A PRELIMINARY LOOK AT DALL RAM HORN GROWTH IN ALASKA AND ITS IMPLICATIONS

By
Wayne E. Heimer and A. C. Smith
Department of Fish and Game
Fairbanks, Alaska

Dall sheep in Alaska are highly prized by the hunting public, and the primary interest in these animals results from the trophy value of the horns carried by mature rams. The oral tradition of Dall sheep trophy hunters has established that there are variations in horn conformation and growth among the mountain ranges which support Dall sheep in Alaska. This impression is also prevalent among mountain sheep researchers. Valerius Geist (1971) has stated in his "Quality Hypothesis," that quality differences exist between sheep populations and that high quality populations are characterized by more rapid horn growth and more massive horns at any given age than are low quality populations.

Data concerning the size of Dall sheep horns in Alaska have been collected by Scott (1951), Hemming (1967), Boone and Crockett Club (1964), and Erickson (1969, 1970). Scott (1951:76) measured the "Average number of inches by which the length of horn exceeded spread in each area," and stated that "In Kenai rams, length exceeded spread by about 4 inches more than the average of all other areas. Between the other areas there is apparently little significant difference." Scott also stated (1951:80) that "The annual rate of growth increases to a maximum in the third (segment) and then decreased each year throughout the life of the animal" and "An average ram will never grow horns as large as 40 inches in length." Taylor (1962), Wishart (1969), and others have written about horn growth in the Bighorn sheep. Both in Bighorn sheep (Taylor 1962) and Dall sheep (Hemming 1967) maximum growth in horn length was reported to have occurred during the second "summer" of the sheep's life. Taylor (1962) found that horn segment lengths and segment diameters were significantly larger (statistically) for Bighorn rams from the Bison Range in Montana than from rams inhabiting Wildhorse Island. Wishart (1969) found statistically larger horn segment lengths and segment diameters in Bighorn sheep south of the Bow River in Alberta than in Bighorn sheep north of the Bow River.

Measurements of Dall sheep horns compiled by the Boone and Crockett Club indicate that the majority of exceptionally large Dall sheep rams are taken in the Wrangell and Chugach Mountains of Alaska, but rare individuals in all Dall sheep ranges may reach the unusually large size necessary to be recorded. The records maintained by Boone and Crockett Club are of limited interest to the serious student of Dall sheep horn growth because they do not contain information on age, increment length or other parameters which describe conformation. Furthermore, the rams recorded by the Boone and Crockett Club in Records of North American Big Game (1964) represent unusual individuals which are far different than the average.

Hunting of mature Dall sheep rams is the predominant use of these animals in Alaska. Harvest statistics compiled by the Alaska Department of Fish and Game indicate that increased sheep hunting pressure in recent years has resulted in decreasing horn size among sheep harvested in some areas (Smith 1973). The regulations defining harvestable sheep as rams of more than 3/4 curl have been in effect for approximately 25 years. During most of this time, weather and a fairly small hunting public, as well as limited means of transportation, combined to keep Dall sheep populations in a rather stable situation in spite of the limited harvest. However, in recent years, increased pressure and more efficient transportation methods have resulted in localized shortages of trophy rams, increased hunter-hunter interactions and a generally deteriorating sheep hunting experience. For these reasons the days of essentially non-regulated harvest of Dall sheep in Alaska have probably come to an end.

The management policy of the Department of Fish and Game (adopted in 1972) states that, "Consistent with its responsibility to manage game species in the best interests of the species and the people, the Department will manage the resource on the basis of a) maximum overall recreational opportunity, b) maximum aesthetic appeal to the user, and occasionally c) maximum sustained yield of animals." In order to realize all management objectives set forth in the policy in light of the predominance of recreational trophy hunting it becomes obvious that at least some portions of Alaska must be managed for trophy production. Reason dictates that these areas be those where the inherent characteristics of the sheep present are compatible with the desired objective. For example, it would be folly to attempt management for trophy production where the Dall sheep present have small, slow-growing horns. In order to make reasoned decisions in planning Dall sheep management, data on rates of horn growth and expected cumulative growth for sheep from different areas of the mountain ranges of Alaska are essential. One purpose of this study was to provide data for making these planning decisions.

