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SHEEP REPORT

by
Lyman Nichols
and
Wayne Heimer

Volume XIII
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-3, Jobs 6.1R, 6.2R, 6.3R, 6.4R and 6.5R and
Project W-17-4, Jobs 6.1R, 6.2R, 6.3R, 6.4R, 6.5R and 6.7R

(Printed September, 1972)

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Wayne Heimer, Arthur C. Smith, Spencer Linderman (ADF&G) and P. D. Shaughnessy, University of Alaska

Project Nos.: W-17-3, W-17-4 — Project Title: Big Game Investigations

Job No.: 6.1 R — Job Title: Dall Sheep Movements and Mineral Lick Use

Period Covered: January 1, 1971 to December 31, 1971

SUMMARY

Collars were placed on 104 of 168 Dall sheep captured with a drop net at a natural mineral lick on Dry Creek, Alaska Range, during 1971. Morphological measurements, blood samples, and fecal pellets were gathered from 131 of the captured sheep. A total of 338 sheep have been captured and 204 sheep have been collared at Dry Creek since this project was begun in 1968.

Morphological characteristics (contour length, chest girth, height at the shoulder, hind foot length and gross weight) were used to compare *Ovis dalli* from the central Alaska Range and the Kenai Peninsula. No significant differences were apparent. The status of Kenai sheep as a separate subspecies may be questioned.

Serum transferrins from blood samples were examined by electrophoresis. The lack of variation in transferrin mobility on 109 samples from the central Alaska Range suggests that they are from one interbreeding population. A similar examination of Dall sheep material representing areas that are isolated from this portion of the Alaska Range may reveal polymorphic protein systems in which phenotypic frequencies provide information on population structure.

Seasonal home range may have a minimum diameter of 4.7 aerial miles, however, this is a tentative figure and is probably influenced by the observational techniques used.

Use of mineral licks by rams precedes use by ewes. Peak lick use probably occurs in the forepart of June, and is apparently influenced by weather conditions. Sheep use periods during a given day are divided into two major peaks, one at 0400 hours and the other at 1200-1400 hours. Also, sheep have averaged approximately 70 minutes per visit. Ewe fidelity is probably greater than 90 percent and that of rams greater than 40 percent based on limited observations. Two-year-old rams have the lowest lick fidelity perhaps because of their propensity for

establishing new home ranges. The average visit to the lick is 1.3 days and occurs at a frequency of each 2-3 days. This may represent 45 percent of a sheep's time in the summer.

CONTENTS

BACKGROUND

The Dall sheep (*Ovis dalli*) in Alaska has been managed traditionally for the harvest of mature rams only. Such harvest has not controlled herd growth and sheep numbers have increased or declined due to natural causes alone. Populations have apparently been increasing during the past decade or longer and, in some areas, may be approaching their maximum safe level.

One herd on Surprise Mountain on the Kenai Peninsula is known to have declined by about 20 percent because of a harsh winter in 1969-70. Similar or more serious declines may face this and other populations which have been allowed to reach overabundance through lack of control.

The main objective of this study, in addition to obtaining basic life history data, is to determine whether such natural declines can be reduced by maintaining sheep populations at a level below the carrying capacity of their winter range through either-sex hunting. The secondary objective is to learn whether intensive hunting for 3/4-curl and larger rams has a detrimental effect on reproduction or survival. Three herds on the Kenai Peninsula were chosen for study: the Crescent Mountain herd, the Surprise Mountain herd and the Cooper Landing Closed Area herd (see Fig. 11). These herds are near each other but appear to be isolated because of topographical features; no significant movement is known to occur between them. The habitats seem to be similar and the herds had been increasing at approximately the same rate prior to the winter of 1969-70 when that on Surprise Mountain declined as stated previously.

Both the Surprise and Crescent mountains herds are readily accessible to hunters from nearby highways. Both have been hunted heavily during past years with almost every ram being harvested as soon as its horns reached the legal status of three-quarter curl. The Cooper Landing Closed Area is, as its name implies, closed to sheep hunting. The herd within its boundaries has been, for practical purposes, unhunted.

The study called for the reduction of the Crescent Mountain herd by some 30 percent during the first year with maintenance at this lowered level for at least four more years. This reduction has been accomplished through a public either-sex hunt in August, 1970 and a collecting program during the winter of 1970-71. The Surprise Mountain herd will be hunted for rams only as it has been, and the Cooper Landing herd will remain protected. Production and survival of young, herd size and herd response to winter stress will be monitored on the three areas. A comparative study of winter range trend and climate on the three areas is underway. Thus, the effects of either-sex hunting and consequent herd control will be compared with those of ram-only hunting and complete protection.

OBJECTIVES

To determine the forage plants eaten by Dall sheep, their feeding habits and changes in their body condition throughout the winter.

To compare the various factors relating to reproduction in Dall sheep, including: body condition, chronology of breeding and parturition, minimum breeding age, pregnancy rate, prenatal sex ratio, fetal growth rate, rutting behavior and differences in rutting behavior between a population which is relatively unhunted and one which is heavily exploited.

To determine the population compositions and trends on Crescent Mountain, Surprise Mountain and Cooper Landing Closed Area, Kenai.

To compare Dall sheep winter range composition, trend and availability and gross winter climate on Crescent Mountain, Cooper Landing Closed Area and Surprise Mountain, Kenai Peninsula.

PROCEDURES

Winter Food Habits and Body Condition

The Crescent Mountain collection program begun in the last segment was completed. Sheep were collected on January 14, February 26, March 18 and April 27, 1971. A Bell 206A Jet Ranger helicopter was used during the collections, with specimens being shot from the helicopter with buckshot. Whole-blood samples were collected immediately from each animal, then carcasses were flown directly to Soldotna where they were autopsied in a heated warehouse.

Initial autopsy and processing of specimens proceeded as described in the 1971 progress report. Rumen samples and fecal pellets were analyzed for food habits information by Dr. Richard Hansen, Department of Range Science, Colorado State University, under special contract. Bone marrow from femurs was analyzed at our Anchorage laboratory for fat content. Blood serum was analyzed by Alaska Medical Laboratories, Inc. for serological and hematological values. Internal organs were sent to our Fairbanks laboratory for parasitological examination. The age of each sheep taken was estimated by counting horn annuli. Carcasses were donated to charitable institutions in the Soldotna area.

Feeding habits were observed while in the field in November and December during the breeding behavior study.

Productivity

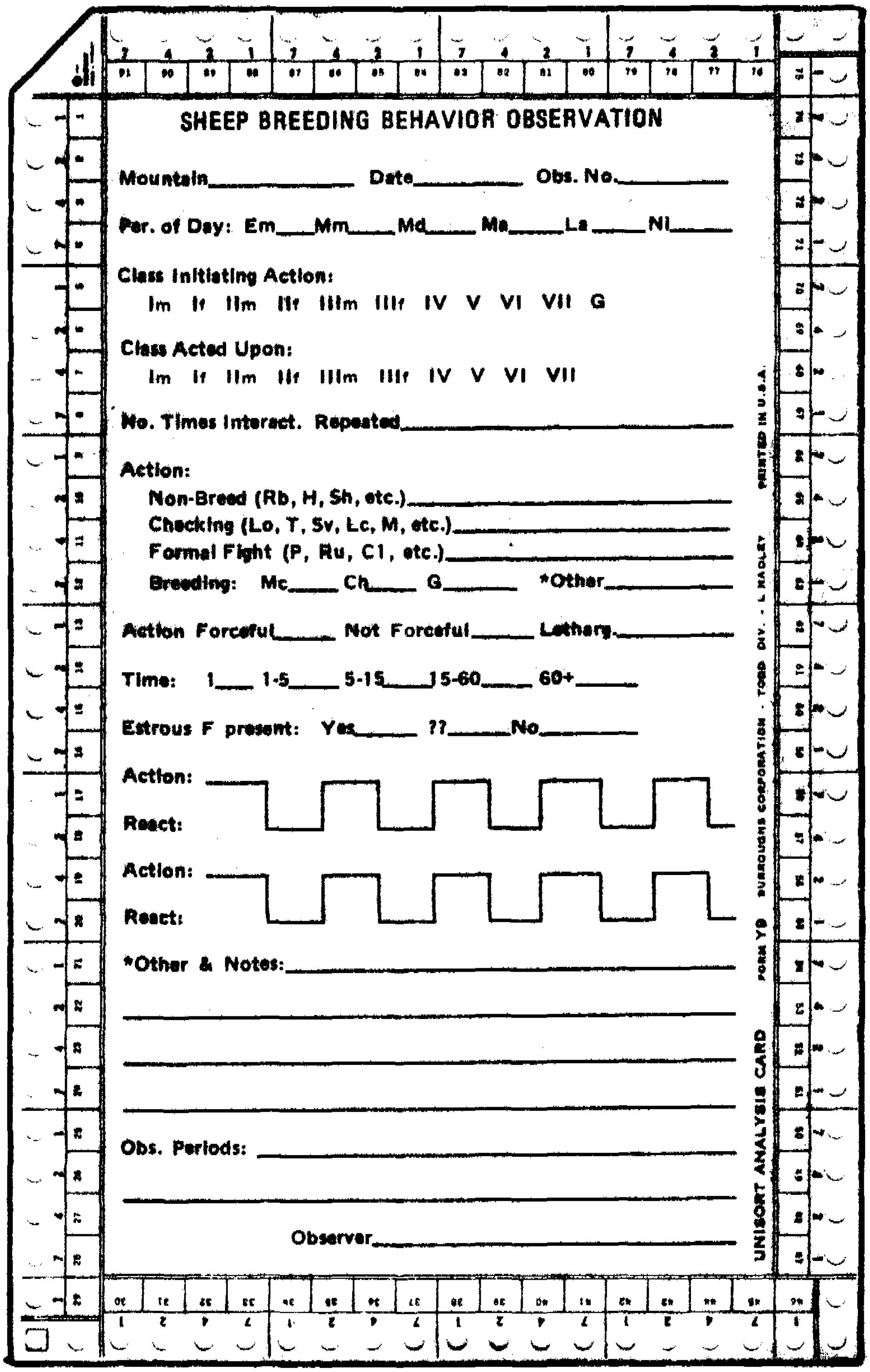
Observations to determine and compare breeding seasons and behavior were again conducted on Surprise Mountain and at the head of Slaughter Creek, Cooper Landing Closed Area. Winter camps were established in each area with one observer stationed in each during most of the assumed breeding season. Two different individuals alternated observation periods out of the Slaughter Creek camp, while one man conducted all observations on Surprise Mountain. The Slaughter Creek camp was manned from November 16 to December 8, and from December 14 to 18, 1971; while the Surprise Mountain camp was manned from November 16 to 23, November 27 to December 9, and December 14 to 18, 1971.

Sheep behavior was observed by means of spotting scope and binoculars at each location during each day that weather permitted (Plate 1). Interactions between animals were recorded on printed Unisort cards which had been simplified somewhat from those used last year (Fig. 1). The cards were designed so that major behaviorism categories between interacting animals could simply be checked off. Space was provided so interesting or unusual sequences of interaction could be followed through if desired. Other pertinent information could also be recorded on the cards.

Information categories were coded as much as possible to minimize the need to write--an advantage under sub-freezing conditions. A key was provided to each observer (Fig. 2). Organization of data was accomplished by designing an appropriate key (Appendix 1), punching the cards accordingly, then sorting them and listing data by categories of interest. Data were then compared and examined as necessary for preliminary analysis. Daily field notes kept by each observer aided in the interpretation of punch-card data.

Reproductive tracts were taken from all female specimens collected from Crescent Mountain. Ovaries were preserved in 10 percent formalin until they could be examined. Uteri were examined and fetuses removed and similarly preserved. Smears were made from testes of male specimens. Unfortunately, some of the slides were lost and no data were obtained. Others were microscopically examined while still fresh for the presence of sperm.

Figure 1. Unisort Sheep Breeding Observation Card, 1971.



SHEEP BREEDING BEHAVIOR OBSERVATION

Mountain________ Date________ Obs. No.________

Per. of Day: Em____ Mm____ Md____ Ma____ La____ Ni____

Class Initiating Action:
Im If IIm IIf IIIm IIIf IV V VI VII G

Class Acted Upon:
Im If IIm IIf IIIm IIIf IV V VI VII

No. Times Interact. Repeated________

Action:
Non-Breed (Rb, H, Sh, etc.)________
Checking (Lo, T, Sv, Lc, M, etc.)________
Formal Fight (P, Ru, C1, etc.)________
Breeding: Mc____ Ch____ G____ *Other________

Action Forceful____ Not Forceful____ Lethargic____

Time: 1____ 1-5____ 5-15____ 15-60____ 60+____

Estrous F present: Yes____ ??____ No____

Action:
React:
Action:
React:

*Other & Notes:________

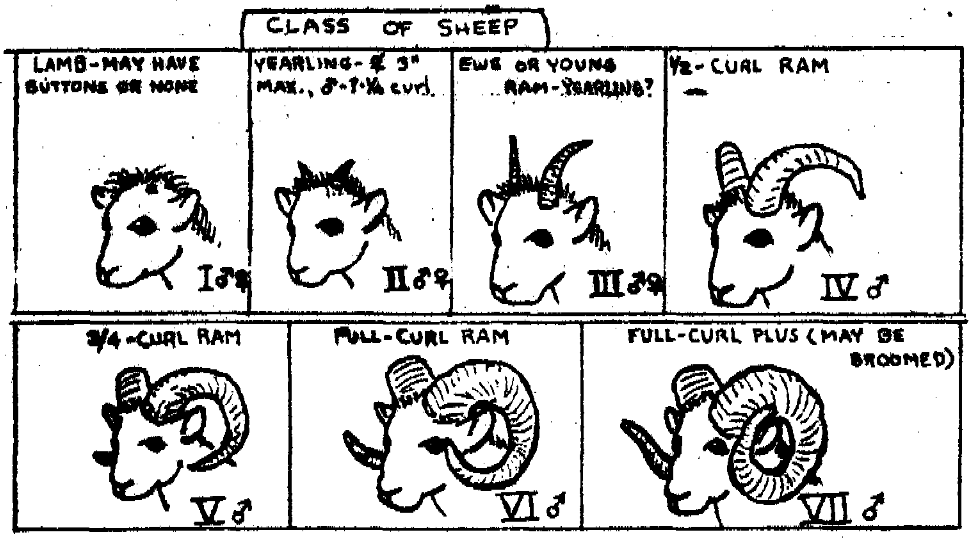
Obs. Periods:________

Observer________

UNISORT ANALYSIS CARD

FORM Y8 BURROUGHS CORPORATION · TODD DIV. · L HADLEY PRINTED IN U.S.A.

Figure 2. Sheep Breeding Observation Card Key, 1971.



Mountain: Cooper Landing = ₵ Surprise = S
Observation No.: Consecutive for the day; start over daily
Period of day: Em - early morning; Mm - mid morning, Md - mid day
Ma - mid afternoon; La - late afternoon; N - night
Class of Sheep: See drawings; note sex if possible; G = Group
No. times interaction repeated: applies only to animal initiating action towards several others - same action repeated. Usually a ram checking several ewes in succession

Actions:

Non-breeding
Rubbing (Rb) Horn Threat (Ht) Head shake (Hs)
Horning (H) Butt (B)

Checking
Lo stretch (Lo) Sniff vulva (Sv) Front kick (Fk) Mount (M)
Twist (T) Lip curl (Lc) Nudge (N)

Formal Fighting
Present (P) Rush (Ru) Front kick (Fk)
Threat jump (Tj) Clash (Cl)

Breeding
Copulation (Mc) Guard (G)
Chase (C) = (includes shoving & fighting during chase)

Other (O)

Reactions:
(Any of above)
Run or move away (Ma) Squat (Sq)
Ignore (Ig) Urinate (U)
Stand still (Ss) Submit (S)

Obs. periods: Time intervals of constant observation, ex: 0800-0930; 1000-1200; 1230-1400 etc.

Action-reaction sequence - only to follow significant or unusual interactions

Weights and body measurements were later obtained from the preserved fetuses. Ovaries were sectioned and examined under low magnification for the presence of ovarian bodies.

A series of replicate aerial counts was conducted from May 19 to June 21, 1971 on the three study areas to determine the chronology of lambing. It was planned to fly all areas on the same day each time, and to fly each series every two or three days. Bad weather made it impossible to follow such a schedule, so each area was flown independently as weather permitted. I did the flying and counting alone in a Piper PA-18-150 Supercub, recording data in a small tape recorder slung around my neck. Each area was flown as completely as possible to obtain as many observations as possible. Duplication was easily avoided. Each group of sheep was counted as many times as necessary for accuracy. First, all "adults" (nonlambs) in the group were tallied and recorded, then all new lambs. Groups and individual ewes were "worked" closely and carefully to locate hiding lambs.

Following each count, recorded data were transcribed and converted to percentages of lambs per 100 "adults" so that chronology and general magnitude of lambing could be compared between the areas.

Population Trends

Aerial classification counts of sheep herds on Surprise Mountain, Crescent Mountain and Cooper Landing Closed Area were conducted as previously described (Nichols, 1970). A Piper PA-18-150 airplane was used for all surveys. Population models were constructed mathematically from the count data for two of the herds.

Winter Range and Climate

Aerial photographs were taken during late winter of sections of all three study areas. The photographs showed consistently open, windblown, exposed ridges used by sheep during late winter when heavy snow crusting confines their feeding sites. Aerial and ground observations of sheep distribution and feeding activity confirmed use of certain ridges. Exposed areas actually in use by sheep were then staked out on Crescent and Surprise mountains in late winter for later identification. Similar sites were staked on Slaughter Mountain (Cooper Landing Closed Area) in the spring.

A contract was let to Dr. Richard M. Hansen, Department of Range Science, Colorado State University, to conduct a comparative range survey on the three areas during the summer of 1971. A copy of Dr. Hansen's final report is appended to this report (Appendix II) in which he describes the methods used in the surveys. Briefly, ten stands were staked out on each mountain within the areas previously marked as winter range. Within each stand, 100 .01-square-meter plots were laid out and the vegetation within each plot estimated by weight and species. The results were programmed and analyzed by computer so that production by species and area could be compared.

To compare gross climates, three Model 1072 self-contained, portable weather stations were purchased from Meteorology Research, Inc., Altadena, California. One was established on an appropriately exposed site on each mountain. The stations on Surprise and Slaughter mountains were fenced to prevent moose damage. That on Crescent Mountain was not since it is well above moose habitat.

Snow depth measurements were obtained by means of a marked probe. Hardness measurements utilized a Chatillon "push-pull" scale with a capacity to 20 pounds, a rod with a 1.0-cm^2 tip and another rod with a 0.5-cm^2 tip.

Hardness in pounds-per-cm^2 of force required to push the rod through snow could be read from the scale. Hardness was measured to a maximum depth of 18 inches. Only preliminary measurements were made during this segment.

FINDINGS

Winter Food Habits and Body Condition

The method used in collecting sheep during the winter of 1970-71 worked well. Prerequisites are a helicopter with adequate power, a very skilled pilot and good weather with little turbulence. Sheep were not shot until they were driven to a site where recovery was possible. The automatic shotgun and buckshot proved very efficient and humane. Not one sheep was lost due to wounding during the entire collection. Only one was lost altogether because it rolled over a cliff where it could not be recovered. I do not believe any other method could be used during the winter for mass collection which would enable specimens to be collected, retrieved and brought rapidly to the lab for processing.

In all, 47 sheep were collected; including 24 adult ewes, 2 adult rams, 11 yearlings and 10 lambs. Accession numbers, sexes, ages, body measurements and weights of all sheep collected from Crescent Mountain plus the five taken on Surprise Mountain in the spring of 1970 are listed in Table 1. It also includes a male lamb (#62114) which was found with a broken leg and starving in the closed area in March, 1971.

Ages were estimated by counting horn annuli and assuming an average birth date of June 1. Horns of some older females were badly cracked and weathered over the surface, making annuli difficult to distinguish. When necessary, these horns were longitudinally sectioned with a band saw so that the internal structure of each annulus could be identified and counted. The external and internal structures are shown in Plate 2.

Incisor teeth were collected from each specimen. These were sectioned and examined by the method described by Hemming (1969) in an attempt to determine ages through cementum layers. Difficulties have been encountered with the method and considerable variation exists between the ages as

Table 1. Ages, measurements (in centimeters) and weights (in pounds) of Dall sheep specimens from Surprise and Crescent Mountains.

Specimen No.	Date	Sex	Age*	Total Length	Head	Ear	Tail	H. Foot	H. Hoof	Shoulder Ht.	Girth	Chest Depth	Whole Weight
						Surprise Mountain - Female							
62051	4/28/70	F	10+	139	28	8.5	10	38	5.3	86	91	37	85
62052	"	F	1+11	126	23	8.5	5	33	3.7	77	77	35	48
62053	"	F	1+11	122	23	8.0	9	35	4.0	74	75	31	45
62054	"	F	7+	144	27	9.2	6	37	4.5	89	90	39	88
62055	"	F	1+11	116	22	8.0	6	34	4.5	67	72	30	42
						Crescent Mountain - Female							
62075	11/13/70	F	7+5	147	27	9.0	7	37	5.2	88	110	40	144
62076	"	F	6+5	144	27	7.0	7	36	5.3	75	104	40	120
62078	"	F	3+5	144	28	9.0	10	38	5.0	86	104	43	129
62079	"	F	8+5	141	25	9.0	9	37	4.9	88	108	39	139
62081	"	F	2+5	141	26	8.0	9	37	5.0	79	101	38	122
62082	"	F	2+5	114	23	8.0	7	35	5.1	76	91	35	91
62084	3/18/71	F	10+10	144	28	8.0	11	38	5.0	85	95	43	108
62085	1/14/71	F	0+7	115	24	7.5	5	33	4.0	70	87	34	61
62088	"	F	3+7	155	29	7.5	10	39	5.0	84	104	38	111
62089	2/26/71	F	13+9	145	28	9.0	7	38	5.7	87	99	44	123
62090	1/14/71	F	6+7	145	30	7.5	6	37	5.0	89	109	42	123
62092	"	F	8+7	145	29	9.0	7	37	5.0	87	102	40	102
62093	3/18/71	F	9+10	141	27	8.5	7	38	5.3	85	97	44	119
62095	2/26/71	F	1+9	132	24	8.0	8	36	4.5	82	88	40	83
62097	"	F	1+9	127	24	8.0	9	37	4.8	81	88	40	87
62098	3/18/71	F	7+	140	27	8.0	9	37	5.0	86	93	46	99
62099	2/26/71	F	9+9	145	26	9.0	8	35	5.5	88	100	46	118
62100	2/26/71	F	2+9	140	26	9.0	8	37	5.0	86	99	46	110
62101	3/18/71	F	0+10	114	21	8.0	8	32	4.1	59	80	35	55
62102	3/18/71	F	1+10	127	24	8.0	8	36	4.3	71	87	39	71
62105	2/26/71	F	6+9	138	27	8.0	10	37	5.4	91	99	43	110
62107	3/18/71	F	1+10	128	24	8.0	6	36	4.7	77	91	41	89
62108	"	F	3+10	142	27	8.5	9	36	4.8	83	95	45	103
62110	2/26/71	F	5+9	146	28	9.0	10	38	5.2	89	101	48	121
62112	3/18/71	F	5+10	148	28	8.0	8	38	5.2	88	98	46	121

Table 1. (cont'd.) Ages, measurements (in centimeters) and weights (in pounds) of Dall sheep specimens from Surprise and Crescent Mountains.

Specimen No.	Date	Sex	Age	Total Length	Head	Ear	Tail	H. Foot	H. Hoof	Shoulder Ht.	Girth	Chest Depth	Whole Weight
62113	4/27/71	F	5+11	138	-	9.0	10	37	5.2	90	95	46	114
62116	"	F	10+11	147	27	8.5	12	37	5.0	86	95	45	127
62118	"	F	13+11	150	28	9.0	11	38	5.2	90	97	46	114
62119	"	F	4+11	137	27	9.0	12	37	4.9	85	89	41	99
62120	"	F	0+11	101	19	7.0	6	30	3.9	62	68	36	34
62123	"	F	0+11	101	19	7.0	7	30	3.8	60	67	33	34
62125	"	F	4+11	144	26	9.0	10	37	5.0	86	93	43	101
						Crescent Mountain - Male							
62077	11/13/70	M	0+5	112	20	8.0	7	33	4.2	70	76	33	65
62080	"	M	0+5	111	19	8.0	6	34	4.5	73	83	33	74
62083	"	M	0+5	106	20	7.0	6	33	4.3	72	86	29	60
62086	1/14/71	M	0+7	106	24	7.5	5	33	4.0	71	83	33	66
62087	"	M	1+7	140	27	8.0	11	40	4.5	83	107	42	103
62091	"	M	1+7	133	28	9.0	11	39	5.5	78	100	35	94
62094	2/26/71	M	2+9	142	26	8.0	10	39	5.3	82	96	48	103
62096	3/18/71	M	0+10	109	20	8.0	5	32	4.0	66	73	37	44
62103	2/26/71	M	3+9	159	28	9.0	10	40	5.8	95	112	52	152
62104	"	M	1+9	140	25	8.0	7	39	5.3	89	95	42	99
62106	3/18/71	M	1+10	123	25	8.0	7	36	4.9	77	85	41	71
62109	"	M	1+10	127	23	8.5	8	37	4.5	68	81	45	69
62114	"	M	0+10	115	20	8.0	7	32	4.0	67	76	35	41
62117	4/27/71	M	0+11	111	21	8.0	8	33	4.2	62	73	34	50
62121	"	M	1+11	124	23	8.0	9	38	4.6	80	84	41	75
62124	"	M	1+11	120	23	9.0	8	35	4.4	71	81	39	59

* Ages by horn annuli to nearest month assuming average birth date of June 1. Expressed as years + months.

determined by horn annuli and cementum layers. Since cementum layers were indefinite and difficult to read in a number of specimens, while horn annuli generally appeared clear and straightforward, I believe the latter gave a more accurate estimate of the specimen ages.

The average weights and sample ranges of sheep collected are plotted by age category and date of collection in Fig. 3. The weights of animals taken in April, 1970 on Surprise Mountain are also plotted. Although not taken from the same area or in the same year, these do illustrate weights of Dall sheep at about the malnutrition level. The weight of a lamb found in Cooper Landing Closed Area in March, 1971 is also shown. This animal had a broken leg and appeared on the verge of starvation, having been bogged in the snow of an avalanche and unable to feed for an unknown number of days.

Relative weight loss through the winter appears greatest in the yearling age class. Some of the late-winter yearlings weighed less than early-winter lambs, and those from Surprise Mountain weighed approximately the same as late-winter lambs.

Femurs were taken from the sheep specimens and percent fat in the bone marrow determined as described by Neiland (1970). Marrow-fat values by date of collection and age class are listed in Table 2. Specimens taken during the public hunt in August, 1970 are included as are those from Surprise Mountain and the lamb with the broken leg. Three other femurs were obtained in May and early June, 1971 from adult sheep found dead in the closed area. All three were reasonably fresh when found.

Average marrow-fat percentages by age class and date are plotted in Fig. 4. Marrow-fat declined markedly in late winter, presumably during the period of greatest nutritional stress. By April, 1971, the percent marrow-fat of yearlings and some lambs taken on Crescent Mountain was in the same range as that of both yearlings and adult ewes from Surprise Mountain in April, 1970. That population had just suffered a die-off believed caused by malnutrition due to a severe winter.

The lowest percentages of marrow-fat occurred in the animals which had just died (possibly from malnutrition), from the crippled lamb on the verge of starvation, and from one adult ewe in the Surprise Mountain collection. A fat level below 10 percent probably indicates imminent death by starvation.

Blood values have not yet been analyzed. A computer program for analysis of moose-blood components is being designed. The program will also be suitable for analysis of the sheep blood specimens; this will be accomplished upon its completion. A complete listing of blood values by specimen number is available but is not included in this report because of length.

Samples of rumen contents and fecal pellets were taken from collected sheep and given to Dr. Hansen for analysis under special

Figure 3. Average Weights and Sample Ranges of Sheep Collected in 1970-71 by Date of Collection.

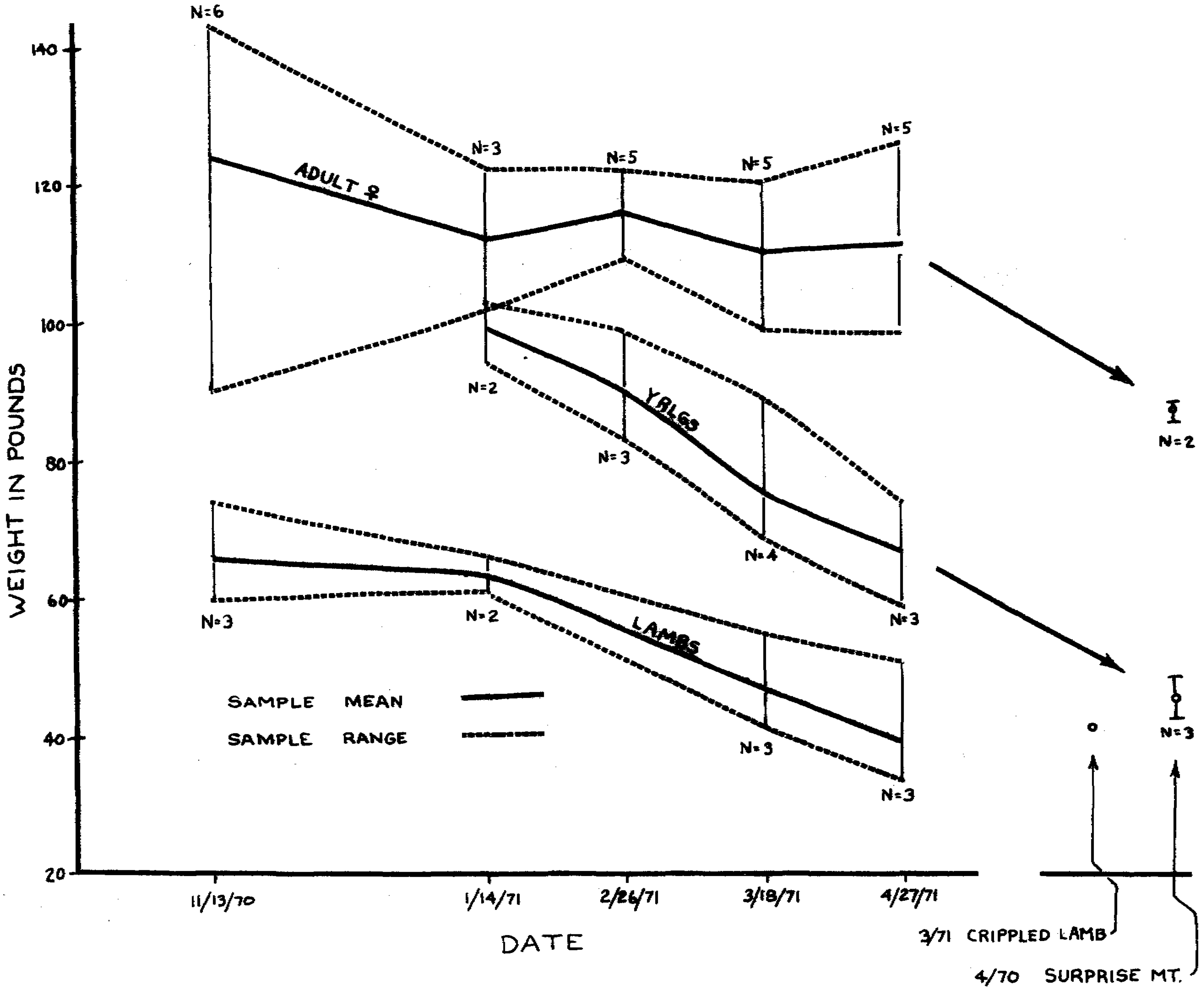


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Table 2. Bone marrow fat by percent of dry weight from Dall sheep specimens, 1970-71.

Date/Location	Age Category	% Fat Average	% Fat Sample Range	Sample Size
Aug. 1970	All	91.7	82.6-94.8	7
Public hunt	Adult	91.7	82.6-94.8	7
Crescent Mt.	Yrlg.	-		-
	Lamb	-		-
Nov. 13, 1970	All	93.2	88.4-95.9	9
Crescent Mt.	Adult	94.7	93.0-95.9	6
	Yrlg.	-		-
	Lamb	90.1	88.4-92.0	3
Jan. 14, 1971	All	88.7	83.9-93.4	6
Crescent Mt.	Adult	88.7	83.9-93.4	2
	Yrlg.	90.0	88.1-91.4	2
	Lamb	87.3	85.3-89.3	2
Feb. 26, 1971	All	87.4	81.3-91.9	10
Crescent Mt.	Adult	88.2	81.3-91.9	7
	Yrlg.	85.6	83.2-89.0	3
	Lamb	-		-
Mar. 18, 1971	All	77.3	53.2-93.6	11
Crescent Mt.	Adult	83.6	64.8-93.6	7
	Yrlg.	76.6	71.6-81.6	2
	Lamb	56.5	53.2-59.8	2
Apr. 27, 1971	All	44.9	14.6-71.2	10
Crescent Mt.	Adult	56.2	42.4-71.2	5
	Yrlg.	33.0	28.4-37.5	2
	Lamb	34.1	14.6-62.0	3
Apr. 28, 1970	All	26.4	5.8-35.6	5
Surprise Mt.	Adult	19.3	5.8-32.8	2
	Yrlg.	31.1	26.0-35.6	3
Mar. 18, 1971 From Cooper Landing-Broken leg	MM Lamb	6.1	6.1	1
May-June, 1971 Pickups from Cooper Landing dead	Adult	6.6	5.5-7.7	3

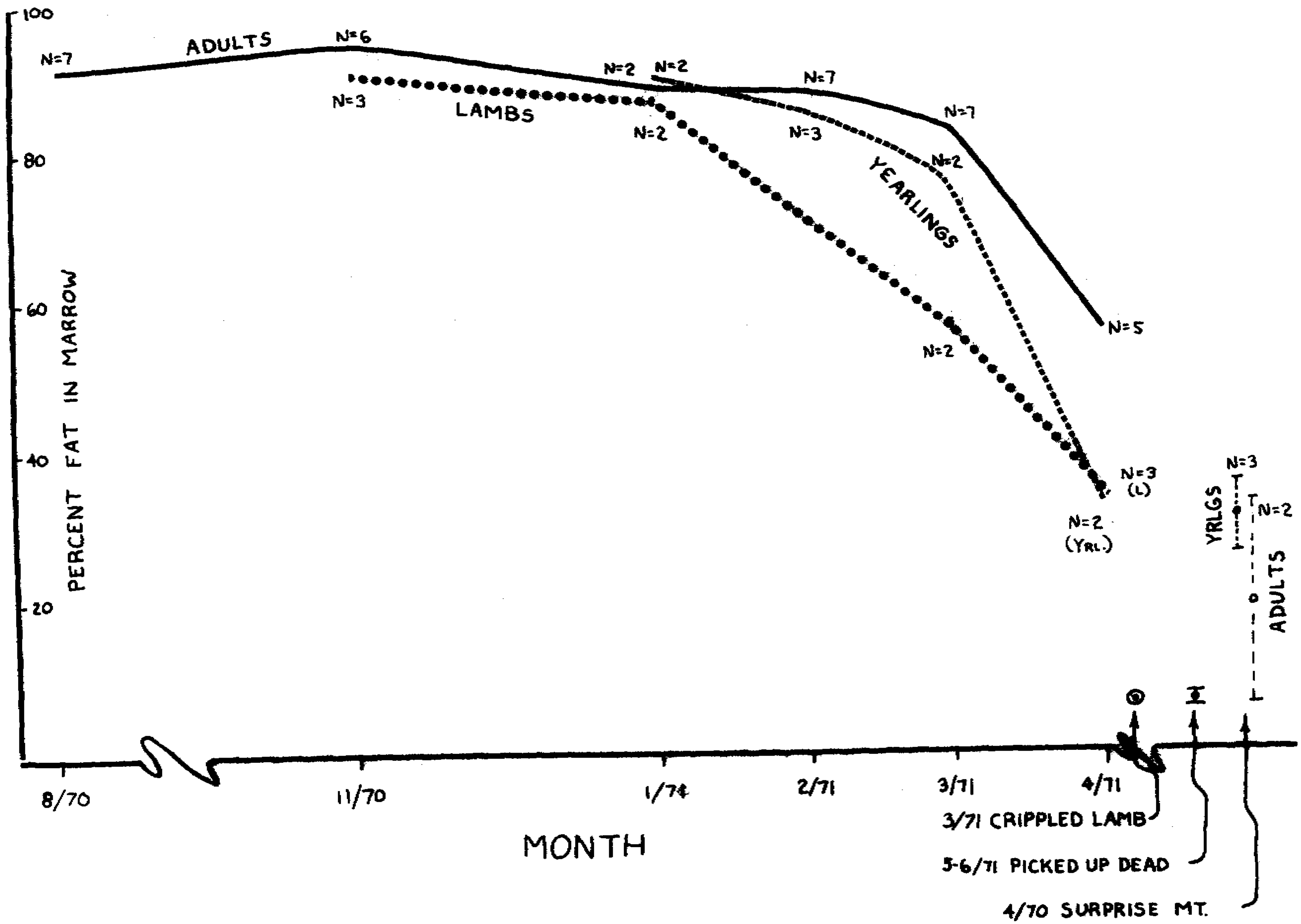


Figure 4. Bone Marrow Fat by Average Percent of Dry Weight, Date and Age Category.

contract. A copy of Dr. Hansen's final report is attached (Appendix II). It was submitted in two parts: one covering winter range survey results and analyses of rumen samples, and one comparing paired rumen-fecal samples. The methods used are described in the report. Briefly, they are based upon microscopic identification by cuticle cell structure and quantification by numbers of recognized fragments of each plant species observed. Digestibility studies were also conducted and reported upon.

Results of the rumen/fecal sample analyses by area, date, sex (when sufficient samples from each were available) and by the major species encountered are summarized in Table 3. Included in this summary for the most part are only those species making up over two percent of the sample dry weight.

Examination of the analyses shows that relatively few plant species make up the majority of the sheep's diet in this area. HIAL (*Hierochloe alpina*), a bunchgrass, was obviously the most important species used throughout the seasons sampled. CARE (*Carex* spp.) was more abundant on Crescent Mountain than HIAL in August, 1971 (see Table 10) and made up a larger portion of the diet in both August 1970 and 1971 samples. It was replaced in quantity consumed by FEBR (*Festuca brachyphylla*) in November despite the relative scarcity of that species. Use of both species was overshadowed throughout the rest of the winter by HIAL. SALI (*Salix* spp.), the second most abundant species on Crescent Mountain in August, was used lightly during summer and early winter, with little or no use indicated in the January and February samples, then light use resumed in March and April. HIAL, CARE and SALI rank about equal in digestibility. FEBR ranked somewhat lower in the tests conducted. (Digestibility studies used cattle as subjects. The various species of forage plants might be digested at different rates by Dall sheep.)

DROC (*Dryas octapetala*) was not found in significant quantity in the summer or early winter diets despite the fact it was the most abundant species present. Use increased to a moderate level during late winter, however. It ranked with HIAL in digestibility. Use of CLAD (*Cladonia* spp.) was low in summer and early winter, but increased toward late winter, especially by the male segment, in which it replaced HIAL as the major component of the samples examined. This change in late winter diet by rams is surprising since HIAL must have remained relatively abundant and available, judging from its use by ewes at the same season, and since CLAD ranks so low in digestibility. Chernyavskii (1967) in discussing the food habits of the snow sheep (*Ovis nivicola*) which inhabits a similar latitudinal zone to the Dall sheep, stated that the major winter foods were grasses, sedges and willows, but he also noted that lichen was important in winter, presumably due to its availability.

HIAL was also the major species found in the April, 1970 Surprise Mountain samples, and in the August, 1971 Slaughter Mountain (Cooper Landing Closed Area) samples. It ranked second by a slight margin to SALI in the June samples from Slaughter Mountain. Willow might be more palatable in early summer than in late summer if the shift in use is indicative.

