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AN UNUSUAL CONTAGIOUS ECTHYMA OUTBREAK IN ROCKY MOUNTAIN BIGHORN SHEEP

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Abstract: An unusual contagious ecthyma outbreak was observed in a herd of approximately 160 Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) in Custer State Park, South Dakota. Symptomatic lesions were observed from February 1997 through January 1998, with all age and sex classes affected. Lambs were severely affected. The most heavily infected lambs exhibited lesions over the majority of their bodies, and associated swollen hooves impeded movement. Previous outbreaks in Custer State Park began in fall or winter and lasted 2-4 months, with severe infections never documented. Lamb survival is usually low in this herd and lamb:ewe ratios in 1997 dropped from roughly 88 lambs:100 ewes in June to 16 lambs:100 ewes by November. Descriptive data on infected lambs suggest that the virus contributed to this mortality. The prevalence, duration, and severity of this outbreak raises questions regarding the length of immunity gained from previous contagious ecthyma infections as well as the influence of physical variables on disease progression.

Contagious ecthyma (CE), otherwise known as orf, soremouth, or pustular dermatitis, is a highly infectious viral disease of the parapox group. The virus is characterized by elevated lesions that predominately affect the epithelial tissue of the lips, udders, hooves, and genitalia (Blood 1971, Lance 1980). Lesions develop rapidly and, in uncomplicated cases, healing is normally complete in 6 weeks (Lance 1980, Jessup et al. 1991). Outbreaks in a population are cyclic, may be indicative of long-term low stress levels, and are symptomatic of poor herd condition (Lance 1980).

In North America, CE was first recognized in a flock of domestic sheep (*Ovis aries*) in 1929 (Howarth 1929). Rocky Mountain bighorn sheep in Banff National Park, Canada, were the first North American wild ungulate to be documented with an infection (Connell 1954). Outbreaks in other wildlife species include California bighorn sheep (*O. c. californiana*; Blaisdell 1976), Dall sheep (*O. dalli;* Smith et al. 1982), mountain goats (*Oreamnos americanus;* Samuel et al. 1975), Himalayan tahr (*Hemitaragus jemlaicus*), chamois (*Rupicapra rupricapra*), steinbock (*Raphicerus campestris;* Kater and Hansen 1962), musk ox (*Ovibos moschatus;* Kummeneje and Krogsrud 1978), and reindeer (*Rangifer tarandus;* Kummeneje and Krogsrud 1979). In addition, mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), pronghorn (*Antilocapra americana*), wapiti (*Cervus elaphus;* Lance et al. 1983), and moose (*Alces alces;* Zarnke et al. 1983) have been infected experimentally.

In Custer State Park (CSP), South Dakota, CE was first documented in Rocky Mountain bighorn sheep in 1982. This outbreak was followed by three others in 1988, 1993, and 1997. The last outbreak was unusual for this herd in its prevalence, duration, and severity, and a descriptive study was begun to document its course. Funding for this study was provided by Federal Aid administered by South Dakota Game, Fish, and Parks and Custer State Park.

STUDY AREA AND METHODS

Custer State Park is located in the Black Hills in the southwestern corner of South Dakota. The park encompasses a 29,500 ha area that ranges from savanna grassland at 1.13 km elevation to rocky crags at 2.07 km elevation (Shave 1983). Ponderosa pine (*Pinus ponderosa*) is the dominant overstory species throughout the bighorn sheep range, with riparian areas containing primarily bur oak (*Quercus macrocarpa*) and paper birch (*Betula papyrifera*). Twenty-two Rocky Mountain bighorn sheep were introduced into the park in 1964 from the Whiskey Mountain herd in Wyoming. This herd has grown to approximately 160 animals, divided into 3 subherds.

Descriptive data on the CE outbreak were collected from June 1997 to January 1998 in conjunction with a bighorn sheep demographic study. During herd composition counts, each sheep was examined with binoculars for characteristic lesions. Age and sex of the sheep, location of lesions, other physical ailments, and notes on behavior were recorded. When possible, characteristics such as broken horns were used to identify individuals. The percent of lactating ewes in June and July was used to estimate the number of lambs produced, and total herd composition counts in November and December were used to calculate lamb survival. Three lambs that were severely affected were necropsied.

RESULTS

Ewes and Yearlings

Park employees noted symptomatic lesions on a small number of ewes and yearlings from February to March in all 3 subherds. After March, visible lesions were not observed on ewes or yearlings until late summer. On 22 August a ewe was seen with small lesions on her lips and a second infected ewe was seen on 14 October. From that date, infected ewes were seen with increasing frequency through December. Infections were limited to the muzzle, with infections ranging from small lesions on the lips to scabs covering the entire muzzle. Few infected yearlings were noted from September through November. Most yearling infections appeared mild, although one female did have lesions surrounding both eyes.

