LUMPY JAW IN THINHORN SHEEP IN THE YUKON

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Yukon
Renewable Resources

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ABSTRACT

Lumpy jaw infection in the lower jaw, age, and horn growth, were assessed in skulls retrieved from sheep shot by licensed hunters in the Yukon from 1979 to 1985.

The frequency of infected jaws, and the frequency and severity of infections in lower jaws were closely correlated and occurred most frequently in the area below the premolars and molars.

Lumpy jaw occurred frequently in rams shot in the Yukon (37% of all lower jaws submitted were infected). Southern rams were more frequently infected (44%) than northern rams (25%).

There was no evidence that infected rams suffered higher rates of mortality; old rams (9+ years) were more frequently infected with more severity than young rams (<9 years).

No significant associations were observed between the frequency and severity of lumpy jaw infection and sheep density or horn growth (basal circumference, length of unbroomed horns, 2nd year's segment, and frequency of brooming), when areas and ages were combined. However, young rams in low density areas were more frequently infected and broomed than young rams in medium and high density areas. The infection and brooming in these young rams was similar to that of old rams. Also, horn growth of unbroomed horns was greater in rams from low density populations.

These two relationships, increased horn growth and higher frequency of brooming in young rams in low density sheep populations, lends support to Geist's (1971) hypothesis,

that horn growth facilitates early social dominance and rams in low density populations enjoy faster horn growth. We suspect young rams in low density populations in the southern Yukon engage in the rut at an earlier age than young rams in higher density populations and are therefore predisposed to brooming and perhaps lumpy jaw infection.

We suggest that lumpy jaw infection in Dall sheep rams is facilitated by physiological and physical stress which is more likely to afflict socially active rams, and therefore is a condition most common in dominant rams. However, we found no evidence that lumpy jaw infection is debilitating to sheep populations in the Yukon.

INTRODUCTION

Lumpy jaw is a disease characterized by localized degeneration of the jaw bone. The disease has been commonly associated with wild sheep (Ovis spp.), and more specifically with Dall sheep (O. dalli dalli; Murie 1944, Neiland 1972, Hoefs and Cowan 1979, W. Heimer, pers. comm.). In Alaska, the Northwest Territories and the Yukon, where Dall sheep lower jaws have been collected, 25 to 50% of collections have been described as having lumpy jaw (Murie 1944, Simmons 1982).

Early reports inferred that lumpy jaw in wild sheep was the result of the bacteria Actinomyces, commonly found in domestic cattle suffering similar symptoms. However, the bacteria has never been isolated from infected sites on either Dall or Bighorn sheep (O. canadensis). The bacteria Corynebacterium pyogenes, and to a lesser degree Fusobacterium necrophorum have been isolated from jaws of wild sheep with the characteristics of the disease commonly referred to as lumpy jaw (Glaze et al. 1982, Neiland 1972).

Predisposition to the ailment is conjectured by Glaze et al. (1982) to result from abnormal wearing of teeth, loss of teeth, or disruption of the tooth arcade, creating sites for infection by the oral necrotizing bacteria. The abnormal wearing or disruption of the tooth row, it is postulated, is the result of impaction of vegetable matter between the teeth (Glaze et al. 1982), mastication of coarse or heavily loess-silted vegetation (Egorov 1967, Hoefs and Cowan 1979, Jensen 1974), defective tooth growth caused by micronutrient or mineral deficiencies (Orr 1979, Broughton 1981), or injury (Uhlenhaut and Stubbe 1980).

Range quality as a predisposing agent to lumpy jaw has not been well-established. Lumpy jaw has been found to be more prevalent in older sheep, and loosely correlated to tooth wear (Glaze et al. 1982). Hoefs and Cowan (1979) and subsequently Glaze et al. (1982) were of the opinion that the high siltation on grasslands in the vicinity of Kluane National Park Reserve resulted in higher levels of lumpy jaw, manifesting itself in old sheep who had suffered higher than usual tooth wear.

Both Orr (1979) and Broughton (1981) suspected that poor early development of teeth, as a result of mineral or dietary deficiencies, set the stage for mandibular anomalies with loss of teeth, thus initiating entry of the bacteria.

The effect of lumpy jaw on longevity or horn quality is unknown. Murie (1944), through analysis of pick-up skulls, suggested that infected sheep were less likely to live as long as uninfected sheep.

The intent of this study was to evaluate the occurrence of lumpy jaw in Dall sheep rams shot in the Yukon in the years 1979 to 1985 and to assess whether this disease has management implications. Dall sheep are managed primarily for trophy hunting. The trophy quality achieved in a given ram is influenced by horn growth rates as well as the degree of horn brooming, and both of these factors are related to the age of the ram. Environmental stress factors, such as this disease may lower life expectancy as well as negatively influence horn quality, and therefore have management relevance.

STUDY AREA

Analysis of lumpy jaw was carried out on lower jaws of sheep submitted through compulsory submissions from sport hunters in the Yukon. Jaws originated from sheep killed throughout the Yukon with the exception of the north (north of 66 latitude), the extreme southwest corner (Kluane National Park Reserve and Kluane Game Sanctuary), and a few protected areas in the central Yukon (Fig. 1). The distribution of sheep killed is a reflection largely of sheep density, road access, and proximity to major human population centres. The licensed sheep kill was regulated according to the Yukon Wildlife Act and Game Regulations, prescribed for 11 Game Management Zones (see Fig. 1). The majority of the submissions were from four zones and six ecological regions (see Fig. 1). These four zones are ecologically distinct, based on biophysical data, primarily vegetation, landform and climate (Oswald and Senyk 1977).

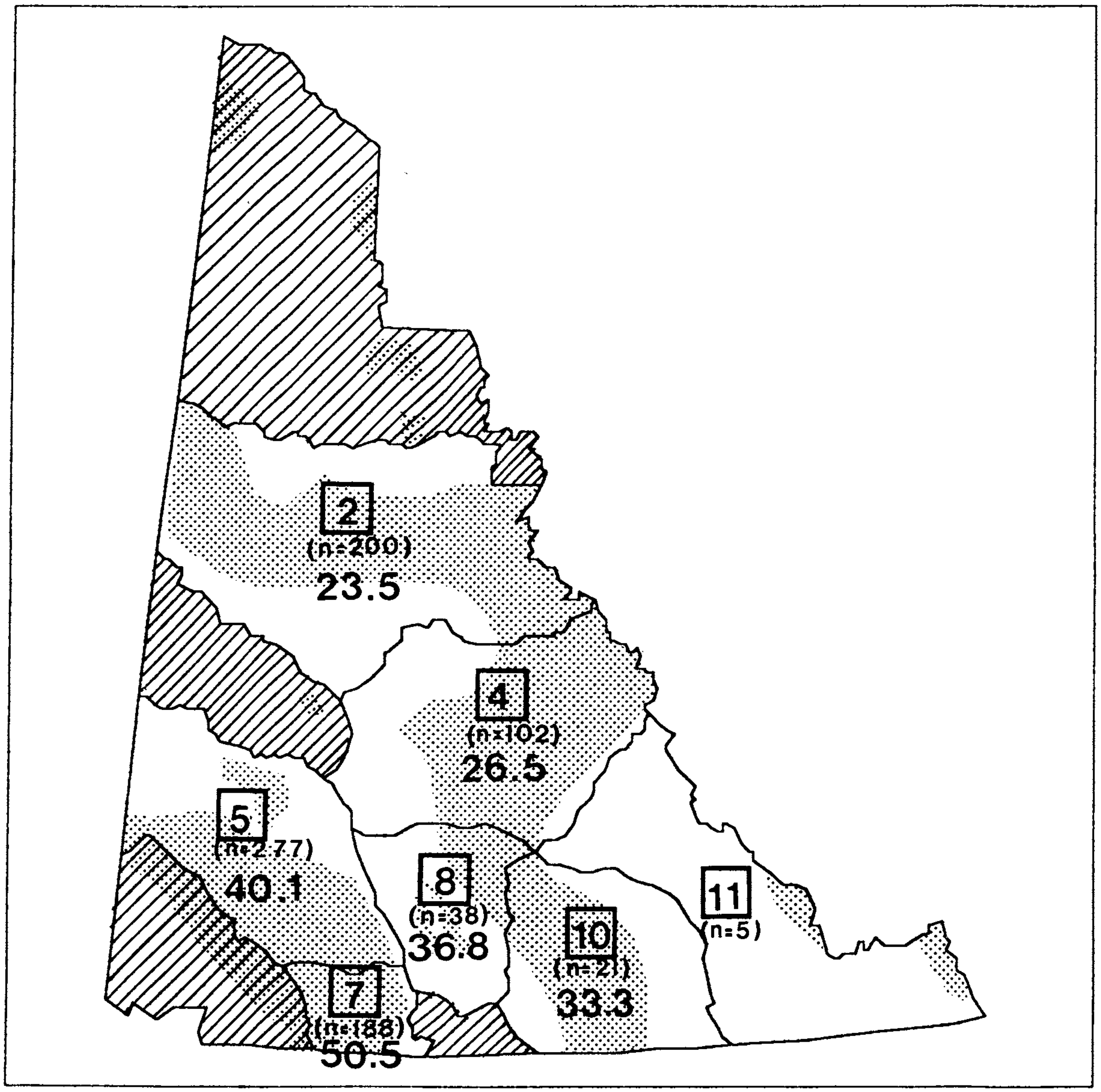


Figure 1: Game Management Zones in the Yukon and number of lower jaws and skulls submitted for measurements. Stippled area (::::::) shows sheep distribution, and hatched areas (/////) are closed to hunting.

In the southern Yukon, data were available on sheep density within Game Management Subzones (subsequently referred to as subzones). Comparisons of frequency of lumpy jaw infection and horn growth were made with density class; 1 being less than 1 non-lamb sheep per 10 km^2 (low density), 2 being 1 to 5 non-lamb sheep per 10 km^2 and 3 being greater than 5 non-lamb sheep per 10 km (high density). Density was derived based on summer population counts within areas which were delineated as subzones.

Lumpy jaw was assessed by identifying 17 sites on the lower jaw and qualitatively assessing the extent and severity of the bone degeneration. The breakdown of 17 sites was made on the basis of tooth location (Fig. 2). Lumpy jaw at each site was assessed from 0 to 3, with "0" being uninfected and "3" representing severe infection, with severe swelling, perforation or honey-combing of the mandible, and erosion of the bone at the base of the teeth. An explanatory note about this assessment is attached as Appendix II.

Five measurements were calculated: frequency of infected sites, the total severity of infection per jaw (sum of all severity measures), the average severity of each infection on each jaw, and an index of severity which was calculated as average severity of each infection multiplied by the frequency of infection on each jaw. Correlations were made on each of these measures of lumpy jaw with age and other parameters.

Statistical treatments included analysis of variance (ANOVA) when continuous variables were treated by categorical variables, and chi-square analysis to compare frequency data.

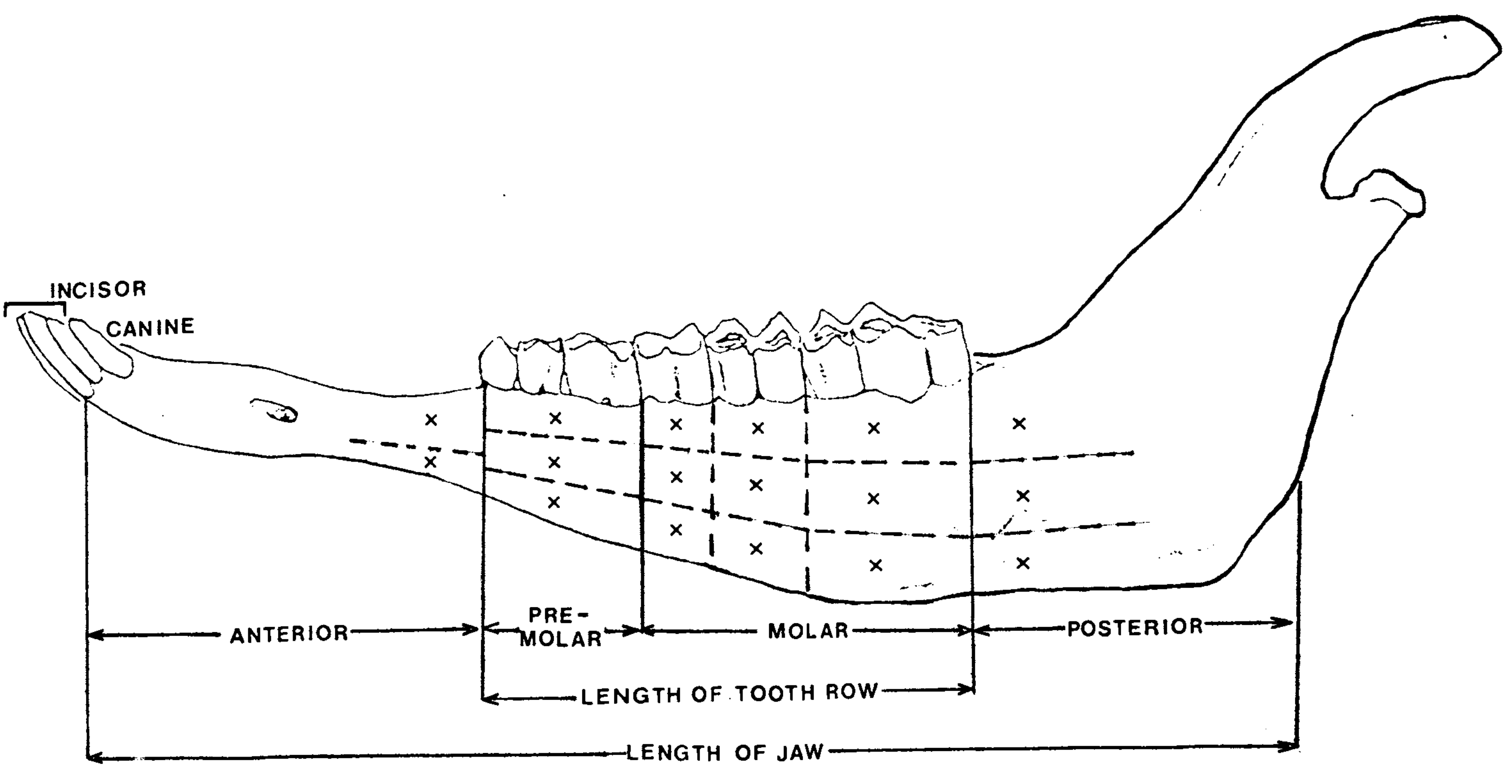


Figure 2: Thinhorn sheep jaw showing location of tooth types and the location of sites on the mandible assessed for lumpy jaw (x).

RESULTS

Measures of frequency of lumpy jaw infection and severity of infection were all closely correlated. Three calculations of lumpy jaw were used in further analysis: (1) presence or absence of infection; (2) the number of sites infected per jaw, and (3) the sum of all severity measures per jaw (referred to as severity).