Table 3. Major foods eaten by Dall sheep by percent dry weight in rumen and/or fecal samples.[1/]

Area	Date & Sex		Type Sample	Species	% D.W.	Date & Sex		Type Sample	Species	% D.W.
Crescent Mt.	8/70	FF	Rumen	CARE	53.8	8/71	Mixed	Fecal	CARE	53.6
				HIAL	23.0				HIAL	30.1
				CLAD	8.5				CLAD	4.9
				SALI	7.4				FEBR	4.9
				FEBR	4.5				SALI	3.3
	8/70	MM	Rumen	CARE	54.1					
				HIAL	23.9					
				FEBR	8.2					
				CLAD	4.0					
				UNKL	2.2					
				CALA	2.1					
	11/70	Mixed	Rumen	FEBR	46.1					
				HIAL	22.0					
				CLAD	10.1					
				SALI	7.3					
				BERI	5.1					
				CALA	3.2					
				CARE	3.2					
	1/70	Mixed	Rumen	HIAL	29.1					
				CLAD	18.0					
				CARE	14.8					
				SEED	12.2					
				DROC	10.2					
				FEBR	9.7					
				COM 1	2.5					

1/ From appended report by R. M. Hansen, species names listed in report.

Table 3. (cont'd.) Major foods eaten by Dall sheep by percent dry weight in rumen and/or fecal samples.[1/]

Area	Date & Sex		Type Sample	Species	% D.W.	Date & Sex		Type Sample	Species	% D.W.
Crescent Mt.	2/71	Mixed	Rumen	HIAL	42.4	2/71	Mixed	Fecal	HIAL	52.0
				CLAD	26.3				CLAD	25.9
				CARE	13.4				CARE	8.0
				DROC	4.5				DROC	5.2
				FEBR	4.4				MOSS	4.2
				MOSS	3.3				VAVI	2.5
				VAVI	2.0				FEBR	1.2
	3/71	FF	Rumen	HIAL	41.2	3/71	FF	Fecal	HIAL	54.4
				CLAD	30.5				MOSS	16.9
				CARE	9.7				CARE	11.9
				DROC	5.8				CLAD	9.4
				MOSS	5.8				DROC	2.6
				FEBR	4.0				VAVI	2.2
	3/71	MM	Rumen	HIAL	43.7	3/71	MM	Fecal	HIAL	44.3
				CLAD	21.4				CLAD	15.9
				FEBR	10.4				DROC	12.0
				CARE	8.8				MOSS	10.5
				DROC	5.0				CARE	9.3
				SEED	4.2				SALI	4.1
				MOSS	3.1				FEBR	1.2
				SALI	2.7					
	4/71	FF	Rumen	HIAL	55.0	4/71	FF	Fecal	HIAL	57.9
				CLAD	10.5				CLAD	15.3
				FEBR	14.0				COM 1	8.7
				BER 1	7.2				BER 1	3.9
				SALI	3.5				CARE	3.7
				CARE	2.7				MOSS	2.7
				MOSS	2.0				FEBR	2.3
									SALI	2.0

1/ From appended report by R. M. Hansen, species names listed in report.

Table 3. (cont'd.) Major foods eaten by Dall sheep by percent dry weight in rumen and/or fecal samples.[1/]

Area	Date & Sex	Type Sample	Species	% D.W.	Date & Sex	Type Sample	Species	% D.W.
Crescent Mt.	4/71 MM	Rumen	CLAD	32.3	4/71 MM	Fecal	CLAD	61.6
			HIAL	25.1			HIAL	19.9
			DROC	13.0			MOSS	8.1
			FEBR	8.1			BERI	2.9
			BERI	5.8			VAVI	2.1
			MOSS	5.7			COM 1	2.0
			SEED	4.4			CARE	1.2
			TRSP	2.2				
			CARE	1.7				
Surprise Mt.	4/70 Mixed	Rumen	HIAL	33.2				
			EMNI	24.9				
			CLAD	17.4				
			VAVI	8.7				
			MOSS	4.5				
			DRIN	4.2				
			SALI	3.3				
			CARE	2.1				
Slaughter Mt.	6/71	Fecal	SALI	40.1	8/71	Fecal	HIAL	50.2
			HIAL	38.8			MOSS	14.7
			CARE	9.3			SALI	8.8
			VAVI	3.5			CARE	8.5
			DRIN	2.5			CLAD	5.0
			CLAD	2.3			DRIN	4.4
							POAS	2.1

1/ From appended report by R. M. Hansen, species names listed in report.

Judging from the foregoing data, *Hierochloe* should be considered the primary "key" species for Dall sheep in this area and so should be useful along with *Carex* and *Festuca*, as an indicator of range use and condition.

The method of fecal analysis to determine food habits as used by Hansen shows promise as a relatively inexpensive and accurate technique. No killing of animals is required, and samples can be obtained easily at all seasons and from different localities. In discussing the variability between some of the paired rumen and fecal samples examined, Dr. Hansen mentioned in his report the possibility of time lag between those recently ingested species in the rumen and older species in the intestine as contributing to variability. This would supposedly allow the sheep to feed on one set of plants at one time and another set at a later time, thus having different compositions at either end of the digestive tract. While this is probably a valid possibility, I believe that inadequate mixing and sampling of rumen contents might be just as important in causing variation. In the future, the entire rumen contents should be removed, well mixed and then sampled. It is possible that much less variation would be found between paired samples which would help validate fecal sampling alone, as an accurate method of determining diets.

The bighorn sheep (*Ovis canadensis*) has two complete feeding cycles each day during the winter (Blood, 1963). Heaviest feeding is at dawn, noon and late afternoon, with periods of rumination between. Our observations during November and December showed peak feeding activity of Dall sheep to be at and just after dawn and again in the afternoon just before and after sunset. During the middle of the day, most sheep were seen to be resting, though some were up at all times. The general pattern of movement each day of reasonably good weather was to feed and move upward in the morning, then back down into the cliffs and gulches in the evening. On days of strong wind and blowing snow, the sheep remained low on the slopes and in the gulches, sometimes moving into the alder zone to feed.

Sheep experienced little difficulty in reaching feed through the snow in November and December on Slaughter Mountain; they were able to paw feeding craters in the soft snow readily, with only the depth limiting them. This was also true on Surprise Mountain until mid-December, by which time wind had hardened the crust over much of the plateau. There were still adequate areas of shallow, soft snow, however, and sheep were feeding in pawed-out craters rather than being restricted to the open, windblown ridges to which they are limited later in the winter (Plates 3 and 4). As long as they are able to do so, they seem to prefer digging for their feed, presumably because forage is more abundant and of better quality where it is protected from dessication and wind-scouring by snow cover. In addition, the exposed soil on the windblown ridges is probably shallower and less able to produce good quality forage. Much of the snow-covered forage was still somewhat green and succulent compared to the dry, brown plants on the open ridges.

In digging feeding craters, sheep would paw snow to the side and rear with either front foot; no preference for right- or left-handed digging could be detected. When a crater was dug, the animal would feed at length in it, enlarging it as it slowly fed forward. Older ewes would often shoulder younger ones and occasionally lambs aside and take over their craters. Rams often shoved ewes aside. Smaller or less dominant animals were thus forced to dig more craters of their own than were more dominant animals. Several fights between ewes were observed, possibly over possession of feeding craters.

Although a number of fresh craters were examined, it was difficult to tell what plants were being fed upon and which were merely broken off and dropped or fractured by the pawing. In both areas, the bunchgrass, *Hierochloe* was the one species obviously heavily used. On Surprise Mountain, *Empetrum nigrum* (EMNI) was observed to have been stripped of leaves and berries in a number of craters.

On Slaughter Mountain, sheep were seen to use what was believed to be a mineral lick during the November-December observations. The lick consisted of three holes in the frozen ground, each about a foot in diameter and all within a radius of some 10 feet. The lick was used daily by all classes of sheep except lambs up until December 3. When the observer returned on December 14 from a short trip away from the area, the lick was found to be drifted in with snow. No tracks were seen around it nor was any more use observed. While in use, sheep would lick at the ground extensively and jostle for space at the holes. The lick could not be reached for close examination. It may or may not have been a true mineral lick. In 1970, sheep in the area were observed to behave similarly toward what was found to be an eaten-out hole which exposed the underground parts of several false hellebore (*Veratrum viride*) plants. The exposed corms, though frozen solidly into the ground, were licked and scraped avidly.

Snow depth was measured around two sets of feeding craters and was found to average about 4.6 inches along the deepest, uphill edges of the first set, and 7.2 inches along the second. The maximum depth found to have been dug through was 10 inches. In hardness, the snow along the first set measured a resistance of 6.5 lbs/cm^2 and that along the second 5.8 lbs/cm^2.

Productivity

Behavioral interactions between sheep as described by Geist (1968) and as noted in the November-December, 1970 observational periods were described in the previous progress report. For simplification in describing the rut, these were lumped into four general categories in 1971. "Nonbreeding" interactions included all those except fighting not directly related to breeding season activities. "Checking" interactions were those used by rams in approaching or examining other sheep for receptivity to breeding. They were generally directed at ewes, presumably to determine their state of estrus, but were occasionally directed at other rams, probably due to error in sex recognition until close approach. "Formal fighting" interactions were those involving dominance establishment and also were not directly related to breeding.

"Breeding" interactions were those directly related to breeding and which could be used by the observer in determining the presence of ewes in or near estrus. These were further broken down to show "Copulation" (Mc), "Chase" (Ch) and "Guard" (G); the three primary interactions conducted toward estrus females. Although there was some overlap in categorizing interactions, most could be interpreted with reasonable assurance by noting the circumstances.

Rams of all classes up to Class VII were present in the closed area. No rams of 3/4-curl or larger were seen on Surprise Mountain. Thus, the ram situation was similar to that in 1970. However, rams with horns of just under 3/4-curl were listed as Class V rams on Surprise Mountain this year to differentiate them from smaller 1/2-curl Class IV rams. No distinction was made in 1970 and all were listed as Class IV in the previous progress report.

Checking and breeding interactions on both Cooper Landing Closed Area and Surprise Mountain, by their percentage of all observed interactions and by period of observation, are plotted in Figs. 5 and 6. It can be seen that in the closed area, checking made up most of the interactions noted. Some breeding interactions were recorded right from the beginning of the observational period, but their frequency increased markedly during the November 26-30 period and decreased slightly during the December 1-5 period. Breeding interactions as a percent of all interactions remained fairly high during the next two five-day periods. However, all interactions decreased markedly during the December 6-10 and 11-15 periods; thus, the relatively high percentage of breeding actions would actually reflect fewer interactions than during the preceding periods. The gross number of recorded interactions was partially a result of fewer days of observation, but was largely due to less interactions being seen per day. It was noted that by December 1, the pace of activity had slowed somewhat, with less intergroup movement by rams. By December 7, activity was markedly less and some sexual segregation had commenced. No observations were made from December 9 to 13, but only 15 interactions were noted altogether from the 14th through the 16th. Thus, it appears that the rut in Cooper Landing Closed Area began largely during the period of November 26-30, 1971, with some breeding beforehand, and was mostly over by about December 10. This compares closely with the chronology observed in 1970, when most rutting activity was carried out from the November 21-25 period to the December 11-15 period.

The situation on Surprise Mountain is much less clear. Most of the problem resulted from extremely poor weather on that mountain during the field study which made it impossible to obtain sufficient data. Although 21 days were spent in camp, only seven full and four partial days could be used for observing sheep. This compares with 16 full and six partial days of observation on the closed area. Only two interactions were observed on Surprise Mountain after December 6, 1971. Both of these were fleeting glimpses in heavy fog of rams apparently guarding ewes.

Figure 5. COOPER LANDING CLOSED AREA.

Significant Interactions by Percentage of all Interactions Recorded and Period of Observation.

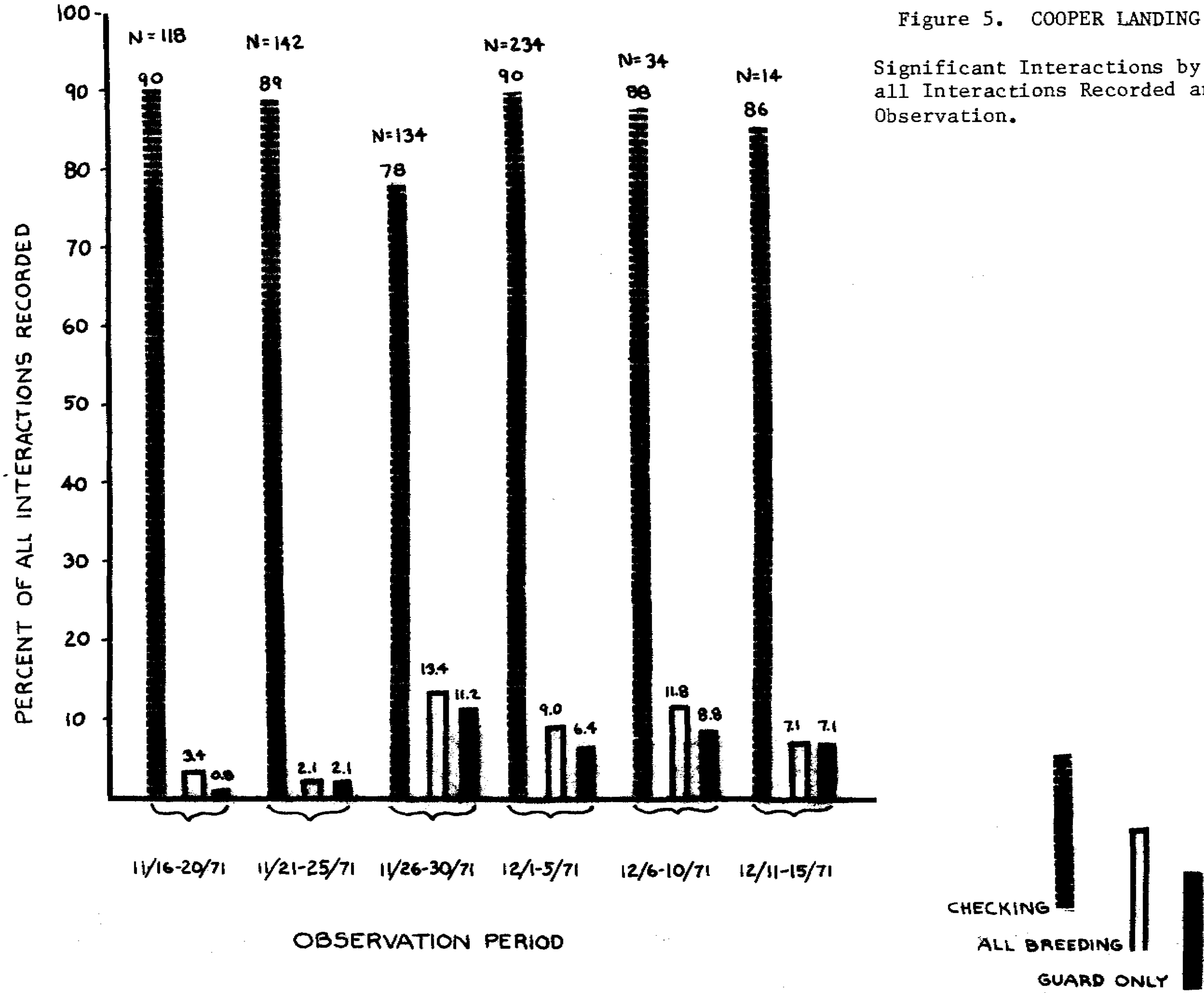


Figure 6. SURPRISE MT.

Significant Interactions by Percentage of all Interactions Recorded and Period of Observation.

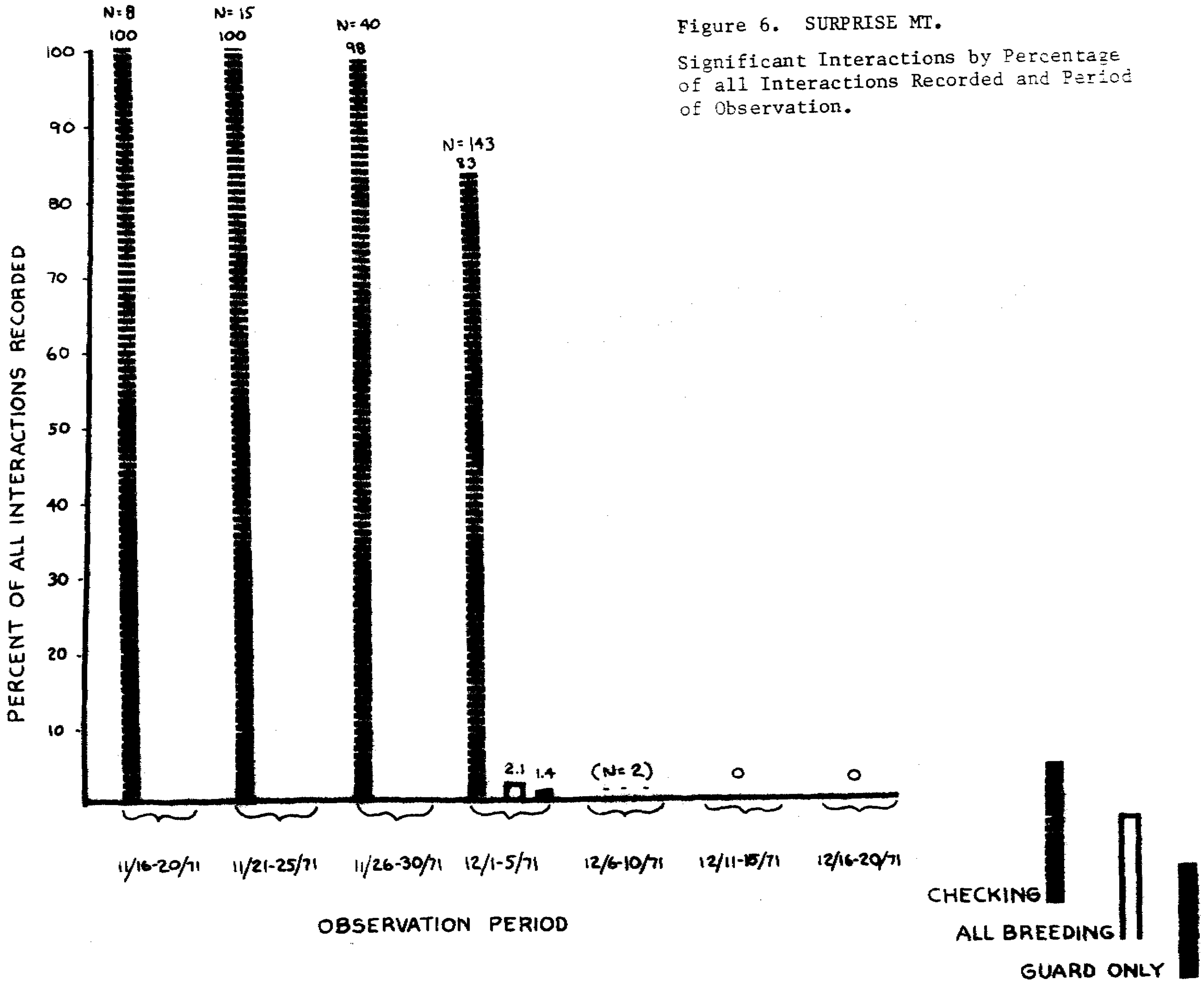


Fig. 6 is useful to some extent despite the lack of later data. It can be seen that of those interactions recorded, no breeding interactions were observed before the December 1-5 period. The small number of checking interactions recorded before November 26 was corroborated by the general observation that there was little intergroup movement by rams prior to that period, and that most rams seen spent most of their time feeding rather than checking ewes. Activity was noted to increase during the November 26-30 period with much more movement and checking by rams. Although the evidence is weak, it thus appears that the rut proper did not commence until at least the December 1-5 period and possibly later. Data on breeding chronology on Surprise Mountain were also weak during 1970 but the distribution of lambing in the spring of 1971 (Fig. 10) indicated that the peak of breeding was probably similar to that in Cooper Landing Closed Area.

Ewe-checking interactions observed on both areas listed by the class of ram initiating the interaction and the class of sheep being acted upon are shown in Table 4. The largest proportion of checking in the closed area was done by Class VI (full-curl) rams, but Class V and IV (3/4 and 1/2 curl) rams were quite active also. Class III rams, which would include mostly 18-month-old animals, participated very little.

By far the largest portion of the checking was directed toward adult ewes (IIIf) as would be expected. Yearling (18-month-old) females (IIf) made up the second largest class checked, though a much lower proportion than adult ewes. This lesser amount of checking may be related to the fewer numbers of yearling females present rather than to lack of interest in them by rams. Yearling males, lambs and occasionally larger males were also checked, probably because of mistaken sex-age identification by the checking ram.

On Surprise Mountain, since no larger rams were present, the greatest amount of checking was done by sub-class V and Class IV rams. Class III yearling rams participated proportionally more than they did in the closed area, while only one Class II (probably a small yearling) ram was seen to check ewes, and that only when no other rams were in the vicinity. Almost all checking was directed at adult ewes. Very few IIf or IIIm animals were seen, reflecting the poor lambing success in 1970.

All observed breeding interactions by class initiating and class being acted upon in both areas are listed in Table 5. If group actions are ignored, it can be seen that full-curl and larger rams conducted most of the actual breeding interactions on the closed area. Class V and IV rams appeared to be active breeders also, but no participation by Class III or smaller rams was observed.

The apparent participation in guarding (G) of estrus females by Class IV and V rams may be somewhat biased by the observer's inability to differentiate between true guarding of estrus ewes and false guarding of anestrus ewes. In several of the instances listed, Class IV or V rams were seen to exhibit guard behavior toward ewes which were ignored by

Table 4. Ewe-checking interactions by class of ram initiating action and class of sheep being acted upon, 1971.

COOPER LANDING CLOSED AREA

Ram Class	No. Observed Interactions By Ram Class	% Observed Interactions By Ram Class	Sheep Class Acted Upon	No. Observed Interactions Upon Class	% Observed Interactions Upon Class
III	5	1%	I MM	1	20%
			III FF	4	80%
IV	132	22%	II MM	1	1%
			II FF	16	12%
			III MM	3	2%
			III FF	109	83%
			V MM	1	1%
V	173	29%	I FF	1	1%
			II MM	5	3%
			II FF	11	6%
			III MM	3	2%
			III FF	153	88%
VI	244	42%	I MM	1	<1%
			1 FF	1	<1%
			II MM	2	1%
			II FF	21	9%
			III MM	8	3%
			III FF	206	84%
			IV MM	4	2%
			V MM	1	<1%
VII	35	6%	I FF	1	3%
			II FF	1	3%
			III MM	3	9%
			III FF	30	85%
	N = 589	100%			

SURPRISE MOUNTAIN

Ram Class	No. Observed Interactions By Ram Class	% Observed Interactions By Ram Class	Sheep Class Acted Upon	No. Observed Interactions Upon Class	% Observed Interactions Upon Class
II	3	2%	III FF	3	100%
III	10	6%	III FF	10	100%
IV	93	51%	II MM	1	1%
			III FF	91	98%
			IV MM	1	1%
V	75	41%	III FF	75	100%
	N = 181	100%			

Table 5. Breeding interactions by class of ram initiating action and class of sheep being acted upon, 1971.

COOPER LANDING CLOSED AREA

Ram Class Initiating	No. Observed Breeding Interaction	% Observed Interactions by Ram Class	Specific Inter-action	Sheep Class Acted Upon	*No. Observed Interactions Upon Class
IV	8	15%	Mc	III FF	3
			Ch	III FF	3
			G	III FF	5
V	6	12%	Mc	III FF	2
			Ch	-	-
			G	III FF	6
VI	18	35%	Mc	III FF	7
			Ch	III FF	2
			G	II FF	1
				III FF	16
VII	8	15%	Mc	III FF	4
			Ch	III FF	1
			G	II FF	1
				III FF	7
Group	12	23%	Mc	III FF	3
			Ch	III FF	11
			**G	III FF	3
	52	100%			

* Observed "breeding interaction" may include more than one "specific interaction".
** Guarding by group usually deteriorated to guarding by largest ram present.

SURPRISE MOUNTAIN

Ram Class Initiating	No. Observed Breeding Interaction	% Observed Interactions by Ram Class	Specific Inter-action	Sheep Class Acted Upon	*No. Observed Interactions Upon Class
IV	3	60%	Mc	III FF	1
			G	III FF	3
V	1	20%	G	III FF	1
Group	1	20%	Ch	III FF	1
	5	100%			

nearby larger rams, an unexpected situation if the female was really in estrus. Thus, 3/4-curl and smaller rams may actually be less involved in breeding than was indicated, especially where guarding behavior is involved.

Almost all breeding activity was directed toward adult ewes. However, the observation that two yearling Class II ewes were actively guarded by large rams indicates breeding involvement of this class also.

On Surpise Mountain, so few breeding interactions were observed that little can be deduced from the table other than that no yearling rams or ewes were seen to participate.

In comparing checking and breeding behavior by rams between Surprise Mountain and Cooper Landing Closed Area, several differences were detected. The lack of 3/4-curl and larger rams obviously put the entire breeding load on smaller rams on Surprise Mountain. Yearling rams participated somewhat more in checking (but not breeding) activities on the latter area. It is possible they also were involved in unseen breeding.

Checking by Class IV and V rams on both the closed area and Surprise Mountain appeared to be less efficient than that by larger rams in that it forced the expenditure of more energy by both rams and ewes. These younger rams would often harrass ewes repeatedly, nudging and kicking at them and forcing them to move again and again. This direct expenditure of energy by excess movement of both sexes appeared unnecessary and wasteful. Ewes so checked were often forced to dig additional feeding craters in the snow, having been forced to move from those they were feeding in.

The full-curl rams, by way of contrast, would usually approach ewes more purposefully and steadily without the sudden rushes of the younger rams, check them and move on. They seemed able to recognize estrus state more readily and did not waste their own or the ewe's energy in repetitious checking. In the closed area, the younger rams did a smaller proportion of the checking due to the presence and activity of larger males, while on Surprise Mountain all checking was done by young rams. Thus, harrassment of ewes and unnecessary energy loss by both sexes was probably greater there.

One interaction seen frequently in the closed area during the beginning of the rut was the group chase of a ewe as described in the past progress report. During these chases, which presumably occurred as the ewe entered estrus, she was commonly seen to be copulated with not the full-curl ram(s) involved, but by the quicker, more nimble 1/2- or 3/4-curl rams participating. The larger rams were usually left behind during the pell-mell scramble through the cliffs, while the younger rams were able to keep up with and copulate with the ewe. When the chase slowed, the larger ram (one was usually present) would catch up, drive away the smaller ones and begin to guard the ewe alone. Only one chase of a ewe by two Class IV rams was briefly seen on Surprise Mountain. Since it is possible that the actual onset of the rut was missed there due to bad weather, more such chases could have occurred.

An interesting interaction observed only on Surprise Mountain was the herding of ewes by both Class IV and sub-class V rams. In each case, the ram singled out a ewe and vigorously attempted to either keep her in a particular group or away from a group. The ewe attempted to go her own way just as vigorously resulting in a violent display of dodging and herding reminiscent of a rodeo cutting horse contest. The ram would attempt to keep himself between the ewe and wherever she wanted to go by twisting and turning, while the ewe would do her best to dodge around him. During the display, the ram unhesitatingly butted the ewe on the rump or flank whenever the opportunity presented itself. At intervals, the ewe might seem to give up and begin to feed or lie down, whereupon the ram would remain stiffly watching her until she again attempted to get around him. In each of the cases observed, the ewe eventually managed to outmaneuver the guarding ram and run off.

None of these ewes appeared to be in or near estrus, nor did the ram act as if they were. This behavior resulted in considerable expenditure of energy on both parts and seemed to accomplish nothing toward reproduction. Nothing resembling this was seen on the closed area. Welles and Welles (1961) described a somewhat similar interaction for the desert bighorn (*Ovis canadensis nelsoni*), but in that case it was directly involved in breeding. Geist (1971b) also described it for the Stone sheep (*O. dalli stonei*) but said that it was seen to be done only by younger rams in the absence of full-curl rams and to anestrus ewes.

Guarding behavior was noticeably different on the two areas. Full-curl rams in Cooper Landing Closed Area seemed to develop a strong tending bond toward the estrus ewe they guarded, remaining with her apparently until the end of her estrus period and, as much as possible, defending her from smaller rams. Guarding behavior was observed by the younger rams on Surprise Mountain but it seemed much weaker and more confused. Rams guarded obviously anestrus ewes for periods of varying length. They guarded apparently estrus ewes for short periods, and defended them from any smaller rams present, but invariably left them for other ewes. Apparently the instinct to guard was there, but it was not strong enough in these young rams to hold them for more than an hour or two at most. Possibly the relative abundance of other ewes distracted them.

It was noted that competition from other rams stimulated ewe-checking or mounting by the "resident" ram(s). On Surprise Mountain, a ram might have joined a group of ewes, checked several of them, then begun feeding. The approach of another ram would often stimulate a dominance display followed by a flurry of vigorous ewe-checking. On the closed area, where guarding and copulating were more easily identified, the approach or interference by another ram would stimulate the guarding ram to mount the ewe one or more times. On Surprise Mountain, where competing rams were relatively much fewer, lack of such stimulation may have influenced the strength of the bond between guarding ram and estrus ewe.

The most difficult interaction to determine was actual copulation since the mount (M) is often used in a nonbreeding sense, and even when apparently used for copulation, it may be of such short duration that it was often not possible to tell whether actual intromission and ejaculation were accomplished. This was especially true at a distance where pelvic motion could not be seen.

Several apparent copulations were timed on Surprise Mountain and were found to last two seconds or less by stop watch. Rapidity of copulation by the bighorn ram (*Ovis canadensis canadensis*), the Stone ram, the desert bighorn ram, the feral Soay ram (*O. aries*) and domestic ram (*O. aries*) is mentioned by other investigators (Geist, 1971b; Wishart, 1958; Welles and Welles, 1961; Grubb and Jewell, 1966; Fraser, 1968).

The point is of less importance in interpreting rutting behavior in Cooper Landing Closed Area, where other specific interactions such as chase and guard enabled the observer to detect the presence of ewes in estrus, than on Surprise Mountain where these indicators of active breeding were absent or unclear. A ewe in or near estrus in the closed area was invariably guarded by a large ram or was being interacted with by several rams. Whether or not the observer saw actual copulation was of no great importance in determining her condition. On Surprise Mountain, guarding behavior was indefinite and early-estrus gathering of rams about a ewe was not observed. Mounts were seen frequently, but it was very difficult to ascertain whether a mount, accomplished with little or no preliminary indication of the female's receptivity, was merely a dominance display or an actual copulation.

No conclusions can be drawn at this time regarding the significance of the observed differences in breeding behavior between the herd with a "normal" distribution of large rams (Cooper Landing Closed Area) and that with no large rams (Surprise Mountain). However, I believe it would be valuable to bring out several points which should be considered when interpreting future data.

Geist (1971a, 1971b) believes that when the breeding load is forced on the younger segment of a ram population in the absence of large rams, increased winter mortality may result. This is because of excessive energy loss by inefficient young rams to both themselves and to over-harassed ewes, which results in poorer body condition when entering the severe part of winter. Such a possibility should be considered in the case of Surprise Mountain even though no evidence is presently available which would indicate it is occurring.

Scarcity of rams, alone, may result in lessened breeding success. With the female part of the population broken up into many small groups, wide circulation by rams seeking receptive ewes appears to be the rule. Fewer rams would result in less coverage and might mean that some estrus ewes would be missed. It has been found in domestic sheep that the estrus drive in ewes varies. When insufficient rams are present, the females which exhibit the strongest drive are those which are successful breeders, claiming the most attention from rams. Weakly estrus ewes, particularly those coming into estrus for the first time, are less likely to be bred (Fraser, 1968; Grubb and Jewell, 1966).

Another factor related to numbers of rams present which may affect breeding success is the increased breeding activity due to ram competition seen in both herds. Geist (1971a) also noted this in his bighorn/Stone sheep studies. In domestic sheep, guarding rams exhibited a decrease in sexual vigor the longer they remained with a given ewe due to the decreasing value of her sexual stimulation to him. The introduction of another ewe in estrus would increase the ram's libido promptly (Fraser, 1968; Grubb and Jewell, 1966). Competition by other rams may be important in maintaining libido by a guarding ram.

Although weak, the available data do suggest that the rut may have commenced later in 1971 on Surprise Mountain than in the closed area. This was not apparent in 1970 nor did there seem to be any difference in the peak of lambing in the spring of 1971. Lambing observations in the spring of 1972 should show whether the rut on Surprise Mountain was actually later than in the other area. A greater spread in lambing was noted in 1971 in the Surprise Mountain herd, however, which could reflect a spread in breeding. Such a spread in parturition may affect lamb survival. It has been found in domestic sheep that the presence of rams affects the time of onset and synchronization of estrus in females (Fraser, 1968; Radford and Watson, 1957; Watson and Radford, 1960). It is not known whether numbers of rams or ages present may also have an effect on timing and synchronization of estrus.

Although large rams were present in ample numbers in the closed area, they were not necessarily the most efficient breeders when ewes were in early estrus, especially during the beginning and most active period of the rut. Young 1/2- and 3/4-curl rams seemed to be at least as effective in copulating with ewes during the chases as were the full-curl rams present. In fact, they usually appeared much more so. If fertilization occurred during these early-estrus chases, natural selection would favor the smaller-horned and quicker rams. There would be no evolutionary benefit in growing large horns and using them to establish dominance. Since selection has obviously favored large horns, these older rams must be more efficient in conceiving progeny than would appear to be the case. Therefore, more conceptions probably occur later in the females' estrus period when these rams are copulating more exclusively with them during the guarding time.

Ovulation occurs toward the end of the heat period in domestic ewes (Asdell, 1964; Winters and Feuffel, 1936). If this is similarly true in Dall ewes, it would explain the probable increase in late-estrus conceptions by large-horned, guarding rams.

If the above assumptions are valid, it follows that a reduced pregnancy rate should occur if most ewes are not copulated with during the latter part of their estrus period when ovulation occurs. The greater the gap between breeding and ovulation, the less numerous and viable the sperm should be. A weak tending bond and short guarding period, such as seemed to be the case on Surprise Mountain, could, therefore, result in a reduced pregnancy rate. This relationship is admittedly speculation at present, but should it be proven true, it could be an important effect resulting from the removal of a large proportion of mature rams from a population.

Before any of the above speculations can be shown to be other than of academic interest, further winter collections of female sheep must be undertaken to compare pregnancy rates on Surprise Mountain and Cooper Landing Closed Area. A reduced pregnancy rate, or large spread in fetal size, would show the need for additional study to determine the cause. The high pregnancy rate in the specimens taken from Crescent Mountain during the winter of 1970-71 certainly raises a question about the validity of that line of thought. There were few rams larger than 3/4-curl present on that mountain during the 1970 breeding season.

Each pair of ovaries, preserved in formalin, was sectioned by parallel slices approximately 1-mm apart as described by Cheatum (1949). Under low-power magnification, ovarian bodies and scars were identified as much as possible and listed. Corpora lutea of pregnancy (CL) were obvious and easily identified. A fetus or embryo was found in the uterus of each specimen containing an identified corpus luteum. All specimens containing identified corpora lutea and fetuses were taken after the rutting season.

Degenerating corpora lutea from the previous pregnancy were identified in some specimens taken prior to the 1970 rutting season as well as in a few taken after breeding. Cheatum (1949) and Golley (1957), working with deer, felt that degenerating corpora lutea of pregnancy (DCL) could be identified with reasonable accuracy up to eight months after parturition. Gibson (1957), also studying deer, was able to recognize scars of degenerating corpora lutea 18 months after parturition. These bodies were easily recognized in the Dall sheep specimens examined five months after assumed parturition, but appeared to deteriorate rapidly with the formation of the new corpus luteum, following impregnation. Only three were identified in ovaries taken after the breeding season, and two of these were questionable. All three were associated with indications of previous lactation, which gave some credence to their identification. Typical corpora lutea and degenerating corpora lutea from the present collection are illustrated in Plates 5 and 6.

Other pigmented scars were counted but could not be identified. The developing corpora lutea of the current pregnancies grew so large in relation to the size of the ovaries that they seemed to crush all other ovarian bodies into small, shapeless, brownish scars which could not be identified by gross examination. There did not appear to be a relationship between the number of these scars found and the age of the ewe. Therefore, the value of using their presence as a numerical indicator of past reproductive history is doubtful.

Pertinent reproductive data obtained from all ewes over one year of age collected on Crescent Mountain are listed in Table 6. Reproductive tracts of all female lambs were examined, but contained no indications of previous or current ovarian activity; uteri of all were much reduced in size.

Of the seven ewes taken prior to the breeding season, five contained degenerating corpora lutea in their ovaries indicating pregnancy the

Table 6. Reproductive data from ewes over one-year old taken on Crescent Mountain, 1970-71.

Date Collected	Access. Number	Age[1] Yrs.Mos.	State of Lactation	Ovarian Bodies CL[2]	DCL[3]	Sex	Fetus Weight Grams	Length mm	Notes
8/11/70	62062	4 + 2	Lact.	-	-	-	-	-	With yrlg. male - no lamb
11/13/70	62082	2 + 5	-	-	-	-	-	-	No previous ovarian scars
"	62081	2 + 5	-	-	1	-	-	-	
"	62078	3 + 5	Lact.	-	1	-	-	-	
"	62076	6 + 5	Lact.	-	1	-	-	-	
"	62075	7 + 5	Lact.	1?	1	-	-	-	New CL or ?
"	62079	8 + 5	-	-	1	-	-	-	
1/14/71	62088	3 + 7	-	1	-	MM	3.7	65	
"	62090	6 + 7	-	1	-	MM	5.5	80	
"	62092	8 + 7	Post Lact.	1	1	?	0.05	<2	2 corpora lutea of estrus
2/26/71	62095	1 + 9	-	1	-	MM	240.0	264	No previous ovarian scars
"	62097	1 + 9	-	1	-	FF	70.5	161	No previous ovarian scars
"	62100	2 + 9	-	1	-	FF	324.8	285	
"	62110	5 + 9	-	1	-	FF	296.5	278	
"	62105	6 + 9	-	1	-	FF	511.0	326	
"	62099	9 + 9	-	1	-	FF	136.0	210	
"	62089	13 + 9	Post Lact.	1	1?	MM	6.5	83	Indefinite DCL
3/18/71	62102	1 + 9	-	-	-	-			No ovarian scars
"	62107	1 + 9	-	1	-	MM	621.0	354	No ovarian scars
"	62108	3 + 9	-	1	-	MM	836.0	377	
"	62112	5 + 9	Post Lact?	1	1?	MM	1156.0	440	
"	62098	7 +	-	1	-	FF	921.5	406	
"	62093	9 + 9	-	1	-	MM	631.5	372	
"	62084	10 + 9	-	1	-	FF	679.0	355	
4/27/71	62119	4 + 11	-	1	-	FF	2940.0	596	
"	62125	4 + 11	-	-	-	MM	2370.0	567	One ovary missing
"	62113	5 + 11	-	1	-	MM	2760.0	620	
"	62116	10 + 11	-	1	-	MM	4025.0	637	
"	62118	13 + 11	-	1	-	MM	2170.0	531	
5/29/71	62126[4]	15 +	No milk	-	-	FF	1825.0	557	Stillborn, dehydrated

1/ Age to nearest month by horn annuli, assuming average June 1 birth date
2/ CL - Corpora Lutea
3/ DCL - Degenerating Corpora Lutea
4/ Ewe and lamb found dead on Cooper Landing Closed Area

previous winter. Three of these were lactating and so had probably successfully raised lambs. A fourth ewe was lactating but was seen to be followed only by a yearling male, according to the hunter who killed her. Her ovaries contained no identifiable DCL and it is assumed that she had not been pregnant the past winter but was merely lactating for an exceptionally long time. In this small sample, 72 percent (5) had probably been impregnated the previous breeding season and 43 percent (3) had raised a lamb.

Twenty-two ewes were collected after the rut and before parturition. Of these, 21 (95 percent) were found to be pregnant. All of the "adult" ewes over two years old were pregnant, while three of the four yearling ewes (approximately 21 months old) were pregnant. This is a high pregnancy rate for a species raising a single young.

