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FURTHER STUDIES ON HORN ABERRATIONS IN DALL'S SHEEP (*OVIS DALLI DALLI*) FROM YUKON TERRITORY, CANADA[1]

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ABSTRACT: The prevalence of horn aberrations in Dall's sheep from the Kluane Lake area of Yukon Territory observed during July 1982 represented 1% of the total population and 7% of rams 6 yr or older. Ewes were not considered in these percentages because they were too difficult to inspect by aerial survey. When these data were combined with other data collected from 1977 through 1981, the prevalence equalled 2.4% of the total population and slightly exceeded 16% in mature rams (≥6 yr). The anomaly followed necrosis of the terminal region of the horn core and the sequestering of portions of the core within the sheath as the sheath continued to grow. Sheath that was produced after the core was anatomically altered resulted in abnormal growth patterns of the horn. Rams with aberrant horns could not maintain homeostatic temperatures within horn cores when horns were experimentally exposed to −80 C for 30 min. Histologic examination of superficial and cornual vascular systems did not reveal any structural alterations that would restrict blood flow within cores of affected horns. Examination of museum specimens consisting of 130 skulls from rams and 81 from ewes collected from Alaska, USA, Yukon Territory, Canada, and Northwest Territories, Canada, established only one ewe and no rams with the horn aberration. The skull was from a ewe and had both horns affected and was collected from the Joe River Drainage, Yukon Territory in 1912.

INTRODUCTION

Horn aberrations in Dall's sheep from the Kluane Lake area of Yukon Territory are of two basic types. In the more prevalent type, one horn is severed at an annual growth check and the remaining terminal segment is a short protuberance (Hoefs, 1980; Hoefs et al., 1982). Rams with this type of horn anomaly are referred to as one-horned. The second type has the characteristics of the first but, in addition, the broken horn undergoes extreme twisting and torquing during subsequent growth and in some cases may grow into the animal's head or neck. In the second aberration type, the horn may be torqued at 90 degrees.

The primary cause of these horn aberrations has not been identified. The anomaly is, however, associated with necrosis of the terminal region of the horn core, cavitation of the sheath between successive periods of annual growth, sequestration of portions of necrotic core within the sheath, and the laying down of keratinized stratum corneum in an irregular fashion (Hoefs et al., 1982). Hoefs et al. (1982) did not believe the anomaly was due to either accident or infectious disease and suggested a possible genetic origin.

The anomaly is a serious problem because affected rams have no esthetic value and are not very marketable to trophy hunters. The prevalence of horn aberrations in the Kluane Lake area is estimated to be 2% of the total Dall's sheep population and 14% of harvestable rams (≥6 yr old). Casual sightings of affected rams in other populations of Dall's sheep have also been reported, but the prevalence is

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believed to be much lower in those cases (Hoefs et al., 1982).

The purpose of this part of a continued study was to reassess the prevalence of the anomaly in the Kluane Lake area, assess its prevalence in other populations of Dall's sheep by examining museum specimens, determine whether the thermoregulatory capacity within an affected horn is inadequate to prevent the core from freezing, and examine superficial temporal and cornual arteries of affected animals for anatomical abnormalities.

MATERIALS AND METHODS

Two rams, one representing each type of horn aberration, and one normal ram were collected in the Ruby Mountain Range of the Kluane Lake area in southwestern Yukon. The collection was part of a survey of approximately 1,200 sheep. Rams were live-captured with a net gun (Williams, 1980). Upon capture, they were tranquilized with 3 cc Valium (5 mg/ml, Hoffmann-LaRoche Inc., Nutley, New Jersey 07110, USA) and then transported to the base camp by helicopter.