A total of 831 jaws were assessed for lumpy jaw, 465 from the southern Yukon, 302 from the northern Yukon and 64 from the east-central Yukon (zones 8, 10 and 11). In the southern Yukon, 153 skulls were measured from low density areas, 204 from moderate densities, and 106 from high densities. Fifty-seven percent of all measured skulls were from young rams (less than 9 years old), and 71% of all skulls were unbroomed.

Lumpy jaw occurred more commonly in the region of the mandible below the premolars and molars, and less frequently in the anterior (area in the jaw below the incisors and in front of the premolars), and posterior sections of the lower jaw (area behind the molars). This distribution of infection in the jaw was similar throughout the Yukon, although frequency and severity varied between regions. From all infected jaws, less than 10% of all sites in the anterior and the posterior sections were infected. In contrast, greater than 30% of all sites in the region of the premolars and molars of infected jaws were infected.

Regional differences

Lumpy jaw infection was linked to zone and ecological region. Jaws from southern zones and ecological regions were more frequently infected and had higher severity of lumpy jaw than jaws from areas to the north. The percentage of jaws infected in each zone ranged from 23.5 to 50.5% (see Fig. 1). Regional differences in lumpy jaw were independent of age; lumpy jaw occurrence and severity were more prevalent in the south in both young and older-aged animals ($p<0.01$).

Age

Older rams were more frequently infected (more jaws were infected and there were more infections per jaw) and had greater severity of infection than younger animals (Table 1), independent of region ($p<0.05$). Differences between age and frequency of infection were particularly evident between 10 and 11 years. Less than 40% of rams, aged 6-10, were infected with lumpy jaw, while over 50% of older rams were infected (see Table 1).

Sheep density

In the southern Yukon, where sheep density estimates were available, no significant relationships were found between sheep density and lumpy jaw occurrence ($p=0.33$), or severity ($p=0.44$). Even comparing the extreme density classes, no relationships were evident between sheep density and either occurrence ($p=0.14$) or severity ($p=0.20$) of lumpy jaw.

The trend in young rams, however, was toward less frequent infections with increasing sheep density (Table 2). Comparing the number of infected sites between density extremes (class 1 and 3) we found a significant decrease in infection in young rams, with increasing density ($p<0.01$; see Table 2), and no relationship between sheep density and lumpy jaw infection of older rams ($p=0.89$).

Table 1: Age distribution of infected and non-infected jaws from rams shot in the Yukon, 1980-85.

Age	Region				Total	
	South		North			
	N	%	N	%	N	%
4	3	0	0	.	3	0
5	25	32.0	2	50.0	30	30.0
6	73	34.2	32	25.0	111	32.4
7	98	42.9	60	21.7	175	34.3
8	78	41.0	57	14.0	147	29.3
9	75	49.3	45	20.0	133	36.8
10	57	49.1	42	19.0	104	37.5
11	31	61.3	30	36.7	66	51.5
12	17	64.7	18	38.9	37	51.4
13	6	50.0	14	50.0	21	52.4
14	2	50.0	1	100.0	3	66.7
15	0	.	1	100.0	1	100.0
Young	277	38.6	151	19.9	466	29.4
Old	188	52.7	151	29.1	365	39.2

Column heading: Number of jaws collected and percentage infected

Pelage, cohort, and year of collection

The rate or the severity of lumpy jaw was not related to the pelage (subspecies) of sheep, its year of birth, or the year in which the collection was taken ($p>0.05$).

Lumpy jaw, horn growth and brooming

We could infer no relationship between horn growth vigour and infection when ages and regions were combined. The frequency of jaws infected was not significantly associated with total horn length of unbroomed horns ($p=0.52$), or the length of the second ($p=0.86$), or third year's horn increment ($p=0.92$). Also, the frequency of jaws infected was not related to the frequency of brooming ($p=0.23$).

However, when sheep density was considered, lumpy jaw infection, brooming, and age appeared to be linked. More young rams were broomed in low density areas (33%), than in moderate (19%), or high density areas (18%; $p=0.01$)(Table 2). In these low density areas brooming of young rams occurred at a rate similar to that of old rams (39%; $p=0.29$). Also, more young rams were infected (50%) in low density areas than in moderate (36%) or high (27%) density areas ($p=0.01$), and again, infection rate in young rams in low density areas was similar to that of old rams in all areas ($p=0.67$; see Table 2).

Also, horn growth was associated with density. As density class increased, total horn length of unbroomed skulls decreased ($p<0.01$; Table 3). The average length of the second year's horn segment and horn base circumference also declined with density, although these relationship were insignificant ($p>0.27$). These patterns were evident in old and young rams.

Table 2: Percentage of jaws infected, mean number of infections per jaw, and percentage of animals with at least one horn broomed, by age class and sheep density class.

Age class	Density	N	infections		%broomed
			%jaws	x/jaw	
Young	Low	94	50.0	5.2	33.3
	Medium	119	36.1	3.8	18.5
	High	62	27.4	2.5	17.7
	All	275	38.6	4.0	24.1
Old	Low	59	49.2	6.3	37.3
	Medium	85	57.7	6.9	41.2
	High	44	47.7	6.8	38.6
	All	188	52.7	6.7	39.4
All	Low	153	49.7	5.6	34.6
	Medium	204	45.1	5.1	27.9
	High	106	35.8	4.3	26.4

Table 3: Average horn measurements (mm), including base circumference, horn length of unbroomed horns, and the second year's horn segment, by age class and density class.

Age	Density	Base		Length		2nd seg.	
		N	Mean	N	Mean	N	Mean
Young	Low	93	341.3	80	887.0	94	21.8
	Medium	119	338.0	97	869.3	119	19.9
	High	62	332.0	51	855.0	62	19.2
	All	274	337.6	228	872.0	275	20.3
Old	Low	59	339.4	37	951.2	56	17.2
	Medium	85	339.4	49	931.2	83	16.5
	High	43	338.8	27	908.6	42	15.4
	All	187	339.3	113	932.4	181	16.5
All	Low	152	340.6	117	907.3	150	20.1
	Medium	204	338.6	146	890.1	202	18.5
	High	105	334.8	78	873.6	104	17.7

Generally, rams shot when they were young had lower incidence of lumpy jaw infection (39% compared to 53%; $p<0.01$), less brooming ($p<0.01$), and better horn growth (length of 2nd year segment, $p<0.01$) than rams shot when they were old (see Tables 2 & 3). As a ram ages it is likely predisposed to lumpy jaw infection and brooming. Young rams in low density areas, however, were similar to old rams in the degree of brooming and lumpy jaw infection, and had a much higher incidence of brooming and infection than young rams in high density areas.

DISCUSSION

Mandibular anomalies have been reported in most studied Dall sheep populations (Sheldon 1930, Murie 1944, Neiland 1972, Glaze et al. 1982), as well as in other wild sheep species. Lumpy jaw is the general term for conditions of the jaw resulting in osteolysis and enlargement, often associated with aberrations of the tooth arcade (Glaze et al. 1982). Severe cases of lumpy jaw result in perforation or honey-combing of the jaw. The bacteria Cornebacterium pyogenes and Fusobacterium necrophorium have been isolated as the infection agents in Dall sheep jaws diagnosed as having lumpy jaw (Glaze et al. 1982).

Lumpy jaw occurred commonly in Yukon Dall sheep rams. More than 36% (n=831) of all harvested rams in the Yukon from 1979 to 1985 were infected with lumpy jaw. In Alaska, Murie (1944) and W. Heimer (pers. comm.) found lumpy jaw to occur in approximately 27% of all Dall sheep. Early examinations in the southwest Yukon reported the prevalence of lumpy jaw in as many as 70% of inspected jaws of pick-up skulls (Glaze et al. 1972). Yet, in the Yukon, Dall sheep populations are considered stable and healthy; no regular occuring die-offs have been observed, and the hunter-kill has been relatively stable since 1978 (Table 4).

We observed lumpy jaw to occur frequently in the area of the mandible below the premolars and molars and infrequently in the anterior and posterior sections of the lower jaw (see Fig. 2). Dental anomolies of wildebeest in Tanzania also occurred most frequently in the mid-section of the mandible, which Gainer (1981) believed was related to the animal´s growth patterns. Gainer (1981) suspected that retarded growth would result in inadequate space between the P3 (2nd premolar from the anterior) and molar teeth to accommodate

Table 4: Number of sheep and average age of rams shot by licenced hunters in the Yukon, by year, from 1980 to 1988.

Year	Number killed	Average age
1980	253	8.7
1981	252	8.8
1982	260	8.6
1983	219	8.5
1984	227	8.0
1985	262	8.3
1986	253	8.5
1987	286	8.7
1988	322	8.9

the later-erupting P4 (3rd premolar from the anterior), and therefore lead to disruption of the tooth arcade. Impaction of vegetation and tooth wear would also be expected to occur more frequently in the area of mastication, in the mid-section of the jaw, than in the anterior and posterior areas.

Lumpy jaw and tooth wear

Aitcheson and Spence (1983) examined heads of domestic sheep in Scotland and also found that where incisor loss, malalignment or looseness occurred there was a likelihood of cheek tooth disease. Glaze et al. (1982), conjectured that lumpy jaw in Dall sheep was related to nutritional conditions which influenced tooth development and wear. It remains unclear whether tooth conditions predispose rams to lumpy jaw, whether lumpy jaw influences tooth conditions, or whether both are independently related to nutrition.

Regional differences

We observed that twice as many jaws were infected with lumpy jaw in the south than the north (see Fig. 1). These regional differences were unrelated to age distribution, which was similar between regions ($p<0.01$).

In the south average sheep densities are higher (unpubl. data) and there is greater average horn vigour in rams than in the north. Southern rams had greater horn base circumferences ($p<0.01$) and greater length of the second year's horn segment ($p<0.01$) than northern rams. Bunnell (1978) found horn growth in Dall sheep associated with range conditions, with the greatest variation in horn growth evident in the early year classes. This has been substantiated by Mindek (unpubl. rep.). Yet, sheep in the south on presumably better range, were much more frequently infected with lumpy jaw.

Higher sheep densities in the south compared to the north did not explain the higher incidence of lumpy jaw infection in southern rams. Where density estimates were available in the south, no association was found between density and lumpy jaw occurrence.

Therefore, we found no inferences that nutrition or density was able to explain the regional disparity in lumpy jaw infection.

Age and Lumpy Jaw

Contrary to Murie's (1944) interpretations, lumpy jaw did not appear to lower life expectancy. Murie (1944) examined sheep skulls picked up after an all-age die-off, and found that sheep afflicted with lumpy jaw were on average younger than uninfected sheep. Infected rams harvested in the Yukon were older than uninfected hunter-killed rams (see Table 1). This relationship was consistent between regions, and also similar to observations made by Glaze et al. (1982). Associated with aging are greater mortality rates and increased tooth wear, including broken and missing teeth (unpubl. data). Hoefs and Cowan (1979) estimated that only 13% of 7 and 8 year old sheep died annually in the Kluane National Park Reserve, compared to 46% of older rams. The links between aging, social activity, physiological stress, and consequently over-winter survival are intuitively obvious. Presumably, old rams are also predisposed to lumpy jaw infection.

Population density, horn growth and lumpy jaw

Generally, rams which were shot as young rams displayed greater horn growth, less brooming, and were less frequently infected than older rams (see Table 2). We suspect that vigorous horn growth increases a ram's vulnerability to hunting when he is young. Brooming of horns has been linked to intra-specific fighting (Shackleton and Hutton 1971), therefore it is reasonable to assume brooming should reflect social activity. Old rams are more socially active (Geist 1971), and therefore more frequently broomed.

However, these general patterns of age, horn brooming and lumpy jaw infection were not observed in low density areas. Here, young rams were more frequently broomed and infected, at rates similar to those of old rams (see Table 2). It is possible that young rams in low density populations are attaining dominance sooner than young rams in higher density areas, as suggested by Geist (1971). Geist noted patterns of greater horn growth and body size, faster growth rates, lower life expectancies, and higher fecundity from low density herds of bighorn and Stone sheep, as compared to high density, stable herds. He hypothesized that rams at low densities would engage in courtship activities at younger age and consequently have a lower life-expectancy. This hypothesis was corroborated by Shackleton (1973).

Consistent with Geist's (1971) hypothesis, lower densities of sheep in the Yukon produced rams with greater total horn length, and a tendency to have a greater second year horn segment than high density populations (see Table 3). Fewer competing, dominant, old rams, or vigorous horn growth of young rams, may facilitate early social dominance in low density areas. Young rams engaged in the rut "prematurely" are predisposed to brooming. In other words, young rams become "old" rams sooner in low density areas.

This suggests that rams actively engaged in rut activities are prone to lumpy jaw infection. The rut is an extremely demanding activity (Geist 1971) likely influencing body condition and subsequent survival. Rams engaged in the rut reduce foraging bouts while expending more energy (Geist 1971). No doubt, there is a deterioration of body condition as the rut proceeds. Full-curl, radio-collared Dall sheep rams in the northern Yukon were more likely to die in the period immediately following the rut than in any other period of the year (YTG unpublished data). Full-curl rams also suffer higher rates of natural mortality than rams with smaller horn-curls (Hoefs and Cowan 1979, Simmons and Bayer 1984). Poorer body condition implies increased physiological stress possibly predisposing rams to disease. Also, the skull battering associated with the rut may result in physical injury to the tooth arcade as a predisposing mechanism. Uhlenhaut and Stubbe (1980) examined 180 Mouflon (O. ammon musimon) ram skulls and found sites of damage in the form of horn, tooth and bone injury in 75% of the skulls, which they related to injuries caused by fighting. Further, they found the injury rate increased when the rams attained sexual maturity. We surmise that lumpy jaw infection in Dall sheep rams is facilitated by physiological and physical stress amplified by social activities, and therefore a condition most common in dominant rams.

REFERENCES

Aitcheson, G.U. and J.A. Spence. 1983. Dental disease in hill sheep: an abattoir survey. J. Comp. Pathol. 94(2): 285-300.

Bunnell, F.L. 1978. Horn growth and population quality in dall sheep. J. Wildl. Manage. 42(4): 764-775.

Egorov, O.V. 1967. Wild Ungulates of Yutia. Israel Program of Sceientific Translations, Jerusalem, Israel. 204 pp.

Gainer, R.S. 1982. Dental anomalies in Nyasa wildebeest. J. Mamm. 63(3): 526-527.

Geist, V. 1971. Mountain sheep: A study in behavior and evolution. Univ. Chicago Press. 383 pp.

Glaze, R.L., M. Hoefs and T.D. Bunch. 1982. Aberrations of the tooth arcade and mandible in Dall's sheep from southwestern Yukon. J. Wild. Dis. 18(3): 305-309.

Hemming, J.E. 1969. Cemental deposition, tooth succession, and horn development as criteria of age in dall sheep. J. Wildl. Manage. 33(3): 552-558.

Hoefs, M., T.D. Bunch, R.L. Glaze and H.S. Ellsworth. 1982. Horn aberrations in Dall's sheep (Ovis dalli) from Yukon Territory, Canada. J. Wildl. Dis. 198(3): 297-304.