Materials and Methods

Alaska's Dall sheep inhabit 7 different mountain ranges throughout the state: Alaska Range (ARE east of Mt. McKinley and ARW west of Mt. McKinley), Brooks Range (BRR), Chugach Mountains, (CMR), Kenai Mountains (KMR), Talkeetna Mountains (TCW), Tanana Hills-White Mountains (THW), and the Wrangell Mountains (WMR). Sport hunting takes place in all of these mountain ranges, and hunters frequently take Dall sheep horns to taxidermy shops to have them prepared for display as trophies. These taxidermy shops were visited and horns from each of the seven mountain ranges were identified and measured. Approximately seven hundred sets of Dall ram horns were obtained for measurement by this means from 1968 through 1970. Additional specimens from areas where interest was high and hunter effort was low during those periods were obtained through cooperation with hunters known to have taken sheep from the areas of interest during other years. Some specimens from the eastern Brooks Range were obtained from Renewable Resources Ltd. which had picked up the remains of natural deaths in the course of their survey of the Canning River in 1973. These specimens were not hunter kills, but it is assumed that growth rates were the same as hunter killed animals from the same area.

The age of each set of horns was determined by counting the annual growth segments according to the procedure of Geist (1966). A flexible steel measuring tape was then fastened to the horn on the frontal (Severtzoff 1873 cited by Brooke and Brooke 1875) surface with masking tape, and the lengths of all growth segments measured. The greatest diameter at the annuli of each segment was then measured using a vernier caliper spanning the distance from the frontal surface to the nunchal edge (in the groove) as defined by Severtzoff (cited by Brooke and Brooke 1875).

After linear measurements were made the extent of curl was determined using an apparatus similar to that described by Taylor (1962) (Fig. 1). The apparatus consisted of a c-clamp mounted in a swivel base. Horns were fastened securely in the apparatus by clamping the skull (a portion of which always accompanies horns prepared for display as trophies) in the c-clamp. The horns were then tilted and swiveled until an observer about 4 meters away could sight along the axis around which the longer horn was coiling (Fig. 2). When viewed along this axis the outer surface of the horn nearly describes a circle. A plexiglass plate with a series of engraved, concentric circles from 20 to 36 cm in diameter was placed about 50 cm from the horns opposite the observer. The outermost circle on this plate was divided into one degree graduations. As the observer sighted along the axis of coiling an assistant moved the horns and the plexiglass "target" until the axis of coiling passed through the center of the concentric circles. The circle described by the horn was then matched with one of the concentric circles on the plate and degrees of curl were read from the graduations (Fig. 2). Finally, the diameter of the circle described by the horn was measured on the 90-270 degree plane at right angles to the axis of coiling with forestry-type calipers.

All measurements were recorded in millimeters, and computer analysis of the linear measurements (horn lengths, segment lengths, and diameters of annuli) was begun. It then became apparent that linear measurements did not give a comprehensive understanding of the actual size or trophy value of a set of Dall sheep horns. Consequently, the volume of each horn was calculated from the linear measurements available. For purposes of calculation it was assumed that the horn was a regular cone which had been bent into a spiral with no deformation, and that each annular segment was a frustum of the cone. The volumes of each frustum were then calculated using the formula, $v = \frac{h}{3}(r_1^2 + r_1 r_2 + r_2^2)$, where r_1 and r_2 are the radii at the annuli describing the upper and lower limits of each frustum. The frustal volumes were then summed to determine the total volume of the horn. Of course, these calculated volumes are but an approximation of the true volume, but they could be used if necessary as indices of true volume.

