessibility for winter viewing and sport hunting opportunities.

During the winter of 1990, about one fourth of the Whiskey Mountain herd died in a major pneumonia epizootic. Effects on population size, lamb production, and yearling recruitment during and 1 year after the die-off were described in Ryder et al. (1992). This paper documents herd reproductive performance, winter forage utilization, and disease seroprevalence in years 2 and 3 following the epizootic.

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### STUDY AREA

Summer ranges of the Whiskey Mountain bighorn sheep herd are distributed throughout the Fitzpatrick Wilderness, Wind River Mountains (Thorne et al. 1979). Winter habitats, comprising the Whiskey Mountain Wildlife Habitat Management Area (WHMA), are located immediately south and east of Dubois, Wyoming. The WHMA is managed by the Whiskey Mountain Technical Committee, an interagency group consisting of personnel from the Wyoming Game and Fish Department, U. S. Bureau of Land Management, and U. S. Forest Service (Whiskey Mountain Bighorn Sheep Technical Committee 1991). Seasonal migrations between summer and winter ranges vary from 5-48 km (Thorne et al. 1979). Geology, climate, and vegetation of the area were summarized by Butler (1977).

Within the WHMA, bighorns have historically wintered on 3 "key" sites including Sheep Ridge, BLM Ridge, and Torrey Rim. The combined number of animals utilizing these sites varies between 600-900 annually. Other wildlife, livestock, and human uses of the study area were described in Ryder et al. (1992).

## METHODS

Bighorn sheep wintering on the Whiskey Mountain WHMA were surveyed from a vehicle in December 1992 and 1993 using 8X40 binoculars and window-mounted 20-5X telescopes. During the same periods, animals wintering off the WHMA at high elevations were surveyed using Bell Jet Ranger helicopters. All animals observed were classified as to sex and age (Geist 1968). Data from ground and aerial surveys were combined each year to determine herd composition.

The effect of herd composition changes each year on population size was determined using Version 7.05 of the computer model POP-II (Bartholow 1992). Simulations were directed at data alignment from 1986-1993 using harvest mortality, post-hunting season sex and age ratios, and trapping/transplanting removals.

Forage production/utilization data presented in this paper were collected by clipping all herbaceous vegetation within standard Daubenmire quadrats in spring and fall each year (Butler 1977). These data were collected along 150 m transects permanently located on BLM Ridge, Torrey Rim and Sheep Ridge. Following clipping, vegetation was dried and weighed to determine the amount of forage produced (fall) and utilized (spring) by bighorn sheep on these 3 key wintering sites.

Swabs of the pharyngeal area of bighorn sheep were collected in January 1993 and 1994 during processing of captured animals under dropnets. These were either plated within several hours onto Columbia blood agar with 5% sheep blood or were placed in modified Cary and Blair medium (Port-A-Cul, Becton-Dickinson, Cockysville, Maryland) for transport to the laboratory. Transported samples were plated within 48 hours of collection. Plates were incubated aerobically in 5% CO<sub>2</sub>. Isolates were identified using standard techniques (Lennette et al. 1985, Carter and Cole 1990).

Blood was collected by jugular venipuncture into clean glass tubes, allowed to clot, and serum was removed within 48 hours and frozen until tested. Sera were tested by virus neutralization (Carbrey et al. 1971) for antibodies against bovine virus diarrhea virus (BVDV), respiratory syncytial virus (RSV), parainfluenza 3 virus (PI3V), and by complement fixation for antibodies against chlamydia (Texas Veterinary Medical Diagnostic Laboratory, College Station, Texas).

## RESULTS

### Herd Composition

For 2 years following the 1990 epizootic, lamb production fell below the 1986-90 average of 38 lambs:100 ewes (Table 1). Consequently, yearling recruitment declined by 50% in 1992 and 58% in 1993 from previous years (1986-91 mean = 24 yearlings:100 ewes). Production rebounded in 1993 to 23 lambs:100 ewes.

Survival rates of lambs to the yearling age class varied prior to, during, and after the pneumonia die-off (Table 1). From 1986-90, an average of 67% of the previous years lambs survived to age 1. During the epizootic year of 1990, only 45% of the lambs observed in December survived to the yearling age class in 1991. Following the die-off, survival rates of lambs to age 1 averaged 82% in 1992 and 1993.

Sex ratios remained relatively constant from 1986 through 1991 (mean = 39 rams:100 ewes), varying by only 1-2 animals (Table 1). In 1992, as a result of low 1991 lamb production and continued removal of older aged animals through hunter harvest, ratios dropped to 36 rams:100 ewes. The decline continued in 1993, following another poor recruitment and high male harvest year, to 32 rams:100 ewes.

### Forage Utilization

From 1986-1989, forage utilization averaged 75% on the 3 "key" wintering sites (Table 2). Utilization increased during each of these years, corresponding to increasing sheep numbers. No forage data could be collected during the die-off year of 1990 due to snow cover, but the population peaked at 1,474 animals. One year after the epizootic, herd size and forage use declined to 1,151 and 71%, respectively. In 1992 and 1993, herd size and forage utilization declined to their lowest levels since prior to 1986 (means of 1,000 animals and 60%).