Lambs

In late June, composition counts and observations were begun in the subherds as part of a pilot study on lamb mortality. On 7 July characteristic lesions were seen on a lamb, whose hoof was scabby and bleeding. Infected lambs were seen through the summer and fall, with symptoms ranging from scabby lips to lesions covering most of the body. Infected lambs were not seen after November. Three lambs with severe infections were recovered and necropsied. Three additional dead lambs with small lesions on their lips were found but they were too decomposed to necropsy.

Necropsy #1 (17 July) A female lamb approximately 1 month old was found lying on a trail, unable to stand. Two hooves were swollen, 2 were split open and infected with maggots, and scabs were located around the coronet, on the lips and muzzle, and a few on the sides of its body. The lamb died within an hour of being located and was taken to Fall River Veterinary Clinic to be necropsied. No additional abnormalities were found and samples of the lesions and all major organs were sent to South Dakota State University (SDSU) and the National Veterinary Services Laboratory. Both labs identified a virus with morphological characteristics compatible with contagious ecthyma through electron microscopy. The lamb's rumen was 3/4 full of grass and contained a small amount of milk. Information on the dam's infection status or lactating condition was not available.

Necropsy #2 (1 August) This female lamb was between 1-2 months old and had been dead for 24-48 hours when it was located. All 4 hooves were infected around the coronet, and 1 was split open and infected with maggots. Lesions were also present around its lips and muzzle. Decomposition hampered the necropsy and only tissue samples from the lips were sent to SDSU for virus identification. The lab determined that a virus was present but the tissue was too autolyzed to make a positive identification. A fecal sample was processed for lungworm larvae and none were found. The lamb's rumen was full of grass. The dam exhibited no visible symptoms of CE and had a shrunken udder.

Necropsy #3 (4 September) This lamb was euthanized due to the severity of its infection. Approximately 2 months old, the female lamb could barely walk when it was discovered. All 4 hooves were infected, with 1 split open and infected with maggots. Scabs were located from the coronet past the ankle on all 4 legs, with occasional scabs up to the knee. The muzzle was completely covered with scabs and the eyes were surrounded with scabs. Both ears were almost detached at the base due to the depth of lesions and necrosis present. Lesions literally covered the body, with notable ones along the spine, sternum, and at the base of the tail. On the rest of the body, you could part the hair and see scab material. Samples of all the major organs, the head, all four legs, and major lesions were sent to SDSU. The spleen had marked lymphoid depletion, and electron microscopy suggested contagious ecthyma. A fecal sample was processed for lungworm larvae levels and it contained 11 LPG of *Muellerius capillarius.* The dam exhibited no external CE symptoms and the lamb's rumen was full of milk.

Rams

Rams of all classes (after Geist 1971) were observed with characteristic lesions from October through January 1998. Similar to ewes, infections on the muzzle ranged in intensity and one ram was observed with an infected hoof.

Infection rates

Without individual markers, it was not possible to track how many sheep in each sex/age class were infected over time or how long individual sheep were infected. Descriptions of individual infections were used to create a minimum count (Table 1). If a sheep with a similar infection was documented at any time later in the outbreak, it was not counted. This is a conservative count and the numbers were likely much higher.

Lamb Survival

An estimated 88% of ewes produced a lamb (88 lambs:100 ewes) based on 57 subherd observations in June and July. Subherd counts in October and November, when large groups were visible, were used to estimate the number of ewes and lambs in the herd. Based on an estimate of 93 ewes and 15 lambs, the lamb:ewe ratio in November was 16 lambs:100 ewes. The fall yearling:ewe ratio was 25 yearlings:100 ewes. The fall lamb ratio was lower than has been previously documented in the park (Table 2).

Table 1. Minimum counts of Rocky Mountain bighorn sheep infected with contabious echthyma during 1997 outbreak in Custer State Park, South Dakota.

	June - September	October-January[a]	Total
Lambs[b]	13	7	20
Yearlings[c]	1	1	2
Ewes	3	30	33
Rams	0	5	5

[a]If a sheep with a similar infection was counted in summer, it was not included in fall count.
[b]Count for 1997 lambs, does not include 1996 lambs infected in February or March.
[c]Count for 1997 yearlings, does not include 1996 yearlings infected in February or March.

Table 2. Lamb:ewe and yearling:ewe ratio counts for Rocky Mountain bighorn sheep in Custer State Park, South Dakota.