The rams were prepared to have their horns subjected to −80 C by treating them intravenously with 4 cc of a mixture (5.0 mg/cc and 95 mg/cc, respectively) of Rompun (Haver-Lockhart, Shawnee, Kansas 66201, USA) and Ketaset (Bristol-Myers, Syracuse, New York 13201, USA) to maintain a sedated state. After each ram was sedated, a series of holes was bored through the sheath of an affected horn with a 1.5-mm sterilized drill to determine the position of the tip of the horn core. Once this was determined, a type E probe chromel-constanton (Omega Engineering Inc., Stramford, Connecticut 06907, USA) was inserted through the sheath approximately 12 mm from the end of the horn core and about 4–5 mm into the core. The openings of the holes were sealed with sterile bone wax (Ethicon Corp., Sommerville, New Jersey 08676, USA). The wire leading from the core was fastened to the horn sheath with filament tape (Scotch Brand 3M, St. Paul, Minnesota 55144, USA) to prevent the wire from being pulled out during treatment. A cotton cloth bag approximately ½ m sq was filled with finely crushed dry ice and wrapped around the horn. Around the cloth bag was wrapped 48-cm-wide polyethylene coated freezer wrap (H. P. Smith, Chicago, Illinois 60638, USA), which was then sealed at the base and tip of the horn with filament tape. A 10-cm opening was made through the freezer wrap on the upper side of the horn. The lead wire of the probe was then inserted into a 450 AET Thermocouple Thermometer (Omega Engineering Inc., Stramford, Connecticut 06097, USA). Ethanol alcohol cooled to −80 C with carbonic ice was poured through the opening of the freezer wrap until the cloth bag was saturated. Rectal (monitored with a glass thermometer) and horn core temperatures were recorded every minute for 30 min. The affected rams were then killed by severing the jugular vein and carotid arteries and the control ram was released to its native habitat.

The superficial temporal arteries and adjoining cornual arteries were dissected away between the juncture of the external carotid artery and the base of the horn sheath in the two affected rams. Arteries were fixed in formalin, microsectioned and then stained with elastin Verhoff stain and hematoxylin-eosin stain following the methodology outlined by Lamberg and Rothstein (1978). The horns were described, sagittally sectioned and photographed.

Skulls from museum specimens were examined at the American Museum of Natural History, New York City, New York 10024, USA; Field Museum of Natural History, Chicago, Illinois 60600, USA; National Museum of Natural History, Washington, D.C. 20560, USA; Museum of Natural History, Denver, Colorado 80200, USA; and Museum of Natural History, University of Alaska, Fairbanks, Alaska 99701, USA. Skulls from 81 ewes and 130 rams were studied.

RESULTS

A total of 1,203 sheep were counted in the study area. Of these, 349 were rams separated from the nursery bands, which indicated they were 3 yr or older. We estimated that 130 of the 349 rams were over 6 yr of age. Nine of the 1,203 sheep surveyed had aberrant horns. Since all nine affected sheep were believed to be rams 6 yr or older, 7% of the mature rams were affected. No attempt was made to evaluate the prevalence of horn aberrations in ewes because it would have been too disruptive to the nursery bands.

Only one of 211 skulls examined in museum specimens exhibited the anomaly. The skull was that of a mature ewe collected from the Joe River Drainage, Yu-

FIGURE 1. Skull from 6-yr-old ram collected at Kluane Lake, southwestern Yukon in 1982. Left horn was broken away at an annual growth check.

kon Territory in 1912. Both horns were affected with approximately ⅓ of the sheath severed away.

The captured sheep represented animals with both types of horn aberrations. Of the first type, the horn had broken away at an annual growth check when the ran was 5 yr of age (Fig. 1). This animal's other horn was intact and had not deviated from its normal pattern. The other ram had both of its horns affected. A segment of the sheath was missing from each horn, which had apparently occurred at an early age. Both horns had undergone abnormal torquing, and the circumference of the horns had become enlarged.