### Bacteriology and Serology

In 1993, pharyngeal swabs collected from 29 bighorn sheep yielded *Pasteurella haemolytica* from 27 animals and *Moraxella* sp. from 1 animal. Of 9 pharyngeal swabs cultured in 1994, 5 contained *P. haemolytica*, 3 *Moraxella* spp., and 1 did not contain significant bacterial isolates. There was no serologic evidence of antibodies against

**Table 1. Age and sex composition of Whiskey Mountain bighorn sheep, 1986-93.**

Year	Rams: 100 Ewes	Lambs: 100 Ewes	Yearlings: 100 Ewes	Survival rates <sup>a</sup>
1986	40	27	22	61
1987	38	38	16	5
1988	39	47	28	73
1989	39	32	38	80
1990	39	44	20	63
1991	41	10	20	45
1992	36	12	8	80
1993	32	23	10	83

<sup>a</sup> Percentage of previous year's lambs surviving to yearling age classes.

BVDV in contrast to high prevalence of antibodies against PI3V, RSV, and chlamydia (Table 3).

## DISCUSSION

Onderka and Wishart (1984) reported reduced lamb production and recruitment for 2 years (23 lambs:100 ewes and 18:100, respectively) following a pneumonia die-off in southern Alberta. In another Alberta study, only 13% of the lambs born the year of a die-off survived to age 1 (Festa-Bianchet 1988). Lamb survival 2-3 years later averaged 38%. Coggins and Matthews (1992) reported lamb:ewe ratios of 11 and 10:100 for 2 years following a die-off of sheep in Oregon. The 1990 pneumonia epizootic resulted in similar changes in population performance at Whiskey Mountain. Observed reductions in lamb production were similar to that reported by Coggins and Matthews (1992), but lower than that observed by Onderka and Wishart (1984). Survival rates were higher than those reported by Festa-Bianchet (1988).

Forage utilization rates appear directly related to bighorn sheep population size on Whiskey Mountain. Although body condition did not appear to be a factor in the 1990 pneumonia outbreak (Ryder et al. 1992), forage utilization on "key" wintering sites approached 90% 1 year prior to the die-off. Similarly, herd size was estimated to be higher than at any other time. We recommend forage utilization rates continue to be monitored yearly as they may provide a means of predicting an impending pneumonia outbreak.

Bacteriologic and serologic data indicate potential respiratory pathogens continue to circulate within the Whiskey Mountain bighorn sheep herd. The rate of isolations of *P. haemolytica* is greater than in past years and probably reflects use of improved transport and isolation techniques (Wild and Miller 1994). Isolation of *Moraxella* sp. may also be improved by use of the modified Cary and Blair transport medium.

While some strains of *P. haemolytica* are associated with pneumonia (Onderka and Wishart 1988, Foreyt 1989), others apparently circulate in healthy animals (Dunbar et al., 1990, Ward et al.,

**Table 2. Herbaceous forage utilization (%) and estimated population of Whiskey Mountain bighorn sheep, 1986-93.**

Year	Torrey Rim	BLM Ridge	Sheep Ridge	WHMA average	Population estimate
1986 <sup>a</sup>	ND	ND	ND	ND	1,242
1987	58	62	63	61	1,254
1988	64	88	78	77	1,326
1989	86	94	85	88	1,320
1990 <sup>a</sup>	ND	ND	ND	ND	1,474
1991	62	70	81	71	1,151
1992	65	40	72	59	1,018
1993	64	49	69	60	1,000

<sup>a</sup> ND = No data were collected due to snow cover.

**Table 3. Serologic results of testing Whiskey Mountain bighorn sheep for evidence of exposure to respiratory pathogens, 1990-94.**

Pathogen <sup>a</sup>	1989-90	1990-91	1991-92	1992-93	1993-94
BVDV	0/12 <sup>b</sup>	Nd <sup>c</sup>	0/27	ND	0/19
PI3V	11/12 (16-256)	ND	27/27 (16-1024)	13/14 (8-256)	19/19 (16-1024)
RSV	11/12 (16-512)	ND	27/27 (16-1024)	14/14 (8-512)	21/21 (8-256)
Chlamydia	12/12 (16-64)	ND	25/27 (16-64)	8/14 (16)	13/16 (16-32)

<sup>a</sup> BVDV = bovine virus diarrhea virus; PI3V = parainfluenza 3 virus; RSV = respiratory syncytial virus.

<sup>b</sup> Number of animals positive for antibodies/number of animals tested (range or titres).

<sup>c</sup> ND = No data were collected

Queen et al. 1994). Similarly, *Moraxella* spp. are usually considered to be commensals of the upper respiratory tract and not primary pathogens (Timoney et al. 1988). *Moraxella* spp. have been isolated from healthy sheep in this herd (Thorne et al. 1982) and a recent survey of healthy bighorn in Idaho found this bacteria in 6 of 14 samples (Queen et al. 1994). However, *Moraxella* spp. was isolated from pneumonic bighorn sheep from Whiskey Mountain in 1991 (Ryder et al. 1992). Additional study and characterization of the bacteria isolated from Whiskey Mountain will be necessary to understanding their role as pathogens in this herd.

Antibodies against viral and chlamydial respiratory pathogens continue to be present at high prevalence. An earlier study of the Whiskey Mountain herd showed seroprevalence to PI3V to be 77% (23/30 tested) in 1976 and 1977 (Thorne et al. 1979). A previous study failed to incriminate these potential pathogens in cases of pneumonia in Whiskey Mountain sheep (Ryder et al. 1992) and seroprevalence prior to the epizootic was essentially the same as in years following the die-off. There is no direct evidence that these agents are of primary importance in pneumonia in this bighorn sheep herd.

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