Year	Lambs:ewes	Yearlings:ewes
1983	45:100[a]	19:100[b]
1984	36:100[a]	21:100[b]
1985	42:100[b]	23:100[b]
1987	39:100[b]	20:100[b]
1988	77:100	24:100[b]
1989	42:100	
1997	16:100[b]	25:100[b]

[a]Ratio counts from November
[b]Ratio counts from August
[c]Ratio counts from January

DISCUSSION

The primary difference between the 1997 outbreak and the three previous infections in CSP was the effect on the new lamb crop. The 1982, 1988, and 1993 outbreaks occurred only during fall or winter, with no severe infections reported. Severe infections in lambs are not exceptional (Blood 1971, Samuel et al. 1975, Dieterich et al. 1981, Zarnke et al. 1983), but it was unique to the outbreaks in CSP. Additional underlying stress factors, as well as general poor herd condition, have been offered as explanations for other severe infections (Samuel et al. 1975, Lance 1980, Jessup et al. 1991, L'Heureux et al. 1996) and seems a likely explanation for the CSP outbreak. The CSP bighorn sheep herd has remained static at 120-160 animals since 1975, and periodic counts and employee observations indicate lamb survival has been low throughout this time (CSP, unpub. data). Lungworm infections, poor nutrition, and limited genetic variability are some of the factors that CSP has identified as potential limiting factors to lamb survival, all of which might explain the 1997 lamb crop's vulnerability to CE.

Lungworm Infections

Lungworms can adversely affect lambs directly through infection or indirectly by reducing nutritional condition of the ewes. Infections by lungworms can dispose bighorn sheep to viral and bacterial pneumonia (Buechner 1960, Forrester 1971, Stelfox 1971, Hibler et al. 1972, Demartini and Davies 1977) and the resulting lungworm-pneumonia complex has been implicated in several catastrophic lamb die-offs (Hibler et al. 1972, 1974; Woodward et al. 1974; Spraker 1979; Spraker and Hibler 1982). While pneumonia has never affected this herd, transplacental migration of *Muellerius capillarius* has been documented (Brundige 1985) and lungworm infections might be depressing lambs' immune responses. Furthermore, high parasitic loads of the ewe during gestation may increase metabolic demand for maintenance and may result in poor condition ewes (Festa-Bianchet 1991). In turn, these ewes may produce smaller, less viable young that will have greater difficulty coping with severe weather, disease, and parasites (Geist 1971). The lungworm *Muellerius capillarius* has been considered ubiquitous in this herd since 1984 (Pybus and Shave 1984) and LPG >4000 have been reported (Brundige 1985).

Poor Nutrition

Inadequate nutrition during gestation and lactation may result in weaker lambs. Udder size and lactation capacity (Thomson and Thomson 1949, 1953), as well as the onset of copious lactation and the rate of milk secretion (McCance 1960), are negatively affected by poor nutrition during gestation. When less milk is available, lambs may graze earlier and more intensely. Horejsi (1976) found that lambs in a low survival year tried to increase forage intake when the milk supply became inadequate, but by then forage quality had declined. Low milk intake and early reliance on poor forage resulted in retarded growth, a determinant of lamb mortality during his study. Severe lesions on lambs in CSP did not appear to impact their ability to feed, but several lambs were observed vigorously eating grass within 1-2 months of birth. Additionally, descriptive data from a pilot study in 1997 suggests that the bighorn sheep in CSP grow slower and reach a smaller size than those in areas with higher lamb survival (Merwin 2000).

Limited Genetic Variability

In 1990, Fitzsimmons (1992) found that the bighorn herd in CSP had an effective population size of 21, with an estimated herd size of 145 animals. The CSP herd also had significantly lower heterzygosity than its founder herd. Franklin (1980) recommend an effective population size of $\geq$ 50 animals in order to maintain genetic variability over the short term and a herd of > 500 to reduce genetic loss over the long term. Factors related to reproduction and viability of offspring are described to be the first factors depressed through an increase in homozygosity (Farnsworth 1978).

The duration of the outbreak was also unique for this CSP infection, and potentially for any CE outbreak. Lesions were seen for nine months between February 1997 and January 1998, although presumably some animals in the herd were likely infected between April-June. Again, why this outbreak was unique is linked to the infection of the new lamb crop. Lambs carried the infection through most of the summer, while yearlings and adults exhibited symptoms in the previous winter and proceeding fall. In addition, the prevalence of the infection appeared unusual compared to other CSP outbreaks. The actual percentage of the population that was infected, or the duration of individual infections, was unknown. However, given the duration of the outbreak and the consistency with which infected sheep were seen, either a smaller number of individuals were infected for much longer than the typical 4-6 weeks (Lance 1980, Jessup et al. 1991) or a majority of the herd was infected. It seems more likely that the latter is true, given the minimum number of sheep infected (see Table 1). If a majority of the herd was infected in 1997, and given that the last CE infection was in 1993, immunity to CE may be short term (Lance, personal communication) rather than long term (Blood 1971, Samuel et al. 1975, Zarnke et al. 1983, L'Heuruex et al. 1996). The prevalence of the infection supports that lambs are not protected with colostrum from infected dams (Kerry and Powell 1971).

This latest CE outbreak has emphasized the need to investigate the factors affecting lamb survival in CSP. Several potential factors, including those mentioned previously, are being examined in two separate studies. Through these investigations, we hope to gain insight in how to better manage the bighorn sheep herd for increased lamb survival and overall herd condition.

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