The sagittal section of what appeared to be normal horn on the one-horned ram showed various structural changes (Fig. 2). The typical conical appearance of the tip of the horn core was altered into two protrusions. Part of the horn core had been displaced and was sequestered in the sheath of the previous two growth periods. Vascularization was still maintained to the sequestered core. Horn sections of the ram with two affected horns showed that the aberrant patterns of torquing had persisted over four growth periods (Fig. 3). Instead of the characteristic conical pattern that commonly occurs from one growth period to the next, these sections revealed three different growth patterns. The horns had broken away approximately 3 yr prior to capture of this ram. The other sectioned horn revealed part of the process that accompanies development of the anomaly (Fig. 4). The terminal portion of the core showed evidence of separating from the remaining core and of becoming sequestered in the sheath. Sequestering of a portion of the core at the point of initiation of the previous year's growth can also be observed embedded within the sheath. The left core of this ram was laterally displaced to lie over the dorsal and posterior region of the orbit (Fig. 5). The ventral border of the left zygomatic arch

FIGURE 2. The typical conical shape of the horn core of ram described in Figure 1 had become altered into two protrusions. Part of the core can be seen sequestered in the previous year's growth of sheath.

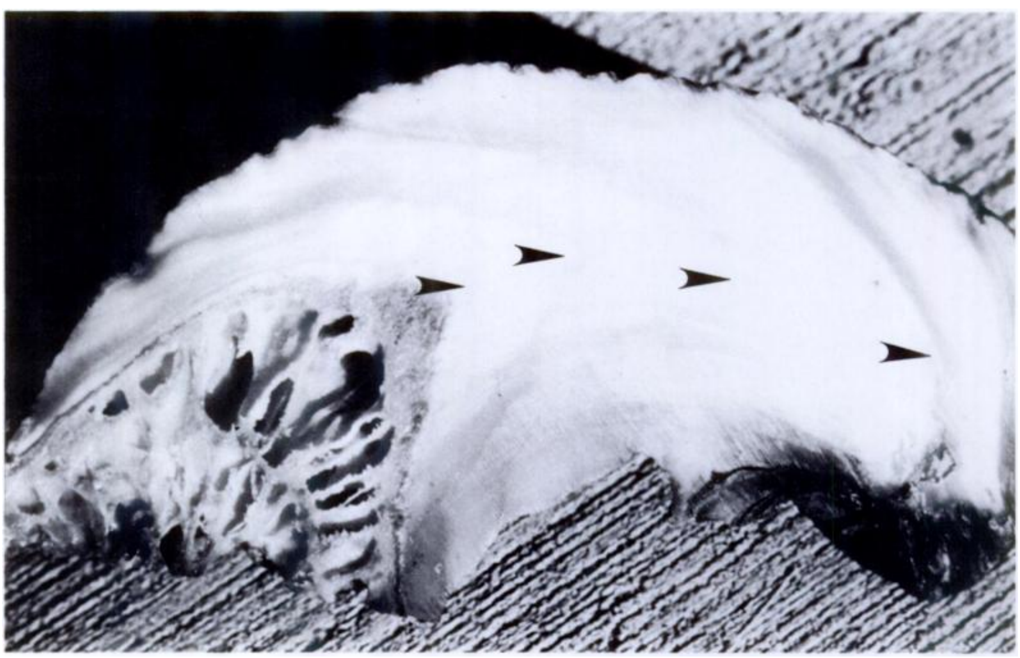

FIGURE 3. Abnormal patterns in right horn sheath development of 8-yr-old ram collected at Kluane Lake, southwestern Yukon (1982) occurred over four growth periods and contributed to the aberrant torquing of the horn.