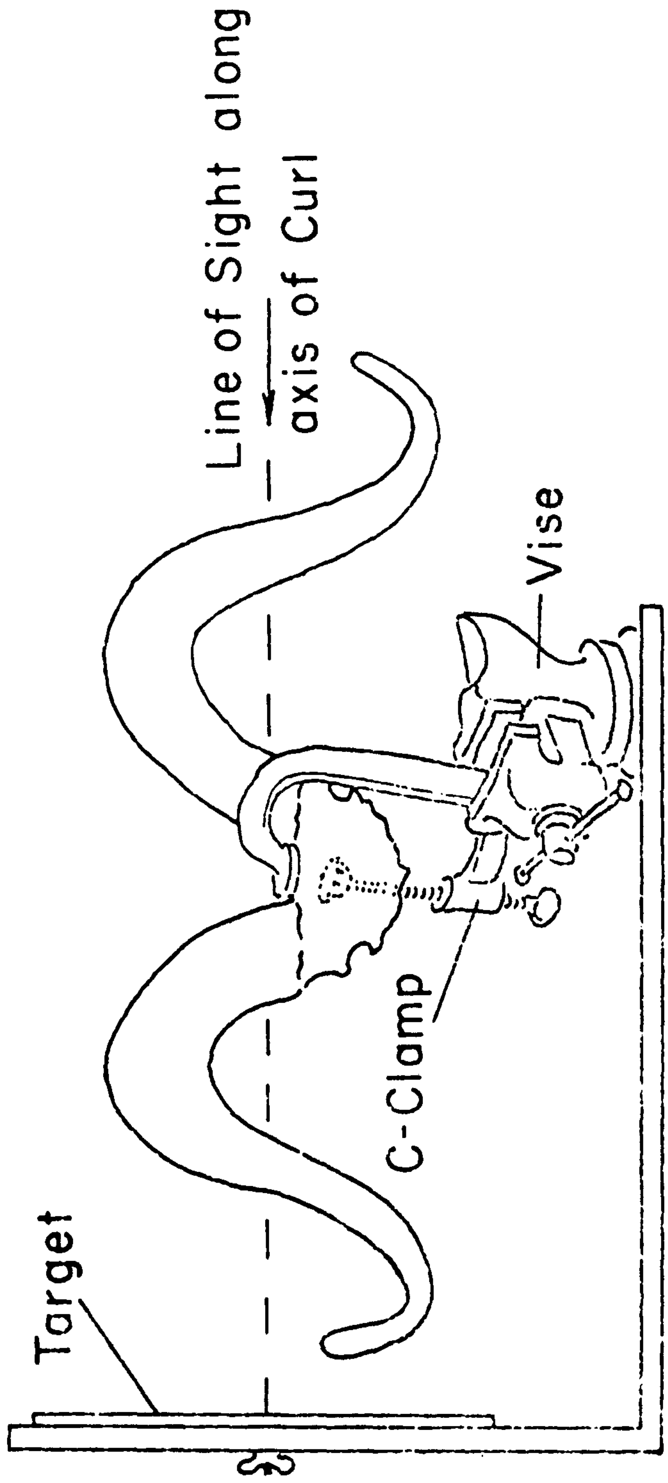


Figure 1. Horn measuring apparatus.