Hoefs, M. and I. McT. Cowan. 1979. Ecological investigation of a population of Dall sheep. Syesis Vol. 12, Suppl. 1.

Jensen, R. 1974. Diseases of Sheep. Lea and Febiger, Philadelphia, Penn. 389 pp.

Murie, A. 1944. The Wolves of Mount McKinley. U.S. Govt. Printing Office, Washington. 2338 pp.

Neiland, K.A. 1972. Sheep disease studies. Alaska Dept. of Fish and Game Project Program No. W-17-3 & 4. Unpubl. Rep. 31 pp.

Orr, M.B. 1979. A syndrom of dental abnormalities of sheep II. The pathology and radiology. N.Z. Vet. J. 27:276-278.

Oswald, E.T. and J.P. Senyk. 1977. Ecoregions of Yukon Territory. Report by Fisheries and Environment Canada. 115 pp.

Shackleton, D.M. 1973. Population quality and bighorn sheep. Ph.D. Thesis. Univ. Calgary, Calgary, Alberta. 227 pp.

Shackleton, D.M. and D.A. Hutton. 1971. An analysis of the mechanisms of brooming of mountain sheep horns. Sonderdrucke Aus. Z.F. Saugetierkunde kBd. H.6,S. 342-350.

Sheldon, C. 1930. The wilderness of Denali: Exploration of a hunter-naturalist in Northern Alaska. Charles Scribner´s Sons, New York 412 pp.

Simmons, N.M. 1982. Seasonal ranges of Dall´s sheep, Mackenzie Mountains, Northwest Territories. Arctic 35(4): 512-518.

Simmons, N.M., M.B. Bayer and L.O. Sinkey. 1984. Demography of Dall's sheep in the Mackenzie Mountains, Northwest Territories. J. Wildl. Manage. 48(1):156-162.

Uhlenhaut, M. and M. Stubbe. 1980. Kampfbeschadigungen bei Muffelwiddern (Ovis ammon musimon). pg. 151-169, in Beitrage zur Jagd und Wildforschung XI, edited by H. Stubbe, Veb Deutscher Landwirtschaftsverlag, Berlin.

Yukon
Department of Renewable Resources

YUKON BIOLOGICAL SUBMISSIONS

8003

SPECIES: 1 SHEEP; 2 GOAT; 3 GRIZZLY BEAR; 4 BLACK BEAR; 5 MOOSE; 6 CARIBOU; 7 OTHER ______ (SPECIFY)

KILL TYPE: 1 OPEN SEASON; 2 QUOTA; 3 PERMIT; 4 ROAD KILL; 5 FOUND IN FIELD; 6 CONFISCATED; 7 ANIMAL CONTROL; 8 OTHER ______ (SPECIFY)

RECORDER'S NAME ______ LOCATION ______ YEAR MON. DAY

HUNTER INFORMATION

1 RESIDENT
2 NON-RESIDENT

LICENCE NUMBER | SEAL NUMBER | PERMIT OR QUOTA NO. IF APPLICABLE | OUTFITTER NAME | AREA

HUNTER'S LAST NAME | ADDRESS

KILL INFORMATION

ZONE | SUB-ZONE | SPECIFIC LOCATION

HABITAT: 1 ALPINE; 2 SUB-ALPINE; 3 FOREST; 4 WET MEADOW; 5 RIVER SIDE; 6 LAKE SHORE; 7 DUMP; 8 ROAD; 9 OTHER(SPECIFY) ______

KILL DATE: YEAR MON. DAY HOUR

DAYS HUNTED FOR SPECIES IN CURRENT YEAR

AGE

CONFIDENCE IN AGE: GOOD 1; FAIR 2; POOR 3

SEX OF ANIMAL: 1 MALE; 2 FEMALE

TOOTH OR JAW SUBMITTED: 1 YES; 2 NO

REPROTRACT OR BACULUM SUBMITTED: 1 YES; 2 NO

PELT EXAMINED: 1 YES; 2 NO

PHOTO TAKEN? 1 YES; 2 NO

FOLLOW-UP CORRESPONDENCE: 1 YES; 2 NO ______ (SPECIFY)

SPECIMEN: 1 KEEP; 2 RETURN; 3 N/A

SHEEP AND GOATS

TOTAL LENGTH
BASE CIRCUM.
TIP SPREAD

MEASURE LONGEST HORN

	LENGTH	CIRCUMFERENCE
TIP TO 1ST		
TIP TO 2ND		
TIP TO 3RD		
TIP TO 4TH		
TIP TO 5TH		
TIP TO 6TH		
TIP TO 7TH		
TIP TO 8TH		
TIP TO 9TH		
TIP TO 10TH		
TIP TO 11TH		
TIP TO 12TH		
TIP TO 13TH		
TIP TO 14TH		
TIP TO 15TH		
TIP TO 16TH		

SHEEP ONLY

BODY COLOR: 1 WHITE; 2 FANNIN (GREY); 3 DARK

TAIL COLOUR: 1 WHITE; 2 DARK

HORN MEASURED: 1 RIGHT; 2 LEFT

LENGTH TO THIRD ANNULI ON SHORT SIDE

PLUG NUMBER

BEARS ONLY

COLOUR OF UPPER SIDE: 1 BROWN; 2 BLONDE; 3 BLACK; 4 SILVER TIP; 5 LIGHT BROWN

CONDITION OF PELAGE: 1 NORMAL; 2 RUBBED

RUMP FAT (OF BEAR): 1 NONE; 2 0" TO 1"; 3 OVER 1"

TEETH WEAR: 1 NO WEAR; 2 INCISORS ONLY; 3 SOME WEAR ON MOLARS; 4 HEAVY WEAR ON MOLARS

SKULL MEASUREMENTS (IN MILLIMETERS)

SKULL LENGTH ______ 1 FLESH ON

ZYGOMATIC WIDTH ______ 2 FLESH OFF

GRIZZLY ONLY FRONT CLAW COLOUR: 1 LIGHT; 2 DARK; 3 BOTH

COMMENTS (ALL SPECIES) ______

COPY DISTRIBUTION:
1. YELLOW - DATA PROCESSING COPY
2. WHITE - DISTRICT C.O.
3. PINK - APPROPRIATE BID
4. GREEN - HUNTER
5. GREEN - OUTFITTER

YG(1784) NC5 REV 2/85

DATA PROCESSING COPY

INSTRUCTIONS FOR THE COMPLETION OF "STANDARD" FORM TO DOCUMENT SIZES OF MANDIBLES OF SHEEP AND GOATS, TOOTH WEAR RATES AND PRESENCE AND SEVERITY OF "LUMPY JAW"

a) Definitions and terminology:

Sheep and goat teeth are classified as follows:

Incisors: I-1, I-2, I-3

Canines: C-1

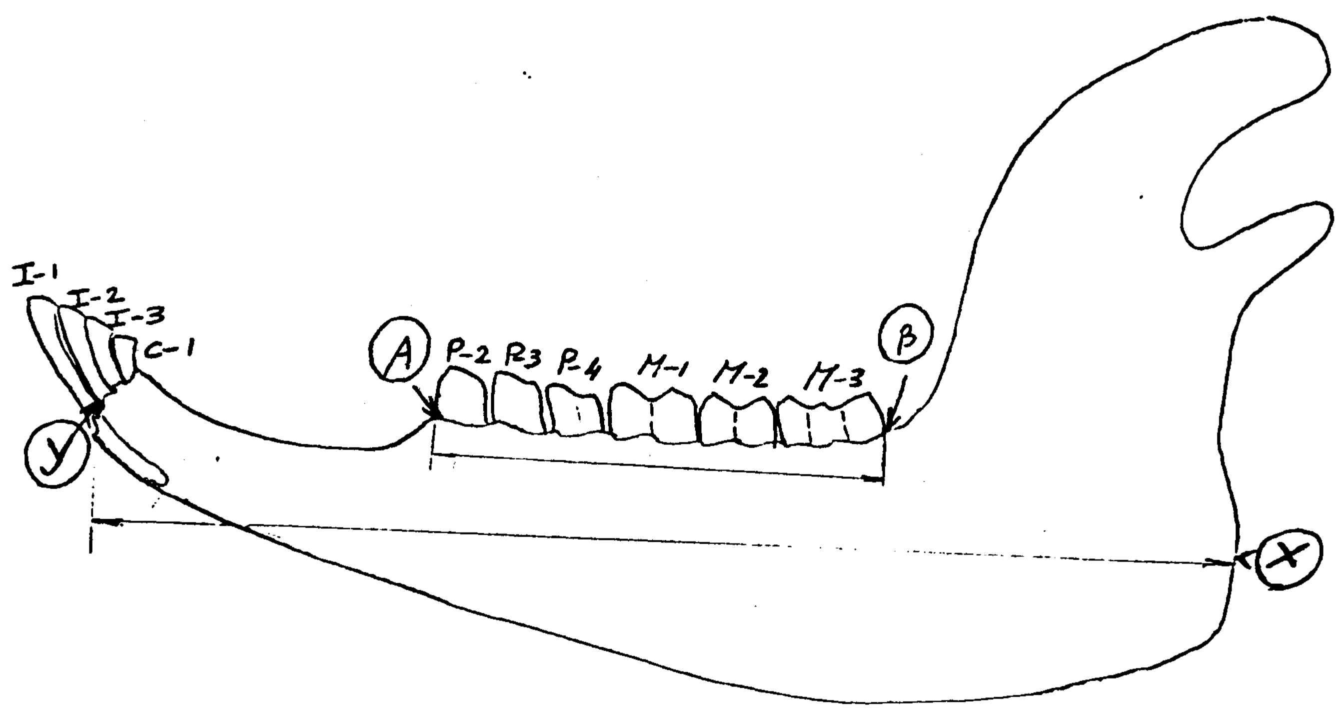
Premolars: P-2, P-3, P-4

Molars: M-1, M-2, M-3

Incisors and canine teeth are incisiform, while premolars and molars are molariform; the third molar, M-3, having three cusps in the mandible but only two cusps in the maxilla.

The tooth formula is as follows: I-0/3, C-0/1 P-3/3 M-3/3

Deviation from the normal formula are referred to as "oligodonty", if (naturally) the animal does not have a complete set, or as "polydonty" if it has supernumerary teeth. Both these phenomena have been observed in sheep. Often the first premolar, P-2, is missing, while a canine may be found in the maxilla.



the inside of the mandible, where the tongue is located, is referred to as the "lingual" side, while the outside [illegible], where the lips are located, is referred to as the "buccal" side.

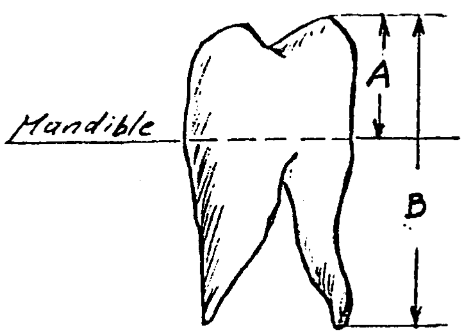
b) Measurements of jaw and teeth:

All measurements are done in metric, on this form in mm.

(7) Total length of jaw.
The mandible is measured with a caliper from its most posterior extension ("X" on drawing) to the base of the first incisor ("Y" on drawing).

(8) Length of the molariform tooth row is measured from the anterior side of P-2, where its base touches the mandible ("A" on drawing) to the posterior side of M-3, where its base protrudes from the mandible ("B" on drawing).

Total length of teeth is determined either from X-ray photographs or, in the case of I-1, by pulling the tooth out of the mandible. Maximal lengths are determined from the longest extent of the root to the highest portion of the tooth protruding out of the mandible.



A = length above mandible

B = total length of tooth

Usually the posterior most cusp of molariform teeth is the highest and should be measured.

Of the incisiform teeth only I-1 will be measured, for the others the following notations will be made:

p = present   m = missing (naturally) (oligodonty)   b = broken

"m" or "b" will also be used for molariform teeth, if they are not present.

All teeth are to be measured on the lingual side of jaw.

Width of I-1 refers to width of crown.

Assessment of extent and severity of lumpy jaw

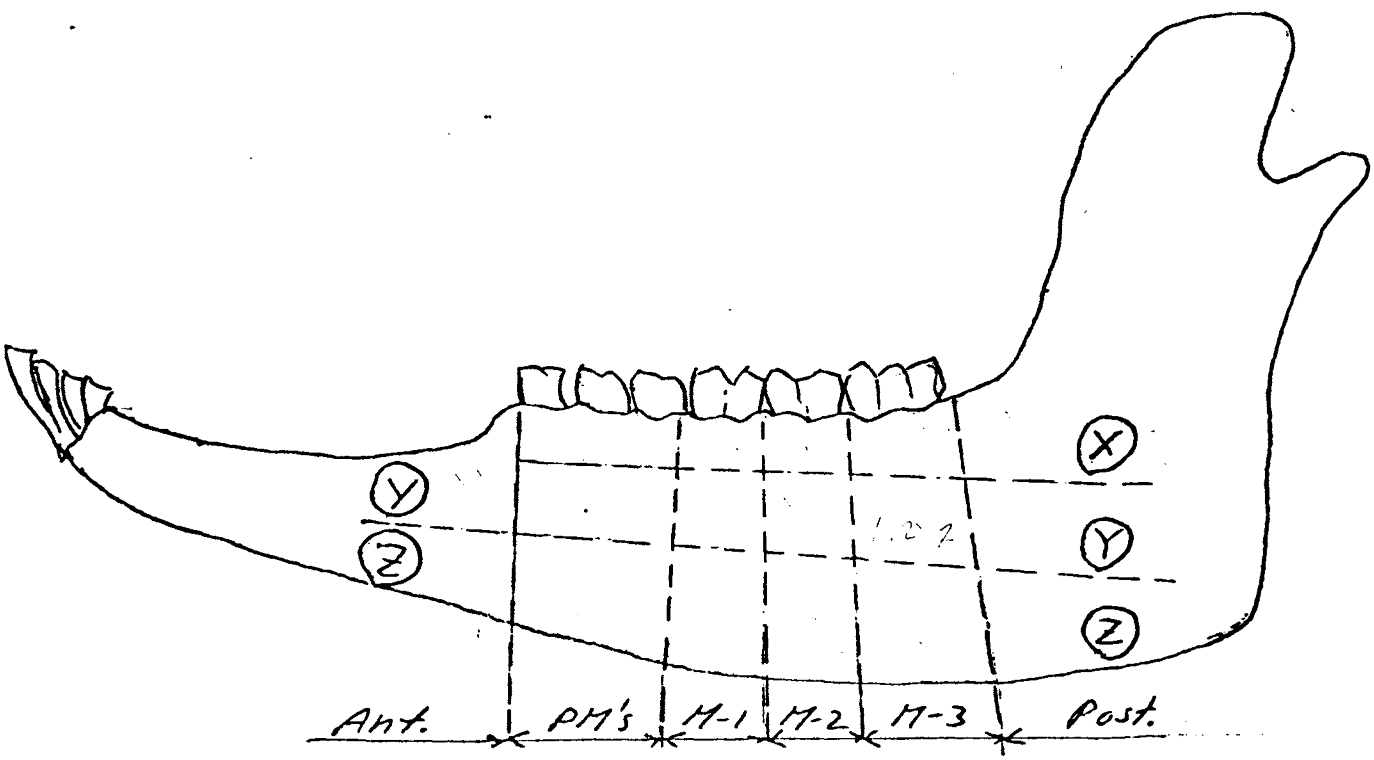
An attempt has been made to quantify as far as possible the documentation of the mandibular disease commonly referred to as "lumpy jaw", so that different people inspecting these jaws come up with similar assessments and that comparisons are possible with other sheep populations affected by this disease.