One of the ewes taken November 13, 1970, prior to the expected breeding season, contained an ovarian body resembling a newly-formed corpus luteum. This could have been either a corpus luteum of pregnancy or of estrus. It is possible that this ewe had ovulated early and had been successfully bred.

A ewe taken on January 14, 1971 with a smaller-than-normal embryo had two ovarian bodies in addition to the obvious corpus luteum. These may have been corpora lutea of estrus resulting from two previous ovulations. She may have gone through two estrus cycles without being bred, then was impregnated in the third. Another ewe collected in February, 1971 contained a smaller-than-average fetus indicating late breeding. No additional corpora lutea of estrus could be identified in her case.

Listed in Table 6 are the sexes, weights and total lengths of all embryos and fetuses recovered from pregnant ewes. The sex, weight and length of a newborn lamb picked up in Cooper Landing Closed Area are also included. This lamb apparently was born dead. It had lost an unknown amount of weight through dehydration since it was not recovered until about one day after death, and may have been a sub-normal individual to start with. Thus, it may not be representative of a normal full-term fetus.

Weights and lengths of the recovered fetuses are plotted against time in Figs. 7 and 8. The two abnormally small specimens, #62092 and #62089, have not been included. Nothing is known of the breeding dates of the ewes involved; therefore, the fetuses are of unknown age which probably accounts for the great variation in size/weight within each collection period. More specimens are needed, particularly at or near full-term, to complete these rough growth curves.

None of the fetuses examined from the January and February collections had hair. Of the five taken on March 18, 1971, one had no hair follicles visible; one had follicles but no hair; two had fine hair on the muzzle, only, and eyelashes; and one had hair on a number of body parts. All of those taken in late April were fully haired with incisor

Figure 7. Weights in Grams of Fetuses by Dates of Collection

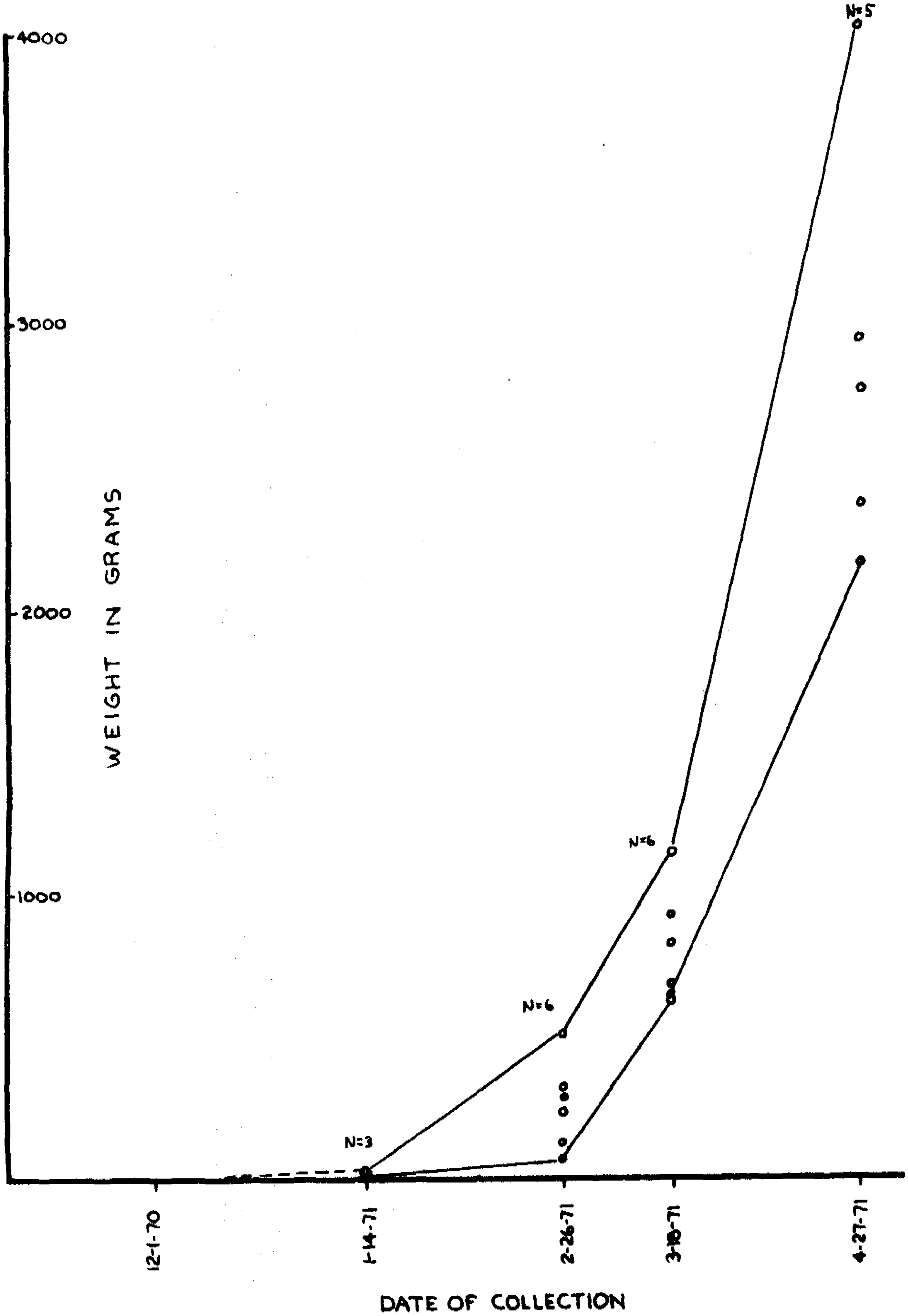
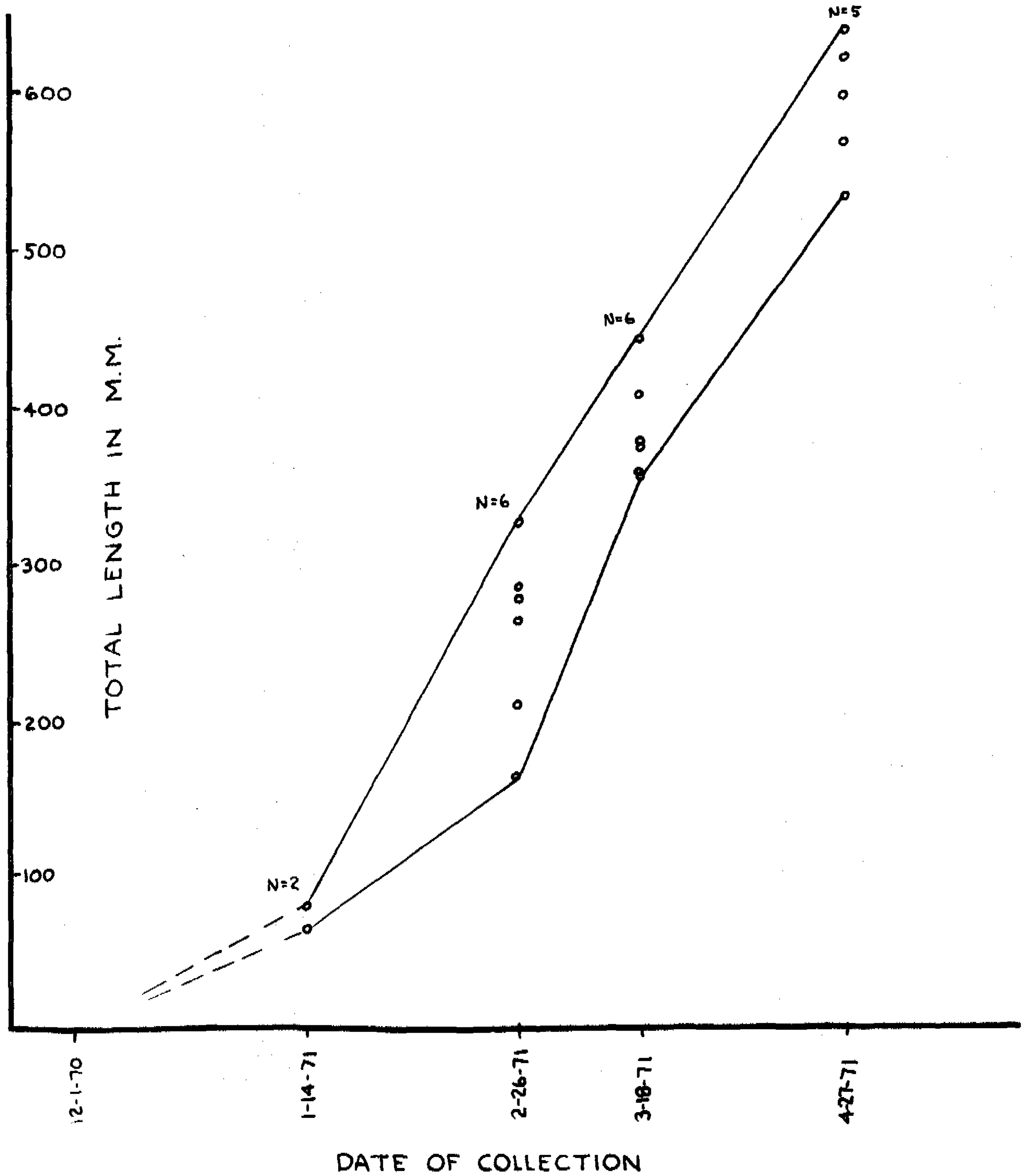


Figure 8. Total Lengths in M.M. of Fetuses by Dates of Collections.



teeth forming within tooth buds in the gum. Hair color varied among these five specimens from nearly white to a dark, brownish-grey. All had dorsal stripes of light to dark brown hair running down the neck to about mid-back, and dark hair covering the brisket. Other dark hairs were found on the dorsal surface of the tail, at the rear base of the ears, and between the toes of the front feet. The newborn lamb found on May 29 was almost white in color, and had the two center incisors, only, erupted.

During the aerial parturition counts, many of the young lambs were noted to be grey or brownish in color. Dark hairs and coloration may be relics of ancestral color or may be protective mechanisms. Dark lambs are certainly much harder to see among the rocks of the lambing grounds than white ones. If such protection is truly an advantage to lamb survival, it would seem that natural selection would have favored this coloration in most or all Dall lambs. The dark appearance is lost within a few weeks after birth; no dark lambs have been observed later in the summer.

Of the 20 fetuses in which the sex could be determined, 12 were male and eight female. The prenatal sex ratio in this sample was 150 MM: 100 FF. The sample is too small to be representative of the species.

The analyses of reproductive tracts show that many Dall sheep females are sexually mature at a minimum of 18 months of age (Table 6); three of the four specimens examined were pregnant. Ewes over le years of age were carrying fetuses and one, which was at least 15 years old, gave birth to a lamb in Cooper Landing Closed area. In that case, however, both ewe and lamb were found dead. The lamb apparently was born dead, or died very shortly after birth. The ewe died within a short period of parturition too, judging from the condition of the reproductive tract. She was in very poor condition, and may have been unable to raise the lamb had both lived.

Unfortunately, sperm smear slides from all but one of the yearling rams were lost. The one examined was made from the epididymis of a 21-month-old (estimated) male collected on February 26, 1971, at least two months after the expected end of the past rutting season. Some apparently mature sperm were present in the seminal fluid, but they were relatively scarce and the epididymis was flaccid. A slide made the same date from a 33-month-old ram showed numerous mature sperm, although the epididymis was not turgid. A one-year-older ram (estimated 45 months old) taken on that same day had very numerous sperm and a turgid epididymis.

At least some yearling males, approximately 18 months of age and listed as Class II or III MM, depending on horn size, are probably sexually mature and able to participate in the rut. In domestic sheep, puberty is related to weight rather than age alone (Asdell, 1964). Large-bodied yearling Dall males (Class III MM by horn size?) may reach puberty at 18 months, while slower growing males (Class II MM?) may not be sexually mature until older. Regardless of physical ability, yearling males appear behaviorally or otherwise unable to participate in actual breeding, at least where older rams are present. On the other hand, both field observations and examination of reproductive tracts have shown that many female yearlings are pregnant.

The method of aerial counting used for recording lambing chronology worked well. Although the size of the sample varied according to counting conditions, classification of "adults" vs. lambs within the sample was accurate. By flying alone, weight was decreased and aircraft performance was increased so that it was possible to fly slower and closer to the sheep.

Ability to locate more of the sheep in each population improved as the snow cover disappeared. This increased the sample size until most of each population could be seen during each count.

Each ewe or group was examined closely and repetitively (if necessary) until I was satisfied I had missed no lambs. A very young lamb would often hide under its dam if she were standing, or between her and the mountain slope if she were bedded. Ewes were forced to move at least a few steps so that any lambs present could be seen.

The magnitude of lambing progression cannot be compared accurately by this method unless further classification is accomplished to find the proportion of ewes in each sample, enabling the computation of the ratios of lambs per 100 ewes. Such detailed classification requires much more time and effort and was not considered necessary for the objective in mind.

It is possible that the frequent close counting had some effect on lamb survival through harrassment. Some sheep--usually yearlings and lambless ewes--became excited over the close approach of the plane. Most, however, paid little attention or merely moved casually away. It was often necessary to "buzz" bedded animals several times before they would even stand. Standing or feeding sheep frequently refused to move unless pushed. The frequent harrassment certainly did not force an observable number of sheep to abandon their range. No unnatural movements were noted, and sheep could be seen in the same general areas day after day.

Listed in Table 7 are the results of the aerial counts by date for each area. The results in lambs per 100 "adults" are plotted graphically in Fig. 9. In order to better visualize progression, each curve was smoothed with a visually-fitted curve from beginning to the point of maximum lamb:"adult" ratio, then converted into a rate-of-increase curve. These are shown in Fig. 10. They are approximations but probably represent the theoretical lambing progression on each area fairly closely. Nothing was known of the beginning date of lambing on Crescent Mountain, but incidental observations and reports by local residents indicated the first lamb was born in the closed area about May 10. No lambs were seen on Surprise Mountain during a careful reconnaissance flight on May 18.

Table 7. Aerial lambing progression counts, 1971.

Area	Date	"Adults"	New Lambs	Lambs per 100 "Adults"
Surprise Mt.	5/19/71	100	1	1.0
	5/24/71	115	9	7.8
	5/27/71	121	12	10.1
	6/4/71	127	17	13.4
	6/7/71	155	16	10.3
	6/10/71	153	21	13.7
	6/14/71	156	23	14.7
	6/18/71	155	24	15.5
	6/21/71	150	21	14.0
Crescent Mt.	5/19/71	97	2	2.1
	5/23/71	147	9	6.1
	5/29/71	84	7	8.3
	6/3/71	138	8	5.8
	6/5/71	162	14	8.6
	6/10/71	198	16	8.1
	6/18/71	202	21	10.4
	6/21/71	208	20	9.6
Cooper Landing Closed Area	5/19/71	142	11	7.8
	5/24/71	188	38	20.2
	5/29/71	204	39	19.1
	6/3/71	219	44	20.1
	6/5/71	219	47	21.4
	6/7/71	222	44	19.8
	6/10/71	227	45	19.8
	6/14/71	235	49	20.9
	6/18/71	244	50	20.5
	6/20/71	238	50	21.0

Figure 9. Lambing Progression by Observed Lambs per 100 "Adults" and Date, 1971

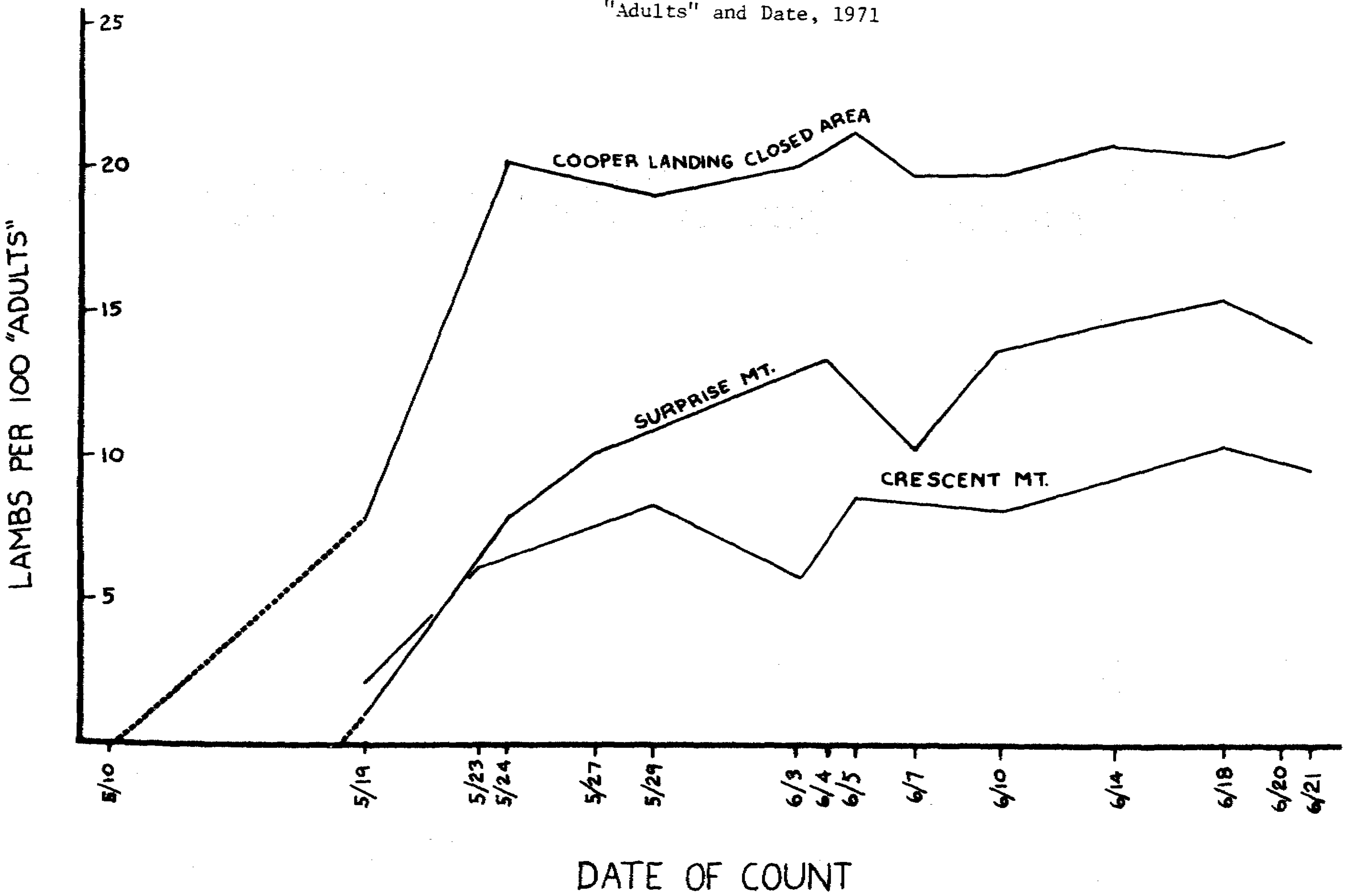
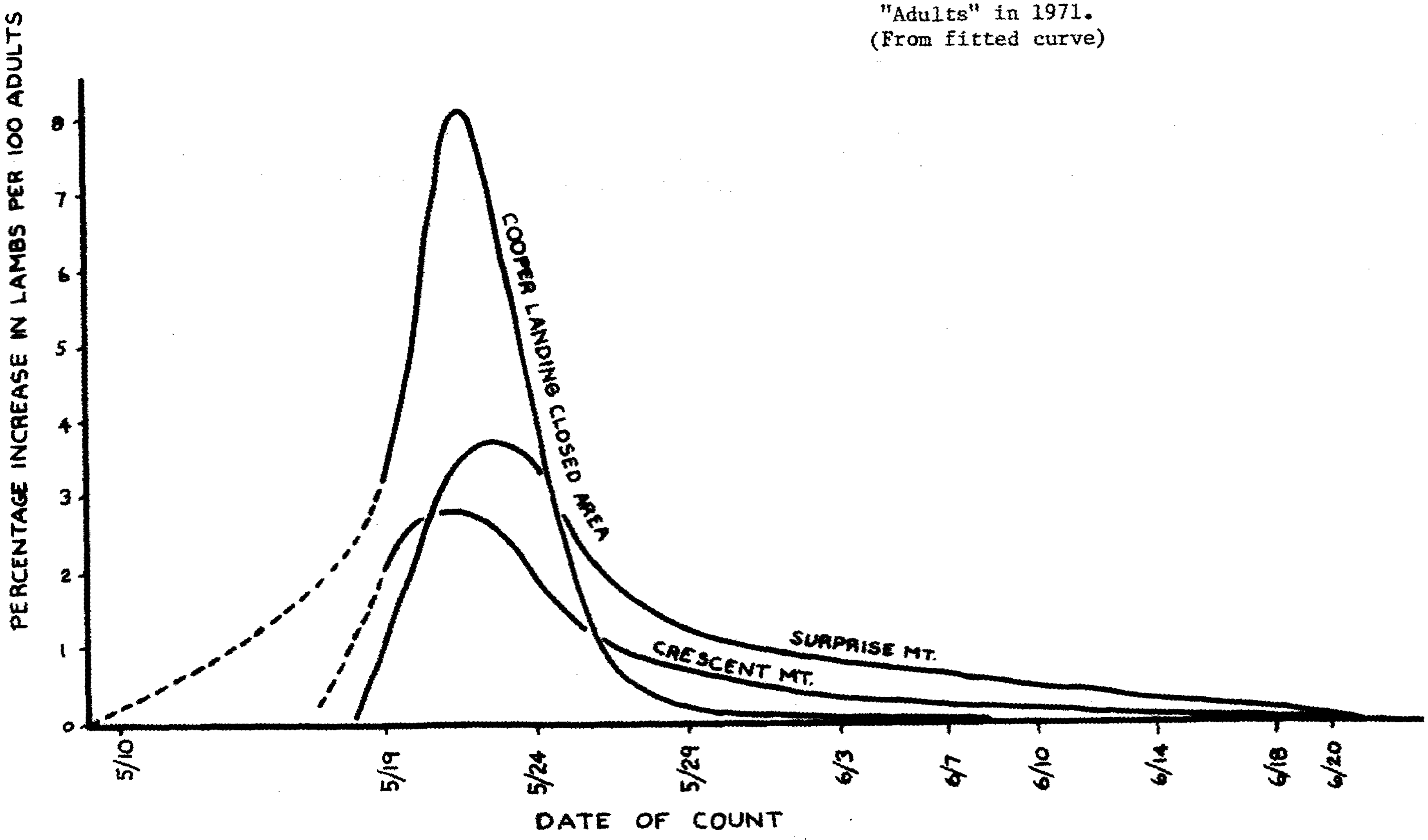


Figure 10. Estimated Lambing Progression by Rate of Increase in Lambs per 100 "Adults" in 1971. (From fitted curve)



Lambing apparently commenced earlier in the closed area than on Surprise Mountain, but ended much more rapidly than it did on either Surprise or Crescent mountains. The maximum rate of increase--or "peak" of lambing--seems to have been close to the same time on all three areas; from about May 20-24, 1971.

A source of error which could affect these observed and estimated values is the unknown rate of mortality of newborn lambs. Considerable mortality occurs during and immediately following parturition. If the rate of mortality is not chronologically relative to the rate of natality, observed values might not represent the true chronology and rate of lambing. Regardless of mortality, the observed curves should represent "effective" lambing; that is, the progression of production of surviving lambs, which is the real concern of the game manager. In practice, it was noted that almost no newborn lambs were seen after the observed lambing peak on the closed area, while obviously newborn lambs were commonly seen on both Surprise and Crescent mountains late in the season. Thus, differential mortality has probably not skewed the curves appreciably.

The observed peak in rutting activity was during the period of November 21-25, 1970 in Cooper Landing Closed Area, and the observed peak in lambing was approximately between May 18 and 23, 1971. This would indicate a gestation period in the neighborhood of 175-180 days.

Population Trends

Aerial counts were made of the Surprise Mountain herd on April 1, 1971 and again on August 3, 1971. The Crescent Mountain herd was counted on June 21, 1971 and on July 9, 1971; and the Cooper Landing Closed Area herd on June 20, 1971. Results of these counts are shown in Table 8. Results of several counts made in 1970 are also shown for comparison.

The June, 1971 census of the Crescent Mountain herd showed that the desired reduction to approximately 200 animals through public hunting, collecting and natural mortality has been accomplished. A total of 208 animals was counted, exclusive of new lambs.

Bad weather and other duties made it impossible to conduct the planned winter ram classification counts on the herds. Inclement weather also prevented completion of spring lamb survival counts on Crescent Mountain and Cooper Landing Closed Area. Yearlings were classified in the closed area during the last lamb production count in June, however, so lamb survival could be determined for that herd. Weather and unavailability of aircraft also prevented midsummer counts of the closed area herd. Distance from Anchorage and an almost complete lack of weather reporting service covering the study areas made it very difficult to plan and conduct aerial counts so as to hit the relatively infrequent days of suitable weather during 1971.

With good weather and little snow cover, accuracy of "total" counts and lamb classification can be surprisingly good. For example, the best

Table 8. Results of aerial sheep classification surveys, 1970-71.

Area	Date	Young Rams	Legal Rams	All Rams	Ewes plus Yrlgs.[1]	Ewes	Yrlgs.[2]	Lambs[3]	Total
Surprise Mt.	3/2/70	16	-	16	137	132	5	-	153
	7/15/70	-	-	19	146	-	-	20	185
	4/1/71	24	-	24	116	108	8	-	140
	8/3/71	-	-	27	129	-	-	21	177
Crescent Mt.	3/2,9/70	37	6	43	212	162	50	-	255
	7/7/70	-	-	84	159	-	-	44	287
				(6 MM, 9 FF removed by hunting)					
	9/22/70	-	-	64	165	-	-	44	273
				(2 MM, 25 FF, 11 Yrlg, 10 L removed by collection)					
	6/21/71	-	-	-	-	-	-	20	228
	7/9/71	-	-	63	133	-	-	17	213
Cooper Landing Closed Area	5/8/70	14	19	33	167	143	24	-	200
	8/4/70	-	-	84	193	-	-	34	311
	6/20/71	-	-	88	150	133	17	50	288

1/ This category includes young rams mis-identified as "ewes" and is the main source of error in aerial classification.
2/ "Yearlings" is used to distinguish lambs of the previous summer from new lambs.
3/ "Lambs" as used here includes those born in the summer of the survey year.

counts of "adults" (nonlambs) and lambs made on Surprise Mountain during the repeated lamb surveys showed 156 adults and 21 lambs to be present in June. When the herd was again counted in August, the same numbers were tallied. On Crescent Mountain, a total of 287 sheep, including 44 lambs, was counted in July, 1970. Following the hunting season, which removed a known 15 adults, a count revealed a total of 273, again including 44 lambs. Such accuracy is not always obtainable of course. Identification and classification of small rams, ewes and yearlings is especially difficult from the air and can only be accomplished with reasonable accuracy under ideal conditions.

Because of the difficulty in accurately counting total numbers and classifying sex and age classes at the same time, the construction of population models is necessary in order to determine ratios needed to compare populations, production or survival by area or year (Nichols, 1970). Models were computed for the Surprise Mountain and Cooper Landing Closed Area herds in 1970 and 1971 (Table 9). Insufficient data were obtained to construct a similar model for Crescent Mountain.

The model shows a change in ratio on Surprise Mountain of 14 lambs per 100 ewes in 1970 to 7 yearlings per 100 ewes in 1971, indicating a 50 percent mortality over the first winter. This ratio changed in the closed area from 21 lambs per 100 ewes to 13 yearlings per 100 ewes, showing a lower winter mortality rate of some 38 percent. Lamb production was higher during the second year on both areas, and, in 1971, was over twice as high in the Cooper Landing herd as in the Surprise Mountain herd.

With the present inaccuracies in classification, these models are probably more useful in comparing long-term trends than in noting minor year-to-year or herd-to-herd variations. Improvement in classification accuracy--especially in identifying young rams and yearlings--will make the models more representative of the actual populations. Conducting the aerial counts at the best seasons and under the best conditions for identification of sex and age classes will be the first requirement for improved accuracy.

Winter Range and Climate

The locations of the 10 stands used in the range survey in each area are shown in Fig. 11. On Crescent Mountain, they are on ridges with a south to southwest exposure. They vary in elevation from 2,500 to about 4,000 feet. The ridges are steeply sloping, thinly covered with soil and are entirely within the alpine zone. Just above these ridges lies a fairly flat bench which serves as a winter access point for landing a ski-equipped Supercub when winds are light. It can be used on a year-round basis by helicopters. Most of the sheep collected from Crescent Mountain were killed on this bench.

The range stands on Slaughter Mountain, Cooper Landing Closed Area, are on small ridges on a steep, south-facing slope and extend from about

Table 9. Computed population models and ratios, 1970-71.

Area	Date	Rams	Ewes	Yearlings	Lambs	Total
Surprise Mt.	7/70	19 13:100 FF	141	5 4:100 FF	20 14:100 FF	185
	8/71	27 23:100 FF	120	9 7:100 FF	21 18:100 FF	177
Cooper Landing Closed Area	8/70	84 51:100 FF	165	28 17:100 FF	34 21:100 FF	311
	6/71	88 66:100 FF	133	17 13:100 FF	50 38:100 FF	288

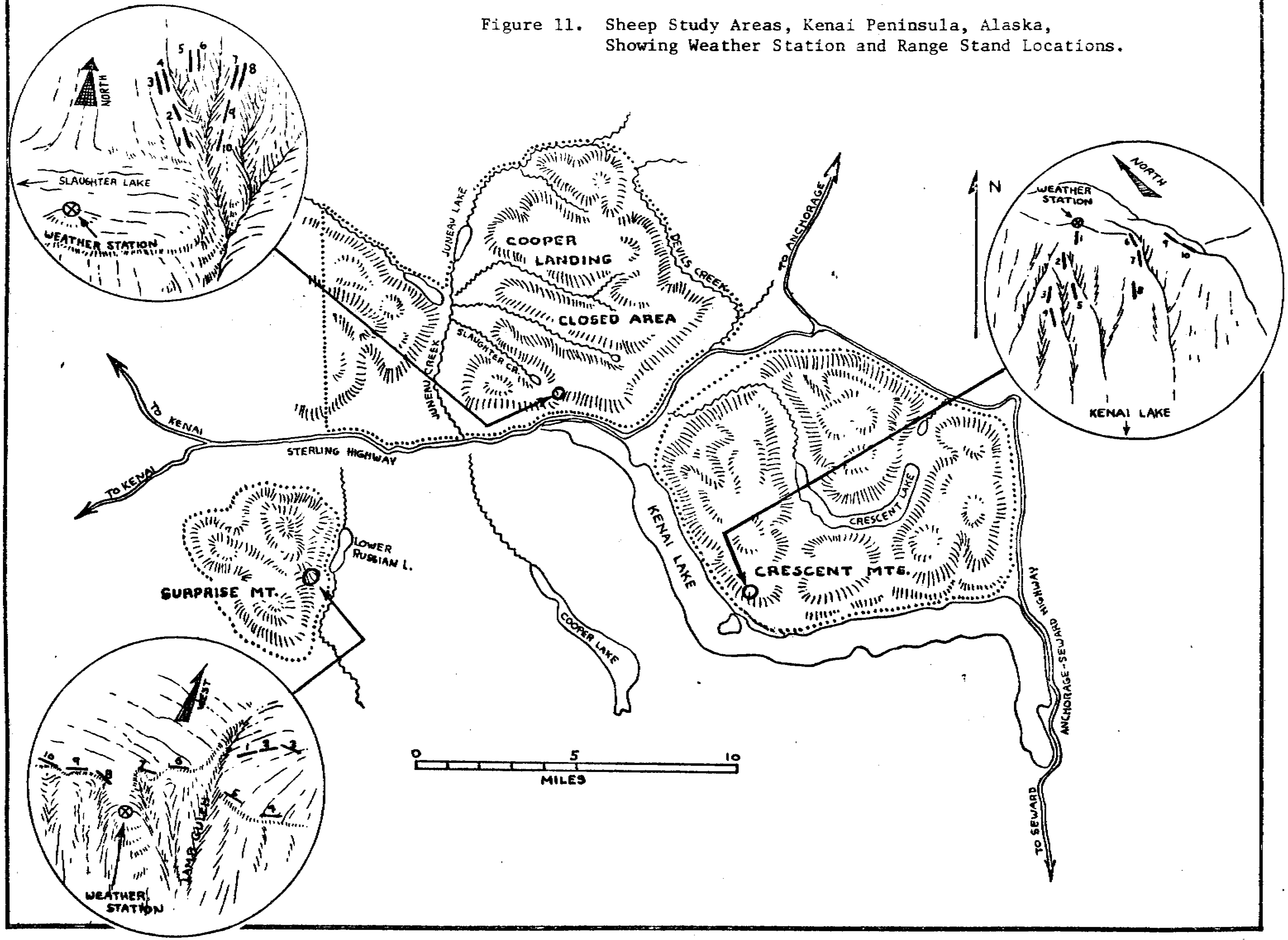


Figure 11. Sheep Study Areas, Kenai Peninsula, Alaska, Showing Weather Station and Range Stand Locations.

2,300 to 3,100 feet elevation. Although the ridges themselves are open and alpine in type, many patches of alders extend above them on adjacent slopes. Just west of the stands lies a rolling basin forming the head of Slaughter Creek, and containing Slaughter Lake. The lake, about a mile away, is used for access by a Supercub on floats in summer and skis in winter. A helicopter may be landed in the low brush much closer to the stands.

On Surprise Mountain, the range stands are located more or less along the brink of a steep, east-facing slope at elevations from approximately 2,500 to 2,700 feet. The area covered is all alpine and open, though a few small stands of alpine hemlock occur on the rolling plateau. A ski plane can be landed in several places nearby in winter, and a helicopter can provide year-round access.

Results of the comparative range surveys conducted during the summer of 1971 by Dr. R. M. Hansen are included in detail in his report (Appendix II). Some of the highlights of his findings are summarized in Table 10. All three areas differed significantly in forage production with Slaughter Mountain being the most productive and Crescent Mountain the least. Variety of species was greatest on Slaughter Mountain and least on Surprise Mountain. Production by species was also significantly different in most cases. There was about 4.6 times as much *Hierochloe* produced on Slaughter Mountain as on Surprise Mountain, and about 18 times as much on Slaughter Mountain as on Crescent Mountain. Since *Hierochloe* appears to be the key forage species for sheep, the relative carrying capacities of the three mountains might be roughly indicated. However, before any conclusions could be drawn about comparative winter carrying capacity, the available acreage of *Hierochloe* and other important species must be known as well as their production in pounds per acre.

Locations of the three weather stations are indicated in Fig. 11. Considerable trouble has been experienced with two of these instruments. The anemometer on the Crescent Mountain station has twice blown apart, resulting in vibration damage to the instrument and stoppage of recording charts (Plates 7 and 8). It has subsequently been repaired but most data have been lost. The Surprise Mountain station has unaccountably stopped recording for several periods, resulting in lost data. The Slaughter Mountain station appears to be working well.

These instruments are designed to record continuous wind velocity and direction and temperature for a period of up to 60 days without servicing. I found that they would not record with certainty beyond about 40 days under our winter conditions. This may be a result of shortened battery life due to cold. Regardless of cause, they require servicing at about 40-day intervals. Servicing consists merely of changing batteries and recording charts. No analysis of recorded data has been attempted as yet; charts are being stored for future examination.

No snow depth or hardness surveys were conducted under this segment except for preliminary tests to check the method. Two experimental

Table 10. Forage production by rank of major species in lbs. dry weight per acre, 1971. 1/

Surprise Mt.				Slaughter Mt.				Crescent Mt.			
All Species		Grasslikes		All Species		Grasslikes		All Species		Grasslikes	
Species	Weight	Species	Weight	Species	Weight	Species	Weight	Species	Weight	Species	Weight
DRIN	187.9	CARE	61.4	DRIN	450.3	HIAL	155.9	DROC	88.3	CARE	30.3
ARAL	173.1	HIAL	34.1	HIAL	155.9	CARE	35.6	SALI	63.9	HIAL	8.7
BENA	112.5	FEBR	3.5	VAVI	145.8	POAS	23.2	SATR	32.5	TRSP	5.1
VAVI	111.7	POAS	0.9	BENA	77.8	BRSP	7.7	CARE	30.3	POAS	4.6
VAUL	81.6			ARUU	71.6			POUN	22.2	FEBR	4.3
CARE	61.4			SALI	56.5			ANNA	15.8		
SALI	60.4			ARAL	47.1			ARAR	13.1		
EMNI	46.7			EPAN	45.7			MOSS	9.0		
HIAL	34.1			CARE	35.6			HIAL	8.7		
				ARAR	29.5						
Total Weight	978.7			Total Weight	1289.8			Total Weight	352.8		

1/ From appended report by R. M. Hansen. Species names listed in report.

CONTENTS

BACKGROUND

Investigations of general group movements and seasonal distributions of Dall sheep (*Ovis dalli*) in various areas of Alaska have been conducted previously. Distribution of sheep in June, July and early August 1962 in Dry Creek, Alaska Range was plotted by Viereck (1963b). His data show an up-valley and up-slope movement trend from June through early August and also a shift from the westward limit of Dry Creek below the West Fork of Dry Creek to the adjacent Slate Creek and Forgotten Creek drainages (Fig. 1). Palmer (1941) listed areas used by sheep at different seasons in Dry Creek, the Little Delta River and the Wood River areas. Scott (1951) outlined seasonal ranges and trails in the Indian Creek area of the Kenai Mountains. Viereck (1963a) described seasonal range in the Tonzona River area. Murie (1944) described sheep movements in McKinley Park, and Gross (1963) described sheep movements on Victoria and Schwatka mountains in the White Mountains.

The movements of significant numbers of individually marked Alaska Dall sheep have been only partially described (Nichols and Smith 1971). These data have been gathered mainly for animals on summer range. Before discrete populations can be identified and meaningful management programs instituted description of specific wintering areas for populations and population segments must be completed.

Mineral lick utilization by sheep is thought to have primary and profound effects on sheep distribution and movements. Pitzman (1970) stated, "Sheep distribution...is also influenced by the use of mineral licks. ...Mineral licks seem to be a characteristic of most Alaska sheep habitats that have been studied." Erickson (1970) agreed that, "One of the factors which may influence sheep population distribution is the presence of mineral licks." Others, Palmer (1941) and Viereck (1963a and b), have made specific references to this concept. However, few specific data are available to credibly support this seemingly reasonable idea.

To provide this information, observations of sheep mineral lick use were made incidental to trapping operations in 1969, 1970 and 1971. These data were compiled and have been reported in earlier progress reports; however, analysis allowing their relation to the influence of mineral licks on movements was deferred until enough data were available to justify the effort.