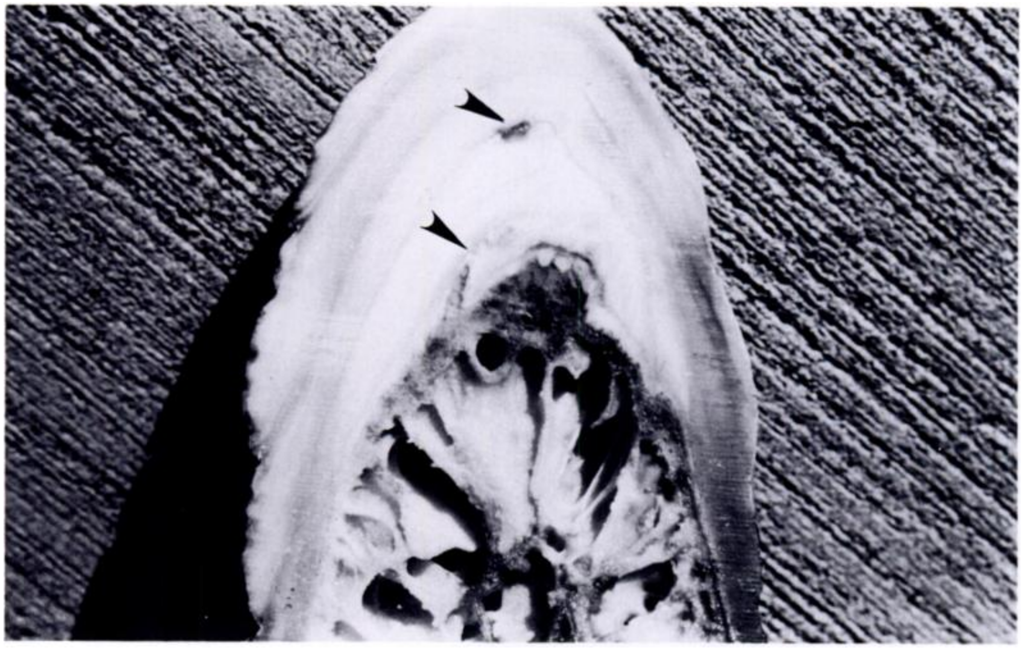

FIGURE 4. A small segment of the left core of 8-yr-old ram was sequestered in the beginning of the previous year's growth of sheath and some vascularization was still maintained. The terminal area of the core was in the process of becoming separated from the body of the core and would have become sequestered in the present growth period of sheath.

was positioned lower on the skull than on the right (Fig. 6).

Temperature changes within the horn cores during their exposure to −80 C are shown in Figure 7. For the control ram, horn core temperature at the initiation of the study was 38 C, declined by 3 C within 20 min and then remained at 35 C. The one-horned ram started out with a horn core temperature at 38 C and rapidly declined to 19 C within 30 min. Core temperatures in both horns of the other affected ram were measured. At the initiation of treatment, the temperature in both horns was at 38 C. They gradually declined over the 30-min treatment period with a final left-core temperature of 32 C and a right one of 31 C. Rectal temperatures of the rams remained constant at 37.5 C, 40 C, and 37 C for the control and affected rams 1 and 2, respectively.

DISCUSSION

The total sheep count of 1,203 during this survey period (July 1982) was down from the July 1980 survey of an estimated 1,300 sheep (Hoefs et al., 1982). The reduction was due probably to the severity of the previous winter and the subsequently smaller lamb crop during the spring of 1982. The number of sheep seen to be affected with the horn anomaly during this study represented 1% of the total population and 7% of mature rams. When these data are integrated with previously collected data and calculated back to 1977, the prevalence rate was believed to be more representative of the population since it reflects several years of observation (Hoefs et al., 1982). From 1977 to July of 1982, 31 rams in the Kluane Lake population were identified as having aber-

FIGURE 5. Left horn core of 8-yr-old ram arises from the posterior region of the orbital bone and zygomatic arch. In a normal skull the core is positioned 15–20 mm dorsal-posterior to the rim of the orbit.

rant horns. All but one of these rams had been alive in 1977. The exception was a yearling when he was collected in 1980. Except in 1982, the population has remained fairly stable at about 1,300 sheep. Based on cumulative data, the prevalence would be 2.4% of the total population, 9% of rams 3 yr or older, and slightly over 16% of rams that are 6 yr of age or older. The latter percentage is of major importance to the Yukon Department of Renewable Resources because it represents a significant proportion of harvestable rams. Rams with horn aberrations have little trophy or esthetic value and, therefore, are of lesser importance from the game manager's viewpoint.