The mandible to be inspected is divided arbitrarily into 17 sections to allow detailed description of initiation and spread of disease and to correlate these with age of animal.

The 17 sections are distributed into three "vertical" layers in a dorso-ventral plane, and into six sections in an anterior-posterior direction.

The vertical layers are each about 1/3 the width of the mandible X-Y-Z, except for the anterior most portion where only two are found (Y & Z) because of the narrowing of the jaw between molariform and incisiform teeth; the six horizontal sections refer to areas (1) "anterior" to premolars, (2) under premolars, (3) under M-1, (4) under M-2, (5) under M-3, and (6) posterior to the molariform tooth row.

The following drawing shows this division:



For each of these 17 divisions the presence and extent of infection will be rated into four degrees of severity as follows:

0 = not infected, bone natural and compact

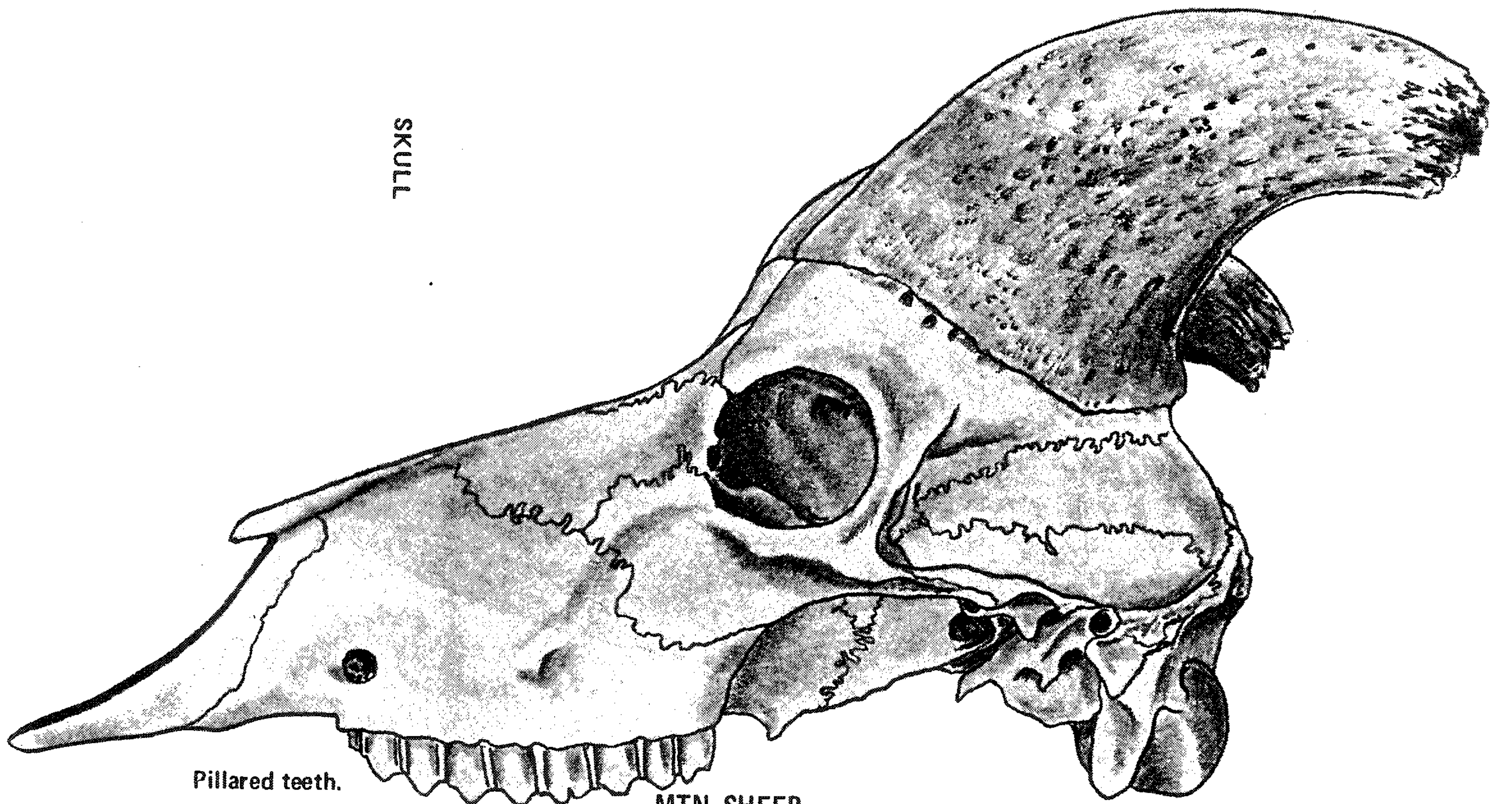
1 = slightly infected, swelling of mandible in this region as revealed by increase in width, some perforation of bone, but teeth normal, no necrosis or osteolysis.

2 = infection of medium severity. Pronounced swelling of mandibular region, increased perforation of bone, some necrosis (erosion of bone) at base of teeth, uneven wear of teeth, angle of teeth affected.

3 = severe infection: severe necrosis and osteolysis, teeth deformed, growing in displaced angles, broken or missing entirely. Severe swelling of mandible. Large holes in mandible, "honey-combing" of jaw. Bone at base of teeth eroded away, resulting in appearance of greatly elongated cheek teeth.

Photographs of various stages of infection will be made up for reference; and assessments of infected jaws should only be carried out if a healthy jaw is at hand for comparisons.

SKULL



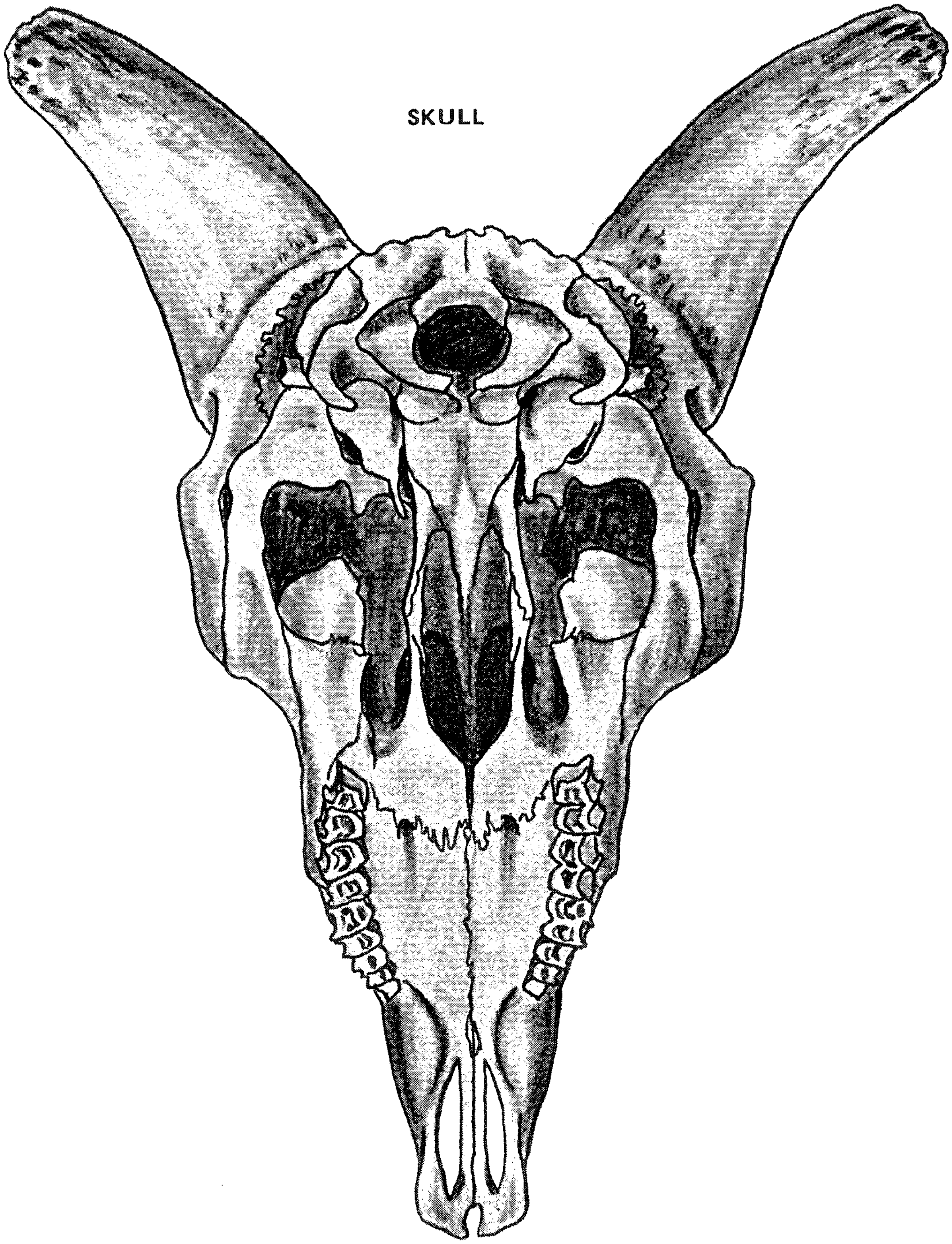
Pillared teeth.