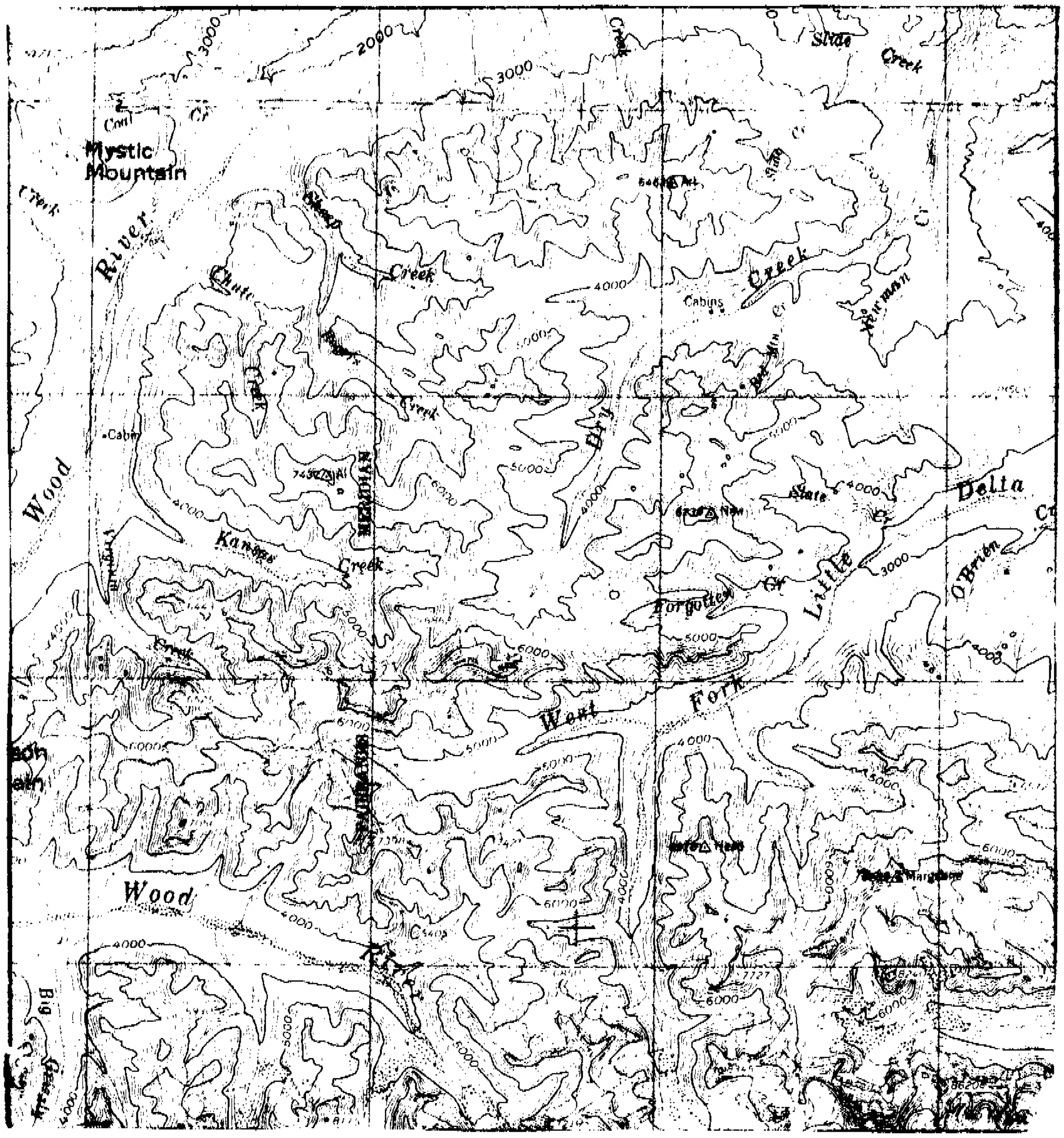


Fig. 1. Sheep study area in Dry Creek and adjacent drainages, about 70 miles south of Fairbanks, Alaska.

OBJECTIVES

To define and characterize the discrete sheep population or populations of the Dry Creek area.

To determine the daily movement pattern and seasonal home ranges of sheep captured and collared at the main Dry Creek mineral lick.

To describe mineral lick use patterns in relation to age and sex of sheep at different seasons.

PROCEDURES

Study Area and General Method

The sheep study area is centered on the Dry Creek drainage in the Alaska Range south of Fairbanks and includes adjacent drainages (Fig. 1). All animals utilized in the study were captured during June and July at the main mineral lick on Dry Creek using the drop net method described by Erickson (1970).

Characterization and Definition of Sheep Populations

Growth and Morphology of Dry Creek Sheep:

After capture the living sheep were weighed using a spring balance and the following measurements were taken:

1. Contour length-measured from the tip of the nose to the end of the tail.

2. Shoulder height-measured from the hoof tip of the front foot to the top of the back.

3. Chest girth-measured as circumference of chest immediately behind the front legs.

4. Hind foot length-measured from hoof tip to the proximal end of the *tuber calcis* with the foot extended and reflected dorsally.

Age was determined by the horn annuli method of Geist (1966). Sampling was not random; an effort was made to obtain the greatest number of animals possible from all age classes of the population. This resulted in bypassing some younger animals and selecting for older ewes.

Other measurements (horn length, spread, and tail length) were also taken but were not used in analysis because of their variation. Data for a comparison of the Dry Creek sheep with sheep from the Kenai Peninsula were provided by Lyman Nichols, Alaska Department of Fish and Game. These sheep were taken on Crescent Mountain between January and

April in 1971, with most collecting taking place in February and March. Measurements were made as described previously. Measurements of Dry Creek sheep and Kenai Peninsula sheep are contained in Appendix I, Part 1 and Part 2, respectively.

Thirty ewe sheep made up the Kenai Peninsula sample. The Dry Creek sample consisted of 293 sheep of both sexes and all age classes.

<u>Population Blood Genetics</u>

Blood samples were taken from 109 live Dall sheep at Dry Creek, Alaska Range in June and July 1971. Serum was removed from the clotted blood and stored frozen in liquid nitrogen. After transport to Fairbanks the serum samples were examined using acrylamide gel electrophoresis by Peter D. Shaughnessy of the Institute of Arctic Biology. A report on methods and findings is contained in Appendix II.

<u>Determination of Daily Movement Pattern and Seasonal Home Range</u>

Daily Movement Pattern:

No data were collected on daily movement patterns in 1971.

Seasonal Home Range:

Sheep were captured with a drop net as described by Erickson (1970). After capture each sheep was marked with a collar consisting of a polypropylene rope strung through a numbered pendant and secured by hog rings. Other types of collars have been used at Dry Creek in the past (Nichols and Smith, 1971) but have not been satisfactory. Sheep were then weighed, measured and then released.

Some observations of collared sheep were made from the mineral lick, and numerous resightings of collared sheep occurred there (see Findings: Mineral lick use patterns). Some collars were resighted from aircraft, but the bulk of resightings were made from foot surveys in the study area. The pendant collar numbers are discernible at distances of up to 250 or 300 yards using a 60X spotting scope in good light.

Sheep were identified on home ranges throughout the year, and locations were plotted on topographical maps. Most observations were made on foot surveys, but some aircraft surveillance was utilized. Success with aerial survey techniques was limited to occasional sightings of collars which were used in 1969-70. The smaller pendant collars used in 1971 are impossible to identify from aircraft. A compilation of all resightings is found in Appendix IV.

Aerial and foot surveys of sheep in the Dietrich River for purposes of defining seasonal sheep ranges and river crossing sites were conducted by Spencer Linderman in the summer of 1971. The report of these findings appears in its entirety in Appendix III.

While conducting the sheep capture operation at the mineral lick in June, 1971, a single wolf was observed chasing and killing a three-year-old ram. On an aerial sheep survey in August, 1971, a similar event was observed. Accounts of both observations are contained in Appendix V.

Mineral Lick Use Patterns

Data consisting of resightings at the main Dry Creek mineral lick in the summers of 1969, 1970, and 1971 were collected. Collared sheep were identified as they entered the lick. Observers were stationed in an observation blind above the lick at a distance of approximately 250 yards. In 1969 observations were conducted for 15 hours per day from 0300 to 1800 hours from June 16 to June 26. In 1970 twenty-four hour per day observations were conducted from June 3 to June 12 and June 29 to July 3. Records were made of air temperature each hour. During 1971 no periods of continuous observation were made. However, collared sheep were noted as they entered the lick during trapping efforts from June 2 to July 24.

Data from these years of observation were tabulated utilizing a digital format which produced a representation of lick use by all animals on a yearly basis over the last three observation years (Fig. 2). This figure allowed calculation of fidelity of age and sex classes to the mineral lick, time spent using the lick, and frequency of utilization. Fidel Fidelity was defined and interpreted according to Geist (1971).

FINDINGS

Characterization and Definition of Sheep Populations

Growth and Morphology of Dry Creek Sheep:

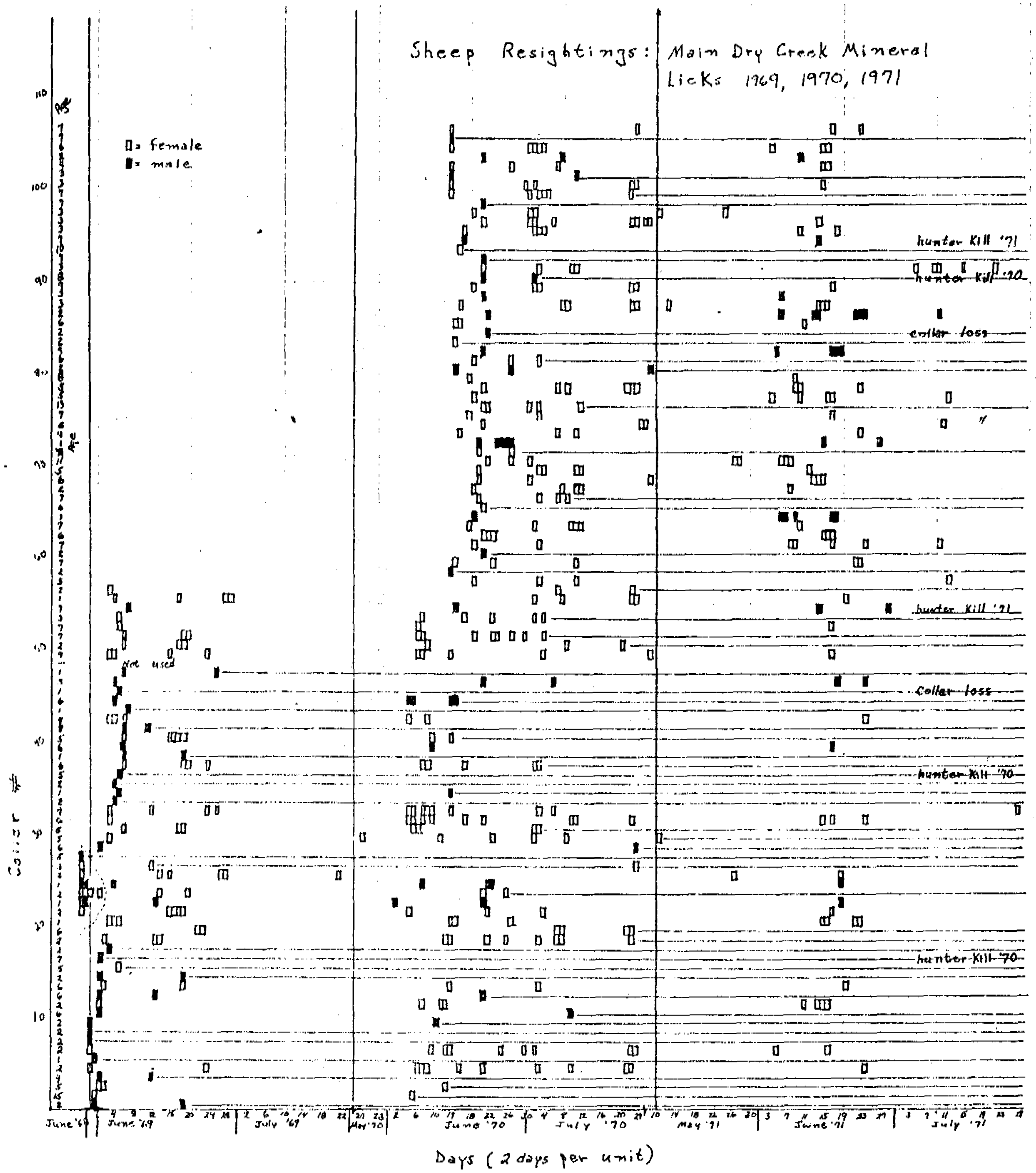
Differences which might serve as a basis for characterizing the two sheep populations (Dry Creek and Kenai Peninsula) as separate on the basis of their morphology were not discovered.

Gross weight was not critically evaluated because the collection times were different enough that winter weight loss was likely to have affected the Alaska Range sheep more than the Kenai Peninsula sheep. The results for ewes five years of age or older are tabulated in Table 1.

TABLE I

	Kenai Sheep	Sample Size	Alaska Range	Sample Size
Mean contour length in mm	1430	16	1475	56
Mean shoulder height in mm	867	16	866	56
Mean chest girth in mm	995	16	977	56
Mean hind foot length in mm	372	16	363	56

Fig. 2. Collared sheep resightings at the main mineral lick on Dry Creek 1968-71.



Figures representing morphological development of Dry Creek sheep were presented earlier (Nichols and Smith, 1971). These plots were not significantly altered by acquisition of another year's data, but the total data have been assembled and comparison of ewes from the Kenai Peninsula and ewes from Dry Creek are presented in Figs. 3 through 6.

It appears that there is little reason to separate the *Ovis dalli* of the Kenai Peninsula from those of the Alaska Range on the basis of morphology. These parameters, with the exception of gross weight and chest girth, are skeletal measurements and should not reflect short-term environmental influences.

Population Blood Genetics

A report on population blood genetics is contained in Appendix II.

Determination of Daily Movement Pattern and Seasonal Home Range

Daily Movement Pattern:

No data were gathered on daily movement patterns in 1971.

Seasonal Home Range:

All sheep were tagged at the main mineral lick on Dry Creek. This portion of their total range is frequented intermittently throughout the summer months (Nichols and Smith, 1971), and may or may not be included in the immediate geographic locality where the remainder of summer time is spent. Observations from 1969, 1970, and 1971 indicate that the greatest mean distance collared sheep move from the mineral lick is 4.7 aerial miles. These observations do not include sheep resighted at the lick only. Still, it must be recognized that this may represent a conservative figure because most of the sightings were of sheep in the area of the lick because observers were stationed there, and all observations of collared sheep seen from the lick area are included. Maximum distances for sheep from the lick range from 0.5 to 16.6 miles for 81 resightings. Most of these resightings are results of summer observations and are indicative of summer range. They are tabulated in Appendix IV.

Movement patterns of sheep at the headwaters of the Dietrich River in the Brooks Range are reported in Appendix III.

Mineral Lick Use Patterns

Observations of mineral lick use by the Dry Creek sheep from 1969 to 1971 have revealed trends. However, these observations were not strictly comparable from year to year and may suggest conclusions of questionable veracity.

It appears that lick use by rams may be generally earlier and possibly less than use by ewes and lambs. The earliest recorded observations of rams in the lick was May 15 (Jones, 1963). Also, Smith (1971) has

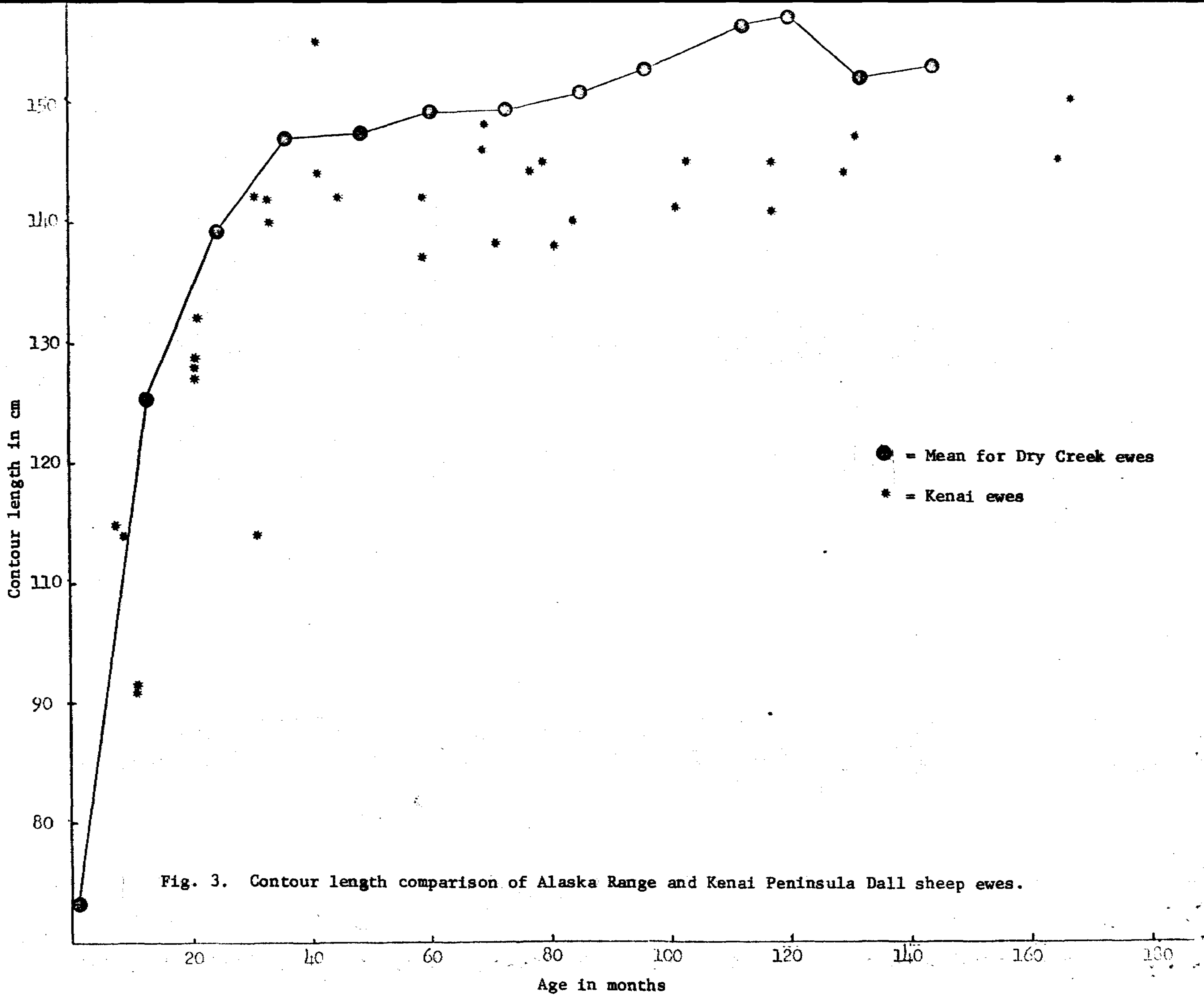


Fig. 3. Contour length comparison of Alaska Range and Kenai Peninsula Dall sheep ewes.

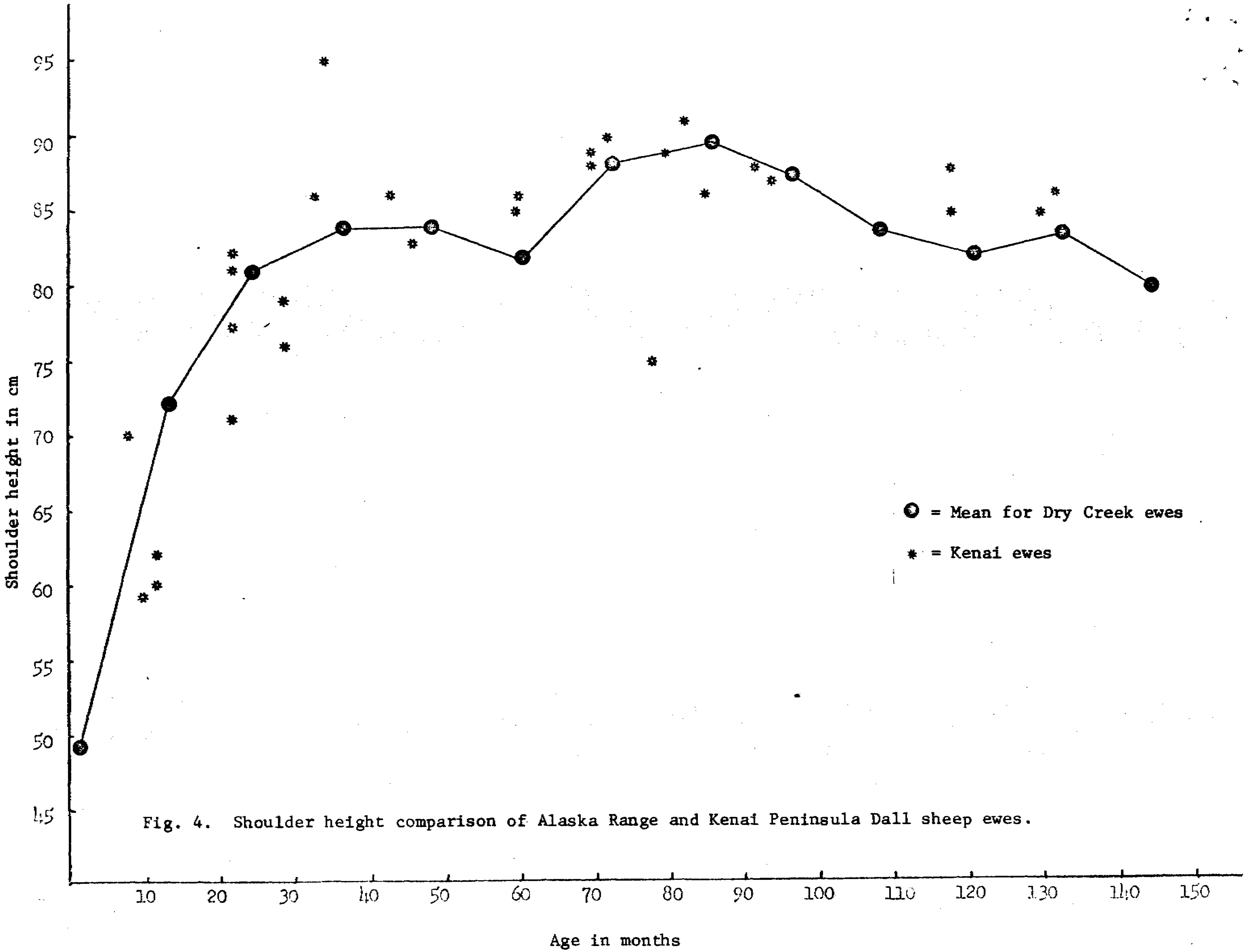


Fig. 4. Shoulder height comparison of Alaska Range and Kenai Peninsula Dall sheep ewes.

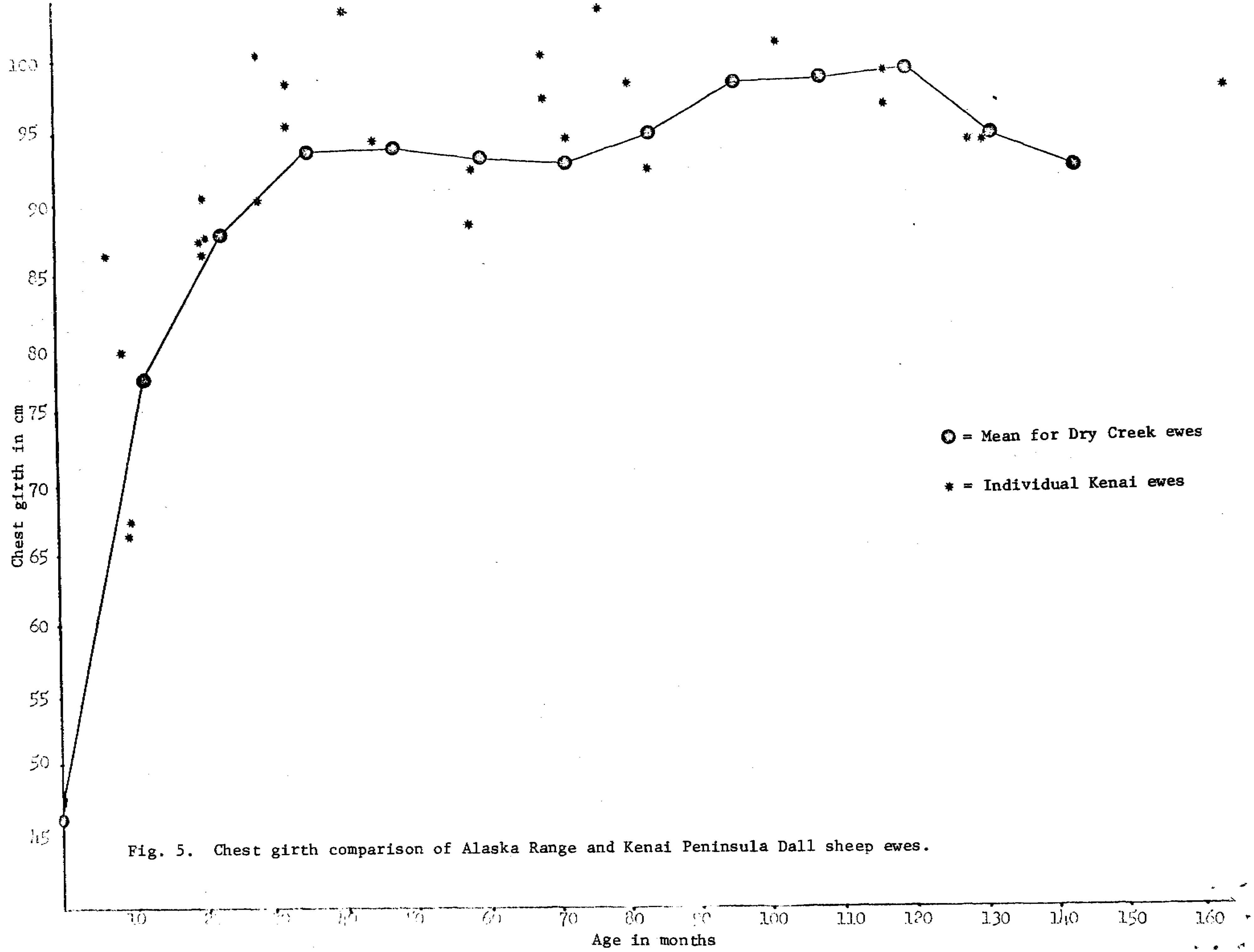


Fig. 5. Chest girth comparison of Alaska Range and Kenai Peninsula Dall sheep ewes.

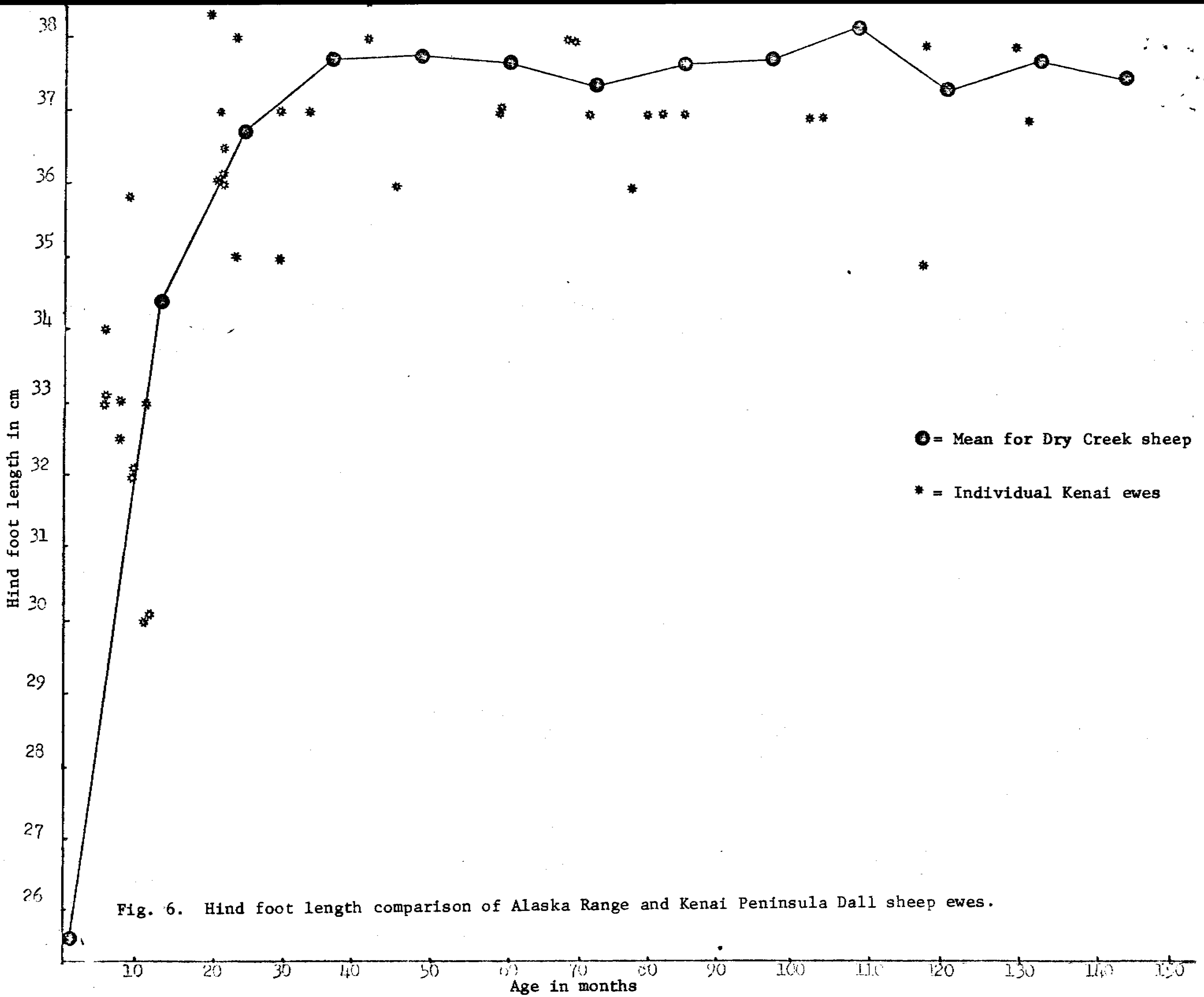


Fig. 6. Hind foot length comparison of Alaska Range and Kenai Peninsula Dall sheep ewes.

stated that during 1969, 1970, and 1971 the early use of the main lick at Dry Creek was predominantly by rams. Ewes have been seen at the lick as early as the end of May or the forepart of June, but never preceding the bulk of ram use. The dates when utilization commences are possibly influenced by weather, but occur always in the order described, i.e. rams first and ewes later.

The recorded peak use of the mineral lick has been observed to be in early summer. In 1969 the observed peak use was June 19 with 1500 lick-use units that day. A lick-use unit is defined as the presence of a sheep during a counting period (which occurred each 15 minutes), and equals approximately 15 sheep-minutes spent in the lick. This converts to 375 sheep-hours for the 15 hours of observation on 19 June 1969 (Erickson, 1970) and extrapolates to 600 sheep-hours for a 24-hour day. The day of peak use observed during 1970 was June 6 when 925 sheep-hours of lick use were recorded in a 24-hour day (Nichols and Smith, 1971). It should be noted here that these observations were only conducted during selected portions of the total summer, and may be biased in this regard.

Sheep visiting the lick use it approximately 1 to 1.5 hours per visit. Jones (1963) found that on the Tonzona River the average time spent by ewes and lambs (sample size = 22) was 60 minutes. Erickson (1970) found the average time spent per sheep at the Dry Creek lick was 90 minutes per visit in 1969. This estimate was based on a sample size of 48 collared sheep. Smith found that the average length of visitation of 90 collared sheep at Dry Creek was 64 minutes (Nichols and Smith, 1971). A weighted average of these three sets of data gives an overall average of near 70 minutes per visit.

Visitation of the mineral lick by sheep appears to be influenced to some degree by weather. Viereck (1963b) noted that on hotter days more sheep used the lick. These data are supported by the data of Nichols and Smith (1971) who reported that maximum lick use for the period from June 3 to June 11 correlated relatively well with mean daily temperature (Corr. Coeff. = 0.72). However, the correlation with mean hourly temperature was quite poor (Corr. Coeff. = 0.15). These two seemingly contradictory observations indicate that there may be some influence, presumably atmospheric, but not mean hourly temperature, which influences mean daily temperature and mineral lick use by sheep. This is particularly evident when it is postulated that daily activity patterns may be expected to correlate well with mean hourly temperature because of the supposed predictable nature of both phenomena.

These daily activity patterns may be reflected in the daily use patterns of the mineral lick, which show two peak periods per day. One peak is about 0400 hours (Erickson, 1970) and the other at 1200 hours (Nichols and Smith, 1971). The observations in 1969 were for 15 hours per day and those in 1970 for 24 hours per day. Consequently it seems likely that there are two peaks with the major activity centered at 0400 hours if a choice must be made.

During the summer sheep activities may center about the mineral licks which they utilize. As reported earlier (Seasonal Home Range), the average maximum distance that sheep were seen from the mineral lick was 4.7 miles. Data taken in the summers of 1969-71 also indicate that sheep return to the lick throughout the course of June and July, and that they can be expected to return to the lick every year.

Fidelity, as defined by Geist (1971), is the number of identifiable sheep returning to a given seasonal home range in one year divided by the number of identifiable individuals seen there in the preceding year. For example, in 1969 two collared rams were seen at the main mineral lick in Dry Creek during the second week in June. In 1968, the preceding year, these rams and one other had been captured and tagged at the mineral lick. Thus:

$$\frac{\text{2 rams seen in 1969}}{\text{3 rams seen in 1968}} \times 100 = 67\% \text{ fidelity to the lick}$$

Of course, corrections must be made for mortality and other factors which may affect the number of animals seen in succeeding years after tagging. Using information which was available to him, Geist (1971) has derived an equation which predicts the number of sheep one can expect to see "t" years after first seeing them at a given location: $N_t = N_o\ U(1-m)^t$. Here N_o is the number of sheep seen in the year "o"; N_t is the number of sheep expected "t" years hence; U is the fidelity constant determined for each case; and "m" is the population mortality per year; (1-m) is survival. Table II displays the fidelity constants determined from lick observations in 1969-71. It also gives the probable explanation for failures on the part of some sheep to reappear at the lick in subsequent years.

From Table II it can be calculated that over three years the average ewe fidelity was 0.78. Fifteen percent of the infidelity observed is attributable (albeit arbitrarily) to collar loss and mortality (see Murie 1944). Thus correction for the attributable lack of fidelity on the part of ewes gives a final figure of 0.93 for ewe fidelity to the lick. Mortality cannot be calculated because limited observations have made the determination of the fidelity constant somewhat arbitrary.

Ram fidelity is even less well-defined in the Dry Creek sheep. In 1970-71 the ram fidelity constants were 0.41 and 0.44. These figures are probably low because observations were begun after the presumed early ram utilization had terminated. Because of this situation little can be said about the fidelity of rams to the lick. It is at least 0.42 and may be higher, however, it is not likely to be as great as that of the ewes (Geist, 1971). Table II reveals that the two-year-old segment of the ram population has a particularly low fidelity. This may be due to high likelihood of collar loss, predation mortality, or a propensity among this group to forsake their traditional juvenile home ranges. Geist (1971) cites data that support this third alternative. Mortality of rams is probably greater than that of ewes, but limited resighting data forbid even an attempt to estimate it.

TABLE II

OBSERVED LICK FIDELITY

Year	U_{male}	U_{female}	percent females not resighted	percent males not resighted	Remarks
1968	-	-	-	-	7 sheep tagged: 4 females and 3 males
1968-69	0.67	1.00	0.0	33	A 5 yr. old male was never seen again
	-	-	-	-	49 more sheep tagged
1969-70	0.41	0.96	4.0		A 5 yr. old ewe was never sighted again. She is assumed dead or to have lost her collar.
				59	The 16 males (59%) not seen in 1970 had the following age distribution 6 (22%) were 2 yrs. old 4 (15%) were 1 yr. old 1 (4%) had lost its collar 4 (15%) were mature rams and were likely missed when they came to the lick earlier
	-	-	-	-	49 more sheep tagged
1970-71	0.44	0.62	38.0		The 23 females (38%) not seen in 1971 had the following age distribution: 1 was 16 yrs.* 1 was 13 yrs.* 2 were 8 yrs.* 5 were 7 yrs.* 18 were less than 7 yrs.*
				56	The 15 males (56%) not seen in 1971 had the following age distribution: 3 (11%) were hunter kills 3 were 10 yrs. old 6 were 7 yrs. old 1 was 3 yrs. old 4 (15%) were 2 yrs. old (one of these lost its collar)
	-	-	-	-	104 more sheep collared

*Murie (1944) found that ewes in McKinley Park above the age of 7 yrs. had an 83% chance of dying.

Valid data which may be used to calculate the frequency of return and lick use by collared sheep are those produced as the result of 24-hour per day observations. Only in June and July (June 3-12 and June 29-July 3, 1970) were such observations made. These observations indicate that the average period of use is 1.3 days and the average frequency of return is one return every 2-3 days. These observations may have occurred during a period of maximal lick use and may not be representative of the situation at other times, however. The results are graphically depicted in Fig. 7. The time spent in 24 hour per day observations was 14 days in total. Of these 14 days the sheep spent an average of 6.5 days using the lick. Thus 45 percent of the observed time was spent using the lick. This figure takes no account of the possible use of other licks in the area and indicates at the least that lick utilization may be important in sheep ecology.

RECOMMENDATION

No specific management recommendation may be made from preliminary results of this study.

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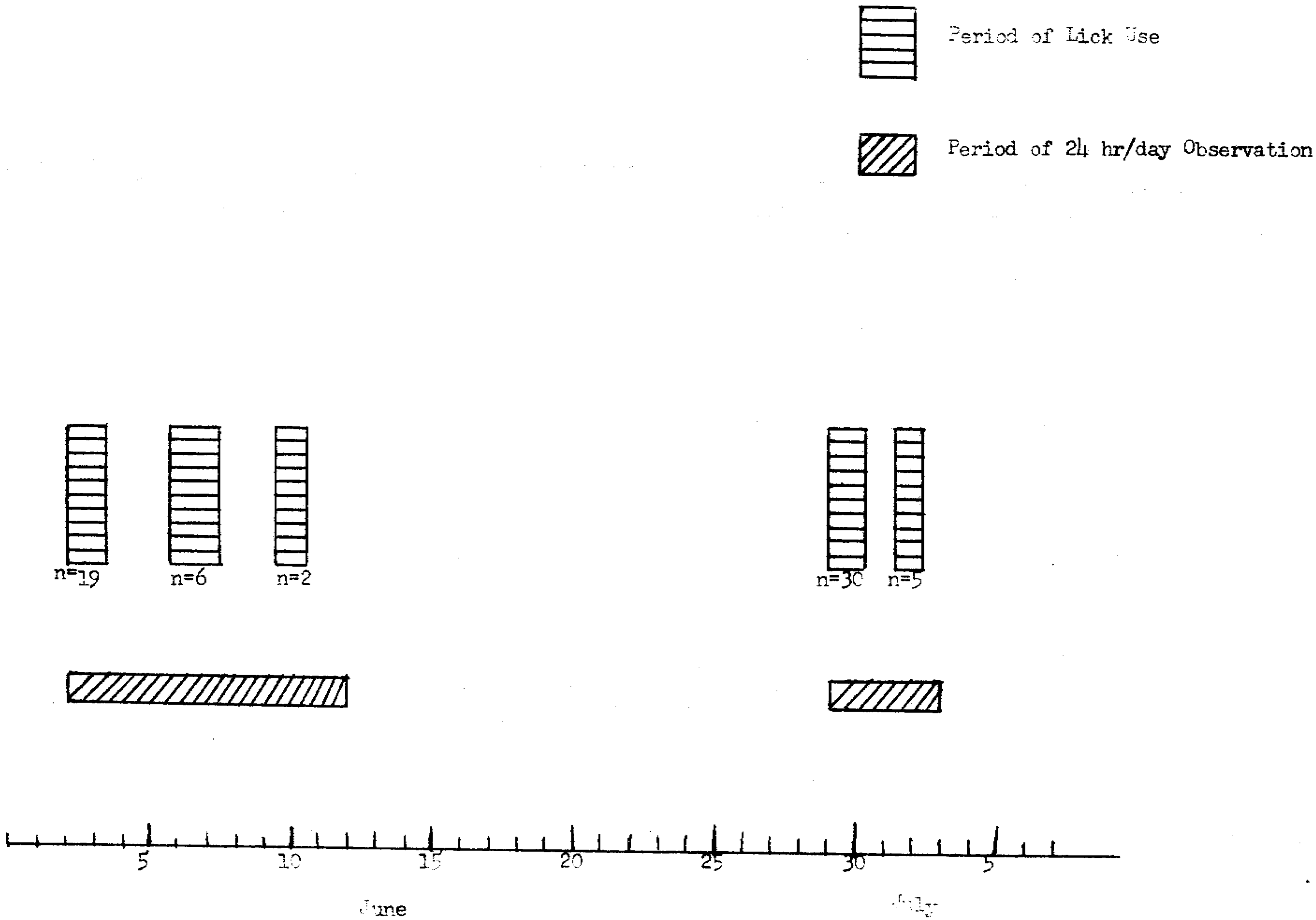
Fig. 8. Average lick utilization and frequency of return for periods of 24 hour observation in 1970. (One appearance counted as one day).