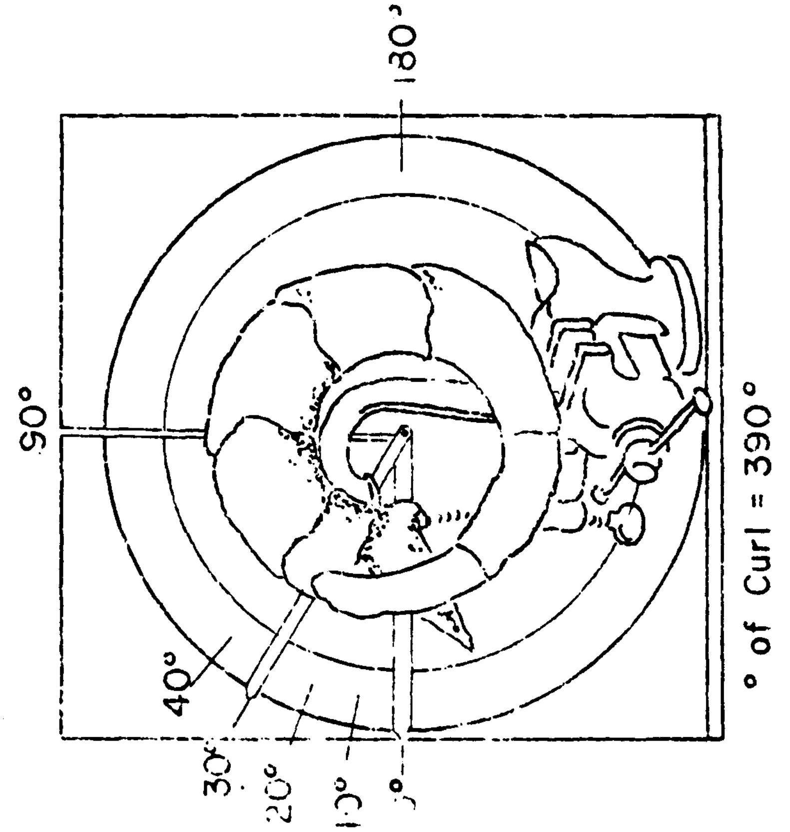


Figure 2. Axial view of Dall ram horn in measuring apparatus.

Approximation of true volume was accomplished by calculating the volumes of 29 sets of horns and then measuring their actual volume by displacement. The mean percentage difference between calculated volume and actual volume for the 29 sets was 54.4 percent. That is, the actual volume was only 54.4 percent of the calculated volume (standard deviation = 3.3 percent). All calculated frustal volumes were then multiplied by 0.456 to give an estimate of true volume.