MTN. SHEEP

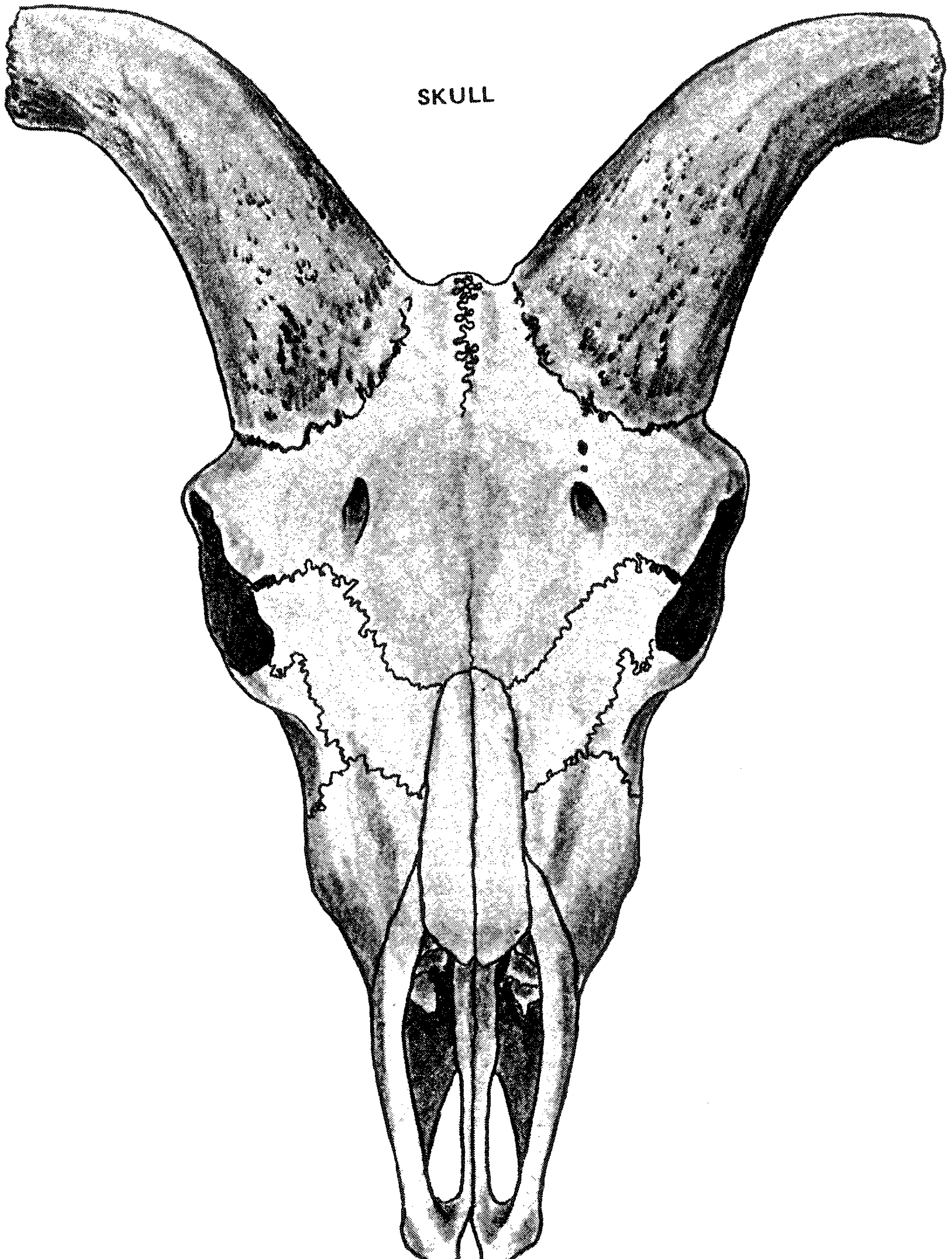
Ovis canadensis

311

SKULL

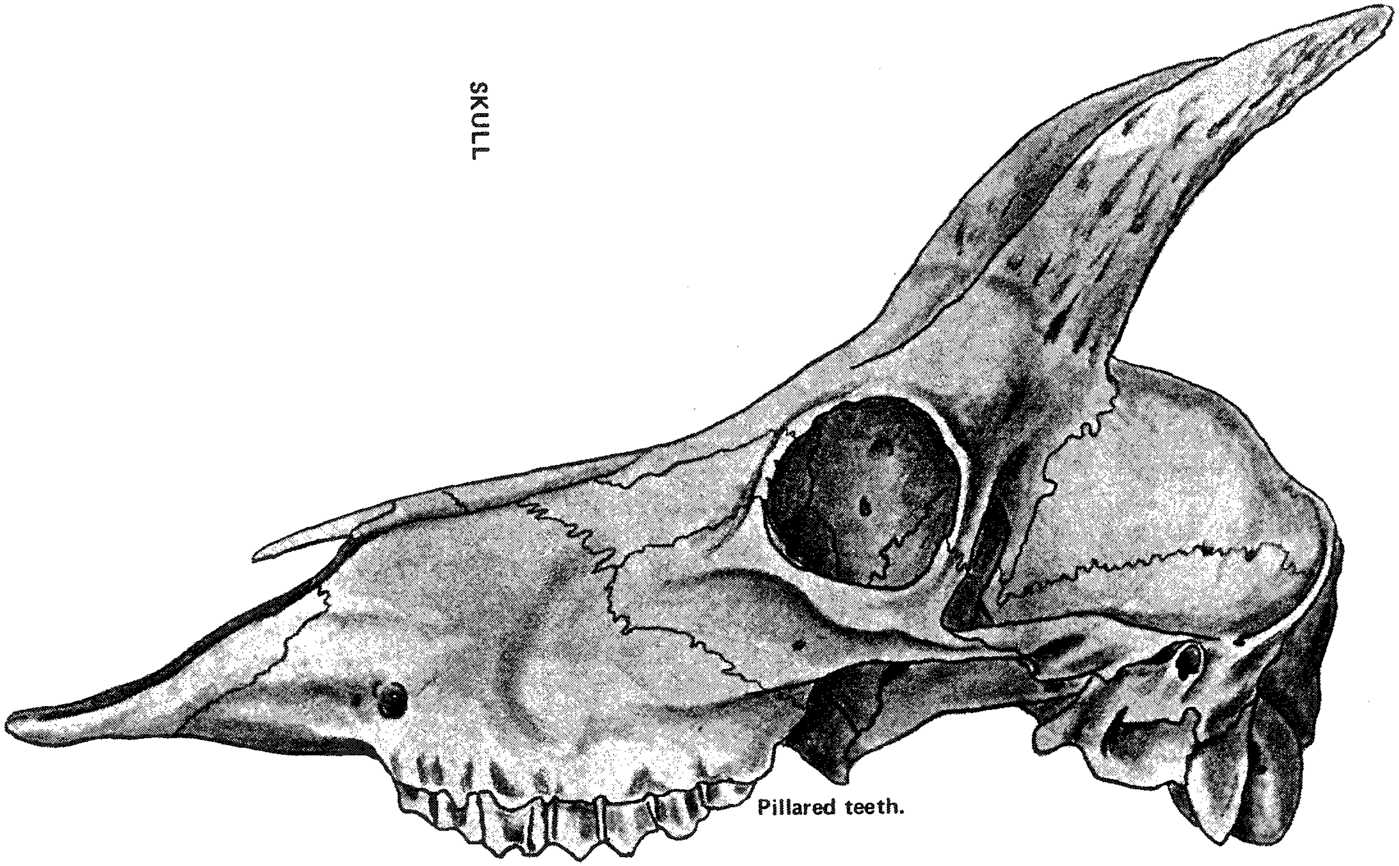


MTN. SHEEP
Ovis canadensis
311



MTN. SHEEP
Ovis canadensis
311

SKULL

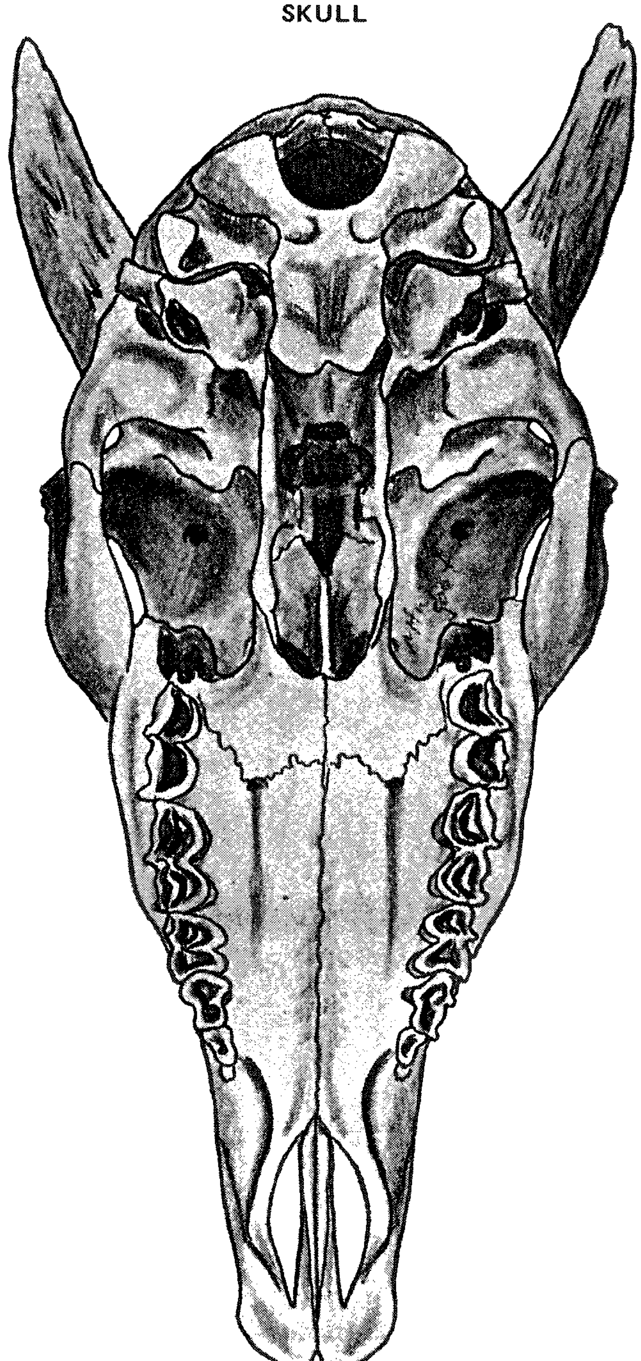


MTN. GOAT

Oreamnos americanus

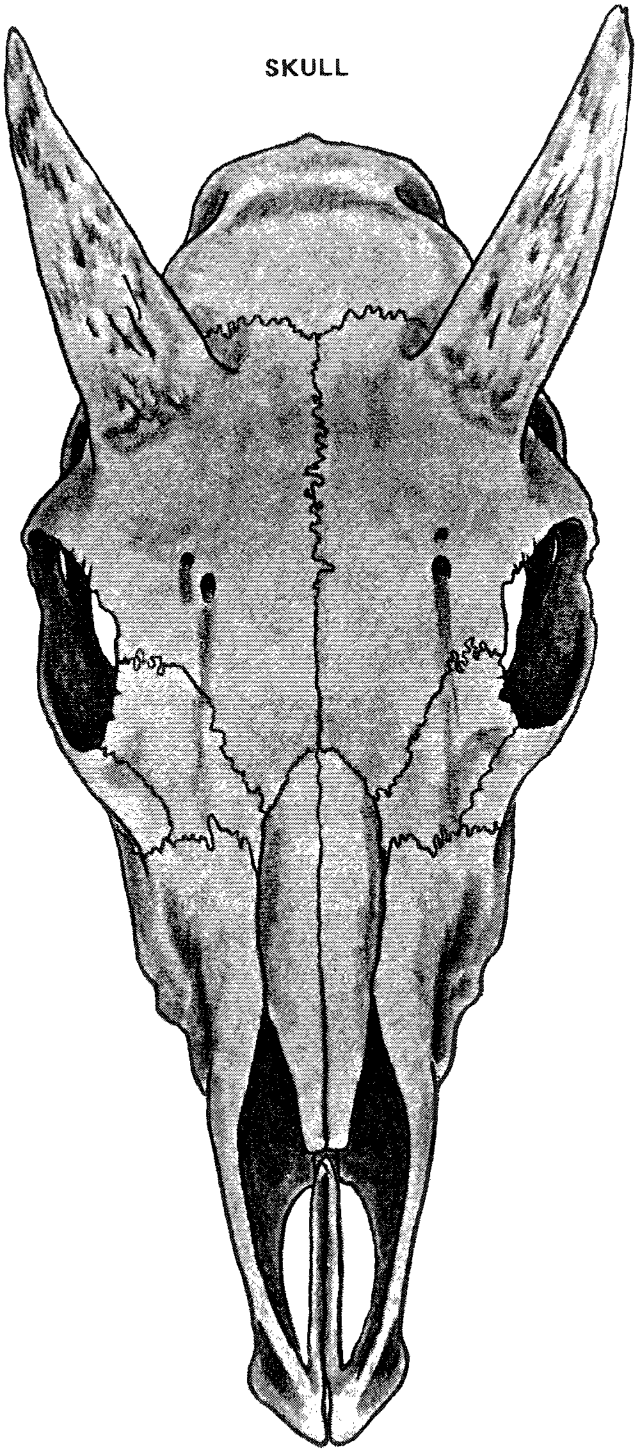
223

SKULL

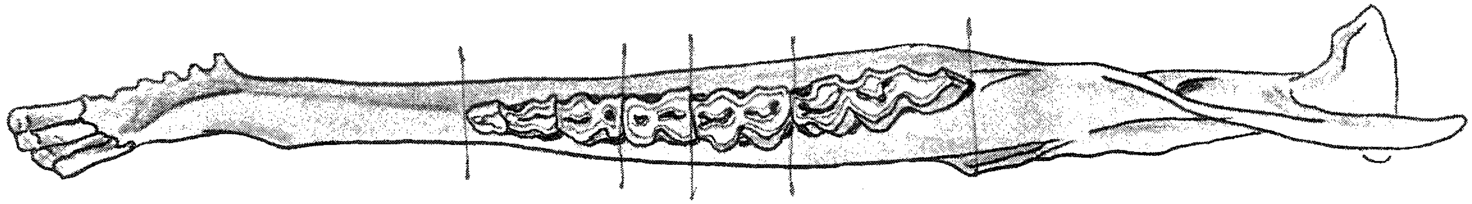


MTN. GOAT
Oreamnos americanus
223

SKULL

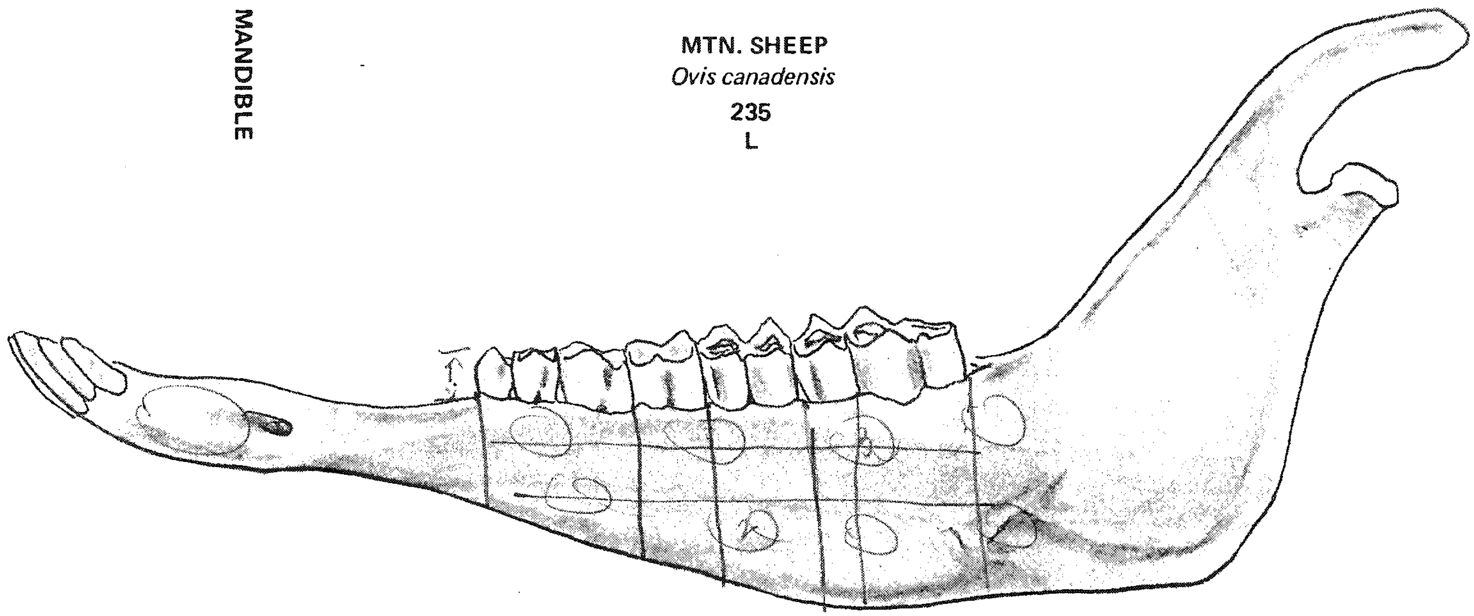


MTN. GOAT
Oreamnos americanus
223



MANDIBLE

MTN. SHEEP
Ovis canadensis
235
L



Lumpy jaw in thinhorn sheep in the Yukon.

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Abstract

Norman Barichello, Jean Carey, Manfred Hoefs, and Hanne Hoefs. Lumpy jaw in thinhorn sheep in the Yukon.

Lumpy jaw infection in the lower jaw, age, and horn growth, were assessed in skulls retrieved from sheep shot by licensed hunters in the Yukon from 1979 to 1985.

The frequency of infected jaws, and the frequency and severity of infections in lower jaws were closely correlated and occurred most frequently in the area below the premolars and molars.

Lumpy jaw occurred frequently in rams shot in the Yukon (37% of all lower jaws submitted were infected). Southern rams were more frequently infected (44%) than northern rams (25%).

There was no evidence that infected rams suffered higher rates of mortality; old rams (9+ years) were more frequently infected with more severity than young rams (<9 years).

No significant associations were observed between the frequency and severity of lumpy jaw infection and sheep density or horn growth (basal circumference, length of unbroomed horns, 2nd year's segment, and frequency of brooming), when areas and ages were combined. However, young rams in low density areas were more frequently infected and broomed than young rams in medium and high density areas. The infection and brooming in these young rams was similar to that of old rams. Also, horn growth of

unbroomed horns was greater in rams from low density populations.

These two relationships, increased horn growth and higher frequency of brooming in young rams in low density sheep populations, lends support to Geist's (1971) hypothesis, that horn growth facilitates early social dominance and rams in low density populations enjoy faster horn growth. We suspect young rams in low density populations in the southern Yukon engage in the rut at an earlier age than young rams in higher density populations and are therefore predisposed to brooming and perhaps lumpy jaw infection.

We suggest that lumpy jaw infection in Dall sheep rams is facilitated by physiological and physical stress which is more likely to afflict socially active rams, and therefore is a condition most common in dominant rams. However, we found no evidence that lumpy jaw infection is debilitating to sheep populations in the Yukon.

Introduction

Lumpy jaw is a disease characterized by localized degeneration of the jaw bone. The disease has been commonly associated with wild sheep (Ovis spp.), and more specifically with Dall sheep (O. dalli dalli; Murie 1944, Neiland 1972, Hoefs and Cowan 1979, W. Heimer, pers. comm.). In Alaska, the Northwest Territories and the Yukon, where Dall sheep lower jaws have been collected, 25 to 50% of collections have been described as having lumpy jaw (Murie 1944, Simmons 1982).