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Appendix I. Part 1. Sex, age, and measurements of Dall sheep captured 1968, 1969, 1970, and 1971 at Dry Creek, Alaska Range.

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
M	1	6/14/70	-	-	845	45	470	500	18	0	268	-	-	-	-	70	
M	2	7/17/70	-	-	645	35	425	360	10	0	221	-	-	-	-	70	
M	1	6/17/70	-	-	920	45	560	530	25	0	280	-	-	-	-	70	
M	1	6/20/70	-	-	825	40	535	490	20	0	261	-	-	-	-	70	
M	1	6/8/71	-	596L	810	55	524	500	25	0	270	-	-	-	-	71	
M	1	6/17/71	-	677L	780	41	497	450	15	0	245	-	-	-	-	71	Weighed in small net, umbilicus still hanging.
M	1	6/18/71	-	732L	840	43	547	490	19	0	272	-	-	-	-	71	
M	1	6/9/71	-	701L	780	38	510	470	15	0	200	-	-	-	-	71	Weighed in small net, umbilicus still hanging.
F	1	6/14/70	-	-	800	35	420	500	18	0	258	-	-	-	-	70	
F	1	6/14/70	-	-	855	50	485	460	18	0	255	-	-	-	-	70	
F	1	6/15/70	-	-	795	50	495	445	15	0	245	-	-	-	-	70	
F	1	6/17/70	-	-	890	50	480	505	21	0	255	-	-	-	-	70	
F	1	6/18/70	-	-	810	50	450	445	16	0	255	-	-	-	-	70	
F	1	6/19/70	-	-	920	50	555	500	25	0	278	-	-	-	-	70	
F	1	6/18/71	-	706	870	38	550	510	19	0	268	-	-	-	-	71	
F	1	6/19/71	-	706	822	32	512	465	17	0	258	-	-	-	-	71	Sore on left shoulder.
F	1	6/19/71	-	740L	705	35	470	390	11	0	235	-	-	-	-	71	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
M	12	6/23/68	25	010L												67	
M	12	6/23/68	23	-	-	-	-	-	-	-	-	-	-	-	-	67	
M	12	5/30/69	-	099						1	340		95	95		68	
M	13	6/1/69	6	027R							360		100	98		68	
M	13	6/3/69		061R							348			78		68	
M	13	6/6/69	46	034L						30						68	
M	13	6/6/69	39	091R						10				104		68	
M	13	6/6/69	35	019R						10				122		68	
M	13	6/6/69	48	017R							348			106		68	
M	13	6/7/69	44	018L						10	358		119			68	
M	13	6/12/70		044L	1230	69	745	792	70	50	361		140	142	127	69	
M	13	6/12/70		510R 071L	1365	65	785	810	75	5	379					69	
M	13	6/12/70		512R 070L	1390	75	740	830	80	15	375		167	181	230	69	
M	13	6/13/70		515R 066L	1270	55	735	810	70	60	363		91	81	250	69	
M	13	6/13/70		516R 065L	1300	60	770	800	70	60	380		175	170	242	69	
M	13	6/14/70		521R 074L	1280	75	700	800	65	50	357		134	132	162	69	
M	13	6/16/70		025R 527L	1320	55	740	790	70	70	350		95	90	100	69	
M	13	6/16/70		530R	1280	60	745	830	78	75	355		145	140	192	69	
M	13	6/18/70		540L	1345	60	715	860	-	40	367		200	199	270	69	
M	13	6/19/70			1125	50	695	735	65	90	333		110	115	175	69	Dead

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
M	13	6/19/70		562R	1330	70	690	830	46	95	354		152	145	200	69	
M	13	6/20/70		566R	1250	65	695	730	65	95	350		140	136	185	69	
M	13	6/20/70		565L	1280	70	670	790	75	55	355		139	143	215	69	
M	13	6/20/70		570	1290	80	780	780	71	25	360		152	156	206	69	
M	13	6/21/71	-	734L	1285	72	780	850	75	85	358	-	138	138	180	70	Lamb Seg. 82mm
M	13	6/21/71	-	702L												70	Blood sample only.
M	13	-	-	726L													Blood sample only.
M	13	6/7/71	-	647L												70	Blood sample only.
M	13	6/6/71	-	642L	1270	75	772	865	49	1	362	-	97	95	142	70	
M	13	6/6/71	-	643L	1200	60	798	800	52	1	344	-	37	41	102	70	
M	13	6/9/71	128	630L	1330	77	735	862	62	5	347	-	103	104	145	70	
M	13	6/11/71	-	691L	1335	47	752	810	56	30	355	-	67	66	112	70	Lamb Seg. 30mm
M	13	6/15/71	-	635L	1300	63	695	810	62	20	360	-	110	100	160	70	Lamb Seg. 50mm
M	13	6/15/71	-	640L	1370	60	748	815	64	35	362	-	140	129	200	70	Lamb Seg. 80mm
M	13	6/27/71	-	728L								-				70	Blood & pellet samples only.
F	13	6/4/69	56	057R							389		88			68	
F	13	6/6/69		033						10	334	N	23			68	
F	13	6/6/69		082R							338	N		61		68	
F	13	6/12/70		501 046	1252	60	775	820	70	50	340	N	89	95	102	69	
F	13	6/13/70		518 049	1180	50	642	710	60	60	333	N	42	42	70	69	
F	13	6/16/70		068	1210	55	635	740	60		330	N	23	22	70	69	
F	13	6/19/70		545	1315	65	705	790	70	40	348	N	45			69	
F	13	6/20/70		578	1340	60	740	805	75	90	350	N		90		69	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	13	6/20/70		573	1115	60	655	720	50	30	315	N	26	28	65	69	
F	13	6/20/70		574	1220	55	655	740	58	10	325	N	43	73		69	
F	13	6/2//70		589	1290	60	665	750	67	40	346	N	115	108	132	69	
F	13	6/7/71	–	666L												70	Blood sample only.
F	13	6/3/71	–	626L	1215	75	747	820	51	0	325	N	40	25	75	70	Art Mtn.
F	13	6/17/71	–	671L	1309	59	794	795	51	10	328	N	30	57	70	70	
F	13	6/17/71	–	674L	1295	74	799	823	63	70	355	N	91	94	82	70	
F	13	6/19/71	–	744L	1310	64	750	780	64	15	340	N	35	41	85	70	
F	13	6/19/71	–	710L													Blood sample only.
F	13	6/23/71	–	822	1325	68	780	830	66	50	363	N	70	60	110	70	For zoo.
F	13	6/23/71	–	823												70	Blood sample only, for zoo.
F	13	6/28/71	–	824	1260	63	735	820	–	40	355	N	40	44	88	70	For zoo.
F	13	6/28/71	–	825	1190	55	750	760	–	5	335	N	30	38	84	70	For zoo.
M	24	5/31/69	10	100L						1	375		195	200		67	
M	24	5/31/69	8	98							375		270	265		67	
M	24	5/31/69	9	97R							400		297	292		67	
M	24	6/1/69	1	089L						10	390		279	278		67	
M	24	6/2/69	15	087R						15	402		276			67	
M	24	6/4/69	18	058L							382		177			67	
M	24	6/5/69	36	032L						20	398		247	242		67	
M	24	6/5/69	34	029L						5	376			211		67	
M	24	6/12/70	59	042L	1400	65	875	880	100	50	400		335	355	434	68	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
M	24	6/12/70	G3	048L 508R	1400	80	790	970		-5*	395		405	400	440	68	
M	24	6/13/70	81	040L	1390	65	780	870	95	75	390		282	286	370	68	
M	24	6/19/70	G5	551L	1380	55	752	840	80	60	387		275	282	350	68	
M	24	6/19/70	61	548L	1510	75	775	940	100	10	400		299	300	380	68	
M	25	6/20/70		579L	1340	70	728	845	100	40	375		262	242	331	68	
M	25	6/20/70		580R	1305	80	770	840	90	95	379		280	296	355	68	
M	25	6/20/70		581R	1490	60	770	910	115	95	394		339	336	384	68	
M	25	6/20/70		583R	1460	75	792	960	95	30	392		266	313	389	68	
M	25	6/20/70	87	575L	1380	65	770	870	100	75	386		324	335	418	68	
M	25	6/20/70	85	576R	1530	75	820	980	118	50	405		390	390	470	68	
M	25	6/21/70		590L	1490	90	735	870	107	80	385		383	390	485	68	
M	24	6/10/71	143	617L	1590	85	946	995	104	30	388	-	352	341	460	69	
M	24	6/9/71	126	619L	1583	70	885	975	86	10	405	-	354	355	416	69	
M	24	6/9/71	127	615L	1510	75	942	1040	102	2	402	-	315	389	403	69	Open sore rt. jaw, left clean.
M	24	6/11/71	158	700L	1550	80	839	990	89	5	380	-	293	303	381	69	
M	24	6/11/71	156	683L	1490	55	878	1010	96	15	400	-	290	285	405	69	Brown hair on tip of tail.
M	24	6/14/71	149	692L	1565	58	818	970	94	5	410	-	285	279	382	69	
M	24	6/17/71	165	632L	1550	88	895	940	94	25	397	-	269	263	326	69	
M	24	6/16/71	144	530R	1582	101	910	965	102	40	352	-	303	298	398	69	Recapture from 1970.
M	24	6/16/71	159	673L	1500	72	905	995	106	25	390	-	370	361	427	69	Brown hair on tip of tail.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
M	24	6/18/71	176	741L	1620	67	890	940	99	20	395	-	305	295	370	69	
M	25	6/20/71	184	715L	1450	80	854	980	100	30	395	-	324	332	440	69	
M	25	6/27/71	195													69	
M	24	6/7/71	118	624L	1595	97	890	1000	99	1	395	-	283	254	348	69	
M	24	6/7/71	116	661L	1575	72	928	1005	94	1	403	-	303	302	425	69	
M	24	6/6/71	108	641L	1510	87	892	1030	109	0	404	-	255	252	380	69	
M	24	6/7/71	107	645L	1530	82	874	925	83	0	370	-	267	222	288	69	
M	24	6/5/71	104	629L	1370	85	862	975	86	0	380	-	246	240	356	69	
M	24	6/4/71	105	628L	1390	80	842	985	94	0	382	-	337	357	430	69	
M	24	6/10/71	157	684L	1460	66	880	970	94	10	402	-	292	298	411	69	
M	24	6/10/71	153	687L	1490	78	806	952	87	5	393	-	244	224	310	69	
M	24	6/10/71	152	681L	1610	80	864	950	91	10	390	-	285	285	354	69	
F	25	6/23/68	24	008L 007R												66	
F	25	6/23/68	22													66	
F	25	6/23/68	26									Y				66	
F	24	5/30/69	7	028L						1	375	N	150	140		67	
F	24	5/31/69	5	026							360		125			67	
F	24	6/2/69	12	095R						10			114	115		67	
F	24	6/3/69	19	077L							360			122		67	
F	24	6/3/69	57	081L							376		121			67	
F	24	6/6/69	51	031						5	357	N	112			67	
F	24	6/13/70	84	514L 092R	1370	75	762	860	75	-5*	360	N	142	134	90	68	
F	24	6/17/70		536R	1370	60	795	850	90	90	365	N	158	135	145	68	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	24	6/18/70	68	538R	1340	75	770	810	70	-5*	365	Y	142	140	140	68	
F	24	6/18/70	72	539R	1420	75	751	840	85	85	376	N	125	150	150	68	
F	24	6/18/70		544L	1455	60	815	880	95	80	375	N	141	170	180	68	
F	24	6/19/70		553L	1450	75	770	870	90	-5*	365	N	147	140	165	68	
F	25	6/20/70		657R	1480	80	771	890	110	40	378	N	165	160	156	68	
F	25	6/20/70		563L	1320	50	770	860	80	-5*	368	Y	130	165		68	
F	25	6/20/70		569L	1410	70	710	860	81	5	367	Y	145	154	170	68	
F	24	6/6/71	112	518	1350	75	785	950	62	0	356	N	105	77	108	69	Recapture
F	24	6/6/71	110	650L	1490	115	865	980	104	0	387	N	135	180	187	69	
F	24	6/3/71	103	627L	1360	80	820	890	80	2	360	N	138	125	180	69	Art Mtn.
F	24	6/10/71	142	620L	1290	70	875	920	85	30	366	N	120	145	115	69	Both jaws moderate swelling.
F	24	6/10/71	145	611L	1450	80	832	905	65	10	370	N	147	149	175	69	
F	24	6/8/71	130	623L	1355	61	870	940	80	0	388	N	157	165	195	69	Both jaws slight swelling.
F	24	6/8/71	122	664L	1375	87	880	900	81	1	362	N	157	166	215	69	
F	24	6/17/71	133	679L	1380	85	850	866	70	35	355	N	100	76	92	69	Slight swelling left jaw.
F	24	6/17/71	166	695L	1335	74	861	845	81	80	360	N	153	150	192	69	Slight swelling right jaw.
F	24	6/18/71	174	737L	1395	85	832	860	73	40	355	N	75	104	122	69	
F	25	6/23/71	191	745L												69	Blood and pellet samples only, two sores left shoulder.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	25	6/23/71	192	703L								Y				69	Blood & pellet samples, only.
F	25	6/23/71	162	731L												69	Blood & pellet samples only.
F	25	6/23/71	190	708L												69	Pellet sample only.
M	36	6/17/70	65	537L 088R	1465	55	818	880	110	30	395		431	435	495	67	
M	36	6/19/70	89	552L	1480	80	870	970	130	90	410		465	468	475	67	
M	36	6/21/70		587R	1560	80	835	960	135	90	401		589	582	510	67	
M	36	6/21/70		585	1450	70	825	980	120	75	443		471	463	534	67	
M	36	6/17/71	160	634L	1570	74	997	1009	112	40	408	-	443	438	432	68	
M	36	6/18/71	171	711L	1415	81	908	980	100	20	400	-	394	413	470	68	
M	37	6/23/71	177	735L													
M	36	6/2/71	101	622R	1320	-	1000	1000	115	2	410	-	465	455	488	68	
M	36	6/6/71	115	648L	1580	95	930	1030	102	3	410	-	395	377	445	68	
M	36	6/10/71	139	696L	1660	80	946	1080	125	3	405	-	462	472	530	68	Moderate swelling right jaw.
M	36	6/10/71	146	618L	1610	75	932	1050	116	10	393	-	480	455	520	68	
M	36	6/2/71	100	621R	1620	150	942	1000	130	25	410	-	600	600	517	68	
M	36	6/14/71	150	682L	1510	82	937	1020	110	5	406	-	532	522	540	68	Slight swelling right jaw.
M	36	6/15/71	151	636L	1665	70	907	1020	125	5	386	-	585	568	-	68	Slight swelling right jaw.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	37	6/24/68	27	012R								Y				65	
F	36	6/6/69	54	035L						10	387	N	176			66	
F	36	6/12/70	G2	036L 511R	1480	60	770	900	90	-5*	368	Y	188	220	250	67	
F	36	6/14/70	88	522L 039R	1445	65	800	920	105	-5*	375	N	211	185	175	67	
F	36	6/15/70	96	067L 523R	1485	70	772	890	85	5	385	Y	140	140	115	67	
F	36	6/17/70	98	534L	1420	55	780	890	82	-5*	375	Y	195	152	175	67	
F	36	6/19/70	92	546L	1420	70	800	900	90	-5*	355	Y	200	205	275	67	
F	36	6/19/70	97	559L	1445	55	740	900	80	-5*	370	Y	180			67	
F	36	6/6/71	113	649L	1380	83	870	925	67	5	386	Y	134	135	160	68	Slight swelling both jaws.
F	36	6/3/71	102	625L	1530	100	910	1010	95	2	385	Y	188	160	177	68	Art Mtn.
F	36	6/10/71	123	614L	1565	70	890	950	93	5	375	N	178	160	180	68	
F	36	6/10/71	125	612L	1545	92	802	950	82	10	385	N	215	185	185	68	Slight swelling right jaw.
F	36	6/10/71	138	569L	1435	85	842	920	84	2	370	N	165	175	190	68	Moderate swelling both jaws, recapture.
F	36	6/8/71	129	668L	1550	65	910	1030	95	0	377	Y	183	181	179	68	Slight swelling both jaws.
F	36	6/17/71	164	697L	1375	72	878	972	82	10	361	N	160	163	172	68	
F	36	6/18/71	175	750L	1535	94	852	910	95	40	372	N	175	142	107	68	
F	36	6/19/71	136	729L	1450	74	870	1020	93	5	373	Y	165	145	183	68	
F	36	6/19/71	189	748L	1480	80	862	940	97	75	391	N	205	207	170	68	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	36	6/19/71	187	707L	1420	78	894	990	94	0	395	Y	170	200	185	68	
F	37	6/27/71	210	053												68	Recapture.
F	37	6/22/71	178	544L	1445	68	910	920	103	95	380	N	183	212	210	68	
F	37	6/24/71	204	712L												68	
F	37	6/23/71	188	730L	1440	73	890	990	-	10	382	Y	178	222	177	68	
M	48	6/2/69	4	025R						5	421			494		67	
M	48	6/19/70	83	550R	1460	75	880	1000	145	40	402		578	590	535	66	
M	48	6/10/71	124	613L	1755	106	900	1110	132	5	410	-	542	542	530	67	
M	48	6/17/71	161	676L	1625	92	982	1045	125	30	409	-	608	605	552	67	
M	48	6/18/71	135	680L	1525	86	940	945	110	60	392	-	486	487	571	67	Slight swelling right jaw, open sore left shoulder.
M	48	6/27/71	193													67	
F	48	6/12/70	G4	045L 502R	1420	75	772	930	95	-5*	368	Y	209	210	250	66	
F	48	6/17/70	78	531L	1380	75	850	920	115	40	370	Y	187	190		66	See photo.
F	48	6/7/71	119	662L	1570	60	884	965	97	2	390	N	165	210	257	67	
F	48	6/6/71	120	644L	1460	93	845	927	67	2	382	N	217	213	264	67	
F	48	6/10/71	140	693L	1490	90	830	980	80	4	387	N	212	220	231	67	Recapture #12.
F	48	6/14/71	147	619L	1570	95	810	950	94	20	370	N	196	192	152	67	
F	48	6/14/71	155	685L	1510	53	890	950	84	3	384	N	193	182	183	67	Slight swelling both jaws.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	48	6/19/71	186	746L	1395	65	842	940	87	0	375	Y	215	203	212	67	Slight swelling both jaws.
F	48	6/21/71	179	546L													Recapture #92
M	60	6/28/68	28										640	410		63	
M	60	6/5/69	47	030L						5	402		456			64	
M	60	6/6/69	37	055R						20	411		609			64	Hunter kill 1970.
F	60	6/2/69	3	024L						5	360	Y	227	238		64	
F	60	6/2/69	30	023R						15	404	N	234	231		64	
F	*	6/3/69	43	062L							381	N	193	192			Annuli not clear 3, 4, or 5 yrs. old
F	60	6/6/69	41	079L						5		N				64	
F	60	6/6/69	16	021R						10		N				64	
F	60	6/17/70	58	532L	1460	60	795	920	105	-5*	370	Y	210	213	192	65	
F	60	6/18/70	70	541L	1400	60	810	910	100	-5*	375	Y	236	229	266	65	
F	60	6/19/70	79	561R	1475	60	770	900	105	80	366	Y	210	211	213	65	
F	60	6/6/71	109	667L	1630	70	902	1020	100	5	385	Y	210	223	223	66	
M	72	6/2/69	13	078L							460			668		63	
M	72	6/2/69	11	084R							403			697		63	
M	72	6/2/69	29	094R						10	414			668		63	
M	72	6/5/69	45	083L						10	413		617			63	
M	72	6/5/69	44	064L						5	396		731			63	Dead
M	72	6/5/69	40	052R						5	400		782			63	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	72	6/2/69	14	086L							400	Y	211	210		63	
F	72	6/3/69	32							15-20	370	N	259			63	
F	72	6/4/69	20	056L							391		205			63	
F	72	6/6/69	31	011L						5		Y				63	
F	72	6/6/69	38	080R						10		Y				63	
F	72	6/12/70	G6	043L 505R	1525	75	870	960	110	-5*	380	Y	294	326	314	64	
F	72	6/14/70	86	050L 519R	1535	85	789	940	115	-5*	390	Y	225	234		64	
F	72	6/17/70	82	528L	1465	50	815	885	105	-5*	385	Y	215	215	225	64	
F	72	6/18/70	69	542L	1570	70	830	935	120	30	372	Y	215	215	175	64	
F	72	6/18/70	67	543L	1560	60	800	900	100	5	370	Y	199	170	140	64	
F	72	6/19/70	66	547L	1535	65	820	940	101	10	365	Y	240	230	212	64	
F	72	6/19/70	63	560R	1485	50	790	970	115	-5*	380	Y	273	250	395	64	
F	72	6/19/70	75	557L	1405	70	750	850	85	5	343	Y	248	254	190	64	
F	72	6/20/70		564R	1410	65	770	880	95	-5*	360	Y	221	213	155	64	
F	72	6/21/70		586R	1510	80	766	915	111	5	372	Y	217	226	197	64	
F	72	6/11/71	154	699R	1540	55	842	1020	98	2	377	N	236	232	268	65	Major swelling with open sore right jaw. Recapture #70
F	72	6/16/71	163	637L	1460	68	920	925	92	20	365	N	210	203	162	65	Large swelling right jaw, open sore.
F	72	6/18/71	168	727L	1470	82	844	990	94	2	364	Y	227	214	232	65	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	72	6/19/71	169	738L	1490	67	875	990	94	10	374	Y	265	269	260	65	
F	72	6/25/71	-	742L	1520	75	875	920	-	60	380	Y	230	230	202	65	
F	72	6/27/71	208	-												65	
M	84	6/2/69	17	076R						10	394			752		62	Hunter kill 1970.
M	84	6/7/69	55	015R						50	398			731		62	
M	84	6/12/70	G7	037L 504R	1610	75	800	1000	145	30	400		692	694		63	
M	84	6/19/70	99	549L	1680	75	925	1070	185	90	415			816		63	
M	84	6/19/70	93	558R	1635	65	915	1070	150	80	420		735	764	555	63	
M	84	6/20/70	95	582L	1650	80	939	1040	163	99	399		715	702	540	63	
F	84	6/4/69	53	054R							365			208		62	
F	84	6/6/69	52	016L						5		Y				62	
F	84	6/12/70	G1	041L 503R	1520	75	830	915	103	30	367	Y	281	274	195	63	
F	84	6/12/70	G8	047L 506R	1515	77	835	1020	100	5	376	Y	255	256	342	63	
F	84	6/13/70	60	038L 513R	1560	70	812	940	110	50	382	Y	249	228	307	63	
F	84	6/16/70	64	529L	1565	65	830	935	115	10	370	Y	275	232	335	63	
F	84	6/16/70	76	525L 069R	1420	70	830	950	129	-5*	380	N	272	258	165	63	
F	84	6/17/70	62	535L	1460	55	845	940		50	380	Y	201	194	212	63	

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	84	6/20/70		571R	1430	70	820	820	106	-5*	365	Y	227	221	307	63	
F	84	6/23/71	181	739L	1565	65	870	990	-	10	383	Y	207	211	255	64	Large swelling left jaw.
F	84	6/14/71	148	689L	1610	62	912	970	110	10	378	Y	272	221	256	64	
F	84	6/15/71	-	690L	1510	57	900	1000	90	5	410	N	207	226	262	64	Fbks. - Massive swelling both jaws, infection by teat.
F	84	6/16/71	141	639L	1430	67	875	990	91	20	366	Y	268	274	267	64	Jaw clean.
F	84	6/18/71	172	716L	1490	60	852	980	87	0	373	Y	260	230	347	64	Brown secretion from vagina.
M	96	6/7/69	42	020R						20	403			822		61	
M	96	6/19/70	91	554L	1557	80	930	940	140	95	400		678	692	635	62	Hunter kill 1970.
M	96	6/18/71	167	631L	1580	78	985	1109	137	15	398	N	769	767	698	63	Slight swelling left jaw.
M	96	6/18/71	170	672L	1570	77	981	1035	124	25	409	N	636	665	585	63	Slight swelling right jaw.
F	96	6/16/70	80	072L 542R	1530	70	875	1005	125	25	380	N	265	257	242	62	
F	96	6/14/70	74	526L 073R	1470	70	850	920	95	-5*	360	Y	244	210	180	62	
F	96	6/23/71	194													63	Recapture #G8.
F	96	6/6/71	106	646L	1560	83	903	1000	79	1	379	Y	248	215	191	63	Mod. swelling.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year Class	Remarks
F	96	6/7/71	117	665L	1565	77	860	1010	97	2	378	N	280	248	205	63	Lump and open sore on left jaw - photo.
F	96	6/7/71	114	669L	1505	78	848	1040	97	0	379	N	240	250	216	63	Jaw clean.
F	96	6/15/71	-	633L	1493	-	850	1020	90	0	380	Y	238	247	225	63	Trapped for Fbks. but injured self and was killed 6/17/71, skeleton saved.
F	96	6/17/71	131	675L	1515	75	827	913	98	20	357	Y	52	151	157	63	Mod. swelling left jaw.
M	108	6/21/70		600L	1788	100	925	1100	184	70	416		915	892	624	61	
F	108	6/3/69	50	063L						10		N	206	259		60	
F	108	6/3/69	33	059						10		Y		275		60	
F	108	6/14/70	94	013L 520R	1470	70	755	970	105	-5*	370	Y	310	323	398	61	
F	108	6/17/70	90	533L	1550	60	845	950	120	60	375	Y	239	249	145	61	
F	108	6/20/70		572L	1500	75	810	961	120	30	367	Y	255	246	298	61	
F	108	6/20/70		568R	1450	70	815	940	120	15	383	Y	273	275	342	61	
F	108	6/8/71	121	524R	1680	75	872	1070	110	0	392	Y	-	-	-	62	Recapture #80.
F	108	6/14/71	137	694L	1685	70	848	1010	-	0	390	Y	215	212	210	62	
F	108	6/17/71	132	638L	1485	74	925	1004	100	35	377	Y	291	285	204	62	Jaw clean.

Appendix I, Part 1 (Continued).

Sex	Age	Capture date	Collar number	Ear tag number	Total contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	% coat shed	Hind foot length (mm)	Lactating	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)	Year class	Remarks
F	108	6/19/71	185	743L	1610	70	837	1050	97	0	400	Y	310	290	250	62	**Lamb captured.**
F	108	6/27/71	207													62	
F	108	6/27/71	202													62	
F	108	6/21/71	180	716L								Y				62	**Blood sample only.**
M	120	6/18/71	134	678L	1655	101	1000	1125	153	10	395	-	875	805	540	61	
F	120	6/20/70		571L	1540	60	810	960	120	-5*	370	Y	248	250	217	60	**Dead.**
F	120	6/21/70	71	584L	1559	80	839	1010	125	5	372	Y	229	199	256	60	
F	120	6/22/71	182	714L	1610	65	815	1040	114	0	380	Y	240	250	225	61	
F	132	6/19/70	77	556L	1555	75	793	940	118	-5*	365	Y	275	264	282		
F	132	6/7/71	111	584L	1510	86	838	910	110	2	392	N	232	200	257	60	Yearling w/ewe, Recapture #71.
F	132	6/18/71	173	749L	1505	54	870	1020	100	0	378	N	236	262	255	60	Mod. swelling right jaw.
F	144+	6/23/70		591L	1530	80	800	935	123	30	381	N	223	239	272	57	
F	144+	6/1/69	2	090L							370	N	281	288		56	

-* Indicates less than.

Appendix I, Part 2. Sex, age and measurements of Dall sheep collected from Crescent Mountain, Kenai Peninsula from January to April, 1971.

Sex	Age	Collection date	Accession number	Contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	Hind foot length (mm)	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)
M	5	11/13/70	62077	1120	70	700	760	65	330	634	634	-
M	5	11/13/70	62080	1110	60	730	830	74	340	760	710	-
M	5	11/13/70	62083	1060	60	720	860	60	330	530	510	-
M	7	1/14/71	62086	1060	50	710	830	66	325	520	540	-
M	9	2/18/71	62096	1090	50	660	730	44	320	-	-	-
M	11	4/21/71	62117	1110	80	680	730	50	330	-	-	-
F	7	1/14/71	62085	1150	50	700	870	61	330	67	62	-
F	9	3/18/71	62101	1140	80	590	800	55	320	-	-	-
F	11	4/27/71	62123	1010	70	600	670	34	300	-	-	-
F	11	4/27/71	62120	1010	60	620	680	34	300	-	-	-
M	19	1/14/71	62091	1330	110	780	1000	94	385	200	200	-
M	19	1/14/71	62087	1400	110	830	1070	103	400	310	315	-
M	21	2/26/71	62104	1400	70	890	950	99	390	-	-	-
M	21	3/18/71	62106	1230	70	770	850	71	360	-	-	-
M	21	3/18/71	62109	1270	80	680	810	69	365	-	-	-
M	23	4/27/71	62124	1200	80	710	810	59	350	-	-	-
M	23	4/27/71	62121	1240	90	800	840	75	380	-	-	-
F	21	2/26/71	62099	1270	90	810	880	87	370	-	-	-
F	21	2/26/71	62095	1320	80	820	880	83	360	-	-	-
F	21	3/18/71	62107	1280	60	770	910	89	360	-	-	-
F	21	3/18/71	62102	1270	80	710	870	71	360	-	-	-

Appendix I, Part 2 (Continued).

Sex	Age	Collection date	Accession number	Contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	Hind foot length (mm)	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)
M	33	2/26/71	62094	1420	70	820	960	103	390	-	-	-
F	29	11/13/70	62082	1140	70	760	910	91	350	110	120	-
F	29	11/13/70	62081	1410	90	790	1010	122	370	190	220	181
F	33	2/26/71	62100	1400	80	860	990	110	370	-	-	-
F	33	2/26/71	62103	1590	100	950	1120	152	400	-	-	-
F	41	11/13/70	62078	1440	100	860	1040	129	380	199	-	-
F	41	1/14/71	62088	1550	95	840	1040	111	385	-	-	-
F	45	3/18/71	62108	1420	90	830	950	103	360	-	-	-
F	59	4/27/71	62125	1440	100	860	930	101	370	-	-	-
F	59	4/27/71	62119	1370	120	850	890	99	370	-	-	-
F	69	2/26/71	62100	1460	100	890	1010	121	380	-	-	-
F	69	3/18/71	62112	1480	90	880	980	121	380	-	-	-
F	71	4/27/71	62113	1380	100	900	950	114	370	-	-	-
F	77	11/13/70	62076	1440	70	750	1040	120	360	-	-	-
F	79	1/14/71	62090	1450	60	890	1090	123	370	230	205	175
F	81	2/26/71	62105	1380	100	910	990	110	370	-	-	-
F	84	3/18/71	62098	1400	90	860	930	99	370	-	-	-
F	101	11/13/70	62079	1410	90	880	108	139	370	-	-	-
F	103	1/14/71	62092	1450	70	870	1020	102	370	-	-	-
F	117	2/26/71	62099	1450	80	880	1000	118	350	-	-	-
F	117	3/18/71	62093	1410	70	850	970	119	380	-	-	-

Appendix I, Part 2 (Continued).

Sex	Age	Collection date	Accession number	Contour length (mm)	Tail length (mm)	Shoulder height (mm)	Chest girth (mm)	Weight (lbs.)	Hind foot length (mm)	Left horn length (mm)	Right horn length (mm)	Horn spread (mm)
F	129	3/18/71	62084	1440	110	850	950	108	380	-	-	-
F	131	4/27/71	62116	1470	120	860	950	127	370	-	-	-
F	165	2/26/71	62089	1450	70	870	990	123	380	-	-	-
F	167	4/27/71	62118	1500	110	900	970	114	380	-	-	-

Appendix II. Preliminary Report, An Electrophoretic Examination of Serum Transferrin and Lactate Dehydrogenase of Dall Sheep (*Ovis dalli*), by Peter D. Shaughnessy, Institute of Arctic Biology, University of Alaska.

Blood samples were taken from 109 live Dall sheep at Dry Creek, Alaska Range in June and July 1971. Serum was removed from the clotted blood and stored frozen in liquid nitrogen. The material was collected by Alaska Department of Fish and Game personnel Tony Smith and Dave Harkness.

Methods

Serum samples were examined by acrylamide gel electrophoresis in an EC Apparatus Co. Standard Vertical Gel Cell (EC 470). For the examination of transferrins, a gel buffer system similar to that of Kristjansson and Hickman (1965) was used. It consisted of 0.0162 M tris and 0.0136 M cacodylic acid, pH 7.6. The electrode solution consisted of 0.8 gm/l lithuim hydroxide and 11.8 gm/l boric acid, pH 7.5. Each slot was loaded with 3 ml of serum diluted 1:4 with 20 percent sucrose. Gels were run for two hours with 300 volts across the gel cell, and then stained with amido black (a general protein stain).

For the examination of lactate dehydrogenase (LDH) activity, the buffer system of Fine and Costello (1963) was used. Each slot was loaded with 3 ml of serum diluted 1:1 with 20 per cent sucrose solution. Gels were run for four hours with about 200 volts across the gel cell, and then incubated at 37°C in a mixture of substrate, cofactors and dye coupler (see Fine and Costello, 1963) for an hour.

A total of 20 gels were run, 10 each for transferrin and LDH. Gels are stored in plastic bags in a refrigerator and have been photographed.

Results and Discussion

No variation in the mobility of transferrin was observed in the 109 Dall sheep. It should be pointed out that at this stage these are the putative transferrins; identification using autoradiographic techniques with radioactive iron has not been done as yet. In each animal, transferrin appears as a major zone with a faster migrating minor zone. This is a similar type of pattern to that found in domestic sheep *Ovis aries* (Ashton and Ferguson, 1963).

No variation in the mobility of these LDH zones was observed. In most animals three zones can be observed migrating towards the anode, while in a few in which these zones are more heavily stained, a fourth slower migrating zone is also visible. In those species in which skeletal and heart muscle have been examined by electrophoresis, a total of five LDH zones are detectable, but fewer than five are seen in serum. If LDH variation in these Dall sheep was present, it would not have been missed by examining serum, because an alteration in the mobility of one of the

LDH zones of an animal causes an alteration in the mobility of several of its LDH zones.

Conclusions

The lack of variation in two serum protein markers in the 109 Dall sheep from Dry Creek, Alaska Range suggests that they are from one interbreeding population. A similar examination of Dall sheep material from areas that are isolated from this portion of the Alaska Range may reveal polymorphic protein systems in which phenotypic frequencies provide information on population structure.

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Appendix III. A report on the sheep study at the Dietrich River Headwaters, Spencer Linderman, Investigator

ABSTRACT

Distribution, movement patterns and productivity of Dall sheep (*Ovis dalli*) were studied at the headwaters of the Dietrich River in the summer of 1971. Approximately 300 sheep occupy the alpine habitat within six miles of the Dietrich River from Dietrich oil camp to the Chandalar Shelf and Atigun Pass. Most sheep winter and lamb on the slopes adjacent to the Dietrich River. Movements to summer ranges and mineral licks generally take sheep away from the main drainage. Dall sheep do cross the Dietrich River during these movements. Six mineral licks were located in the study area. Use patterns and disturbance factors are discussed. Lambing began before May 19 and continued to at least June 9. Lamb:ewe ratio of 32:100 for 1971 compares with 37:100 for July, 1970. The effects of low altitude aircraft traffic on sheep distribution are discussed. Recommendations concerning pipeline construction are given and the occurrence of other wildlife in the study area is briefly listed.

BACKGROUND

In order to assess the probable impact of the proposed Alyeska oil pipeline and its construction on Dall sheep in the Brooks Range, information on distribution and abundance, movement patterns, winter and summer ranges, mineral lick locations, mineral lick use patterns and lambing areas were needed.

In July, 1970 the Department conducted a survey of Dall sheep distribution and abundance along the pipeline corridor through the Brooks Range. Approximately 2000 sheep were found within 10 miles of the proposed route. Mineral licks within the survey area were located. A lamb:ewe ratio was also obtained.

In May, 1971 a study of sheep at the headwaters of the Dietrich River was undertaken by Spencer Linderman, Game Biologist I, temporary.

OBJECTIVES

To determine Dall sheep distribution and movement patterns.

To determine mineral lick location and use patterns.

To determine lambing areas and basic productivity for 1971.

TECHNIQUES

Description of the Study Area

The study area (Fig. 1) was the upper Dietrich River and Atigun Pass area on the south slope of the Brooks Range. The area north of Kuyuktuvuk Creek on the Dietrich River and south of Atigun Pass received most of the ground study.

Distribution and Movement Patterns

Between May 19 and August 12, seven aerial surveys were made to plot numbers and distribution of sheep in the study area. Fixed wing aircraft (PA-18, 150 Supercub) and helicopters (Bell Jet Ranger 205 and Hiller FH 1100) were used. Survey routes were plotted on 1:250,000 scale maps. Sex and age classifications of observed sheep were noted on standard forms keyed to the survey map by number.

Sheep movements at the headwaters of the Dietrich River were observed from the ground May 24 to July 6 and August 14 to August 31, 1971.

Mineral Licks

Possible mineral lick locations were plotted during aerial surveys and later confirmed by ground observations. Other mineral licks were located during ground study. Observations revealed routes of travel to and from several licks and the approximate numbers of sheep using these licks. The relative importance of several licks was estimated by lick size, trail systems, the number of sheep using the licks and the degree of influence a lick exerted on daily summer movement patterns.

Lambing Areas and Productivity

Observations of sheep actually lambing are difficult to procure. First sightings of lambs and their increasing abundance in specific locations were taken as evidence of lambing times and lambing areas. Whenever possible, exact numbers of ewes, yearlings, young rams, and lambs within a band of sheep were noted. The lamb:ewe ratio was calculated.

Effect of Low Altitude Aircraft Flights

Observations of sheep bands and their reactions to low flying aircraft were noted incidental to the above study during ground observations.