Museum specimens were used to assess the prevalence of the anomaly in other populations of Dall's sheep. Although this method has its own bias, since some aberrant forms may be discarded, they still provide an additional method to study a skeletal deformity. Of the 130 skulls from rams, none were recognized as having the anomaly. Only one of 81 skulls from ewes was affected. These data suggest the horn aberration outside our study area occurred at a much lower frequency.

As reported in our 1980 finding (Hoefs et al., 1982), horn aberrations are associated with necrosis of the terminal portion of the horn core. This usually involves a relatively small area; however, as much as

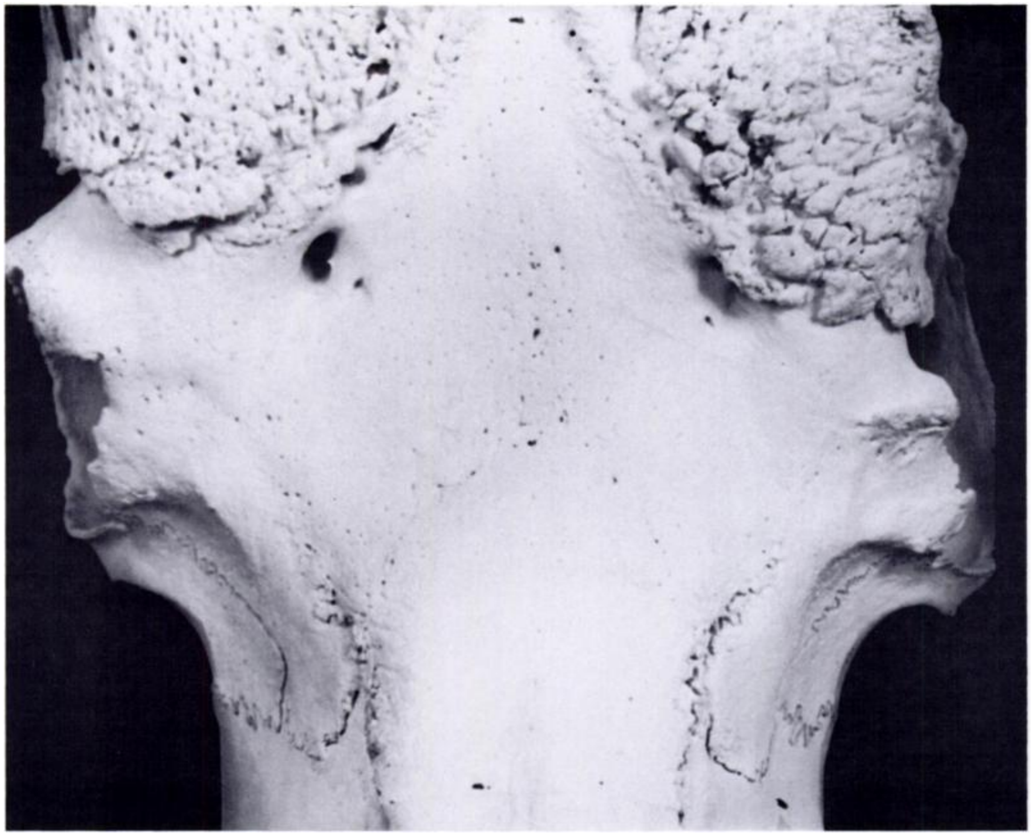

FIGURE 6. The left horn core of 8-yr-old ram is laterally and frontally displaced and the zygomatic arch is lower as compared to the more typical position on the right.

⅓ of the core can be involved. Sagittal sections of aberrant horns of the two affected rams collected during July of 1982 revealed the same basic pathological changes as reported previously. In the one horned ram, a large portion of the core in the remaining horn had separated and had become sequestered in the sheath. The region of sequestration was dispersed throughout nearly a year's growth of sheath, which suggested the necrosis was a gradual process. New sheath had been laid down from the terminal end of the disrupted core and followed the pattern of the external shape of the core. The other affected ram had similar abnormal changes in core structure. In this ram, however, only the extreme terminal area of the core appeared to be involved. In one sagittal section, a portion of the core could be seen that had separated from the remaining core at the beginning (Nov–Dec) of the present year's growth of sheath. In addition to the terminal region of the core being altered, the periphery was also affected and resulted in an increased diameter of the horn.