Early reports inferred that lumpy jaw in wild sheep was the result of the bacteria Actinomyces, commonly found in domestic cattle suffering similar symptoms. However, the bacteria has never been isolated from infected sites on either Dall or Bighorn sheep (O. canadensis). The bacteria Corynebacterium pyogenes, and to a lesser degree Fusobacterium necrophorum have been isolated from jaws of wild sheep with the characteristics of the disease commonly referred to as lumpy jaw (Glaze et al. 1982, Neiland 1972).

Predisposition to the ailment is conjectured by Glaze et al. (1982) to result from abnormal wearing of teeth, loss of teeth, or disruption of the tooth arcade, creating sites for infection by the oral necrotizing bacteria. The abnormal wearing or disruption of the tooth row, it is postulated, is the result of impaction of vegetable matter between the teeth (Glaze et al. 1982), mastication of coarse or heavily loess-silted vegetation (Egorov 1967, Hoefs and

Cowan 1979, Jensen 1974), defective tooth growth caused by micronutrient or mineral deficiencies (Orr 1979), or injury (Uhlenhaut and Stubbe 1980).

Range quality as a predisposing agent to lumpy jaw has not been well-established. Lumpy jaw has been found to be more prevalent in older sheep, and loosely correlated to tooth wear (Glaze et al. 1982). Hoefs and Cowan (1979) and subsequently Glaze et al. (1982) were of the opinion that the high siltation on grasslands in the vicinity of Kluane National Park Reserve resulted in higher levels of lumpy jaw, manifesting itself in old sheep who had suffered higher than usual tooth wear.

Both Orr (1979) and Broughton (pers. comm) suspected that poor early development of teeth, as a result of mineral or dietary deficiencies, set the stage for mandibular anomalies with loss of teeth, thus initiating entry of the bacteria.

The effect of lumpy jaw on longevity or horn quality is unknown. Murie (1944), through analysis of pick-up skulls, suggested that infected sheep were less likely to live as long as uninfected sheep.

The intent of this study was to evaluate the occurrence of lumpy jaw in Dall sheep rams shot in the Yukon in the years 1979 to 1985 and to assess whether this disease has management implications. Dall sheep are managed primarily for trophy hunting. The trophy quality achieved in a given ram is influenced by horn growth rates as well as the degree of horn brooming, and both of these factors are related to the age of the ram. Environmental stress factors, such as this disease may lower life expectancy as well as negatively influence horn quality, and therefore have management relevance.

Materials and Methods

Analysis of lumpy jaw was carried out on lower jaws of sheep submitted through compulsory submissions from licensed sport hunters throughout most of the Yukon (Fig. 1) from 1979 to 1985. The distribution of sheep killed was a reflection largely of sheep density, road access, and proximity to major human population centres. The licensed sheep kill was regulated according to the Yukon Wildlife Act and Game Regulations, prescribed for 11 Game Management Zones (see Fig. 1). The majority of the submissions were from four zones and six ecological regions. These four zones are ecologically distinct, based on biophysical data, primarily vegetation, landform and climate (Oswald and Senyk 1977).

Information regarding the kill was recorded on standard Yukon Biological submission forms (Appendix I). Data pertaining to the ram killed included date and location of the kill, age, colour of pelage (indicating subspecies: O. d. dalli or O. d. stonei), length and circumference of each horn annuli and year of birth.

Location of the kill was assigned a Game Management Zone (subsequently referred to as zone) and an ecological region, as defined by Oswald and Senyk (1977). For much of the analysis, comparisons were made between north, which included zones 2 and 4, and south, which included zones 5 and 7 (see Fig. 1). Ages were determined by counting horn annuli, according to Hemming (1969), and grouped as "young", being 8 years of age or less, and "old", being 9 years of age or greater. Three measures of horn growth were used in the analysis; total horn length of unbroomed rams, length of the second year's horn segment of unbroomed rams, and horn base circumference. Broomed horns were broken horns and did not include horns which had gradually worn at the tips (Hemmings 1969, Hoefs et al. 1982). If at least one horn was broomed the skull was classified as "broomed". The length of the second year's horn segment was thought to reflect vigour of young animals. Hemming (1969), Giest (1971), Shackleton (1973) and Bunnell (1978) all reported that the maximum horn length was attained in the second year, and unpublished data in the Yukon have indicated that the second years segment length displays the greatest variation.

In the southern Yukon, data were available on sheep density within Game Management Subzones (subsequently referred to as subzones). Comparisons of frequency of lumpy jaw infection and horn growth were made with density class; 1 being less than 1 non-lamb sheep per 10 km^2 (low density), 2 being 1 to 5 non-lamb sheep per 10 km^2 and 3 being greater than 5 non-lamb sheep per 10 km (high density). Density was derived based on summer population counts within areas which were delineated as subzones.

Lumpy jaw was assessed by identifying 17 sites on the lower jaw and qualitatively assessing the extent and severity of the bone degeneration. The breakdown of 17 sites was made on the basis of tooth location (Fig. 2). Lumpy jaw at each site was assessed from 0 to 3, with "0" being uninfected and "3" representing severe infection, with severe swelling, perforation or honey-combing of the mandible, and erosion of the bone at the base of the teeth. An explanatory note about this assessment is attached as Appendix II.

Five measurements were calculated: frequency of infected sites, the total severity of infection per jaw (sum of all severity measures), the average severity of each infection on each jaw, and an index of severity which was calculated as average severity of each infection multiplied by the frequency of infection on each jaw. Correlations were made on each of these measures of lumpy jaw with age and other parameters.

Statistical treatments included analysis of variance (ANOVA) when continuous variables were treated by categorical variables, and chi-square analysis to compare frequency data.

Results

Measures of frequency of lumpy jaw infection and severity of infection were all closely correlated. Three calculations of lumpy jaw were used in further analysis: (1) presence or absence of infection; (2) the number of sites infected per jaw, and (3) the sum of all severity measures per jaw (referred to as severity).

A total of 831 jaws were assessed for lumpy jaw, 465 from the southern Yukon, 302 from the northern Yukon and 64 from the east-central Yukon (zones 8, 10 and 11). In the southern Yukon, 153 skulls were measured from low density areas, 204 from moderate densities, and 106 from high densities. Fifty-seven percent of all measured skulls were from young rams (less than 9 years old), and 71% of all skulls were unbroomed.

Lumpy jaw occurred more commonly in the region of the mandible below the premolars and molars, and less frequently in the anterior (area in the jaw below the incisors and in front of the premolars), and posterior sections of the lower jaw (area behind the molars). This distribution of infection in the jaw was similar throughout the Yukon, although frequency and severity varied between regions. From all infected jaws, less than 10% of all sites in the anterior and the posterior sections were infected. In contrast, greater than 30% of all sites in the region of the premolars and molars of infected jaws were infected.

Regional differences

Lumpy jaw infection was linked to zone and ecological region. Jaws from southern zones and ecological regions were more frequently infected and had higher severity of lumpy jaw than jaws from areas to the north. The percentage of jaws infected in each zone ranged from 23.5 to 50.5% (see Fig. 1). Regional differences in lumpy jaw were independent of age; lumpy jaw occurrence and severity were more prevalent in the south in both young and older-aged animals ($p<0.01$).

Age

Older rams were more frequently infected (more jaws were infected and there were more infections per jaw) and had greater severity of infection than younger animals (Table 1), independent of region ($p<0.05$). Differences between age and frequency of infection were particularly evident between 10 and 11 years. Less than 40% of rams, aged 6-10, were infected with lumpy jaw, while over 50% of older rams were infected (see Table 1).

Sheep density

In the southern Yukon, where sheep density estimates were available, no significant relationships were found between sheep density and lumpy jaw occurrence ($p=0.33$), or severity ($p=0.44$). Even comparing the extreme density classes, no relationships were evident between sheep density and either occurrence ($p=0.14$) or severity ($p=0.20$) of lumpy jaw.

The trend in young rams, however, was toward less frequent infections with increasing sheep density (Table 2). Comparing the number of infected sites between density extremes (class 1 and 3) we found a significant decrease in infection in young rams, with increasing density ($p<0.01$; see Table 2), and no relationship between sheep density and lumpy jaw infection of older rams ($p=0.89$).

Year of birth

The rate or the severity of lumpy jaw was not related to the ram's birth year ($p=0.26$ and $p=0.52$, respectively).

Lumpy jaw, horn growth and brooming

We could infer no relationship between horn growth vigour and infection when ages and regions were combined. The frequency of jaws infected was not significantly associated with total horn length of unbroomed horns ($p=0.52$), or the length of the second ($p=0.86$), or third year's horn increment ($p=0.92$). Also, the frequency of jaws infected was not related to the frequency of brooming ($p=0.23$).

However, when sheep density was considered, lumpy jaw infection, brooming, and age appeared to be linked. More young rams were broomed in low density areas (33%), than in moderate (19%), or high density areas (18%; $p=0.01$)(Table 2). In these low density areas brooming of young rams occurred at a rate similar to that of old rams (39%; $p=0.29$). Also, more young rams were infected (50%) in low density areas than in moderate (36%) or high (27%) density areas ($p=0.01$), and again, infection rate in young rams in low density areas was similar to that of old rams in all areas ($p=0.67$; see Table 2).

Also, horn growth was associated with density. As density class increased, total horn length of unbroomed skulls decreased ($p<0.01$; Table 3). The average length of the second year's horn segment and horn base circumference also declined with density, although these relationship were insignificant ($p>0.27$). These patterns were evident in old and young rams.

Generally, rams shot when they were young had lower incidence of lumpy jaw infection (39% compared to 53%; $p<0.01$), less brooming ($p<0.01$), and better horn growth (length of 2nd year segment, $p<0.01$) than rams shot when they were old (see Tables 2 & 3). As a ram ages it is likely predisposed to lumpy jaw infection and brooming. Young rams in low density areas, however, were similar to old rams in the degree of brooming and lumpy jaw infection, and had a much higher incidence of brooming and infection than young rams in high density areas.

Discussion

Mandibular anomalies have been reported in most studied Dall sheep populations (Sheldon 1930, Murie 1944, Neiland 1972, Glaze et al. 1982), as well as in other wild sheep species. Lumpy jaw is the general term for conditions of the jaw resulting in osteolysis and enlargement, often associated with aberrations of the tooth arcade (Glaze et al. 1982). Severe cases of lumpy jaw result in perforation or honey-combing of the jaw. The bacteria Cornebacterium pyogenes and Fusobacterium necrophorum have been isolated as the infection agents in Dall sheep jaws diagnosed as having lumpy jaw (Glaze et al. 1982).

Lumpy jaw occurred commonly in Yukon Dall sheep rams. More than 36% (n=831) of all harvested rams in the Yukon from 1979 to 1985 were infected with lumpy jaw. In Alaska, Murie (1944) and W. Heimer (pers. comm.) found lumpy jaw to occur in approximately 27% of all Dall sheep. Early examinations in the southwest Yukon reported the prevalence of lumpy jaw in as many as 70% of inspected jaws of pick-up skulls (Glaze et al. 1972). Yet, in the Yukon, Dall sheep populations are considered stable and healthy; no regular occuring die-offs have been observed, and the hunter-kill has been relatively stable since 1978 (Table 4).

We observed lumpy jaw to occur frequently in the area of the mandible below the premolars and molars and infrequently in the anterior and posterior sections of the lower jaw (see Fig. 2). Dental anomolies of wildebeest in Tanzania also occurred most frequently in the mid-section of the mandible, which Gainer (1981) believed was related to the animal's growth patterns. Gainer (1981) suspected that retarded growth would result in inadequate space between the P3 (2nd premolar from the anterior) and molar teeth to accommodate the later-erupting P4 (3rd premolar from the anterior), and therefore lead to disruption of the tooth arcade. Impaction of vegetation and tooth wear would also be expected to occur more frequently in the area of mastication, in the mid-section of the jaw, than in the anterior and posterior areas.

Aitcheson and Spence (1983) examined heads of domestic sheep in Scotland and also found that where incisor loss, malalignment or looseness occurred there was a likelihood of cheek tooth disease. Glaze et al. (1982), conjectured that lumpy jaw in Dall sheep was related to nutritional conditions which influenced tooth development and wear. It remains unclear whether tooth conditions predispose rams to lumpy jaw, whether lumpy jaw influences tooth conditions, or whether both are independently related to nutrition.

We observed that twice as many jaws were infected with lumpy jaw in the south than the north (see Fig. 1). These regional differences were unrelated to age distribution, which was similar between regions ($p<0.01$).

In the south average sheep densities are higher (unpubl. data) and there is greater average horn vigour in rams than in the north. Southern rams had greater horn base circumferences ($p<0.01$) and greater length of the second year's horn segment ($p<0.01$) than northern rams. Horn length and mass in thinhorn (O. dalli) and bighorn (O. canadensis) sheep has been correlated with latitude (Wishart and Brochu 1982), glacial cover (Heimer and Smith 1975), population density (Geist 1971; Shackleton 1973), and summer precipitation (Bunnell 1978); factors presumably linked to range quality. Yet, sheep in the southern Yukon on presumably better range, were much more frequently infected with lumpy jaw.

Higher sheep densities in the south compared to the north did not explain the higher incidence of lumpy jaw infection in southern rams. Where density estimates were available in the south, no association was found between density and lumpy jaw occurrence.

Therefore, we found no inferences that nutrition or density was able to explain the regional disparity in lumpy jaw infection.

Bunnell (1978) found significant annual variation in horn growth of Dall sheep which he correlated with recruitment rates and summer precipitation. Bunnell suggested that annual variation in range quality influenced horn growth particularly in younger age-classes. Poor horn growth is probably associated with generally poor physical development (Geist 1971) and possibly poor tooth development. Orr (1979) suggested that poor tooth development would predispose sheep to lumpy jaw infection. Although we do not know the relationship between year and physical condition or tooth development in Yukon Dall sheep, we were unable to link lumpy jaw infection to the year of a rams birth.

Contrary to Murie's (1944) interpretations, lumpy jaw did not appear to lower life expectancy. Murie (1944) examined sheep skulls picked up after an all-age die-off, and found that sheep afflicted with lumpy jaw were on average younger than uninfected sheep. Infected rams harvested in the Yukon were older than uninfected hunter-killed rams (see Table 1). This relationship was consistent between regions, and also similar to observations made by Glaze et al. (1982). Associated with aging are greater mortality rates and increased tooth wear, including broken and missing teeth (unpubl. data). Hoefs and Cowan (1979) estimated that only 13% of 7 and 8 year old sheep died annually in the Kluane National Park Reserve, compared to 46% of older rams. Similar age-related mortality rates were calculated from Murie's (1944) Dall sheep demographic data. The links between aging, social activity, physiological stress, and consequently over-winter survival are intuitively obvious. Presumably, old rams are also predisposed to lumpy jaw infection.

Generally, rams which were shot as young rams displayed greater horn growth, less brooming, and were less frequently infected than older rams (see Table 2). We suspect that vigorous horn growth increases a ram's vulnerability to hunting when he is young. Brooming of horns has been linked to intra-specific fighting (Shackleton and Hutton 1971), therefore it is reasonable to assume brooming should reflect social activity. Old rams are more socially active (Geist 1971), and therefore more frequently broomed.