FINDINGS

Distribution and Movement Patterns

A partial picture of seasonal movements in the Dietrich River Valley was obtained by comparing distribution patterns of spring aerial surveys

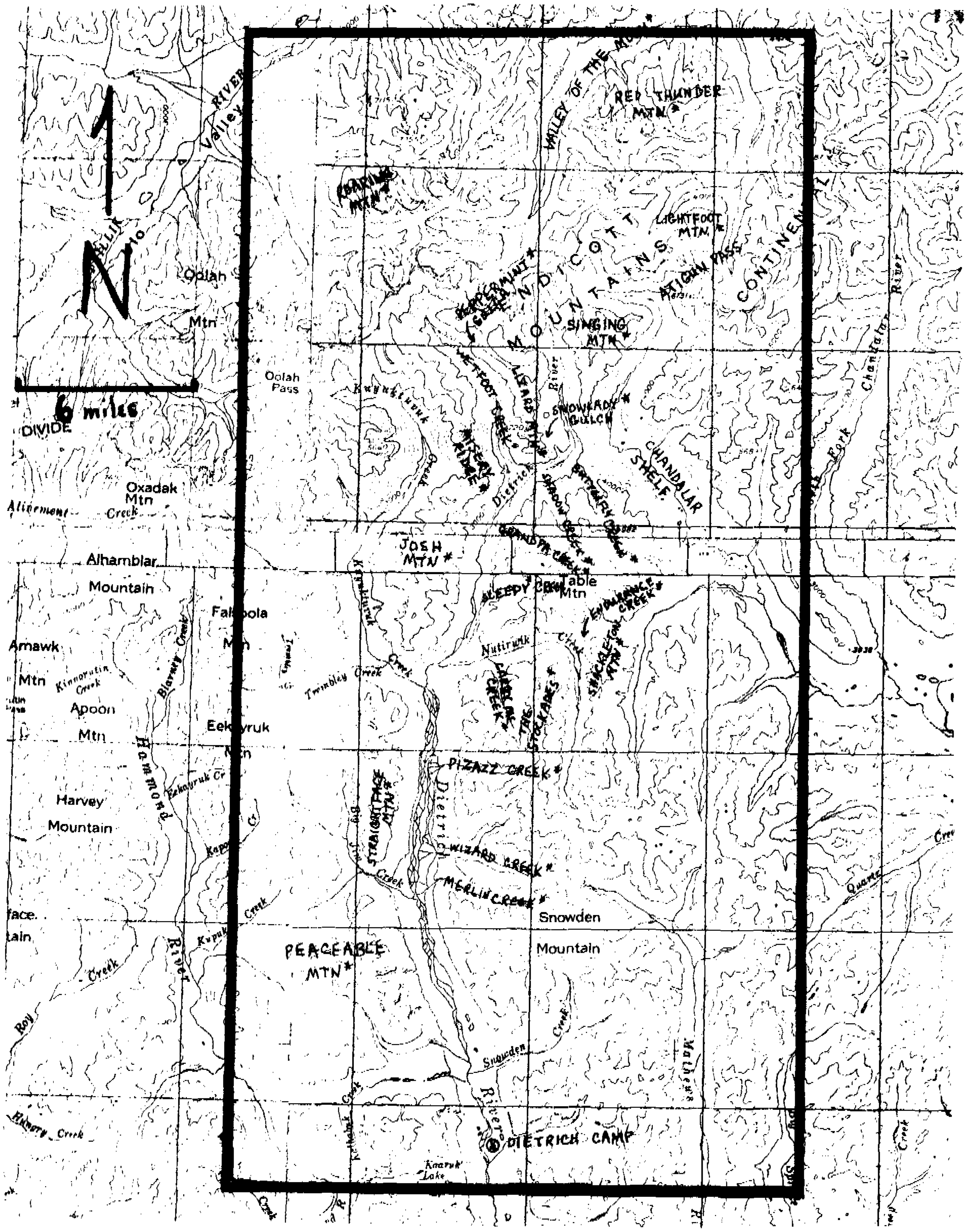

Fig. 1. Dietrich River - Atigun Pass study areas. (*Place name listed only on this map).

(May 19 and June 5) with later summer aerial surveys (July 22 and August 12) (Fig. 2).

During the spring surveys sheep were found low in the alpine habitat adjacent to the Dietrich River. Spring distribution pattern here closely paralleled spring distribution patterns in the Dry Creek study area during the same period in the Alaska Range (Smith, 1971). In Dry Creek most wintering areas are found adjacent to the main drainages and away from the tributary creeks. Wind, snow depth and vegetation patterns are factors which probably affect this distribution.

During the late summer surveys sheep were higher on the slopes, near the headwaters of the Dietrich River and at the heads of the tributary creeks. Ground observations revealed sheep had vacated lambing areas #1, #2 and #3 (Fig. 3) by June 18. Ground observations further indicated that movements away from the wintering and lambing areas occurred in several patterns. Some sheep moved parallel to the Dietrich River slowly working toward the headwaters, but nearly all sheep moved away from the Dietrich River to the headwaters of the tributary creeks. Circumstantial evidence revealed that several groups of sheep moved across the Dietrich River (Fig. 4) and then toward its headwaters or to the headwaters of the tributary creeks. One area, the west side of Snowden Mountain, supported sheep throughout the study period. In this area sheep were often found further away from the Dietrich River after lambing though still within lambing areas #4 and #5 (Fig. 3). Mineral licks in this area (Fig. 4) may have served to hold this resident population.

The distribution of all sheep from June 15 to August 12 appeared to be influenced by mineral licks (Fig. 4) since during this period most sheep could be found in or near licks (Fig. 2). For example, during a three-day period of observation of lick #4, 92 of 128 sheep in the area used the lick on a daily basis, ranging only two miles north or east from the lick for forage and rest. In Dry Creek on the north slope of the Alaska Range sheep are found in the area of natural mineral licks from early June through early August, and in traveling to these mineral licks sheep regularly cross valleys and often pass through timbered areas (Smith, 1971). Circumstantial evidence indicates that sheep wintering on the west and perhaps the east side of the Dietrich River cross the river in the course of utilizing mineral licks. No mineral licks have been located on the west side of the Dietrich River below Kuyuktuvuk Creek. Locations of observed crossings and probable crossings are plotted in Fig. 4.

Information on the movement patterns from summer range back to rutting and winter ranges was not gathered because the study terminated in late August. At this time sheep were still using summer ranges.

Mineral Licks

Mineral lick names, locations, descriptions and observed use are presented in Appendix I. From the evidence available it appears that

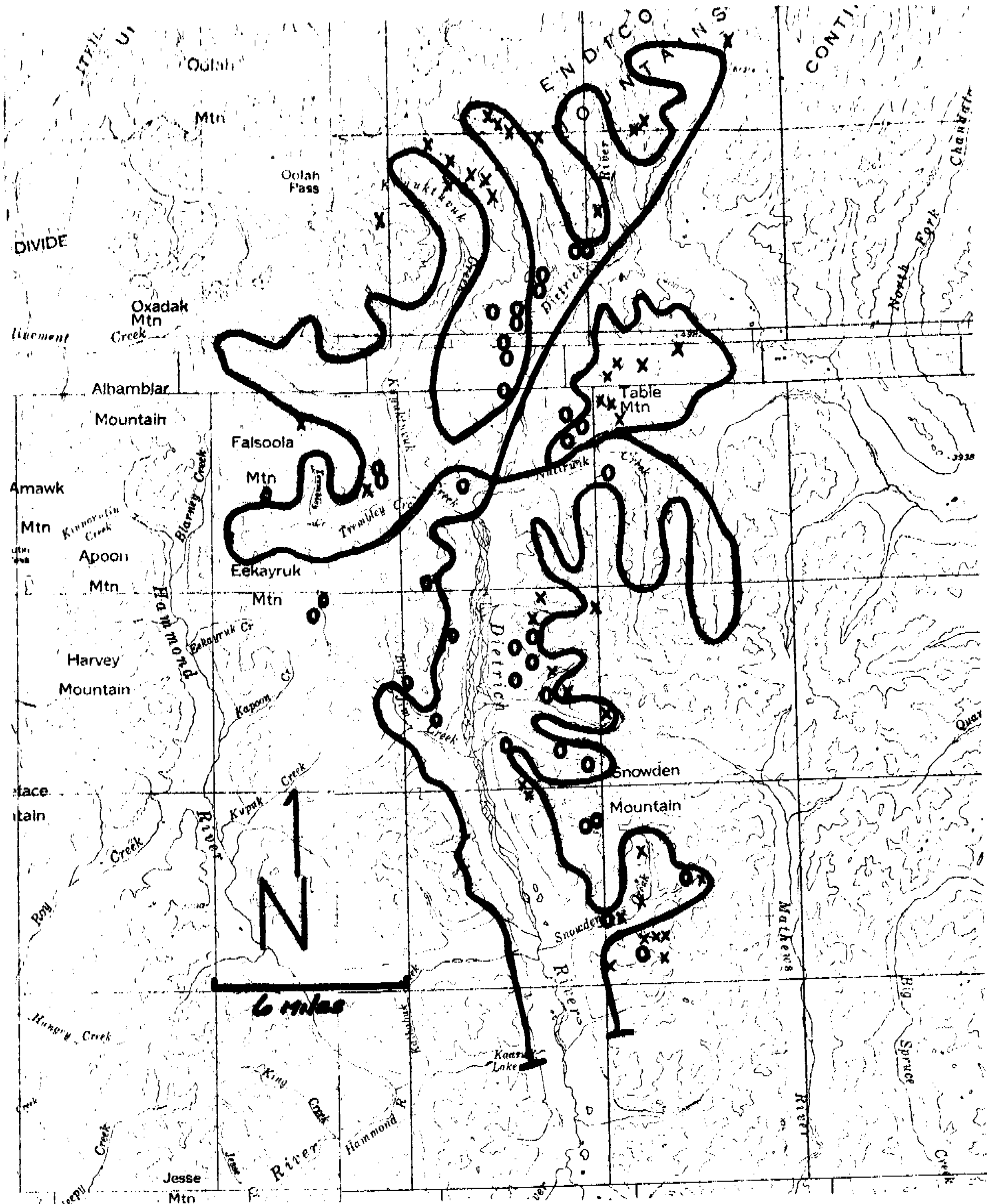

Fig. 2. Distribution of sheep in the Upper Dietrich River. "O" represents a sheep group observed during May 19 or June 5, 1971 surveys. "X" represents a sheep group observed during July 22 or August 12, 1971 surveys. Solid line indicates the general survey route. Not all surveys included the entire route.

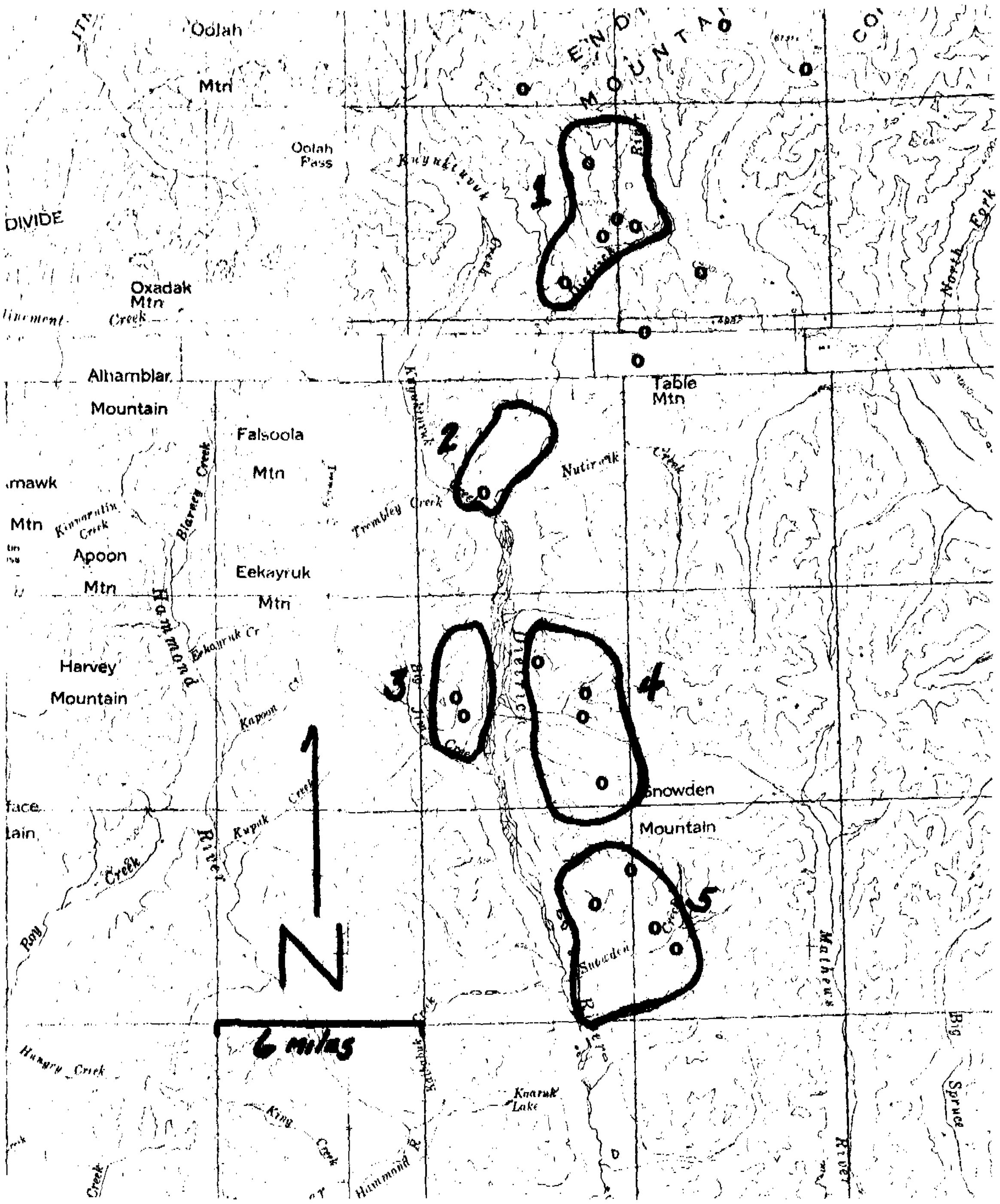

Fig. 3. Several lambing areas along the Upper Dietrich River. Lambing areas outlined. "O" indicates actual sightings of one or more lambs.

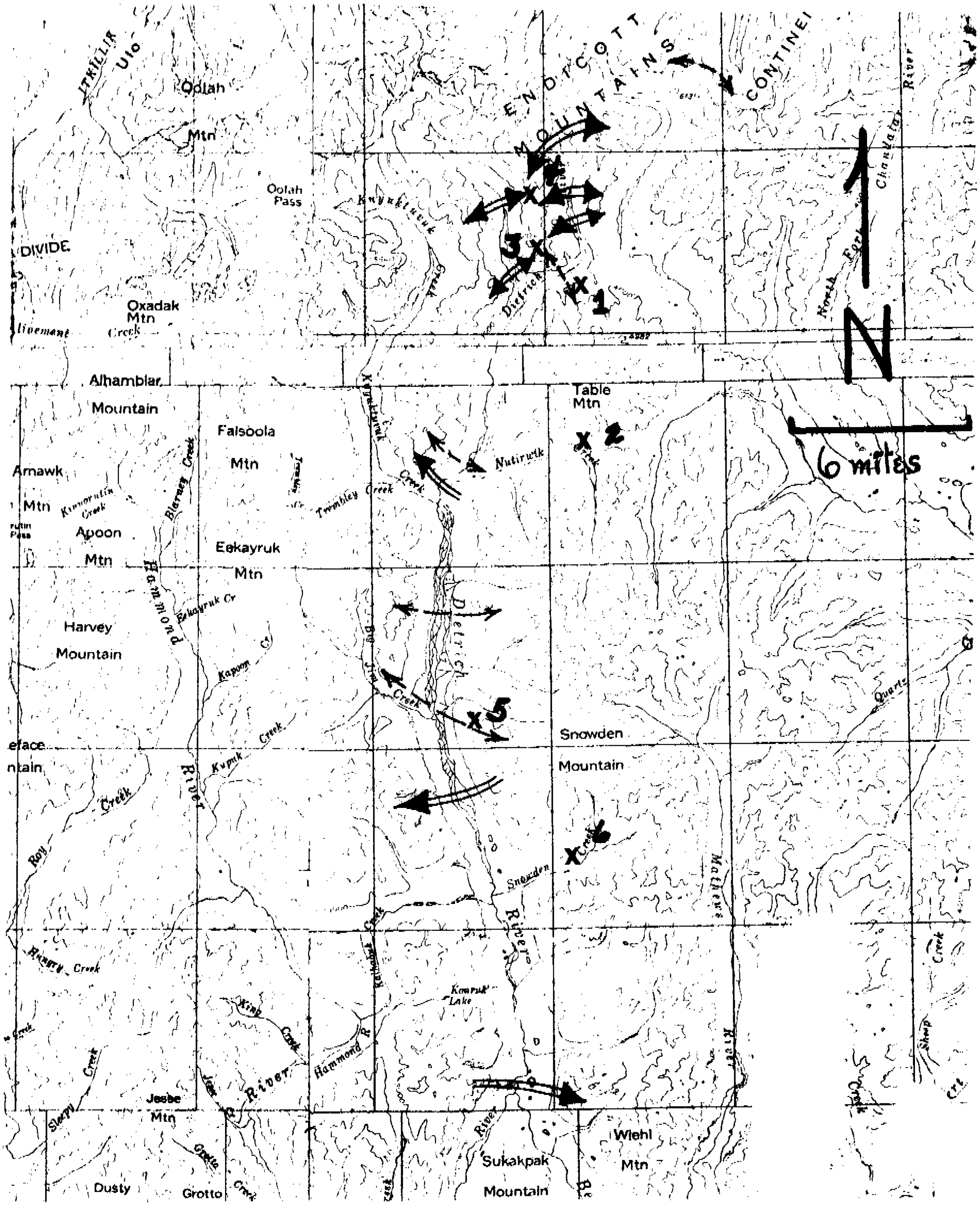

Fig. 4. Sheep crossing routes and known mineral lick locations on the Upper Dietrich River. "⟹" indicates definite crossings determined from tracks. "←–→" indicates suspected crossing points. "X" indicates location of known mineral licks.

licks #4 and #5 are of major importance and along with lick #6 are relatively more important than licks #1, #2 and #3. Licks #1 and #3 deserve further discussion.

Trails in the area of these two licks indicate much greater traditional use than was observed in 1971. Lick #1, particularly, had well-used trails converging on it, one even crossing a small creek. Yet aerial surveys and considerable ground study directed at this lick produced only two observations of sheep near the lick. Sheep were never observed actually using the lick, despite five days of intensive observation at the lick when 10 ewes and five lambs were using summer range on the north slope of Table Mountain above the lick.

This lick was the most vulnerable of the six to disturbance, lying only 600 feet above the river on gentle slopes. A pipeline survey line passed within 30 yards of the lick's center and a red and white survey pole lay a few yards away.

An aerial survey of Table Mountain in July 1970 showed 73 sheep on Table Mountain as compared with 29 in July of 1971.

Considering the traditional seasonal movement patterns of sheep (Geist, 1971) this 60 percent difference in summering populations is notable. The decrease might possibly be explained by mortality, random error, natural movement away from the mountain or abandonment due to disturbance. Unfortunately it is impossible to know what caused this difference since it had occurred before this study was initiated. However, it seems likely to this investigator that human activity at the Dietrich River headwaters may have contributed significantly to the reduction in the summer sheep population in this area.

Since the North Slope oil discovery there has been increased human activity in the Dietrich River along the proposed oil pipeline corridor. Aircraft (single engine, twin engine, and helicopters) passed over the study area an average of four times a day. Three of these flights were low enough to evoke responses from sheep. The communications site on the top of Table Mountain was serviced bi-weekly by helicopter and the sound of the site's generator can be heard more than six miles away. Survey crews have staked the proposed route utilizing helicopter transport and heavy equipment has been operated along the valley bottom.

Considering the close proximity of the proposed route to sheep habitat in this particular area, it is entirely possible human activity has caused the abandonment of Table Mountain and the nearby mineral licks as a summering area. (#1 and #3, Fig. 4).

Lambing

Lambs were first observed on the May 19 aerial survey and must have been only a few days old. The number of lambs in the study area increased to at least 32 by June 10. Three lambs were found in the less studied

Atigun Pass area but may have moved into this area from the north. Calculations from ground and aerial surveys show a lamb:ewe ratio of 32:100 for 1971. This compares with 37:100 ratio for 1970.

Numbers and locations of lambs and probable lambing areas are plotted in Fig. 3. Several of the lambing areas overlap with summer or winter ranges.

Human Disturbance

Effects of low flying aircraft were noted incidental to pursuing the main study objectives when it became apparent there was disturbance occurring even in the absence of full construction activity. An average of more than four aircraft per day consisting of two helicopters and two fixed-wing aircraft passed over the study area. Seventy-five percent of these passed low enough to evoke a response from the sheep.

Sheep always reacted to these low-flying aircraft but the nature of the reaction was unpredictable. Sheep sometimes crowded close together without running or remained apart, but always assumed the alarm posture (Geist, 1971) until the disturbance had passed. They sometimes ran to rocky outcrops nearby, ran wildly down trails, or ran through meadows, bypassing outcrops that appeared to be excellent escape habitat. These reactions occurred in all possible combinations making quantification and relationship to cause nearly impossible to define. However, the type of aircraft, its elevation and horizontal distance from sheep, the wind direction, velocity, and weather are some of the factors which appear to modify the degree of disturbance and reaction. Further research is needed to determine the effects and variation of these variables. Helicopters appeared to elicit more overt reactions than other types of aircraft, probably because of their relatively high noise level and low altitude.

Pilots and personnel involved with the pipeline often reported no reactions from sheep even when approached closely by aircraft. However, the unpredictable nature of aircraft disturbances is illustrated by an observation on August 17.

Five rams and two ewes were feeding in the high meadows of Pizazz Creek. A Wien Airlines twin engine Skyvan passed at an estimated 7000 to 8000 feet and a mile or two east of the sheep. The plane frightened the rams, all of which fled at a full run toward rocky outcrops, and away from the plane. They ran more than one-half mile. The ewes watched the fleeing rams and resumed grazing shortly thereafter.

I have witnessed sheep subjected, in my estimation, to more disturbing situations which did not run. However, close observation of sheep and simultaneous aircraft passage has shown that sheep always appear nervous even though they may not be driven to flight. Therefore, aerial observations of sheep which appear undisturbed should not be considered to demonstrate sheep tolerance of aircraft.

Observations were also recorded of aircraft frightening adult bull moose and grizzly bears.

All the effects of aircraft disturbance on sheep are not known. Certainly, some injuries occur when sheep run in rocky alpine habitat. The effects of seemingly less stressful situations may not be apparent, but is possible that traditional movement patterns may be disrupted to the point of their abandonment. This appears to have been the case to some degree with summer range and mineral licks on Table Mountain and Lizard Mountain.

Other Wildlife in the Study Area

The study area was rich in wildlife species other than Dall sheep.

From observations of and encounters with grizzly bears it is estimated that nine different bears utilized the Upper Dietrich River from May through August.

Wolves were abundant and fresh tracks were regularly seen on the river bars. Four times during the study period wolves were sighted at distances of 100 yards or less. Three times wolves were observed chasing caribou.

Caribou were a daily occurrence in bands as large as 30 from May 24 to June 4. No caribou resided in the study area during the later summer.

Several moose calved along the Upper Dietrich River. Moose became more abundant during the late August study period and were observed from Sukapak Mountain to the middle of the treeless Chandalar Shelf.

Although there were old traces of beaver in several places, the only active lodge discovered was on the east side of the Dietrich River one-half mile downstream from Nutirwik Creek. A large lodge and series of dams is partially obscured by a stand of willow and cottonwood trees. At least two large adult beaver occupy the lodge.

Ptarmigan, hares and red fox were present though not abundant.

Grayling were observed in the Dietrich River headwaters on June 31.

RECOMMENDATIONS

The disturbance of sheep in the Brooks Range by pipeline activity could be kept to a minimum if a route were chosen similar to the proposed route through the Alaska Range, i.e. a wide, deep valley which sheep seldom move across. However, the proposed route follows the Dietrich River and then proceeds north along the Atigun River. If disturbance to sheep is to be kept to a minimum, the following recommendations are offered:

1. It is recommended that construction activity be kept to a minimum on the Upper Dietrich and Atigun Rivers (Dietrich camp-Chandalar Shelf-Upper Atigun River) during the May 15 to June 20 lambing period and that major construction effort take place between June 20 and November 15. The November 15 to December 30 rutting period should also be avoided. The December 30 to May 15 winter period is probably less critical.

2. It is recommended that destruction and disturbance of all natural mineral licks be avoided. Currently, one lick in the study area (Table Mountain lick #1) will be destroyed if the pipeline is constructed as proposed.

3. It is recommended that provisions be made for sheep crossing the pipeline in the Upper Dietrich River where the pipeline will be constructed above ground. Several crossing areas are indicated in Fig. 4.

4. It is recommended that all helicopters, and other aircraft not having specific low-level assignments, be required to maintain a minimum altitude of at least 6000 feet while passing over the Upper Dietrich River whenever possible.

5. It is further recommended that the Department of Fish and Game consider the establishment of a controlled use area for nonconsumptive uses of wildlife. Specifically, an area closed to hunting and off-road vehicular traffic six to 10 miles wide on either side of the Dietrich River from Dietrich oil camp to Atigun Pass is recommended.

ACKNOWLEDGMENTS

Gene Ludlow, Bureau of Land Management, coordinated support of the study. His efforts are gratefully acknowledged. Logistical support was provided by Alyeska Pipeline Services Co., coordinated by William Brody and D. W. Nelson. The Bureau of Sport Fisheries and Wildlife provided charter funds for one aerial survey. Arthur Smith, Alaska Department of Fish and Game, flew two of the aerial surveys and assisted in preparation of this report.

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Table 1. Mineral Licks.

#	Lick Name	Location	Description of Lick	Observed Use	Remarks
1	Table Mountain	North side of Table Mt. 600' above valley bottom between Shadow and Butterfly Cr.	A circular area of wet, gray clay 10 meters in diameter plus a 50m x 5m silty clay streak down the side of ridge	1. Two ewes and one lamb were observed on June 4 and 5 in the area but not in lick. 2. Eleven ewes and two lambs were observed on June 20 just above the lick. They had been in the lick. 3. Ten ewes and five lambs were observed from July 2-6 in the area. They did not visit the lick.	A survey stake for the Alyeska pipeline located approximately 30 meters north of mineral lick. Sheep appear to have abandoned this mineral lick. See text.
2	Nutirwik	South side Table Mt. at head of Nutirwik Cr.	Lick not checked on ground.	Four ewes and one lamb were observed in the area of the lick June 14.	The elaborate trail system, observed from air, would indicate that this lick has received high use in the past.
3	Lizard Mountain	South side of Lizard Mt. 3800 ft.	An area 10x20 meters of light brown clay-like soil.	Three young rams and a small group of ewes and lambs were observed in lick on June 6.	

Table 1. (Continued).

#	Lick Name	Location	Description of Lick	Observed Use	Remarks
4	Wetfoot	North side of Wetfoot approximately 5 miles upstream from the confluence of Wetfoot Cr.	An area 200x 100 meters and consisting of a gray soil.	Sixty sheep were observed in the lick A minimum of 92 to 128 sheep were using the lick on a daily basis between June 29 and July 2. Ewe groups were still visiting the lick sporadically Aug. 22.	An elaborate trail system surrounding the lick. The size of the lick and the number of sheep indicate this is a major lick.
5	Snowden	West side of Snowden Mt. just south of Marlin Cr.	An area 50x 5 meters of light colored soil.	Several ewe groups were found near lick June 5. 24 ewes and 2 lambs were using the lick June 26. Ewe-lamb groups were still using the lick Aug. 31.	Mineral lick is visible from Dietrich River.
6	Big	North side of Snowden Creek 5 miles upstream from mouth of the creek.	A broad vertical exposure of gray soil.	Sheep were in the area of the lick throughout the study period.	Trails lead to the lick from both the north and south side of the creek.

Appendix IV. Resightings of collared sheep near Dry Creek, Alaska Range.

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
1	2 - M	6/1/69	6/19/70	Lick
			5/30/71	Bird Nest Creek
2	14-16 - F	6/1/69	6/13/69	Trail Gulch
			10/19/69	Exclosure Creek
			11/26/69	Icing Creek
			11/28/69	Exclosure Creek
			5/22/70	Icing Creek
			6/4/70	Lick
3	5 - F	6/2/69	6/3/69	Lick
			6/11/70	Lick
4	4 - M	6/2/69	6/12/79	Lick
5	2 - F	5/31/69	6/11/69	Cross Creek
			6/12/69	Cross Creek
			6/13/69	Red Mountain Creek
			6/25/69	Lick
			11/19/69	Two Ram Creek
			6/6/70	Lick
			6/7/70	Lick
			6/8/70	Lick
			6/15/70	Lick
			6/20/70	Lick
			7/2/70	Lick
			7/9/70	Lick
			7/20/70	Lick
			7/21/70	Lick
			6/23/71	Lick
6	1 - M	6/1/69	6/2/69	Seclusion Creek
7	2 - F	5/30/69	6/19/69	Lick
			5/20/70	Exclosure Creek
			6/8/70	Lick
			6/11/70	Lick
			6/12/70	Lick
			6/25/70	Lick
			6/29/70	Lick
			7/2/70	Lick
			7/22/70	Lick
			7/23/70	Lick
			5/25/71	Big Foot Creek
			5/28/71	Big Foot Creek
			6/3/71	South Creek
			6/4/71	Lick
			6/8/71	South Creek
			6/15/71	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
8	2 - M	5/31/69	6/9/69	East Creek
			7/11/71	Red Mountain Creek
9	2 - M	5/31/69	7/10/69	Icing Creek
			10/15/69	Traveller Creek
			11/26/69	Icing Creek
			11/28/69	Exclosure Creek
			12/2/69	Big Foot Creek
			12/3/69	Big Foot Creek
			4/28/70	Icing Creek
			5/19/70	Spruce Basin
10	2 - M	5/31/69	6/12/69	Trail Gulch
			6/13/69	Trail Gulch
			6/9/70	Lick
11	6 - M	6/2/69	5/10/69	Two Ram Creek
			7/8/70	Lick
12	2 - F	6/2/69	8/31/69	Three-Mile Creek
			6/6/70	Lick
			6/11/70	Lick
			6/12/70	Lick
			6/10/71	Lick (recaptured and collared #140)
			6/13/71	Lick
			6/14/71	Lick
			6/15/71	Lick
13	6 - M	6/2/69	6/13/69	Lick
			4/28/70	Rogers Creek
			6/19/70	Lick
14	6 - F	6/2/69	6/11/69	Slate Creek
			6/19/69	Lick
			7/10/69	Seclusion Creek
			6/12/70	Lick
			7/2/70	Lick
			6/19/71	Lick
15	2 - M	6/2/69	6/19/69	Lick
			10/15/69	South Creek
16	5 - F	6/6/69		
17	7 - M	6/2/69	5/19/70	Spruce Basin
			8/70	Hunter Kill - Slate Creek
18	2 - M	6/4/69	6/9/69	East Creek
19	2 - F	6/3/69	6/11/69	R. Creek
			6/11/70	Lick
			6/12/70	Lick
			6/21/70	Lick
			6/25/70	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			7/2/70	Lick
			7/5/70	Lick
			7/6/70	Lick
			7/21/70	Lick
20	6 - F	6/4/69	6/22/69	Lick
			6/23/69	Lick
			7/5/70	Lick
			7/6/70	Lick
			7/20/70	Lick
			7/21/70	Lick
21	1 - F	6/2/69	6/3/69	Lick
			6/9/69	East Creek
			6/12/70	Lick
			6/13/70	Lick
			6/13/70	Lick (captured and collared #84)
			6/25/70	Southeast Creek
			5/27/71	Spruce Basin
			6/14/71	Lick
			6/15/71	Lick
			6/21/71	Lick
			6/22/71	Lick
			6/27/71	Big Foot Creek
22	2 - F	6/23/68	6/11/69	Trail Gulch
			6/16/69	Lick
			6/17/69	Lick
			6/18/69	Lick
			6/19/69	Lick
			6/3/70	Lick
			6/20/70	Lick
			7/2/70	Lick
			6/16/71	Lick
23	1 - M	6/23/68	6/4/69	Lick
			6/11/69	Trail Gulch
			6/13/69	Lick
			6/1/70	Lick
			6/19/70	Lick
			6/18/71	Lick (captured but escaped, found by local guide dead of strangulation by collar (his feeling) in July)

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
24	2 - F	6/23/68	6/24/68	Lick
			6/26/68	Lick
			6/14/69	Lick
			6/20/69	Lick
			6/19/70	Lick
			6/24/70	Lick
25	1 - M	6/23/68	6/4/69	Lick
			6/6/70	Lick
			6/20/70	Lick
			6/21/70	Lick
			6/21/70	Slide Creek
			6/18/71	Lick
26	2 - F	6/23/68	6/14/69	Lick
			6/16/69	Lick
			6/29/70	Lick
			6/30/70	Lick
			7/22/70	Lick
			5/26/71	Traveller Creek
			6/16/71	Lick
27	3 - F	6/24/68	8/10/68	Forgotten Creek
			6/12/69	Trail Gulch
			7/18/70	Seclusion Creek
			7/23/70	Lick
28	5 - M	6/26/68	8/27/70	Sheep Creek
29	6 - M	6/2/69	6/15/69	Cross Creek
			10/2/69	Red Mountain Creek
			4/23/70	Red Mountain Creek
			7/22/70	Lick
30	5 - F	6/2/69	6/11/69	R Creek
			5/24/70	Lick
			6/10/70	Lick
			6/21/70	Lick
			7/1/70	Lick
			7/2/70	Lick
			7/27/70	Forgotten Creek
31	6 - F	6/6/69	6/18/69	Lick
			6/19/69	Lick
			11/15/69	Rogers Creek
			4/23/70	N. Fork Forgotten Creek
			6/5/70	Lick
			6/6/70	Lick
			7/1/70	Lick
			7/2/70	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
32	6 - F	6/3/69	6/12/69	Cross Creek
			6/13/69	Cross Creek
			11/19/69	Slate Creek
			6/3/70	Lick
			6/4/70	Lick
			6/6/70	Lick
			6/8/70	Lick
			6/15/70	Lick
			6/20/70	Lick
			7/8/70	Lick
			7/9/70	Lick
			7/21/70	Lick
			6/14/71	Lick
			6/16/71	Lick
			6/23/71	Lick
			7/11/71	Red Mountain Creek
33	9 - F	6/3/69	6/11/69	Cross Creek
			6/12/69	Lick
			6/24/69	Lick
			6/26/69	Lick
			11/19/69	Slate Creek
			6/3/70	Lick
			6/4/70	Lick
			6/6/70	Lick
			6/7/70	Lick
			6/8/70	Lick
			6/15/70	Lick
			7/2/70	Lick
			7/5/70	Lick
			7/26/71	Cross Creek
34	2 - M	6/5/69	6/9/69	East Ridge
			6/13/69	Trail Gulch
			5/28/71	Twin Calf Creek
			7/11/71	Red Mountain Creek
35	1 - M	6/6/69	8/27/69	Sheep Creek
			8/28/69	Sheep Creek
			6/13/70	Lick
36	2 - M	6/5/69	4/28/70	Kansas Dreek
			7/27/70	Kansas Creek
37	5 - M	6/6/69	7/10/69	Forgotten Creek
			11/19/69	Red Mountain Creek
			8/70	Hunter Kill - Slate Creek
38	6 - F	6/6/69	6/19/69	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			6/20/69	Lick
			6/24/69	Lick
			4/23/70	Frogotten Creek
			6/6/70	Lick
			6/7/70	Lick
			6/15/70	Lick
			7/1/70	Lick
			7/2/70	Lick
			7/27/70	Forgotten Creek
39	1 - M	6/6/69	6/18/69	Lick
			6/19/69	Lick
40	6 - M	6/5/69	11/25/69	South Creek
			3/4/70	Slide Ridge
			4/28/70	Icing Creek
			6/6/70	Lick
			6/8/70	Lick
			5/26/71	Exclosure Creek
			6/16/71	Lick
41	5 - F	6/6/69	6/16/69	Lick
			6/17/69	Lick
			6/18/69	Lick
			6/19/69	Lick
			6/8/70	Lick
			6/13/70	Lick
42	8 - M	6/7/69	6/11/69	Forgotten Creek
43	3-5 - F	6/3/69	6/3/70	Lick
			6/3/70	East Creek
			6/6/70	Lick
			6/7/70	Lick
			6/24/71	Lick
44	1 - M	6/7/69		
45	6 - M	6/5/69	11/19/69	A Creek
			4/28/70	Icing Creek
			6/3/70	Lick
			6/4/70	Lick
			6/12/70	Lick
			6/13/70	Lick
46	1 - M	6/6/69		Collar found lying on ground by local guide; turned in in July 1971
47	5 - M	6/5/69	7/10/69	Snow Mountain Gulch
			3/4/70	Slide Ridge
			6/3/70	Exclosure Creek

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			6/6/70	Lick
			6/19/70	Lick
			7/5/70	Lick
			6/17/71	Lick
			6/23/71	Lick
48	1 - M	6/6/69	6/26/69	Lick
			10/15/69	Rogers Creek
50	9 - F	6/3/69	6/13/69	Slate Creek
			6/16/69	Lick
			6/24/69	Lick
			4/23/70	Red Mountain Creek
			6/5/70	Lick
			6/6/70	Lick
			6/12/70	Lick
			7/2/70	Lick
			7/25/70	Lick
			6/15/71	Lick
			6/16/71	Lick
51	2 - F	6/6/69	6/18/69	Lick
			6/19/69	Lick
			6/7/70	Lick
			7/7/70	Lick
			7/21/70	Lick
52	7 - F	6/6/69	6/19/69	Lick
			6/20/69	Lick
			6/5/70	Lick
			6/6/70	Lick
			6/17/70	Lick
			6/21/70	Lick
			6/25/70	Lick
			6/29/70	Lick
			7/2/70	Lick
53	7 - F	6/4/69	6/29/70	Lick
			6/30/70	Lick
			7/1/70	Lick
			6/15/71	Lick
54	3 - F	6/6/69	4/23/70	Forgotten Creek
			6/6/70	Lick
			6/15/70	Lick
			6/21/70	Lick
			7/1/70	Lick
			7/3/70	Lick
55	7 - M	6/7/69	6/13/70	Lick
			6/13/71	Lick
			6/28/71	Bird Nest Creek

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
56	1 - F	6/4/69	6/11/69	Trail Gulch
			6/18/70	Lick
			6/30/70	Lick
			7/1/70	Lick
			7/6/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			6/19/71	Lick
57	2 - F	6/3/69	7/5/70	Lick
			7/21/70	Lick
58	5 - F	6/17/70	7/2/70	Lick
			7/9/70	Lick
			7/11/71	Red Mountain Creek
			7/28/71	Slate Creek
			8/16/71	Red Mountain Creek
59	2 - M	6/12/70	7/15/70	Kansas Creek
60	7 - F	6/13/70	6/21/70	Lick
			7/9/70	Lick
			8/26/70	Slate Creek
			6/21/71	Lick
			6/22/71	Lick
61	2 - M	6/19/70	7/12/70	Upper Dry Creek Lick
			7/13/70	Upper Dry Creek Lick
62	7-8 - F	6/17/70	7/2/70	Lick
			6/7/71	Lick
			6/8/71	Lick
			6/23/71	Lick
			7/9/71	Forgotten Creek
63	6 - F	6/19/70	6/20/70	Lick
			6/21/70	Lick
			6/14/71	Lick
			6/15/71	Lick
			6/16/71	Lick
64	7 - F	6/16/70	7/1/70	Lick
			7/8/70	Lick
			7/9/70	Lick
			7/10/70	Lick
			7/18/70	Seclusion Creek
			6/9/71	Lick
65	3 - M	6/17/70	7/8/70	Lick
			6/5/71	Lick
			6/6/71	Lick
			6/8/71	Lick
			6/16/71	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			6/17/71	Lick
			7/25/71	Point Creek
66	6 - F	6/19/70		
67	6-7 - F	6/18/70	7/2/70	Lick
			7/5/70	Lick
			7/7/70	Lick
			7/10/70	Seclusion Creek
68	2 - F	6/18/70	7/6/70	Lick
			7/9/70	Lick
			7/10/70	Lick
			9/24/70	Sheep Creek
			6/7/71	Lick
69	2 - F	6/18/70	6/30/70	Lick
			7/1/70	Lick
			7/2/70	Lick
			7/25/70	Lick
			7/29/70	Two Ram Creek
			6/12/71	Lick
			6/13/71	Lick
			6/14/71	Lick
			7/25/71	Two Ram Creek
70	5 - F	6/18/70	6/29/70	East Creek
			72/70	Lick
			7/3/70	Lick
			7/9/70	Lick
			7/10/70	Lick
			8/27/70	Rogers Creek
			6/11/71	Lick (recaptured and collared #154)
71	10-11 - F	6/21/70	6/25/70	Lick
			6/30/70	Lick
			7/2/70	East Creek
			5/26/71	Traveller Creek
			5/27/71	Jim Creek
			6/5/71	Lick
			6/6/71	Lick
72	2 - F	6/18/70	6/25/70	Lick
			6/29/70	East Creek
73	1 - M	6/18/70	7/22/70	Lick
			7/23/70	Lick
			7/24/70	Lick
			7/25/70	Lick
			6/14/71	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			7/25/71	Forgotten Creek
74	8-9 - F	6/14/70	7/6/70	Lick
			7/9/70	Lick
			6/22/71	Lick
75	6 - F	6/19/70	7/23/70	Lick
			7/24/70	Lick
			9/24/70	Lick
			7/10/71	Lick
			7/25/71	Forgotten Creek
76	7 - F	6/16/70	7/2/70	Lick
			5/30/71	R & G Creek
			6/16/71	Lick
77	11-13 - F	6/19/70	6/19/70	Lick
			6/29/70	Lick
			7/2/70	Lick
			7/9/70	Bird Nest Creek
			7/9/70	East Creek
			7/10/70	Lick
78	4-5 - F	6/17/70	6/3/71	Lick
			6/9/71	Lick
			6/15/71	Lick
			6/16/71	Lick
			7/11/71	Red Mountain Creek
79	5 - F	6/19/70	7/5/70	Lick
			7/7/70	Lick
			7/20/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			7/29/70	Two Ram Creek
			6/8/71	Lick
			6/9/71	Lick
			6/23/71	Lick
			7/24/71	Kansas Creek
			7/25/71	Two Ram Creek
80	8 - F	6/16/70	7/16/70	Seclusion Creek
			8/27/70	G Creek
			9/25/70	Twin Calf Creek
			5/30/71	R & G Creek
			6/8/71	Lick (recaptured)
			7/26/71	Twin Calf Creek
81	2 - M	6/13/70	6/25/70	Lick
			7/25/70	Lick
			9/24/70	Upper West Fork Little Delta R.
			7/23/71	West Fork Little Delta R.
			7/9/71	Forgotten Creek