Another factor in altering the normal pattern of horn growth is the sometimes frontal and lateral displacement of the core. This causes the horn to grow sideways from the head, with the tip curling towards the head or neck.

The primary cause of the anomaly re-

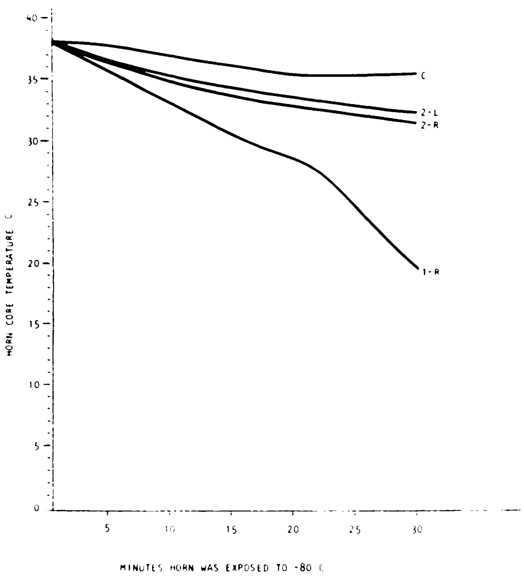

FIGURE 7. Core temperature of horns exposed to −80 C for 30 min (C: control; 1-R: one-horned ram, shown in Fig. 1; and 2-L, 2-R: ram with both horns affected).

mains unknown. Affected rams whose horns were challenged with −80 C temperatures could not maintain homeostatic core temperatures. This was not the case for the control ram. The rapid drop in core temperature of the one-horn ram left little doubt that the terminal segment of the horn core would have frozen under extremely cold temperatures. The drop in core temperature in the other affected ram was not nearly so rapid; however, it might have continued to drop had the experiment persisted past 30 min. While the experimental design theoretically had the potential to produce a temperature as low as −80 C, sheep in the study area more than likely would not be subjected naturally to such temperatures for any length of time. Colder temperatures encountered in the Yukon rarely exceed −49 C. Considering the 30-min treatment period, the challenge to the horns would be comparable to the very lowest temperatures that rams would experience in the wild. Higher temperatures with more prolonged exposure periods could result in the same response as we observed under experimental conditions. From these observations we can only speculate that aberrant horns may be more susceptible to freezing than normal horns.

Histologic examination of blood vessels leading to the horn cores did not reveal any apparent abnormalities. Each vessel had a relatively thin wall and a well-defined intimal elastic membrane. No intimal cell proliferation or thrombosis were observed.

At this point in our investigation, we believe the horn anomaly may be either congenital or occur at a very early age. Although the aberration is generally recognized at 5–6 yr of age, analysis of horn core structure and sheath patterns suggest it begins much earlier. The torquing of a ram's horn is a consequence of several years' events, and its beginning can usually be traced to an early period in the animal's life. Although external horn changes are uncommon in young rams, a yearling ram with a horn aberration was collected in July of 1980 (Hoefs et al., 1982). It was noted that the affected core was much larger than the core of the normal horn. If this ram had lived for several more years, his horn pattern would have been characteristic of rams whose horns grow abnormally. In past studies no obvious infectious diseases have been associated with the horn aberration, and we found no evidence in this study to suggest otherwise. In all affected rams, we have observed skeletal changes of the frontal bone, particularly on the side of the head with the aberrant horn. Some of these changes may have occurred prior to ossification of the skull since they involve the cranial sutures. Displacement of the horn core also suggests an early or congenital onset. This observation further supports the conclusion that the changes that precede observable horn aberrations occur very early in the animal's life.

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