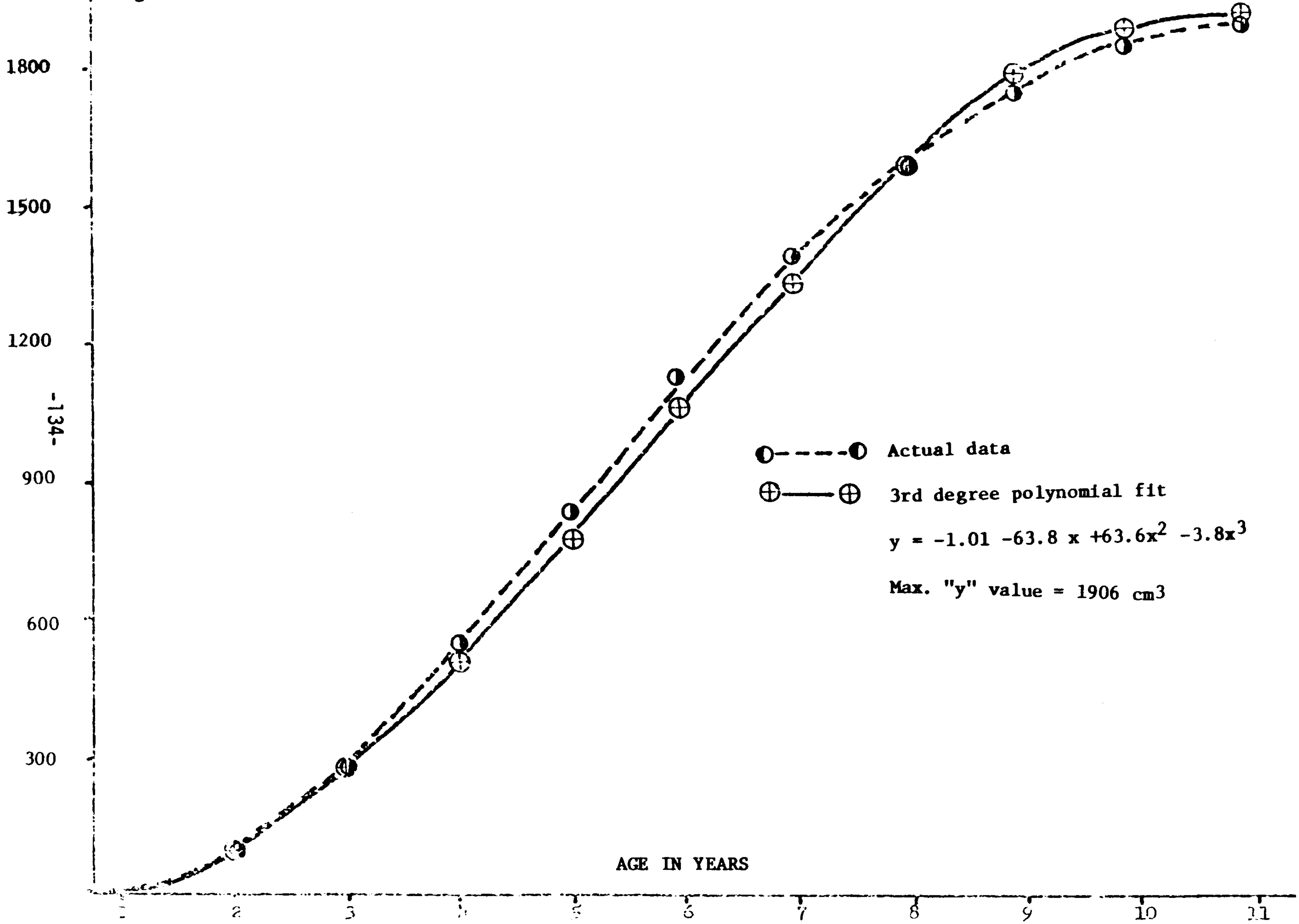
Initial statistical comparisons were made between entire mountain ranges. Further inquiry revealed, however, that there is sufficient variation within a given mountain range that each mountain range was separated into geographical areas on the basis of physiography and these subunits within ranges compared. Growth rates were then determined by plotting cumulative segment volumes against year of growth. This produced a classical "s-shaped" curve, a slow beginning followed by a rapid, nearly linear, period in mid-life and a slowing in rate as the animal reached old age. The computer was then used to "fit" the data to an equation. First and second degree equations were tried but a third degree polynomial of the general form $y = ax^3 + bx^2 + cx + d$ generated the proper "s-shaped" curve. Fit of the data to the curve appeared to be satisfactory.

When the growth patterns of horns from a given area are described by a mathematical expression it opens the possibility of comparison of absolute and relative growth rates between differing groups of sheep. The absolute growth rate can be determined for any given year by evaluating the first derivative of the equation at the year desired. Relative growth rates as percentages of the maximum attainable volume (average) for each area also become calculable if the average maximum attainable volume is known. This term can be obtained by evaluating the first derivative at $x = o$ and determining the sign of the second derivative at $x = o$.

When each of the seven mountain ranges was partitioned according to its physiography the variation of the sample groups decreased. This allowed for more meaningful comparisons within mountain ranges. The different geographical areas were ranked according to average cumulative volume at seven years of age. Seven years was chosen because it represented the upper age which could be used and retain adequate sample sizes for all areas. This age is somewhat below the average age of sheep taken in most ranges but allows a good basis for comparison.

Maximum average growth rate was determined graphically for purposes of early comparison by measuring the slope of the cumulative growth curve in its linear portion. All geographic areas were then ranked according to maximum average growth rate from greatest to least. Both numerical positions for each area were then summed. The sums of the numerical positions on both lists were then ranked in descending order and termed a "Quality Index." This third list according to quality index score was used to evaluate the quality of sheep in different regions of Alaska's mountains. It should be noted that a low quality index score represents high quality.