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
82	6 - F	6/17/70	6/18/70	Lick
			6/25/70	Lick
			7/2/70	Lick
			8/26/70	Right Limit Forgotten Creek
83	4 - M	6/19/70	5/30/71	Rogers Creek
			6/16/71	Lick
			6/17/71	Lick
			6/18/71	Lick
84	2 - F	6/13/70	6/25/70	Southeast Creek
			5/27/71	Spruce Basin
			6/14/71	Lick
			6/15/71	Lick
			6/21/71	Lick
			6/22/71	Lick
			7/27/71	Big Foot Creek
85	2 - M	6/20/70	8/27/70	Rogers Creek
			9/24/70	Sheep Creek
			7/17/71	Rogers Creek (collar found lying on ground)
86	6 - F	6/14/70	6/15/70	Lick
			8/26/70	Right Limit Forgotten Creek
			7/10/71	Lick
87	2 - M	6/20/70	6/5/71	Lick
			6/12/71	Lick
			6/13/71	Lick
			6/21/71	Lick
			6/22/71	Lick
			6/23/71	Lick
			7/9/71	Forgotten Creek
88	3 - F	6/14/70	7/6/70	Lick
			7/7/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			7/29/70	Lick
			6/13/71	Lick
			6/14/71	Lick
			6/15/71	Lick
			7/25/71	Two Ram Creek
89	3 - M	6/19/70	8/27/70	Rogers Creek
			6/5/71	Lick
			7/25/71	Two Ram Creek

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
90	9 - F	6/17/70	7/1/70	Lick
			7/2/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			6/16/71	Lick
			7/9/71	Forgotten Creek
91	8 - M	6/19/70	6/29/70	Lick
			7/1/70	Lick
			8/14/70	Slate Creek - Hunter Kill
92	3 - F	6/19/70	7/2/70	Lick
			7/9/70	Lick
			7/10/70	Lick
			8/27/70	Upper Dry Creek
			6/4/71	Lick
			6/9/71	Lick
			6/10/71	Lick
			6/12/71	Iron Gulch
			6/15/71	Lick
			6/22/71	Lick (recaptured)
93	7 - M	6/19/70		
94	9-10 - F	6/14/70		Collar returned by guide July 1971
95	7 - M	6/20/70	8/27/70	Rugged Creek
			9/24/70	Rugged Creek
			5/28/71	Sheep Creek
			6/12/71	East Ridge
			6/13/71	Lick
			8/17/71	Rugged Creek (Hunter kill 1971)
96	3 - F	6/15/70	7/1/70	Lick
			7/2/70	Lick
			7/3/70	Lick
			6/9/71	Lick
			6/17/71	Lick
			7/9/71	Forgotten Creek
97	3 - F	6/19/70	6/30/70	Lick
			7/1/70	Lick
			7/5/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			7/24/70	Lick
			7/25/70	Lick
			7/29/70	Two Ram Creek

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			8/27/70	Bird Nest Creek
			6/14/71	Lick
			7/25/71	Two Ram Creek
98	3 - F	6/17/70	6/29/70	Lick
			7/1/70	Lick
			8/27/70	Big Foot Creek
			5/10/71	Lick
			5/24/71	Lick
			5/27/71	Jim Creek
			7/9/71	Forgotten Creek
99	7 - M	6/19/70	8/27/70	Rogers Creek
			9/24/70	Rugged Creek
			10/21/70	Rogers Creek
G-1	7 - F	6/12/70	6/30/70	Lick
			7/1/70	Lick
			7/2/70	Lick
			7/3/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			8/27/70	West Fork Dry Creek
			5/26/71	Big Foot Creek
			6/8/71	South Creek
			6/14/71	Lick
G-2	3 - F	6/12/70	6/29/70	Lick
			7/1/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			7/27/70	Forgotten Creek
			8/26/70	Right Limit Slate Creek
			6/14/71	Lick
			7/9/71	Forgotten Creek
G-3	3 - M	6/12/70	7/9/70	Lick
			5/28/71	Sheep Creek
G-4	4 - F	6/12/70	6/25/70	Lick
			7/5/70	Lick
			6/14/71	Lick
			6/15/71	Lick
			7/25/71	Two Ram Creek
G-5	2 - M	6/19/70	7/6/70	Lick
			7/10/70	Lick
			6/9/71	Lick
G-6	6 - F	6/12/70	6/29/70	Lick
			6/30/70	Lick

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
			7/1/70	Lick
			7/2/70	Lick
			7/2/70	East Creek
			8/27/70	Right Limit Southeast Creek
			5/26/71	Big Foot Creek
			6/3/71	Lick and South Creek
			6/14/71	Lick
			6/15/71	Lick
G-7	7 - M	6/12/70		
G-8	7 - F	6/12/70	7/1/70	Lick
			7/21/70	Lick
			7/22/70	Lick
			6/16/71	Lick
			6/23/71	Lick (recaptured and retagged #194)
100	3 - M	6/2/71		
101	3 - M	6/2/71		
102	3 - F	6/3/71	6/9/71	Lick
103	2 - F	6/3/71	6/8/71	Lick
104	2 - M	6/5/71	6/7/71	Lick
			6/16/71	Lick
105	2 - M	6/4/71	6/16/71	Lick
			10/27/71	Slate Creek Ridge
106	8 - F	6/6/71	6/16/71	Lick
			7/26/71	Cross Creek
			7/28/71	Slate Creek
107	2 - M	6/7/71	6/16/71	Lick
108	2 - M	6/6/71	6/16/71	Lick
109	5 - F	6/6/71		
110	2 - F	6/6/71	6/11/71	Lick
111	(see 71)			
112	2 - F	6/6/71		
113	3 - F	6/6/71	6/16/71	Lick
114	8 - F	6/7/71	6/14/71	Lick
115	3 - M	6/6/71	6/8/71	Lick
116	2 - M	6/7/71	7/24/71	Kansas Creek
117	8 - F	6/7/71		
118	2 - M	6/7/71	6/10/71	Lick
			6/16/71	Lick
119	4 - F	6/7/71	6/16/71	Lick
120	4 - F	6/6/71		
121	(see 80)			
122	2 - F	6/8/71		
123	3 - F	6/10/71		

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
124	4 - F	6/10/71	6/14/71	Lick
			6/24/71	Lick
125	3 - F	6/10/71		
126	2 - M	6/9/71	6/16/71	Lick
127	2 - M	6/9/71	6/15/71	Lick
			6/16/71	Lick
			7/9/71	Forgotten Creek
			7/11/71	Slate Creek
128	1 - M	6/9/71		
129	3 - F	6/8/71	6/15/71	Lick
			6/19/71	Lick
130	2 - F	6/8/71		
131	8 - F	6/17/71		
132	8-9 - F	6/17/71		
133	2 - F	6/17/71		
134	10 - M	6/18/71		
135	4 - M	6/18/71		
136	3 - F	6/19/71		
137	9 - F	6/14/71		
138	3 - F	6/10/71	6/16/71	Lick
139	3 - M	6/10/71	6/14/71	Lick
			8/16/71	Red Mountain Creek
140	(see 12)			
141	7 - F	6/16/71	6/19/71	Lick
142	2 - F	6/10/71		
143	2 - M	6/10/71	6/10/71	Lick
			6/14/71	Lick
			8/14/71	Red Mountain Creek
144	2 - M	6/16/71		
145	2 - F	6/10/71		
146	3 - M	6/10/71	6/16/71	Lick
			6/17/71	Lick
147	4 - F	6/14/71		
148	7 - F	6/14/71	6/14/71	Lick
			7/9/71	Forgotten Creek
149	2 - M	6/14/71		
150	3 - M	6/14/71	8/17/71	Rugged Creek
151	3 - M	6/15/71		
152	2 - M	6/10/71		
153	2 - M	6/10/71		
154	(see 70)			
155	4 - F	6/14/71		
156	2 - M	6/11/71		
157	2 - M	6/10/71		

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
158	2 - M	6/11/71	6/16/71	Lick
			7/8/71	Forgotten Creek
			7/25/71	Glory Creek
159	2 - M	6/16/71		
160	3 - M	6/17/71		
161	4 - M	6/17/71		
162	2 - F	6/23/71		
163	6 - F	6/16/71		
164	3 - F	6/17/71		
165	2 - M	6/17/71		
166	2 - F	6/17/71		
167	8 - M	6/18/71	6/21/71	Lick
168	6 - F	6/18/71		
169	6 - F	6/19/71		
170	8 - M	6/18/71	8/13/71	Sheep Creek - Hunter Kill
171	3 - M	6/18/71	10/22/71	West Fork Ridge
172	7 - F	6/8/71	7/10/71	LIck
173	11 - F	6/18/71		
174	2 - F	6/18/71		
175	3 - F	6/18/71		
176	2 - M	6/18/71		
177	3 - F	6/23/71		
178	3 - F	6/22/71	7/10/71	Lick
179	(see 92)			
180	9 - F	6/21/71		
181	7 - F	6/23/71	7/9/71	Forgotten Creek
182	10 - F	6/22/71		
184	2 - M	6/20/71	6/23/71	Lick
			10/25/71	Forgotten Creek Ridge
185	9 - F	6/19/71	7/24/71	Kansas Creek
186	4 - F	6/19/71	7/10/71	Lick
187	3 - F	6/19/71		
188	3 - F	6/23/71		
189	3 - F	6/19/71		
190	2 - F	6/23/71	7/24/71	Kansas Creek
			7/25/71	Oppoint Creek
			7/25/71	Two Ram Creek
191	2 - F	6/23/71		
192	2 - F	6/23/71		
193	4 - M	6/27/71		
194	(see G-8)			
195	2 - M	6/27/71		
202	9 - F	6/27/71		
203	8 - F	6/27/71		

Appendix IV (Continued).

Collar No.	Age & Sex	Date Collared	Resightings Date	Resightings Location
204	3 - F	6/24/71		
207	9 - F	6/27/71	7/28/71	Bird Nest Creek
208	6 - F	6/27/71	7/10/71	Killed on R & G Creek
210	3 - F	6/27/71		Collar found by local guide in July, 1971. He believes it slipped off the animal's head.

Appendix IV. Resightings of ear-tagged sheep near Dry Creek, Alaska Range.

Ear Tags	Age & Sex	Date Tagged	Resightings Date	Resightings Location
501	1 - F	6/12/70		
510	1 - M	6/12/70		
512	1 - M	6/12/70		
515	1 - M	6/13/70		
516	1 - M	6/13/70	7/9/70	Lick
518	1 - F	6/13/70		
521	1 - M	6/14/70	6/30/70	Lick
527	1 - M	6/16/70	7/1/70	Lick
530	1 - M	6/17/70		
536	2 - F	6/17/70	6/30/70	Lick
			7/21/70	Lick
544	2 - F	6/18/70	6/29/70	Lick
553	2 - F	6/19/70	7/9/70	Lick
562	1 - M	6/19/70	7/24/70	Lick
563	2 - F	6/20/70		
564	6 - F	6/20/70		
565	1 - M	6/20/70		
566	1 - M	6/20/70		
567	2 - F	6/20/70		
568	9 - F	6/20/70		
569	2 - F	6/20/70		
570	1 - M	6/20/70		
571	7 - F	6/20/70	7/24/70	Lick
572	9 - F	6/20/70		
573	1 - F	6/20/70		
574	1 - F	6/20/70	7/21/70	Lick
577	10 - F	6/20/70	6/21/70	Lick
578	1 - F	6/20/70		
579	2 - M	6/20/70		
580	2 - M	6/20/70		
581	2 - M	6/20/70		
583	2 - M	6/20/70		
585	Unk - M	Unk 6/70		
586	6 - F	6/21/70	7/25/70	Lick
587	3 - M	6/20/70		
588	3 - M	6/21/70		
589	1 - F	6/21/70		
590	2 - M	6/21/70		
591	13 - F	6/23/70		
596	L - M	6/08/71		
600	9 - M	6/21/70		
626	1 - F	6/03/71		
635	1 - M	6/15/71		
640	1 - M	6/15/71		
642	1 - M	6/06/71		

Appendix IV. Resightings of ear-tagged sheep near Dry Creek, Alaska Range.

Ear Tags	Age & Sex	Date Tagged	Resightings Date	Resightings Location
643	1 - M	6/06/71		
647	1 - M	6/07/71		
666	1 - F	6/17/71		
671	1 - F	6/17/71		
674	1 - M	6/17/71		
677	L - M	6/17/71		
691	1 - M	6/11/71		
701	L - M	6/19/71		
702	1 - M	6/21/71		
706	L - F	6/18/71		
710	1 - F	6/19/71		
726	9 - M	6/27/71		
728	1 - M	6/27/71		
732	L - M	6/18/71		
734	1 - M	6/21/71		
740	L - F	6/18/71		
742	6 - F	6/25/71		
744	1 - F	6/19/71		
822	1 - F	6/23/71		
823	1 - F	6/23/71		
824	1 - F	6/24/71		
825	1 - F	6/24/71		

Appendix V. Two Sightings of a Single Wolf Killing a Dall Sheep.

On June 25, 1971, a sighting was made of a single black wolf (*Canis lupus*) chasing and killing a 3-year-old Dall sheep ram (*Ovis dalli*) at Dry Creek on the north slope of the Alaska Range.

The wolf was observed rounding a knoll just west of the main sheep mineral lick at Dry Creek at 1030 (Fig. 1). At this time there were approximately 35 sheep in the bottom of the lick, a study site. The wolf was headed toward the lick when he spotted one of our blinds, reversed his direction and disappeared around the same knoll. It appeared to this observer that the wolf would have attempted to capture a sheep in the mineral lick had our blind not frightened him.

The wolf was observed several minutes later crossing Dry Creek and trotting along a sheep trail heading for East Ridge (Fig. 1). At the base of East Ridge, 12 Dall sheep rams were resting on a small outcrop. These rams had been observed earlier moving down East Ridge headed for the mineral lick. They became restless as the wolf approached within 300 meters and began moving up East Ridge. The wolf disappeared behind the outcrop and when he reappeared he was galloping after the rams which were then galloping single file up the main sheep trail along East Ridge. When the sheep had run approximately 200 yards, the wolf caught up to and was running approximately 3 to 5 meters behind the last ram. The wolf singled out the last sheep, a mature ram, by running to its right side and forcing the ram to turn left and down the mountain. The ram quickly took refuge in a small outcrop with several 10 to 12 foot cliffs and the wolf immediately gave up the chase. The wolf reversed his direction and headed up the mountain in pursuit of the other rams. With apparent ease he caught up to the band, again singled out the last ram, and turned him down the mountain. This ram ran straight down the mountainside. Twice during the chase the ram fell as the wolf closed the distance to the ram. Lower on the slope, where the terrain leveled out, the wolf ran alongside the ram and, after three or four strides, lunged at the ram's throat. The ram went down with very little struggle and subsequently died.

The wolf, front shoulder and head of the ram were out of sight for approximately 15 minutes. During this time there was no movement of the brush in the surrounding area to indicate that the wolf was struggling with and eating the ram. Later the wolf was seen resting beneath the large spruce tree approximately 20 feet from the kill. The wolf was observed in the area of the kill all the following day, the 26th of June.

At approximately 0830 on the 27th of June, a grizzly sow (*Ursus horribilus*) with two yearling cubs located and devoured the remains of the kill. After the bears left the area on the afternoon of the 27th I inspected the kill location. Only the ram's horns, a few pieces of bone and a scattering of the sheep hide remained.

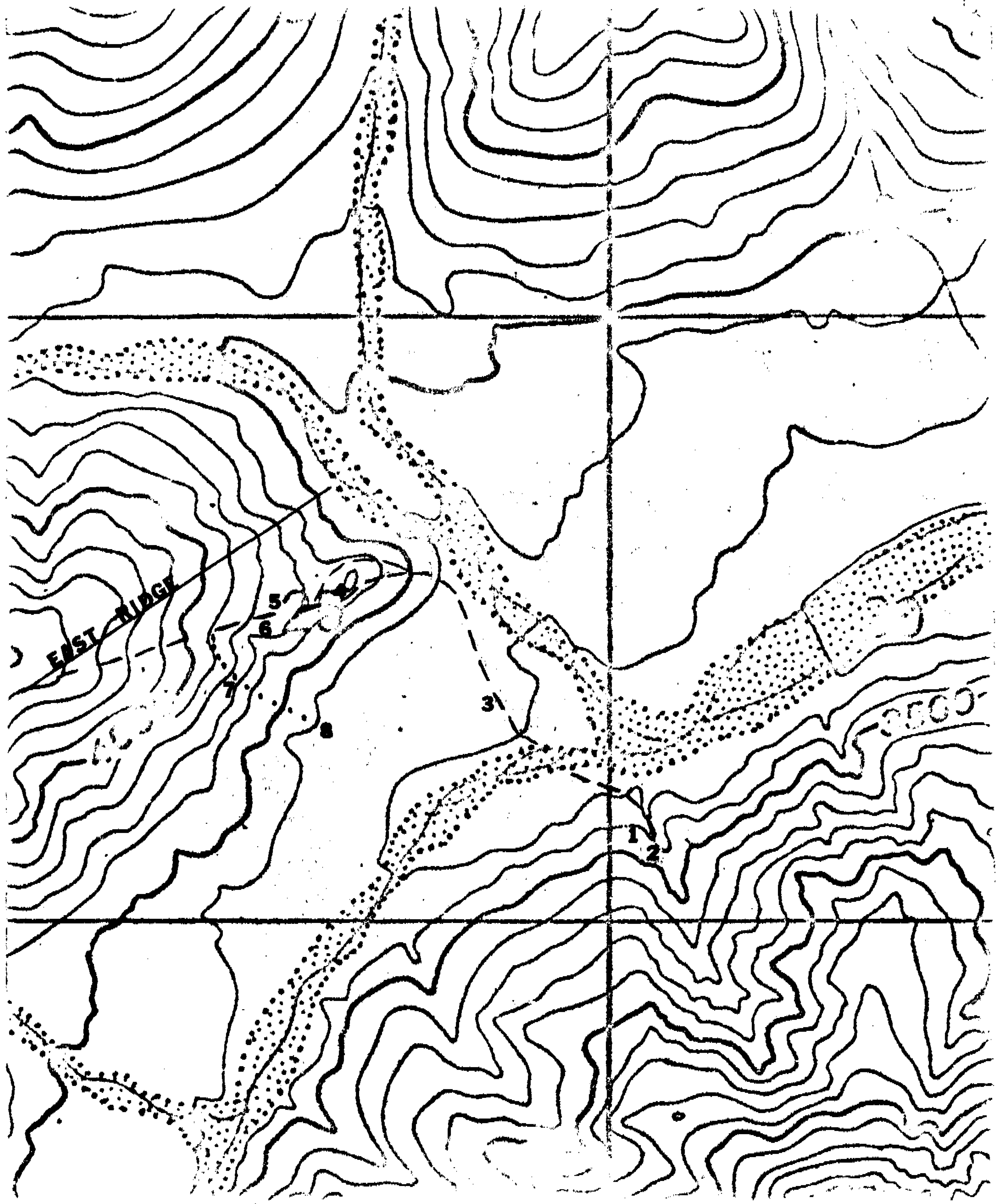

Fig. 1. 1. Wolf first observed. 2. Sheep mineral lick. 3. Sheep trail where wolf was next observed. 4. Outcrop where 12 Dall sheep rams were resting. 5. Wolf chased rams up hill on sheep trail. 6. Outcrop where first ram escaped. 7. Route of wolf chasing 3-year-old ram. 8. Location of kill. SCALE: 1 inch = 1200 feet.

The above incident was observed through a 15-60X Bausch and Lomb spotting scope set at 30X. The distance from the observer to the location of kill was approximately 1300 meters. The sky was high overcast and the temperature was approximately 50°F, wind direction was unknown.

A second sighting of a single wolf killing a Dall sheep occurred while this observer and his pilot were making an aerial sheep distribution survey on August 3, 1971, near the headwaters of the Charley River in the Tanana Hills.

At approximately 1035 hours a group of 13 sheep, consisting of ewes, lambs and yearlings was spotted resting near the top of a rolling hill south of the Charley River approximately six miles downstream from Hosford Creek (Fig. 2). Moments later a single black wolf was observed approaching the band of sheep from the east. We interrupted the survey and climbed to an altitude of approximately 500 feet above ground level to observe the interaction. Neither the sheep nor the wolf appeared to alter their behavior due to the aircraft disturbance.

The sheep broke into two bands and one band of seven sheep ran in a west southwest direction along the top of the hill (Fig. 2). The wolf intercepted this band and turned them down the hill where they ran along a well-worn trail through the tundra. While on this trail it appeared that the wolf gained easily on the band. As the leaders of the band slowed down to jump into the cliffs just above the Charley River, the wolf caught up with the last sheep, a yearling ewe and dragged it down. The position of the aircraft did not allow observation of the moment of capture, however, this observer does not think the wolf grabbed the sheep by the throat. There was a brief struggle and as soon as the sheep was unable to rise, but not dead, the wolf left the sheep and laid down approximately 10 feet from the sheep. The wolf did not move from this position for at least 10 minutes and was observed to be panting heavily.

The weather was generally good with scattered clouds at 6,000 feet, the temperature was unknown and the wind was blowing from the northwest.

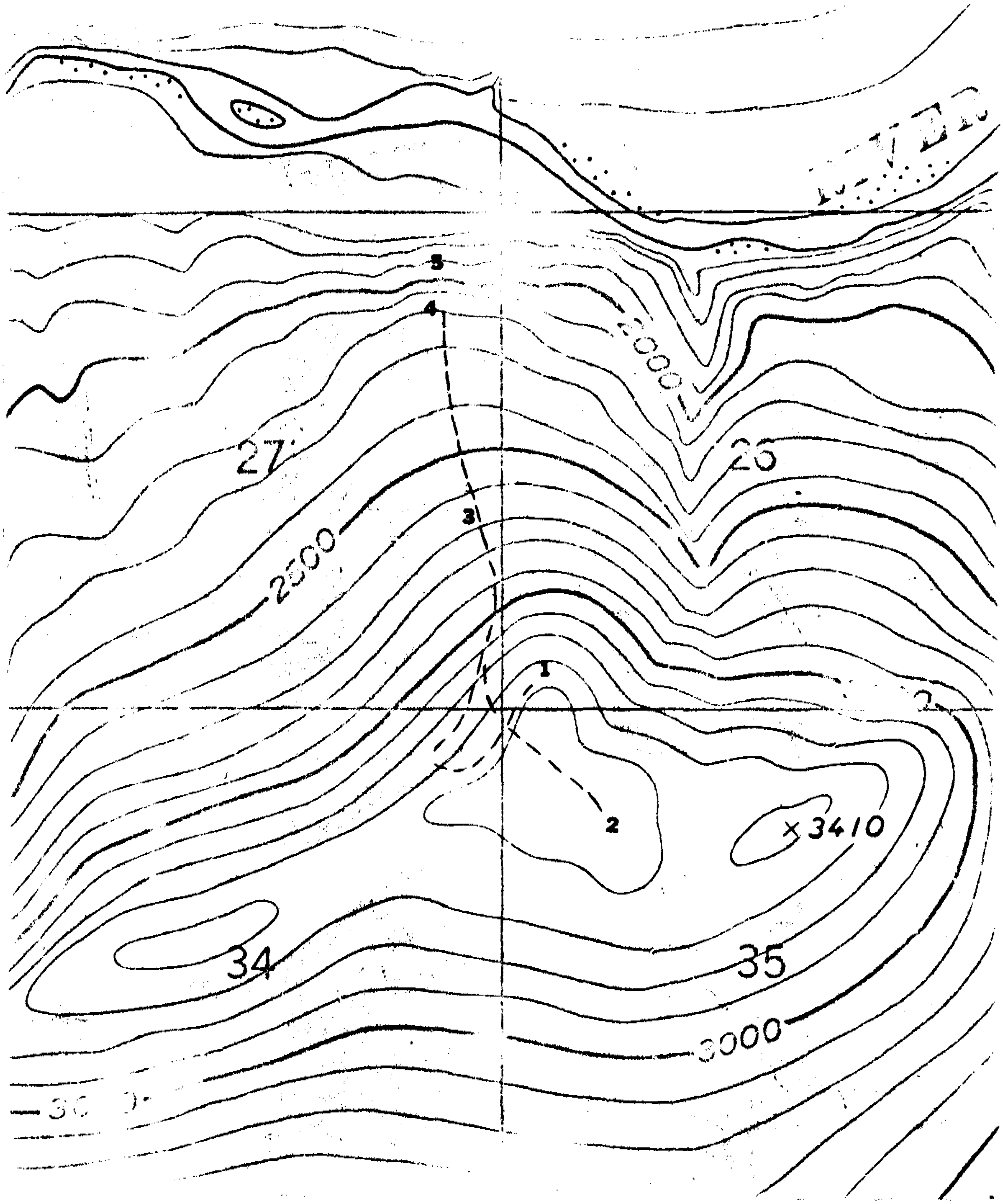

Fig. 2. 1. Sheep first observed resting. 2. Wolf first observed galloping toward 1. 3. Trail taken by sheep and wolf. 4. Kill location on sheep trail just before steep outcrop. 5. Outcrop where other sheep rested. SCALE: 1 inch = 1200 feet.

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Arthur C. Smith and Wayne Heimer

Project Nos.: W-17-3 W-17-4 Project Title: Big Game Investigations

Job No.: 6.2R Job Title: Dall Sheep Horn Growth

Period Covered: January 1, 1971 to December 31, 1971

SUMMARY

Measurements of Dall sheep horns have been completed. Computer analysis of linear measurement (horn length, segment length and annuli diameter) was completed but did not give a clear understanding of actual size or trophy value of a set of Dall sheep horns.

Approximate volumes of each horn and horn growth segments were completed and computer analysis is continuing.

CONTENTS

BACKGROUND

Data have been collected on horn growth characteristics and trophy production of sheep by various investigators (Erickson 1968, 1969, and 1970; Hemming, 1967; Scott, 1951; Taylor, 1962; and Wishart, 1969).

Comparisons of growth patterns of Dall sheep horns within Alaska from the seven different mountain ranges have not been accomplished.

OBJECTIVES

To compare and contrast the age related measurements of Dall sheep ram horns between and among sheep from seven mountain areas in Alaska.

PROCEDURES

Procedures for horn measurement were as described by Erickson (1970).

All sheep horns made available to us through local taxidermy shops in Fairbanks and Anchorage were measured.

FINDINGS

A total of 604 sets of horns were measured in 1967, 1968, 1969 and 1970.

Computer analysis of linear measurements (horn length, segment length and annuli diameter) which comprise the data did not give a clear understanding of the actual size or trophy value of a set of Dall sheep horns. Consequently, the volume of each horn has been calculated. For the purpose of the calculation it was assumed that the horn is a cone bent into a spiral with no deformation. This, of course, is only an approximation and not the true situation. Since the data contain annuli diameters and segment lengths we further assumed that each segment was a frustrum, and added the frusta volumes to obtain an estimate of total horn volume.

This calculation is only an approximation. In order to determine the error involved, a displacement measuring apparatus was constructed and the actual volumes of 29 horns were measured (Table 1). These measurements revealed that the calculated volume is approximately twice as great as actual displacement (actual volume = calculated volume x 0.456). This mean correction factor was then applied to volume calculations from our linear measurements to give a more accurate idea of estimated volumes. This method of volume comparison has provided a more useful means of assessing horn growth and trophy value.

Computer programs for these new data have been rewritten by James Dunlap and analysis and interpretation is continuing.

RECOMMENDATIONS

No specific management recommendation may be made from preliminary results of the study.

ACKNOWLEDGMENTS

We would like to extend thanks to Walter Cunningham, a temporary Game Technician of the Anchorage Game staff, who completed the rather dull task of measuring ram horns as they became available to Anchorage taxidermy shops following the 1970 hunting season.

Many other Fish and Game temporaries and U. S. Army personnel, including Charles Jensen and Michael McBrayer, deserve a hearty thanks for their assistance.

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Table 1. Calculated and Measured Volumes of 29 Dall Sheep Horns.

Horn No.	Measured Volume cc.	Calculated Volume cc.	Weight grams	Percent Difference	Horn Density (Gram/cc.)
1	1590	3727	1576	.427	.99
2	1634	3663	1685	.446	1.03
3	2116	5255	2102	.402	.99
4	1262	2816	1180	.448	.93
5	1320	3267	1228	.392	.93
6	1060	2420	879	.438	.82
7	1616	3518	1615	.460	.99
8	1486	3467	1471	.420	1.01
9	2190	5412	2392	.405	1.09
10	2117	4954	2169	.427	1.02
11	2429	4765	2577	.509	1.06
12	2443	4886	2564	.500	1.04
13	1980	4182	1852	.473	.93
14	2008	4251	2032	.472	1.01
15	2072	3991	2030	.519	.97
16	2030	4055	2043	.500	1.00
17	1238	2658	1095	.466	.88
18	1234	2575	1091	.479	.88
19	1596	3353	1543	.475	.96
20	1586	3563	1377	.445	.86
21	972	2242	954	.434	.98
22	961	2436	946	.394	.98
23	2624	5557	2780	.472	1.05
24	2660	5519	2708	.481	1.01
25	2995	6061	2914	.487	.98
26	2923	6204	2921	.471	.99
27	2735	5974	2872	.458	1.05
28	2610	5782	2698	.451	1.03
29	2588	5255	2610	.492	1.00

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JOB PROGRESS REPORT (RESEARCH)

STATE: Alaska

COOPERATORS: Lyman Nichols

PROJECT NOS.: W-17-3 W-17-4 PROJECT TITLE: Big Game Investigations

JOB NO.: 6.3R JOB TITLE: Dall Sheep Food Habits and Body Condition During Winter

JOB NO.: 6.4R JOB TITLE: Productivity in Unhunted and Heavily Exploited Dall Sheep Populations

JOB NO.: 6.5R JOB TITLE: Dall Sheep Population Trends and Composition on the Kenai Peninsula

JOB NO.: 6.7R JOB TITLE: Dall Sheep Winter Range and Climate

PERIOD COVERED: January 1, 1971 to December 31, 1971

SUMMARY

The Crescent Mountain collection program was completed. Reproductive, physiological and food habits specimens were obtained and analyzed as well as weights, measurements and ages from the 47 sheep taken. Additional data were obtained from specimens collected on Surprise Mountain in 1970 and from several sheep found dead or dying.

Bone marrow fat deteriorated as winter progressed from a high of 96 percent to a low of 15 percent in the Crescent Mountain specimens. Blood values were obtained but not analyzed pending completion of a computer program. Weight loss occurred in all age classes as winter progressed but was most pronounced in yearlings.

Rumen and fecal samples were analyzed by R. M. Hansen, Colorado State University, under contract. The major plant species eaten was *Hierochloe alpina*; this can probably be considered the key species on Dall sheep winter range in this area. Snow conditions during early winter presented little difficulty to feeding by sheep.

Observations of breeding behavior and season were again conducted. The rut commenced in earnest in Cooper Landing Closed Area during the period of November 26-30, 1971, and was mostly over by December 10, 1971.

Data from Surprise Mountain were again scanty due to bad weather, but the rut did not seem to commence until at least the period of December 1-5, 1971.

Breeding activities were carried out by all classes of rams above yearling age in the closed area, but full-curl or larger rams appeared most efficient and probably were responsible for siring most progeny. Yearling ewes were actively participating in breeding activities. On Surprise Mountain, where only 3/4-curl or smaller rams were present, breeding was carried out by 1/2- and 3/4-curl rams. These seemed less efficient and more wasteful of energy than older rams and it is possible they may have been less effective in successfully impregnating receptive ewes.

Examination of reproductive tracts of sheep collected from Crescent Mountain showed 100 percent of ewes over two years old and 75 percent of yearling ewes were pregnant. A large proportion of ewes thus reach breeding age at 18 months. Two specimens over 13 years old were pregnant and one over 15 years old was found to have given birth before dying. Fetuses were examined and their weights and measurements recorded.

The peak of lambing was from May 20-24, 1971 on the three areas under study, but lambing continued for a longer period on Surprise and Crescent mountains than in Cooper Landing Closed Area.

Aerial surveys showed minimum populations after lambing of 177, 228 and 288 sheep on Surprise Mountain, Crescent Mountain and Cooper Landing Closed Area, respectively.

A winter range study was conducted under contract by R. M. Hansen on the three areas. The closed area was most productive in pounds of forage per acre and Crescent Mountain was least productive. Detailed findings are listed.

Self-contained weather stations were purchased and established in each area to compare wind and temperature. Malfunctions caused data loss in two of the instruments. Data have not yet been analyzed. A method of comparing snow depth and hardness has been worked out but no surveys were conducted during the segment.

transects were run over the same course on Surprise Mountain, one on November 21, 1971 and the second on November 30, 1971. Ten points were selected for each transect, the points being 10 steps apart. At each point, depth was measured with the probe and four hardness measurements made. Snow conditions had obviously changed between surveys and the measurements showed such change. Average depth changed from 8.2 inches to 6.3 inches, and hardness from 4.1 lbs/cm^2 to 10.3 lbs/cm^2. Despite occasional snowfall during the period, winds removed snow from the area and hardened the pack. The method was simple and rapid to use and seems to lend itself to a reasonably accurate comparison of snow conditions as well as to statistical analysis.

RECOMMENDATIONS

No specific recommendations for sheep management can be made at this time except that the Crescent Mountain herd be maintained at approximately 200 animals by public hunting and scientific collecting for the duration of this study.

I recommend further studies in determining comparative diets by means of fecal pellet analyses conducted by qualified persons under contract.

Continuation of the winter range study to determine year-to-year variations as well as trends is recommended. This can best be done by contracting qualified individuals.

Laboratory analyses of important forage species to determine food quality should be conducted.

A limited winter collection of adult ewes on Surprise Mountain and Cooper Landing Closed Area should be undertaken toward the end of the study to compare the in-utero pregnancy rates which may be affected by differences in breeding behavior.

If possible, a number of sheep should be marked for future identification as an aid in behavior and movement studies.

ACKNOWLEDGMENTS

Charles Lucier assisted in the post-mortem studies as well as in attempting to determine specimen ages by reading tooth annuli. He also helped in many ways throughout the year by providing laboratory assistance and supplies.

Nick Steen, Carl McIlroy, Ken Pitcher, Bob LeResche, Paul LeRoux, Jim Davis and Tony Smith all contributed time and considerable effort during the hazardous and demanding collecting program.

Dave Harkness cut, ground and prepared the tooth sections for reading.

Dennis Bromley did a large part of the aging by horn annuli and compiled much of the post-mortem data into usable form. He, Carl McIlroy and Chuck Irvine also acted as observers during several aerial surveys.

Nate Johnson and Carl McIlroy conducted the Cooper Landing part of the rutting behavior study. Nate also helped install the weather stations.

This study could not have been conducted without their help and I extend each of them my sincere thanks.

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Plate 1. Observing sheep breeding behavior, Surprise Mt., Dec. 1971

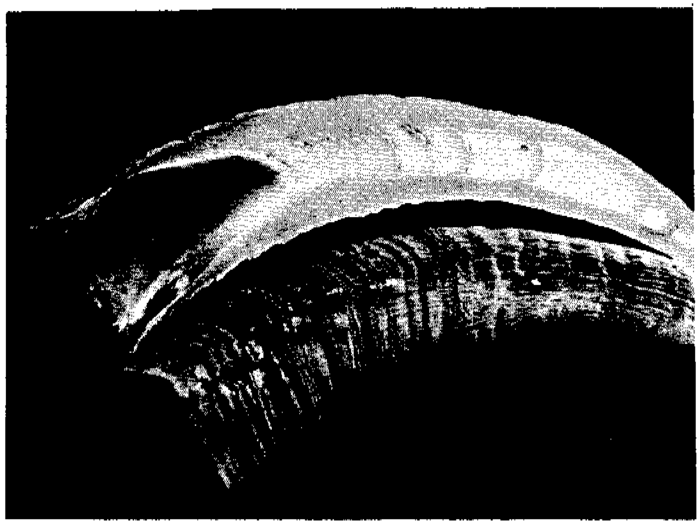

Plate 2. Dall sheep ewe horn showing exterior surface and internal annuli in sectioned horn.

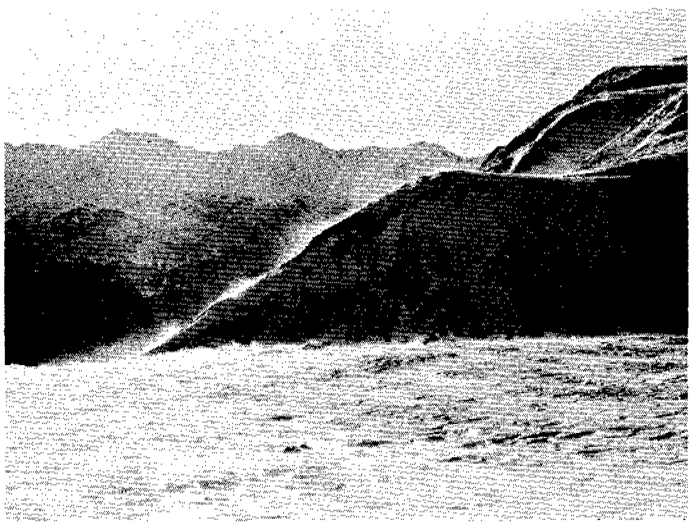

Plate 3. Wind blows powder snow from ridges on Surprise Mt., making forage available to sheep in winter.

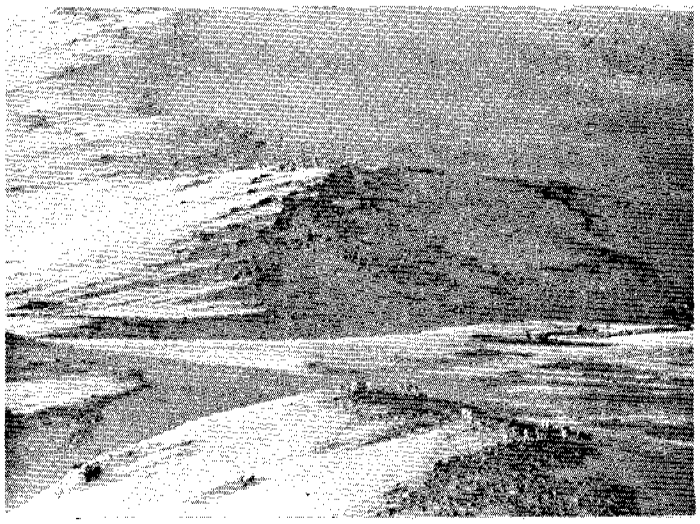

Plate 4. Sheep feeding on windblown ridges on Surprise Mt. in December, 1971.

Plate 5. Sectioned Dall sheep ovary showing degenerating corpus luteum (DCL) and ripening follicles prior to rut.