However, these general patterns of age, horn brooming and lumpy jaw infection were not observed in low density areas. Here, young rams were more frequently broomed and infected, at rates similar to those of old rams (see Table 2). It is possible that young rams in low density populations are attaining dominance sooner than young rams in higher density areas, as suggested by Geist (1971). Geist noted patterns of greater horn growth and body size, faster growth rates, lower life expectancies, and higher fecundity from low density herds of bighorn and Stone (O. dalli stonei) sheep, as compared to high density, stable herds. He hypothesized that rams at low densities would engage in courtship activities at younger age and consequently have a lower life-expectancy. This hypothesis was corroborated by Shackleton (1973).

Consistent with Geist's (1971) hypothesis, lower densities of sheep in the Yukon produced rams with greater total horn length, and a tendency to have a greater second year horn segment than high density populations (see Table 3). Fewer competing, dominant, old rams, or vigorous horn growth of young rams, may facilitate early social dominance in low density areas. Early social dominance likely predisposes young rams to brooming. In other words, young rams become "old" rams sooner in low density areas.

This suggests that rams actively engaged in rut activities are prone to lumpy jaw infection. The rut is an extremely demanding activity (Geist 1971) likely influencing body condition and subsequent survival. Rams engaged in the rut reduce foraging bouts while expending more energy (Geist 1971). No doubt, there is a deterioration of body condition as the rut proceeds. Full-curl, radio-collared Dall sheep rams in the northern Yukon were more likely to die in the period immediately following the rut than in any other period of the year (Barichello et al. unpubl. rep.). Full-curl rams also suffer higher rates of natural mortality than rams with smaller horn-curls (Hoefs and Cowan 1979, Simmons and Bayer 1984). Poorer body condition implies increased physiological stress possibly predisposing rams to disease. Also, the skull battering associated with the rut may result in physical injury to the tooth arcade as a predisposing mechanism. Uhlenhaut and Stubbe (1980) examined 180 Mouflon (O. ammon musimon) ram skulls and found sites of damage in the form of horn, tooth and bone injury in 75% of the skulls, which they related to injuries caused by fighting. Further, they found the injury rate increased when the rams attained sexual maturity. We surmise that lumpy jaw infection in Dall sheep rams is facilitated by physiological and physical stress amplified by social activities, and therefore a condition most common in dominant rams.

Acknowledgments

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Literature cited

Aitcheson, G.U. and J.A. Spence. 1983. Dental disease in hill sheep: an abattoir survey. J. Comp. Pathol. 94(2): 285-300.

Bunnell, F.L. 1978. Horn growth and population quality in dall sheep. J. Wildl. Manage. 42(4): 764-775.

Egorov, O.V. 1967. Wild Ungulates of Yutia. Israel Program of Sceientific Translations, Jerusalem, Israel. 204 pp.

Gainer, R.S. 1982. Dental anomalies in Nyasa wildebeest. J. Mamm. 63(3): 526-527.

Geist, V. 1971. Mountain sheep: A study in behavior and evolution. Univ. Chicago Press. 383 pp.

Glaze, R.L., M. Hoefs and T.D. Bunch. 1982. Aberrations of the tooth arcade and mandible in Dall's sheep from southwestern Yukon. J. Wild. Dis. 18(3): 305-309.

Heimer, W.E. and A.C. Smith. 1975. Ram horn growth and population quality - Their significance to Dall sheep management in Alaska. Alaska Dept. Fish and Game, Wildlife Tech. Bull. 5: 1-41.

Hemming, J.E. 1969. Cemental deposition, tooth succession, and horn development as criteria of age in dall sheep. J. Wildl. Manage. 33(3): 552-558.

Hoefs, M., T.D. Bunch, R.L. Glaze and H.S. Ellsworth. 1982. Horn aberrations in Dall's sheep (Ovis dalli) from Yukon Territory, Canada. J. Wildl. Dis. 198(3): 297-304.

Hoefs, M. and I. McT. Cowan. 1979. Ecological investigation of a population of Dall sheep. Syesis Vol. 12, Suppl. 1.

Jensen, R. 1974. Diseases of Sheep. Lea and Febiger, Philadelphia, Penn. 389 pp.

Murie, A. 1944. The Wolves of Mount McKinley. U.S. Govt. Printing Office, Washington. 2338 pp.

Neiland, K.A. 1972. Sheep disease studies. Alaska Dept. of Fish and Game Project Program No. W-17-3 & 4. Unpubl. Rep. 31 pp.

Orr, M.B. 1979. A syndrom of dental abnormalities of sheep II. The pathology and radiology. N.Z. Vet. J. 27:276-278.

Oswald, E.T. and J.P. Senyk. 1977. Ecoregions of Yukon Territory. Report by Fisheries and Environment Canada. 115 pp.

Shackleton, D.M. 1973. Population quality and bighorn sheep. Ph.D. Thesis. Univ. Calgary, Calgary, Alberta. 227 pp.

Shackleton, D.M. and D.A. Hutton. 1971. An analysis of the mechanisms of brooming of mountain sheep horns. Sonderdrucke Aus. Z.F. Saugetierkunde kBd. H.6,S. 342-350.

Sheldon, C. 1930. The wilderness of Denali: Exploration of a hunter-naturalist in Northern Alaska. Charles Scribner's Sons, New York 412 pp.

Simmons, N.M. 1982. Seasonal ranges of Dall's sheep, Mackenzie Mountains, Northwest Territories. Arctic 35(4): 512-518.

Simmons, N.M., M.B. Bayer and L.O. Sinkey. 1984. Demography of Dall's sheep in the Mackenzie Mountains, Northwest

Territories. J. Wildl. Manage. 48(1):156-162.

Uhlenhaut, M. and M. Stubbe. 1980. Kampfbeschadigungen bei Muffelwiddern (Ovis ammon musimon). pg. 151-169, in Beitrage zur Jagd und Wildforschung XI, edited by H. Stubbe, Veb Deutscher Landwirtschaftsverlag, Berlin.

Wishart, W.D. and D. Brochu. 1982. An evaluation of horn and skull characters as a measure of population quality in Alberta bighorns. Bienn. Symp. North. Wild Sheep and Goat Counc. 3: 127-142.

Table 1: Age distribution of infected and non-infected jaws from rams shot in the Yukon, 1980-85.

Age	Number of jaws collected and percentage infected					
	Region				Total	
	South		North			
	N	%	N	%	N	%
4	3	0	0	.	3	0
5	25	32.0	2	50.0	30	30.0
6	73	34.2	32	25.0	111	32.4
7	98	42.9	60	21.7	175	34.3
8	78	41.0	57	14.0	147	29.3
9	75	49.3	45	20.0	133	36.8
10	57	49.1	42	19.0	104	37.5
11	31	61.3	30	36.7	66	51.5
12	17	64.7	18	38.9	37	51.4
13	6	50.0	14	50.0	21	52.4
14	2	50.0	1	100.0	3	66.7
15	0	.	1	100.0	1	100.0
Young	277	38.6	151	19.9	466	29.4
Old	188	52.7	151	29.1	365	39.2

Table 2: Percentage of jaws infected, mean number of infections per jaw, and percentage of animals with at least one horn broomed, by age class and sheep density class.

Age class	Density	N	infections %jaws	infections x/jaw	%broomed
Young	Low	94	50.0	5.2	33.3
	Medium	119	36.1	3.8	18.5
	High	62	27.4	2.5	17.7
	All	275	38.6	4.0	24.1
Old	Low	59	49.2	6.3	37.3
	Medium	85	57.7	6.9	41.2
	High	44	47.7	6.8	38.6
	All	188	52.7	6.7	39.4
All	Low	153	49.7	5.6	34.6
	Medium	204	45.1	5.1	27.9
	High	106	35.8	4.3	26.4

Table 3: Average horn measurements (mm), including base circumference, horn length of unbroomed horns, and the second year's horn segment, by age class and density class.

Age	Density	Base		Length		2nd seg.	
		N	Mean	N	Mean	N	Mean
Young	Low	93	341.3	80	887.0	94	21.8
	Medium	119	338.0	97	869.3	119	19.9
	High	62	332.0	51	855.0	62	19.2
	All	274	337.6	228	872.0	275	20.3
Old	Low	59	339.4	37	951.2	56	17.2
	Medium	85	339.4	49	931.2	83	16.5
	High	43	338.8	27	908.6	42	15.4
	All	187	339.3	113	932.4	181	16.5
All	Low	152	340.6	117	907.3	150	20.1
	Medium	204	338.6	146	890.1	202	18.5
	High	105	334.8	78	873.6	104	17.7

Table 4: Number of sheep and average age of rams shot by licenced hunters in the Yukon, by year, from 1980 to 1988.

Year	Number killed	Average age
1980	253	8.7
1981	252	8.8
1982	260	8.6
1983	219	8.5
1984	227	8.0
1985	262	8.3
1986	253	8.5
1987	286	8.7
1988	322	8.9

Fig. 1. Game Management Zones in the Yukon (bounded), the number of lower jaws and skulls submitted for measurements (in parenthesis), and the percentage of jaws infected with lumpy jaw. Stippled area shows sheep distribution and hatched areas are closed to hunting.

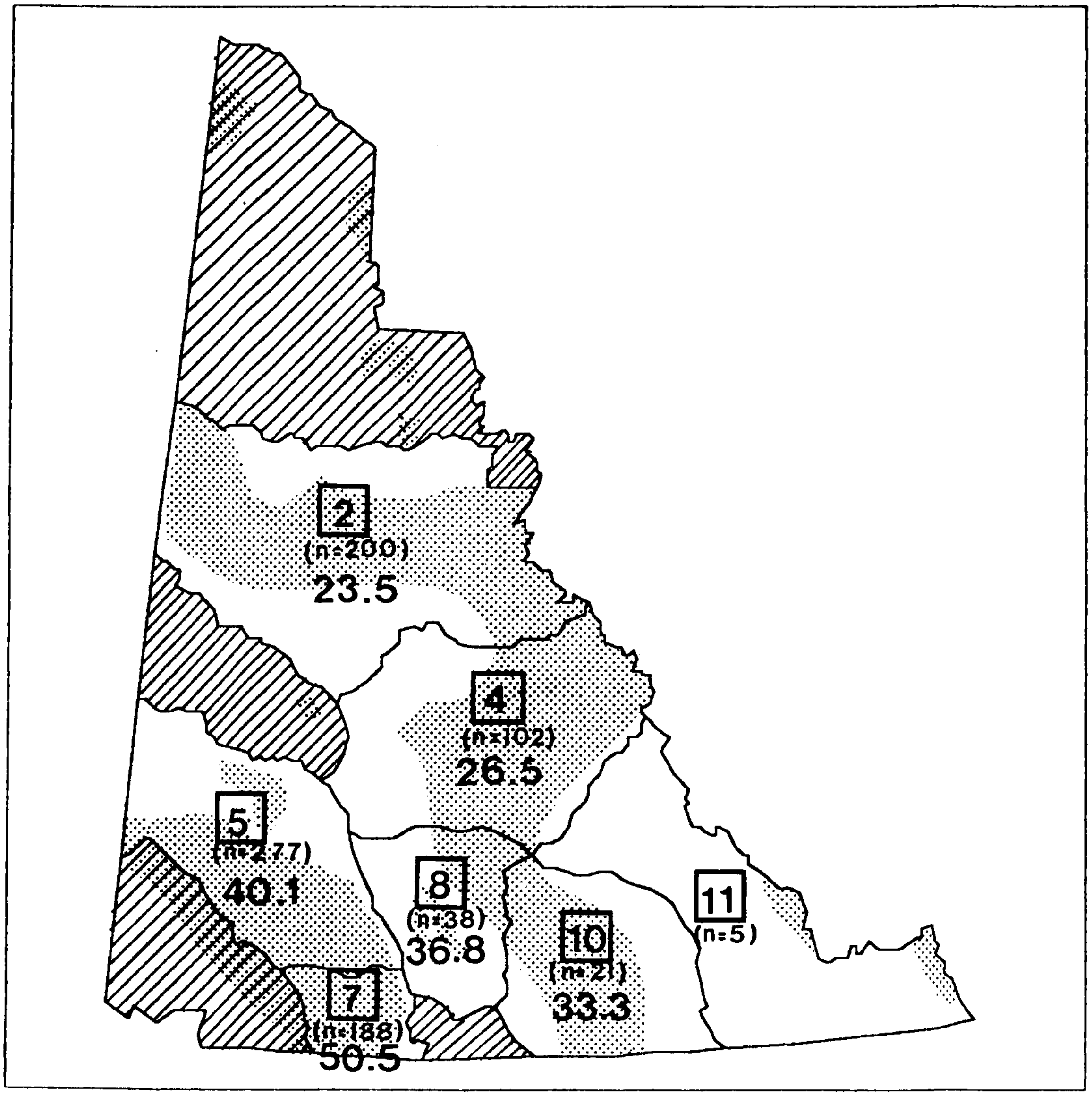
2
(n=200)
23.5
4
(n=102)
26.5
5
(n=277)
40.1
8
(n=38)
36.8
10
(n=21)
33.3
11
(n=5)
7
(n=188)
50.5

Fig. 2. Thinhorn sheep jaw showing location of tooth types and the location of sites on the mandible assessed for lumpy jaw (x).