Figure 3. Comparison plot of predicted growth and actual growth of horns in ARE I.



Results

The geographic areas into which Alaska's mountain ranges were divided are shown in Figure 4. Table 1 shows the ranking according to maximum average horn growth rate and cumulative volume at 7 years as well as the quality index score.

Table 1. Dall ram horn growth in Alaska.

Cumulative volume at 7 years (average)	Average Maximum Growth Rate in cc/year	Quality Index Rank		Quality Index Score
1. WMR II-2110cc	1. WMR II-445	1	WMR II	2
2. CMR II-1998cc	2. CMR II-406	2	CMR II	4
3. ARE III-1975cc	3. TCW I-406	3	TCW I	7
4. TCW I-1882cc	4. KMR II-403	4	ARE III	9
5. KMR II-1805cc	5. THW I-390	5	KMR II	9
6. THW II-1794cc	6. ARE III-386	6	THW I	14
7. ARE II-1726cc	7. ARE II-36[illegible]	7	THW II	14
8. WMR I-1726cc	8. THW II-364	8	ARE II	14
9. THW I-1648cc	9. WMR I-344	9	WMR I	17
10. CMR I-1607cc	10. CMR I-325	10	CMR I	20
11. ARE IV-1591cc	11. KMR I-323	11	KMR I	23
12. KMR I-1587cc	12. ARE IV-321	12	ARE IV	23
13. ARW II-1476cc	13. ARW I-310	13	ARW I	26
14. TCW II-1425cc	14. TCW II-296	14	TCW II	28
15. ARW I-1392cc	15. ARW II-290	15	ARW II	28
16. ARE I-1384cc	16. ARE I-284	16	ARE I	32

Data on conformational parameters are not yet analyzed and will be published elsewhere.

Discussion

The immediate question which must be dealt with in the face of the data presented on quality difference is ... why? This is not an unreported phenomenon and Geist (1971) has proposed mechanisms which may explain such differences.

Several trends of interest are shown by the data. The first of these to be dealt with here is that of a general increase in quality (decrease in quality index score) as one samples along mountain ranges toward the east. Sheep are of generally higher quality further to the east in the Alaska Range, Wrangell Mountains, and the Chugach Mountains. The Brooks Range will not be considered here because the sample sizes for the areas involved are not sufficient for valid comparison. Also, not included were the extreme eastern Chugach (CMR III) and the northern Talkeetna Mountains (TCW III) because of insufficient data. However, indications are that CMR III is the area of highest quality in the Chugach Mountains and TCW III is the area of lowest quality in the Talkeetna Mountains.

Fig. 4. Arbitrarily designated portions of Alaska used in determination of "Quality Index."

In the Alaska Range, the Wrangell Mountains and the Chugach Mountains the increase in quality toward the east parallels an increase in existing glaciation as postulated by Geist (1971). In the Talkeetna Mountains the increase in quality appears to run from TCW III in the north to TCW II in the southeast, and TCW I in the southwest Talkeetnas is the area of highest quality. This pattern also fits the general situation of increasing quality with increased presence of glaciers. In the Kenai Mountains the sheep of higher quality are found on the sheltered side of the peninsula. It appears that there may be more glaciers in the sheep habitat of the western Kenai Mountains (KMR II) than in the eastern area (KMR 1). The Alaska Range west of Mt. McKinley also presents a situation where the sheep of higher quality come from the more glaciated areas.

The notable exception to this trend exists in the Tanana Hills-White Mountains. Sheep from this area rank surprisingly high in the list of overall quality (Table 1), and the area which they occupy has never been extensively glaciated. Currently no glaciers exist in this area of Alaska.