Yukon
Department of Renewable Resources

YUKON BIOLOGICAL SUBMISSIONS

8003

SPECIES: 1 SHEEP | 2 GOAT | 3 GRIZZLY BEAR | 4 BLACK BEAR | 5 MOOSE | 6 CARIBOU | 7 OTHER ____ (SPECIFY)

KILL TYPE: 1 OPEN SEASON | 2 QUOTA | 3 PERMIT | 4 ROAD KILL | 5 FOUND IN FIELD | 6 CONFISCATED | 7 ANIMAL CONTROL | 8 OTHER ____ (SPECIFY)

RECORDER'S NAME ____ LOCATION ____ YEAR | MON. | DAY

HUNTER INFORMATION

1 RESIDENT
2 NON-RESIDENT

LICENCE NUMBER | SEAL NUMBER | PERMIT OR QUOTA NO. IF APPLICABLE | OUTFITTER NAME | AREA

HUNTER'S LAST NAME | ADDRESS

KILL INFORMATION

ZONE | SUB ZONE | SPECIFIC LOCATION

HABITAT: 1 ALPINE | 2 SUB-ALPINE | 3 FOREST | 4 WET MEADOW | 5 RIVER SIDE | 6 LAKE SHORE | 7 DUMP | 8 ROAD | 9 OTHER (SPECIFY) ____

KILL DATE: YEAR | MON. | DAY | HOUR

DAYS HUNTED FOR SPECIES IN CURRENT YEAR

AGE

CONFIDENCE IN AGE: GOOD 1 | FAIR 2 | POOR 3

SEX OF ANIMAL: 1 MALE | 2 FEMALE

TOOTH OR JAW SUBMITTED: 1 YES | 2 NO

REPROTRACT OR BACULUM SUBMITTED: 1 YES | 2 NO

PELT EXAMINED: 1 YES | 2 NO

PHOTO TAKEN? 1 YES | 2 NO

FOLLOW-UP CORRESPONDENCE: 1 YES | 2 NO ____ (SPECIFY)

SPECIMEN: 1 KEEP | 2 RETURN | 3 N/A

SHEEP AND GOATS

TOTAL LENGTH
BASE CIRCUM.
TIP SPREAD

MEASURE LONGEST HORN

	LENGTH	CIRCUMFERENCE
TIP TO 1ST		
TIP TO 2ND		
TIP TO 3RD		
TIP TO 4TH		
TIP TO 5TH		
TIP TO 6TH		
TIP TO 7TH		
TIP TO 8TH		
TIP TO 9TH		
TIP TO 10TH		
TIP TO 11TH		
TIP TO 12TH		
TIP TO 13TH		
TIP TO 14TH		
TIP TO 15TH		
TIP TO 16TH		

SHEEP ONLY

BODY COLOR: 1 WHITE | 2 FANNIN (GREY) | 3 DARK

TAIL COLOUR: 1 WHITE | 2 DARK

HORN MEASURED: 1 RIGHT | 2 LEFT

LENGTH TO THIRD ANNULI ON SHORT SIDE

PLUG NUMBER

BEARS ONLY

COLOUR OF UPPER SIDE: 1 BROWN | 2 BLONDE | 3 BLACK | 4 SILVER TIP | 5 LIGHT BROWN

CONDITION OF PELAGE: 1 NORMAL | 2 RUBBED

RUMP FAT (OF BEAR): 1 NONE | 2 0" TO 1" | 3 OVER 1"

TEETH WEAR: 1 NO WEAR | 2 INCISORS ONLY | 3 SOME WEAR ON MOLARS | 4 HEAVY WEAR ON MOLARS

SKULL MEASUREMENTS (IN MILLIMETERS)

SKULL LENGTH ____ 1 FLESH ON
ZYGOMATIC WIDTH ____ 2 FLESH OFF

GRIZZLY ONLY FRONT CLAW COLOUR: 1 LIGHT | 2 DARK | 3 BOTH

COMMENTS (ALL SPECIES) ____

COPY DISTRIBUTION:
1. YELLOW - DATA PROCESSING COPY
2. WHITE - DISTRICT C.O.
3. PINK - APPROPRIATE BID
4. GREEN - HUNTER
5. GREEN - OUTFITTER

YG(1784) NC5 REV. 2/85

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INSTRUCTIONS FOR THE COMPLETION OF "STANDARD" FORM TO DOCUMENT SIZES OF MANDIBLES OF SHEEP AND GOATS, TOOTH WEAR RATES AND PRESENCE AND SEVERITY OF "LUMPY JAW"

a) Definitions and terminology:

Sheep and goat teeth are classified as follows:

Incisors: I-1, I-2, I-3

Canines: C-1

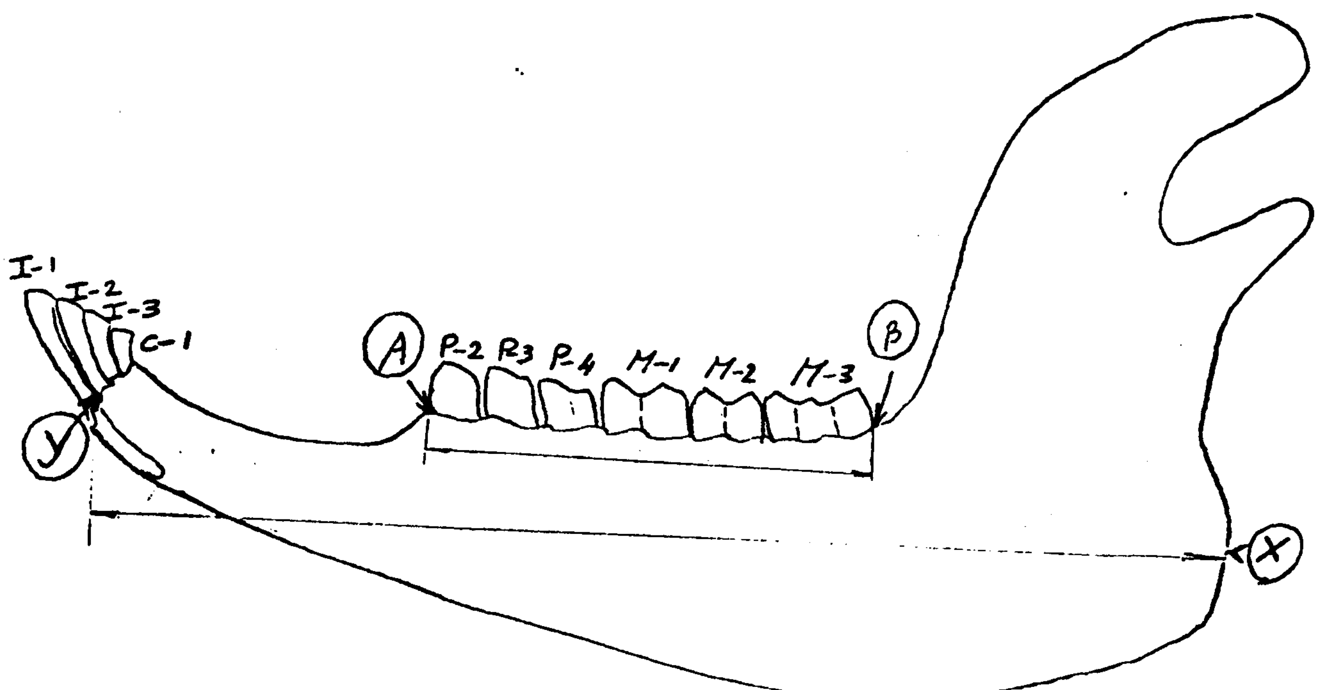
Premolars: P-2, P-3, P-4

Molars: M-1, M-2, M-3

Incisors and canine teeth are incisiform, while premolars and molars are molariform; the third molar, M-3, having three cusps in the mandible but only two cusps in the maxilla.

The tooth formula is as follows: I-0/3, C-0/1 P-3/3 M-3/3

Deviation from the normal formula are referred to as "oligodonty", if (naturally) the animal does not have a complete set, or as "polydonty" if it has supernumerary teeth. Both these phenomena have been observed in sheep. Often the first premolar, P-2, is missing, while a canine may be found in the maxilla.



the inside of the mandible, [illegible] is referred to as the "lingual" side, while the outside, [illegible], where the lips are located, is referred to as the "buccal" side.

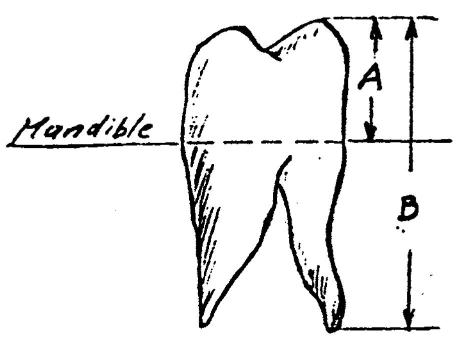
b) Measurements of jaw and teeth:

All measurements are done in metric, on this form in mm.

(7) Total length of jaw.
The mandible is measured with a caliper from its most posterior extension ("X" on drawing) to the base of the first incisor ("Y" on drawing).

(8) Length of the molariform tooth row is measured from the anterior side of P-2, where its base touches the mandible ("A" on drawing) to the posterior side of M-3, where its base protrudes from the mandible ("B" on drawing).

Total length of teeth is determined either from X-ray photographs or, in the case of I-1, by pulling the tooth out of the mandible. Maximal lengths are determined from the longest extent of the root to the highest portion of the tooth protruding out of the mandible.



A = length above mandible

B = total length of tooth

Usually the posterior most cusp of molariform teeth is the highest and should be measured.

Of the incisiform teeth only I-1 will be measured, for the others the following notations will be made:

p = present   m = missing (naturally) (oligodonty)   b = broken

"m" or "b" will also be used for molariform teeth, if they are not present.

All teeth are to be measured on the lingual side of jaw.

Width of I-1 refers to width of crown.

Assessment of extent and severity of lumpy jaw

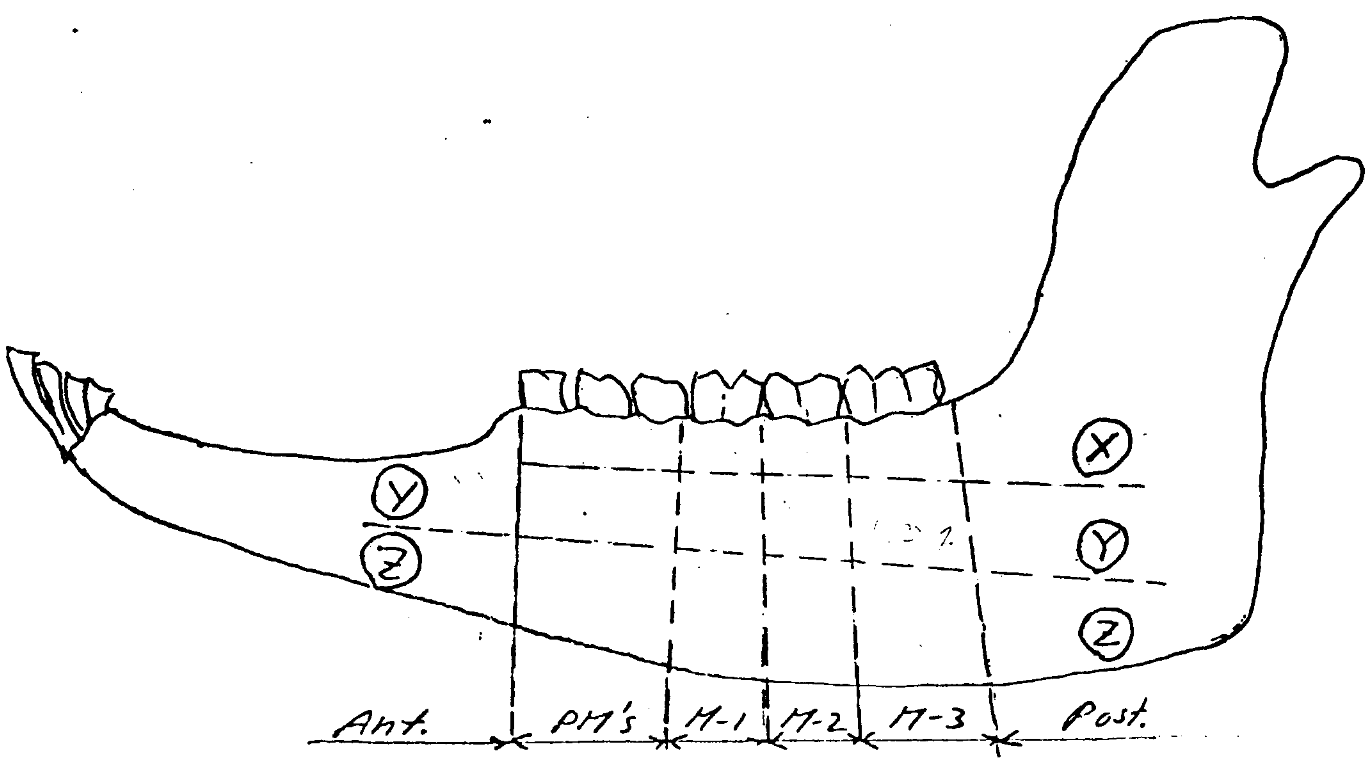
An attempt has been made to quantify as far as possible the documentation of the mandibular disease commonly referred to as "lumpy jaw", so that different people inspecting these jaws come up with similar assessments and that comparisons are possible with other sheep populations affected by this disease.

The mandible to be inspected is divided arbitrarily into 17 sections to allow detailed description of initiation and spread of disease and to correlate these with age of animal.

The 17 sections are distributed into three "vertical" layers in a dorso-ventral plane, and into six sections in an anterior-posterior direction.

The vertical layers are each about 1/3 the width of the mandible X-Y-Z, except for the anterior most portion where only two are found (Y & Z) because of the narrowing of the jaw between molariform and incisiform teeth; the six horizontal sections refer to areas (1) "anterior" to premolars, (2) under premolars, (3) under M-1, (4) under M-2, (5) under M-3, and (6) posterior to the molariform tooth row.

The following drawing shows this division:



For each of the 17 districts the presence and degree of infection will be rated into four degrees of severity as follows:

0 = not infected, bone natural and compact

1 = slightly infected, swelling of mandible in this region as revealed by increase in width, some perforation of bone, but teeth normal, no necrosis or osteolysis.

2 = infection of medium severity. Pronounced swelling of mandibular region, increased perforation of bone, some necrosis (erosion of bone) at base of teeth, uneven wear of teeth, angle of teeth affected.

3 = severe infection: severe necrosis and osteolysis, teeth deformed, growing in displaced angles, broken or missing entirely. Severe swelling of mandible. Large holes in mandible, "honey-combing" of jaw. Bone at base of teeth eroded away, resulting in appearance of greatly elongated cheek teeth.

Photographs of various stages of infection will be made up for reference; and assessments of infected jaws should only be carried out if a healthy jaw is at hand for comparisons.

(b)

STANDARD FORM TO DOCUMENT SIZES OF MANDIBLES OF SHEEP AND GOAT, TOOTH WEAR RATES AND PRESENCE AND SEVERITY OF "LUMPY JAW"

1. Biological submission form #: 2 5 [illegible] [illegible]
2. Sex of animal:
3. Age of animal: 12.5
4. G.M.S.Z. in which animal was killed: 2-2[illegible]
5. Outfitting area in which animal was killed: 03
6. Year when animal was killed: [illegible]

Right Mandible

7. Total length of jaw: 231
8. Length of molariform tooth row: 72
9. Is mandible affected by "lumpy jaw"?: 2

Presence of teeth and wear rates as revealed by tooth length

I-1	I-2	I-3	C-1	P-2	P-3	P-4	M-1	M-2	M-3	
21										presence and total length
11				10	8	[illegible]	7	10	12	length above mandible
4										width of tooth

Assessment of extent and severity of "lumpy jaw"

	Ant.	PM's	M-1	M-2	M-3	Post.
x	X					
y						
z						

Left Mandible

10. Total length of jaw: 24[illegible]
11. Length of molariform tooth row: 73
12. Is mandible affected by "lumpy jaw"?: 2

Presence of teeth and wear rates as revealed by tooth length

I-1	I-2	I-3	C-1	P-2	P-3	P-4	M-1	M-2	M-3	
										presence and total length
				12	9	10	7	10	13	length of teeth above mandible
										width of tooth

Assessment of extent and severity of "lumpy jaw"

	Ant.	PM's	M-1	M-2	M-3	Post.
x	X					
y						
z						

Additional comments (oligo - or polydonty, etc.):
(photograph taken?)