Increases in quality correlate well with lower densities of sheep per unit of available area. Density figures are approximate and the square miles used are the total available mountainous terrain in areas in which sheep are known to exist. Area ARE I, just east of Mt. McKinley Park in the Alaska Range, is clearly the lowest quality area in Alaska (Table 1). This area is known to have a density of 9 sheep per square mile. Further to the east (ARE II) the density is about 3 sheep per square mile. Still further to the east (ARE III) the density is approximately 1 sheep per square mile. East of ARE III, in area ARE IV, quality is lower and the density of animals on the range has increased to 4 sheep per square mile.

In the Wrangell Mountains quality also correlates with sheep density. The eastern Wrangell Mountains (WMR II) has a density of 1 sheep per square mile and ranks higher on the quality list than does the western Wrangell Mountains (WMR I) which have a density of 2 sheep per square mile.

In the Chugach Mountains the generalization again holds with the eastern, less densely populated area, CMR III, ranking higher on the quality list than the more westerly areas, CMR II and CMR I (Table 1).

At the present time there is no known exception to the generalization that higher quality is associated with lower sheep population densities. This may account for the high quality of sheep in the Tanana Hills-White Mountains, an exception to the "Glaciation Hypothesis."

Correspondence between high quality and low density is more consistent than that between high quality and the presence (present or past) of glaciers. Geist's (1971) hypothesis predicts that higher quality should be correlated with glaciation, but also postulates that population numbers should be lower in these areas. The data are generally supportive of the hypothesis, but the questions raised by the exceptions are yet to be answered. Further work utilizing the technique of fitting horn growth data to a third degree polynomial for analysis of growth patterns, particularly as an aid in determining relative growth rates, may be useful. Analysis of the data by this technique should indicate whether Dall sheep follow the pattern described by Wishart (1969) for Bighorns. Wishart found that Bighorns have similar relative growth rates and concluded that overall size was a function of habitat. The answers to these questions may shed some light on the question of whether differences in quality are of genetic or environmental origin.

LITERATURE CITED

Alaska Game Management Policies. 1973. Alaska Department of Fish and Game. Juneau, Alaska. 64pp.

Boone and Crockett Club. 1964. Records of North American Big Game. Holt, New York. 398pp.

Brooke, V. and B. Brooke. 1875. On the large sheep of the Thian Shan, and other Asiatic Argali. Proc. Zool. Soc. 33:509-526.

Erickson, J. A. 1970. Sheep Report. Fed. Aid in Wildl. Rest. Annu. Proj. Prog. Rep. V. XI.

Geist, V. 1966. Validity of horn segment counts in aging bighorn sheep. J. Wildl. Manage. 30:634-646.

__________. 1971. Mountain sheep; a study in behavior and evolution. Univ. Chicago Press, Chicago and London. 371pp.

Hemming, J. E. 1967. Mandibular dentition and horn development as criteria of age in the Dall sheep, *Ovis dalli* Nelson. M.S. Thesis, Univ. Montana, Missoula. 42pp.

Nichols, L. and J. A. Erickson. 1969. Sheep Report. Fed. Aid. Wildl. Rest. Annu. Proj. Prog. Rep. V. X.

Scott, R. F. 1951. Mountain sheep studies. U.S. Fish and Wildl. Serv. Q. Prog. Rep. Work Plan No. 9. 5(3):11-21. Typescript.

Smith, A. C. III. Annu. Rep. Survey Inventory Activities. Fed. Aid in Wildl. Rest. Rep. Proj. W-17-4, Part I.

Taylor, R. A., Jr. 1962. Characteristics of horn growth in bighorn sheep rams. M.S. Thesis Montana State Univ., Missoula. 129pp.

Wishart, B. 1969. Bighorns and "Littlehorns." Alberta, Lands-Forests-Parks-Wildlife. Fall 4-1-.

Northern Wild Sheep and Goat Council

(formerly Northern Wild Sheep Council)

Proceedings of the Biennial Symposium

April 23 - 25, 1974