Plate 6. Sectioned Dall sheep ovary showing large corpus luteum of pregnancy (CL).

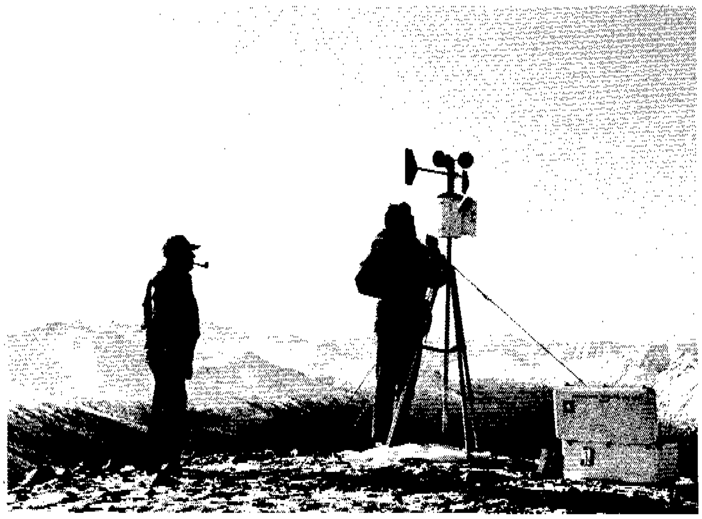

Plate 7. Installing self-contained weather station on Crescent Mt., Oct. 1971.

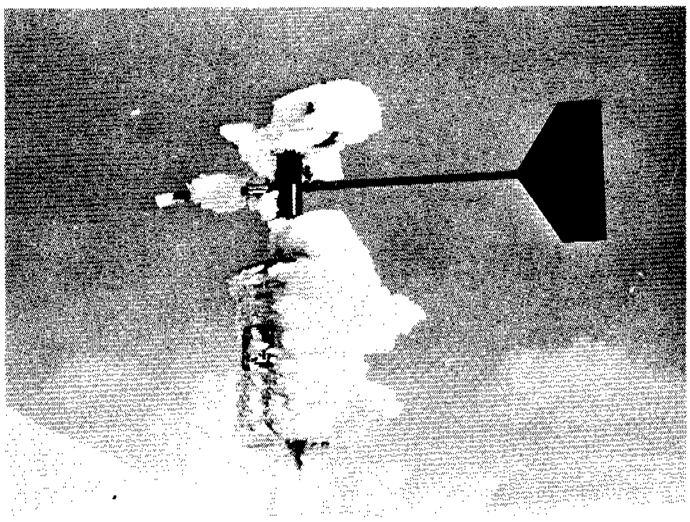

Plate 8. Ice-damaged weather station on Crescent Mt., Nov. 1971. Part of wind vane gone, anemometer broken.

Appendix I. Sheep Breeding Observation Punch Card Key, 1971.

Breeding Observation Form (all)	(Corner)	29.5	
Area:	Surprise Mt	1	
	Cooper Landing Closed Area	2	
	Other	3	
Year:	1970	4	
	1971	5	
	1972	6	
	1973	7	
	1974	8	
Month & Date	Nov. 10-15	9	
	Nov. 16-20	10	
	Nov. 21-25	11	
	Nov. 26-30	12	
	Dec. 1-5	13	
	Dec. 6-10	14	
	Dec. 11-15	15	
	Dec. 16-20	16	
	Dec. 21+	17	
Period of Day	Early morning (Em)	18	
	Midmorning (Mm)	19	
	Midday (Md)	20	
	Midafternoon (Ma)	21	
	Late afternoon (La)	22	
	Night (Ni)	23	
Class Initiating Action	Im	24	
	If	25	
	IIm	26	
	IIf	27	
	IIIm	28	(skip 29)
	IIIf	30	
	IV	31	
	V	32	
	VI	33	
	VII	34	
	G	35	
Class Acted Upon	Im	36	
	If	37	
	IIm	38	
	IIf	39	
	IIIm	40	
	IIIf	41	
	IV	42	
	V	43	
	VI	44	
	VII	45	

Appendix II

Section A. Dall Sheep Range Plants Study

From: Dr. Richard M. Hansen
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This is the Final Report on Service Contracts for range vegetation studies and diet studies of Dall Sheep on Surprise Mountain, Slaughter Mountain and Crescent Mountain of the Kenai Peninsula, Alaska.

March 1, 1972

BACKGROUND

The major cause of Dall sheep declines in Alaska appears to be inclement winter weather (Nichols 1972). These sheep are adapted to cold, dry snow and high winds and they depend on exposed ridges for what winter food they get. The knowledge of how to prevent weather-related natural die-offs of Dall sheep is believed to be a primary objective of the Dall sheep research. Therefore, it appears necessary to identify and quantify the range plants on the exposed ridges used by sheep and to examine the food habits of Dall sheep.

The ridges to be sampled for plant composition and aboveground biomass were selected from photographs taken in the winter of the ridges which were used by Dall sheep. Rumen samples of Dall sheep taken by hunters and rumens from sheep collected in a treatment were analyzed to determine the winter food habits. Summer food habits were determined from fecal samples for Dall sheep.

ABSTRACT OF RANGE WORK

A five-year sheep study began on the Kenai Peninsula in July, 1970. The study objectives are to determine the effects of both either-sex hunting and heavy ram-only hunting on Dall sheep populations as well as to obtain basic life history data. Three isolated but adjacent sheep herds are under study: one of which is being reduced by some 30 percent by either-sex hunting and scientific collecting; another is under intensive ram-only hunting; the third Dall sheep herd has been and will continue to be protected.

A habitat study was designed to determine the plant composition and annual production of plants on Dall sheep winter range on Crescent Mountain, Surprise Mountain and Slaughter Mountain (Cooper Landing Closed Area), Kenai Peninsula. The range plant data collected in July and August 1971 have been analyzed using standard statistical techniques which included the development of a computer program to determine plant species biomass for any future surveys that are to be made. All species of plants encountered on the study plots were collected, preserved and identified. Duplicate specimens were deposited at the Fish and Game Department in Anchorage, and at the Herbarium at Brigham Young University.

Thirty-four kinds of Alaskan plants were in vivo digested by the nylon-bag technique to obtain an index to each plant's relative nutrient value.

Reference microscope slides were made from the plants encountered on the three study areas. Technicians were trained to recognize the fragments of the plants. Each species of plant (or forage category) was identified in the rumen or fecal sample when a fragment was discerned that matched the material on a reference slide. A microscopic analysis was made on samples from 65 rumens and on the summer-collected fecal composite samples of Dall sheep to determine the diets of the sheep.

Only limited statistical comparisons using the Dall sheep habitat and diet data in combination are justified. Controversy stems most often from the lack of good data and to develop statistics from "noncomparable" observations would be as misleading as having too narrow a viewpoint. However, the data on diets and habitats when viewed as "descriptive information" could be extremely valuable in designing future studies.

RANGE SAMPLING TECHNIQUE

Survey of Each Study Area

A thorough survey of each area to be sampled was made prior to keeping estimation records to allow the estimators to learn to recognize the species of plants present. The estimators practiced by recording the frequency of each plant species for 100 quadrats. This gave some indication of which five species were the most common on the stand sample areas. It was desirable and necessary to make up a field identification kit to reference frequently while learning the plants and to speed up recalling symbols and names when the actual records were being taken later. The kit was made by finding plants in each study area that match those in the "master kit" and these were taped into a pocket-size notebook. Such kits sometimes last for several years if carefully taken care of. Each identification kit included the correct symbol and plant species name. The field crew memorized the common names and symbols they expected to encounter before they started to keep records. Whenever new plants were encountered they were collected and identified. The work was done by four persons in two teams as an estimator and a recorder.

Practice Estimation of Plant Species

Estimators spent a minimum of two hours per day in practicing the estimation of field weights of the most frequent plants in the study areas. Practice with all plants which occur in the sample area was valuable, but the major part of the practice time was spent estimating the field weights of the dominant plant species. At the beginning of the practice, several clippings of one to five g size were weighed to give the estimator an idea of what a given weight looks like.

The estimator placed a quadrat over the plant species to be estimated; he estimated its field weight; he clipped the plant (or plants) of that species and gave the clipping to another person to weigh. Five to ten estimates were made in this way before the estimator checked the actual weights to observe his accuracy. Small light plastic "baggies" were used for saving clipped plant samples and for weighing the clipped plants.

Sampling

The number of quadrats to be estimated and the arrangement of the transects varied according to the characteristics of the stand area to be sampled, but the sampling technique was by systematic random placement of the quadrats.

In using a relatively small, 100 cm^2 quadrat (10 cm x 10 cm), the estimator's field of vision could easily conceptualize the weights in all plants to be estimated. This allowed much more rapid sampling than if the plot sizes had been larger. The small quadrat size was compensated for by insuring that data from an adequately large number of quadrats was recorded per sample area. A small quadrat results in a relatively high statistical variance because the mean difference between plots is being expressed. The variance observed is mostly because of the mean high difference between plots and in part due to the estimator's variation in his ability to be consistent in his estimates.

For each quadrat to be read, the estimator placed the quadrat on the ground and estimated the total field weight of each plant species found within the quadrat. Total live biomass of each plant within the quadrat was estimated, not just the biomass of plants rooted in the quadrat. As each estimate was made, the estimator called out the symbol of the plant (a four letter symbol made up of the first two letters of the genus and species of the plant). For example, "BENA" for *Betula nana* and the estimate of its total field weight and this information was recorded by another individual. Unidentifiable species of plants were lumped as unknown grasses or unknown forbs, subscripted for easy reference, and then collected for later identification.

If field conditions permit, actual field weights of plants for which estimates are made should be determined by clipping and weighing after each 100 quadrats. Every 100 quadrats, samples of each plant species occurring in amounts of one g or more in any single quadrat were estimated by weight, clipped, weighed and later oven-dried at 60°C. Estimated weight to actual weight correction factors and wet weight to dry weight correction factors were determined from these samples. Some plants like mosses may never make up one gram/quadrat. They were very common and they were estimated, clipped and weighed to obtain the necessary correction factors to calculate dry weight. Lichens were not recorded and they were not as common as were the mosses.

If adverse field conditions made clipping and weighing every 100 quadrats impractical, this part of the procedure was done as often as possible or as soon as weather conditions permitted.

<u>Correction Factors</u>

The estimated weight to actual weight correction factor and the wet to dry weight correction factor for a plant species which is not collected and weighed was assigned based on the correction factors for a similar plant species for which those data are available. If possible, however, samples of each frequently occurring plant species were collected and oven-dried to obtain the wet/dry correction factor. Because of the variability of the dry weight composition of plants, it is extremely difficult to arbitrarily assign this factor. It is desirable to clip and dry plant species in sufficient quantity to obtain an accurate wet to dry weight correction factor. At least 10 grams wet weight is necessary and 50

	Sampling Locality
	Stand Sample Area No.
	Estimators Initials
	Date of Recordings

Symbols for the Frequent Species of Plants

Quadrat No.											The uncommon species (write-in's)					
___1																
___2																
___3																
___4																
___5																
___6																
___7																
___8																
___9																
___0																

	Sampling Locality
	Stand Sample Area No.
	Estimators Initials
	Date of Recordings

Plant Species Symbols	Estimated Field weight	Actual Field weight	Estimator's Correction	Oven-dry Weight	Live/Dry Correction	

LIST OF SYMBOLS USED FOR PLANT COMPOSITION DETERMINATIONS
ON RIDGES THAT ARE WIND-SWEPT AND SEMI-OPEN IN WINTERS
AT SURPRISE MT., ALASKA, 1971

1. ANNA *Anemone narcissiflora*
2. ARAR *Artemesia arctica*
3. ARAL *Arctostaphylos alpina*
4. BENA *Betula nana*
5. CALA *Campanula lasiocarpa*
6. CARE species of sedges
7. CESP *Cerastium* sp.
8. COCA *Cornus canadensis*
9. DILA *Diapensia lapponica*
10. DRIN *Dryas integrifolia*
11. EMNI *Empetrum nigrum*
12. FEBR *Festuca brachyphylla*
13. HIAL *Hierochloë alpina*
14. LEPA *Ledum palustre*
15. OXYT *Oxytropis* sp.
16. PEOE *Pedicularis oederi*
17. POAS *Poa* sp.
18. POUN *Potentilla uniflora*
19. POVI *Plygonum viviparum*
20. SALI *Salix* sp.
21. SATR *Saxifraga tricuspidata*
22. MOSS species of mosses
23. SOMU *Solidago multiradiata*
24. THSP *Thalaspi* sp.
25. VAUL *Vaccinium uliginosum*
26. VAVI *Vaccinium vitis-idaea*

LIST OF SYMBOLS USED FOR PLANT COMPOSITION DETERMINATIONS
ON RIDGES THAT ARE WIND-SWEPT AND SEMI-OPEN IN WINTERS
AT SLAUGHTER GULCH, ALASKA, 1971

1.	ACBO	*Achillea borealis*
2.	ACDE	*Aconitum delphinifolium*
3.	ALTE	*Alnus* sp.
4.	ANNA	*Anemone narcissiflora*
5.	ANPA	*Antennaria pallida*
6.	ANSE	*Androsace septentrionalis*
7.	ARAR	*Artemesia arctica*
8.	ARAL	*Arctostaphylos alpina*
9.	ARUU	*Arctostaphylos uva-ursi*
10.	BENA	*Betula nana*
11.	BRSP	*Bromus* sp.
12.	CACA	*Calamagrostis canadensis*
13.	CALA	*Campanula lasiocarpa*
14.	CARE	species of sedges
15.	CARO	*Campanula rotundifolia*
16.	CEAR	*Cerastium arvense*
17.	CESP	*Cerastium* sp.
18.	DRIN	*Dryas integrifolia*
19.	DRSP	*Draba* sp.
20.	EMNI	*Empetrum nigrum*
21.	EPAN	*Epilobium angustifolium*
22.	EPLA	*Epilobium latifolium*
23.	ERSP	*Erigeron* sp.
24.	FERN	fern not identified
25.	GEER	*Geranium erianthum*
26.	GESP	*Geum* sp.
27.	HIAL	*Hierochloë alpina*
28.	JUCO	*Juniperus communis*
29.	LEPA	*Ledum palustre*
30.	LIBO	*Linnaea borealis*
31.	LUNO	*Lupinus nootkatensis*
32.	MYPA	*Myosotis palustris*
33.	OXCA	*Oxytropis campestris*
34.	OXTR	*Oxytropis* sp.
35.	PEVE	*Pedicularis verticillata*
36.	POAS	*Poa* sp.
37.	POUN	*Potentilla uniflora*
38.	POVI	*Polygonum viviparum*
39.	ROSA	*Rosa* sp.
40.	RUSP	*Rubus* sp.
41.	SABR	*Saxifraga bronchialis*
42.	SALI	*Salix* sp.
43.	SATR	*Saxifraga tricuspidata*
44.	MOSS	species of mosses
45.	SERO	*Sedum rosea*
46.	SOMU	*Solidago multiradiata*
47.	SPBE	*Spiraea beauverdiana*
48.	TRSP	*Trisetum spicatum*
49.	VAVI	*Vaccinium vitis-idaea*
50.	UNKF	unidentified forb
51.	UNKG	unidentified grass

LIST OF SYMBOLS USED FOR PLANT COMPOSITION DETERMINATIONS
ON RIDGES THAT ARE WIND-SWEPT AND SEMI-OPEN IN WINTERS
AT CRESCENT MT., ALASKA, 1971

1.	ACDE	*Aconitum delphinifolium*
2.	AGSP	*Agropyron* sp.
3.	ANNA	*Anemone narcissiflora*
4.	ARAR	*Artemesia arctica*
5.	ARAL	*Arctostaphylos alpina*
6.	ARSP	*Arnica* sp.
7.	CALA	*Campanula lasiocarpa*
8.	CARE	species of sedges
9.	CESP	*Cerastium* sp.
10.	DROC	*Dryas octapetala*
11.	EPAN	*Epilobium angustifolium*
12.	EPLA	*Epilobium latifolium*
13.	FEBR	*Festuca brachyphylla*
14.	GEER	*Geranium erianthus*
15.	HIAL	*Hierochloë alpina*
16.	JUSP	*Juncus* sp.
17.	LUSP	*Luzula* sp.
18.	MIMA	*Minuartia macrocarpa*
19.	MYPA	*Myosotis palustris*
20.	OXYT	*Oxytropis* sp.
21.	PEFL	*Pentaphylloides floribunda*
22.	PESP	*Pedicularis* sp.
23.	POA	*Poa* sp.
24.	POPU	*Polemonium pulcherrimum*
25.	POUN	*Potentilla uniflora*
26.	POVI	*Polygonum viviparum*
27.	PYSP	*Pyrola* sp.
28.	SABR	*Saxifraga bronchialis*
29.	SALI	*Salix* sp.
30.	SATR	*Saxifraga tricuspidata*
31.	MOSS	species of mosses
32.	SERO	*Sedum rosea*
33.	SIAC	*Silene acaulis*
34.	SOMU	*Solidago multiradiata*
35.	STSP	*Stellaria* sp.
36.	THSP	*Thalaspi* sp.
37.	TRSP	*Trisetum spicatum*
38.	UNKF	unidentified forb
39.	UNKG	unidentified grass
40.	VAVI	*Vaccinium vitis-idaea*

grams wet weight is desirable. For cryptograms it is necessary to estimate and clip many times more often than for grasses or forbs to obtain enough weights so that accurate correction factors can be calculated. These clippings should be kept in a labeled paper sack so the clippings can be dried and so the clippings will not decompose. Frequently it is possible to obtain enough clippings of some common species for chemical, energy or mineral analyses.

PROGRAM ALSAK

The purpose of this program is to summarize the vegetation data for each of three Dall Sheep habitats: Crescent Mountain, Slaughter Gulch and Surprise Mountain. The results obtained are mean field weight, number of occurrences of individual species, mean grams of dry weight for all plants per 100 centimeters squared, the standard error about this mean, the calculated mean pounds of dry weight for all plant categories per acre and the standard error about this mean. However, under the headings TØTGR, TØTFB, and SUMMARY TØTALS the results have a different denotation than the others. In the mean columns the values represent the sums of the previous means. In the S.E. columns the values represent the standard error of the between plot variances. The results were tabulated for each stand (100 plots) and for each area (10 stands).

The field weight was obtained by multiplying the observer's estimate of the weight of a particular species by his correction factor for that species. The observer's correction factor is obtained from a series of estimates which are then weighed to get the actual weight. The correction factor is the mean estimated weights divided into the mean actual weights for a given species. Estimated and actual weights are obtained for the most common species of grasses, forbs and shrubs and based on their phenology and appearance, the minor and incidental plant species are assigned a correction factor measured for a major species.

Dry weight is then calculated by multiplying the field weight by the percent dry weight of the particular species in question. The percent dry weight of all major species is obtained by clipping at least 10 grams (more is better) and obtaining a field weight and the sample is later oven-dried at 60°C for a dry weight. The minor and incidental plant species are assigned a dry weight correction value measured for a major species.

To obtain the above results two sets of data are required for each area. The first set is a list of all of the species encountered in an area with their corresponding percent dry weight and the observers' correction factors for each species. These data should be key punched according to the following format:

Columns

1-5	Species name
6-9	Blank
10-13	Percent dry weight (F4.3)
14-15	Blank
16-19	Observer #1 correction factor (F4.2)
20-21	Blank
22-25	Observer #2 correction factor (F4.2)

This list of species is referred to as the master list. The master list should be divided into two categories. The first category is grasses and grass-likes and should be followed by a card with TØTGR (total grass) punched in columns 1-5. TØTGR tells the program to find the total mean weights for all grasses. Similarly following the forbs, forb-likes and shrubs a card with TØTFB (total forb) punched in columns 1-5.

The master list can be up to 55 species including TØTGR, TØTFB and XXXXX. XXXXX is a trailer card which indicates the end of the master list.

The second set of data consists of a labeled field with area number, stand number, plot number, and observer number and then species with their estimated weights. The cards should be punched as follows:

Columns

1	Area number
3	Stand number (0 - for 10)
4-6	Plot number
8	Observer number
11-15	Species name (right justified)
16-20	Estimated weight (F5.1)
21-25	Species name
26-30	Estimated weight
.	.
:	:
51-55	Species name
56-60	Estimated weight

If there happens to be more than six species observed in one plot another card(s) can be used. It should have the same information in the label field as the previous card.

ALSAK is currently set up to analyze three areas, 10 stands and 100 plots per stand. However, there were three cases of missing data, 10 plots each. To compensate for this, the sample size has been reduced to 980 in area 1 and 990 in area 2. Also the stands in which the observations were missing had their sample sizes reduced for mean and standard error calculation. You should anticipate some cases of missing data in the future because of circumstances that can't be avoided.

Some wet (live) and oven-dry weights of the common plants found on Dall sheep winter ranges near Cooper Landing, Alaska.

Symbol of Sample	Locality	Date	Wet Wt.	Dry Wt. (60"C 2 da)	Shrubs Stems % dry wt	Shrubs Leaves % dry wt
Lepa	Surprise Mtn.	7/27/71	17.5 gm	stems 2.0g, leaves 4.8g	.2941	.7059
Vavi	Surprise Mtn.	7/27/71	15.0 gm	stems 0.6g, leaves 5.1g	.1053	.8947
Moss	Surprise Mtn.	7/27/71	15.0 gm	4.8 gm		
Care	Surprise Mtn.	7/27/71	8.5 gm	2.8 gm		
Aral	Surprise Mtn.	7/27/71	17.5 gm	stems 0.3g, leaves 5.1g	.0556	.9444
Hial	Surprise Mtn.	7/27/71	20 gm	6.3 gm		
Sali	Surprise Mtn.	7/27/71	24 gm	stems,0.5g, leaves 6.7g	.0694	.9306
Drin	Surprise Mtn.	7/27/71	24 gm	9.2 gm		
Bena	Surprise Mtn.	7/27/71	28 gm	stems, 5.4g,leaves 4.7g	.5347	.4653
Geer	Slaughter Gulch	8/1/71	16 gm	3.4 gm		
Epan	Slaughter Gulch	8/1/71	16 gm	3.25 gm		
Peve	Slaughter Gulch	8/1/71	12.5 gm	1.7 gm		
Satr	Slaughter Gulch	8/1/71	29 gm	5.4 gm		
Aral	Slaughter Gulch	8/1/71	24 gm	stems,>0.1g, leaves 6.7g	.0147	.9853
Drin	Slaughter Gulch	8/1/71	20 gm	6.4 gm		
Bena	Slaughter Gulch	8/1/71	38 gm	stems, >0.1gm, leaves 11.2 gm	.0089	.9912
Luno	Slaughter Gulch	8/1/71	19 gm	2.4 gm		
Vavi	Slaughter Gulch	8/1/71	26.0 gm	stems, 1.6g, leaves 8.4g	.1600	.8400
Hial	Slaughter Gulch	8/1/71	33 gm	10.7 gm		
Somu	Slaughter Gulch	8/1/71	22.0 gm	4.0 gm		
Mypa	Slaughter Gulch	8/1/71	11.0 gm	2.0 gm		
Care	Slaughter Gulch	8/1/71	20 gm	6.35 gm		
Sali	Slaughter Gulch	8/1/71	27 gm	stems, 1.2g, leaves 7.0g	.1463	.8537
Arar	Slaughter Gulch	8/1/71	50 gm	7.7 gm		
Vavi	Crescent Mtn.	8/13/71	3.5 gm	stems, 0.3gm, leaves 1.0gm	.2308	.7692
Care	Crescent Mtn.	8/13/71	24.9 gm	9.7 gm		
Poas	Crescent Mtn.	8/13/71	31.8 gm	9.4 gm		
Lusp	Crescent Mtn.	8/13/71	26.4 gm	9.0 gm		
Arar	Crescent Mtn.	8/13/71	85.7 gm	13.0 gm		
Poun	Crescent Mtn.	8/13/71	49.3 gm	16.3 gm		
Cala	Crescent Mtn.	8/13/71	21.8 gm	3.0 gm		
Hial	Crescent Mtn.	8/13/71	31.5 gm	11.8 gm		
Oxyt	Crescent Mtn.	8/13/71	16.3 gm	3.3 gm		
Trsp	Crescent Mtn.	8/13/71	26.5 gm	8.3 gm		
Febr	Crescent Mtn.	8/13/71	41.0 gm	16.4 g		
Dila	Crescent Mtn.	8/13/71	15 gm	stems, 0.3g, leaves 6.6g	.0435	.9565
Droc	Crescent Mtn.	8/13/71	23.5 gm	10.45 gm		
Moss	Crescent Mtn.	8/13/71	.9 gm	.4 gm		
Moss	Crescent Mtn.	8/14/71	29.7 gm	9.2 gm		
Sabr	Crescent Mtn.	8/14/71	35.0 gm	9.5 gm		
Sali	Crescent Mtn.	8/14/71	40.7 gm	stems,0.4g, leaves 13.1g	.0296	.9704
Oxyt	Crescent Mtn.	8/14/71	10.5 gm	2.85 gm		
Anna	Crescent Mtn.	8/14/71	34.1 gm	8.9 gm		

Surprise Mountain, Alaska, July 28, 1971. A summary for 10 stands and 1000 quadrats for the area. The calculated field weights (live) and oven dry weights of the aboveground parts of plants on ridges that are wind swept and are semi open in winter. These stands are used intensively by Dall sheep in winter. Page one of one page.

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
CARE	176.	.1953	.0676	±.0058	61.4438	5.2847
FEBR	10.	.0095	.0038	±.0016	3.4512	1.4828
HIAL	135.	.1109	.0375	±.0040	34.0618	3.6412
POAS	6.	.0035	.0010	±.0004	.9459	.4070
TOTGR	327.	.3193	.1099	±.0071	99.9227	6.4123
ANNA	48.	.0479	.0125	±.0024	11.3615	2.2089
ARAR	1.	.0015	.0002	±.0002	.2065	.2065
ARAL	174.	.6435	.1905	±.0170	173.1489	15.4180
BENA	111.	.3761	.1237	±.0142	112.4917	12.8062
CALA	41.	.0230	.0032	±.0006	2.8907	.5344
CESP	11.	.0047	.0007	±.0002	.6470	.2263
COCA	3.	.0033	.0005	±.0003	.4511	.3034
DILA	42.	.0631	.0290	±.0059	26.3898	5.3746
DRIN	210.	.5873	.2067	±.0166	187.9467	15.1325
EMNI	67.	.1319	.0513	±.0076	46.6550	6.9099
LEPA	82.	.0877	.0341	±.0045	31.0043	4.1022
OXYT	17.	.0105	.0025	±.0009	2.2714	.8084
PEDE	25.	.0345	.0047	±.0013	4.2637	1.1489
POUN	13.	.0123	.0041	±.0013	3.7030	1.2059
POVI	10.	.0083	.0012	±.0006	1.1339	.5031
SALI	116.	.2129	.0664	±.0072	60.3850	6.5481
SATR	2.	.0017	.0003	±.0002	.2876	.2082
MOSS	157.	.0610	.0218	±.0026	19.8517	2.3829
SOMU	1.	.0013	.0002	±.0002	.2189	.2189
THSP	1.	.0007	.0001	±.0001	.1012	.1012
VAUL	169.	.2375	.0898	±.0085	81.6147	7.7184
VAVI	428.	.3251	.1229	±.0075	111.7325	6.8307
TOTFB	1729.	2.8760	.9666	±.0312	878.7568	28.3424
******************** SUMMARY TOTALS ********************						
	2056.	3.1953	1.0765	±.0319	978.6796	29.0172

Slaughter Mountain, Alaska, August 3, 1971. A summary of 10 stands and 1000 quadrats for the area. The calculated field weights (live) and oven dry weights of the aboveground parts of plants on ridges that are wind swept and are semi open in winter. These stands are used intensively by Dall sheep in winter. First page of two pages.

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
BRSP	25.	.0250	.0085	±.0020	7.6940	1.8336
CACA	6.	.0029	.0010	±.0004	.9049	.3898
CARE	96.	.1131	.0391	±.0062	35.5597	5.6565
HIAL	276.	.5073	.1715	±.0128	155.8823	11.6148
POAS	65.	.0863	.0256	±.0049	23.2286	4.4945
TRSP	3.	.0075	.0023	±.0015	2.1341	1.3517
UNKG	4.	.0045	.0015	±.0008	1.3921	.7373
TOTGR	475.	.7467	.2495	±.0149	226.7951	13.5865
ACBO	7.	.0060	.0016	±.0007	1.4273	.6114
ACDE	15.	.0166	.0043	±.0013	3.9332	1.1462
ALTE	3.	.0283	.0093	±.0083	8.4600	7.5828
ANNA	20.	.0262	.0068	±.0025	6.2168	2.2742
ANPA	1.	.0009	.0001	±.0001	.1252	.1252
ANSE	10.	.0030	.0005	±.0001	.4133	.1358
ARAR	102.	.2118	.0324	±.0045	29.4548	4.1234
ARAL	41.	.1750	.0518	±.0095	47.0786	8.6294
ARUU	128.	.2660	.0787	±.0082	71.5894	7.4498
BENA	53.	.2600	.0856	±.0141	77.7728	12.8070
CALA	25.	.0171	.0024	±.0006	2.1476	.5513
CARO	10.	.0094	.0014	±.0005	1.2811	.4275
CEAR	54.	.0362	.0054	±.0009	4.9379	.8430
CESP	1.	.0005	.0001	±.0001	.0689	.0689
DRIN	341.	1.4072	.4953	±.0269	450.2975	24.4562
DRSP	15.	.0099	.0015	±.0004	1.3500	.3855
EMNI	6.	.0276	.0107	±.0061	9.7430	5.5103
EPAN	157.	.2474	.0502	±.0050	45.6614	4.5409
EPLA	4.	.0037	.0007	±.0004	.6779	.3591

Slaughter Mountain, Alaska, August 3, 1971. A summary of 10 stands and 1000 quadrats for the area. The calculated field weights (live) and oven dry weights of the aboveground parts of plants on ridges that are wind swept and are semi open in winter. These stands are used intensively by Dall sheep in winter. Second page of two pages.

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
ERSP	5.	.0064	.0010	.0006	.8729	.5053
FERN	1.	.0009	.0001	.0001	.1252	.1252
GEER	69.	.0694	.0148	.0022	13.4457	2.0411
GESP	1.	.0010	.0002	.0002	.1378	.1378
JUCO	1.	.0081	.0032	.0032	2.9388	2.9388
LEPA	13.	.0352	.0137	.0043	12.4386	3.9072
LIBO	28.	.0334	.0050	.0013	4.5534	1.1961
LUNO	10.	.0048	.0006	.0002	.5470	.1944
MYPA	5.	.0066	.0012	.0006	1.0864	.5343
OXCA	27.	.0211	.0050	.0013	4.5470	1.1695
OXYT	18.	.0161	.0038	.0012	3.4686	1.0612
PEVE	11.	.0045	.0006	.0003	.5507	.2546
POUN	3.	.0137	.0046	.0040	4.1369	3.6639
POVI	23.	.0232	.0035	.0009	3.1684	.8424
ROSA	5.	.0064	.0010	.0005	.8704	.4625
RUSP	1.	.0005	.0001	.0001	.0689	.0689
SABR	1.	.0037	.0010	.0010	.9017	.9017
SALI	41.	.1993	.0622	.0116	56.5391	10.5810
SATR	69.	.1503	.0280	.0044	25.4159	3.9595
MOSS	36.	.0155	.0056	.0017	5.0572	1.5861
SERO	1.	.0014	.0002	.0002	.1878	.1878
SOMU	30.	.0286	.0052	.0014	4.7313	1.2766
SPBE	9.	.0163	.0025	.0010	2.2291	.8682
VAVI	233.	.4244	.1604	.0128	145.8344	11.6351
UNKF	64.	.0481	.0072	.0011	6.5571	1.0160
TOTFB	1698.	3.8917	1.1694	.0366	1063.0469	33.2998
			SUMMARY TOTALS			
	2173.	4.6384	1.4188	.0403	1289.8426	36.6332

Crescent Mountain, Alaska, August 10, 1971. A summary of 10 stands and 1000 quadrats for the area. The calculated field weithts (live) and oven dry weights of the aboveground parts of plants on ridges that are wind swept and are semi open in winter. These stands are used intensively by Dall sheep in winter. First page of two pages.

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
AGSP	2.	.0003	.0001	±.0001	.0830	.0586
CARE	312.	.0962	.0333	±.0020	30.2505	1.8609
FEBR	57.	.0119	.0048	±.0008	4.3353	.7297
HIAL	109.	.0284	.0096	±.0011	8.7136	1.0070
JUSP	2.	.0006	.0002	±.0002	.1841	.1385
LUSP	6.	.0015	.0005	±.0002	.4650	.2099
POA	50.	.0170	.0050	±.0009	4.5665	.8142
TRSP	59.	.0180	.0056	±.0009	5.1210	.8282
UNKG	1.	.0002	.0001	±.0001	.0581	.0581
TOTGR	598.	.1740	.0592	±.0028	53.7770	2.5563
ACDE	3.	.0039	.0010	±.0006	.9218	.5424
ANNA	74.	.0665	.0174	±.0024	15.7767	2.1372
ARAR	82.	.0940	.0144	±.0020	13.0768	1.8271
ARAL	8.	.0230	.0068	±.0029	6.1797	2.5975
ARSP	4.	.0058	.0009	±.0005	.7871	.4470
CALA	119.	.0273	.0038	±.0005	3.4294	.4241
CESP	22.	.0176	.0026	±.0007	2.3989	.6046
DROC	134.	.2182	.0971	±.0100	88.2751	9.1241
EPAN	16.	.0271	.0055	±.0019	5.0027	1.7558
EPLA	6.	.0040	.0008	±.0004	.7380	.3640
GEER	2.	.0039	.0008	±.0007	.7523	.6536
MIMA	37.	.0351	.0053	±.0011	4.7876	1.0223
MYPA	1.	.0006	.0001	±.0001	.0918	.0918
OXYT	106.	.0375	.0089	±.0010	8.0879	.9495
PEFL	1.	.0078	.0026	±.0026	2.3381	2.3381
PESP	3.	.0013	.0002	±.0001	.1569	.0927
POPU	3.	.0028	.0004	±.0002	.3784	.2268

Crescent Mountain, Alaska, August 10, 1971. A summary of 10 stands and 1000 quadrats for the area. The calculated field weights (live) and oven dry weights of the aboveground parts of plants on ridges that are wind swept and are semi open in winter. These stands are used intensively by Dall sheep in winter. Second page of two pages.

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
POUN	69.	.0739	.0245	.0047	22.2342	4.2786
POVI	14.	.0085	.0013	.0004	1.1577	.3534
PYSP	2.	.0009	.0001	.0001	.1252	.1064
SABR	20.	.0259	.0070	.0020	6.3695	1.8360
SALI	202.	.2253	.0703	.0058	63.8956	5.2905
SATR	102.	.1921	.0357	.0047	32.4817	4.2412
MOSS	93.	.0276	.0099	.0018	8.9825	1.6276
SERO	3.	.0039	.0006	.0005	.5375	.4579
SIAC	9.	.0216	.0032	.0012	2.9393	1.0570
SOMU	1.	.0011	.0002	.0002	.1837	.1837
STSP	32.	.0171	.0026	.0006	2.3330	.5178
THSP	1.	.0003	.0000	.0000	.0454	.0454
VAVI	16.	.0132	.0050	.0016	4.5236	1.4691
UNKF	1.	.0001	.0000	.0000	.0151	.0151
TOTFB	1186.	1.1878	.3289	.0150	299.0033	13.6076
* * * * * * * * * * SUMMARY TOTALS * * * * * * * * * *						
	1784.	1.3618	.3881	.0158	352.7803	14.3316

When this program is run in the future an error message may be encountered: "SPECIES---- IS NØT ØN MASTER LIST", where the blanks will be filled by the symbols read in which do not match master list read in. This error implies that either a keypunch error has been made on the master list or the second data set; or a species that was found in the field was not put on the master list or the wrong symbol was used.

COMPOSITION SIMILARITY OF AREAS

There were great differences in the plant composition of the three study areas. As one of many examples, birch was a common plant on the transects at Surprise Mountain and Slaughter Mountain but was not recorded on a single quadrat at Crescent Mountain.

Surprise and Slaughter Mountains

There were 19 common plant data categories (on the quadrats) for Surprise Mountain and Slaughter Mountain. There were seven plant categories on Surprise Mountain that did not occur on plots at Slaughter Mountain while there were 25 plant data categories found on Slaughter Mountain that were absent from the Surprise Mountain data. Plant diversity was higher at Slaughter Mountain than at the other two study areas.

Surprise and Crescent Mountains

There were 19 common plant categories (on the quadrats) between Surprise and Crescent mountains. There were seven data categories on Surprise Mountain that were not at Crescent Mountain and there were 14 plant data categories on Crescent Mountain that were absent from Surprise Mountain. Plant diversity was higher at Crescent Mountain than at Surprise Mountain.

Slaughter and Crescent Mountains

There were 25 plant categories common to Slaughter Mountain and Crescent Mountain. There were 26 plant data categories on Slaughter Mountain that did not occur on plots at Crescent Mountain while there were 14 plant data categories found at Crescent Mountain that were not recorded at Slaughter Mountain.

Conclusions About Composition

All three study areas are significantly different in the plant compositions of the wind-swept ridges that were sampled. Some plants are found exclusively on plots of one area and not at the other study areas. None of the three study areas is intermediate to the other two study areas in plant composition. All three are unique. Diversity is highest at Slaughter Mountain, intermediate at Crescent Mountain and lowest at Surprise Mountain.

ABOVEGROUND BIOMASS OF HERBAGE

There are many statistically significant differences in the total oven-dry weights of herbage classes (grasses, forbs, etc.) between all three study areas. Total plant herbage was highest at Slaughter Mountain, intermediate at Surprise Mountain and lowest at Crescent Mountain. In general, the calculated mean dry weights of shared plants were usually significantly different between each area. Willow biomass was similar on the three areas. Sedges were similar between Slaughter Mountain and Crescent Mountain and neither produced as much sedge biomass as did Surprise Mountain where sedges made up about 60 pounds per acre.

Plants of the genus *Dryas* produced more herbage per acre on each of the three study areas than did any other plant. There may be a correlation between total biomass produced per acre and the standing crop of *Dryas* since there was about 450 pounds per acre at Slaughter Mountain, 188 at Surprise Mountain and only 88 at Crescent Mountain and this is how total biomass ranked for the three study areas.

STATISTICAL DIFFERENCES OF HABITATS AND PLANTS

This section of the Final Report describes the use of the t-test to determine if a statistically significant difference exists between the mean dry weights of herbage categories from any two study areas. This will allow a person to find differences within and between the three winter habitats of Dall sheep. If herbage data are collected in subsequent years the same procedure can be used to test if significant changes occurred from year to year on the same study area.

The t-test is used as a comparison between the dry weight means (averages) of two estimates of dry weight per unit area (per quadrat or per acre) taking into consideration the variations for means that are being compared. The t value can be calculated from the herbage summary sheets.

An example from the summary sheets will be used. Assume that you wish to compare the estimated mean dry weight of TOTFB (forbs and shrubs) on Surprise Mountain and Slaughter Mountain for the 1971 data. Obtain four values from the summary sheets. The mean ($\overline{X}_1$) dry weight per plot in grams per 100 centimeters square and the standard error ($\pm SE_1$) for Surprise Mountain and the corresponding values for Slaughter Mountain ($\overline{X}_1 \pm SE_2$) are obtained.

Surprise Mountain	Slaughter Mountain
$\overline{X}_1$ = .9666 grams per quadrat	$\overline{X}_2$ = 1.1694 grams per quadrat
SE_1 = .0312	SE_2 = .0366

Using these four values it is possible to calculate a t value which indicates the similarity of the two mean dry weights.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_p\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

N_1 = number of quadrats sampled at Surprise Mountain

N_2 = number of quadrats sampled at Slaughter Mountain

N_1 = 990 (there were 10 missing plots out of 1000)

N_2 = 980 (there were 20 missing plots our of 1000)

Sp = the square root of the pooled mean square estimate of the variance obtained by the following

$$Sp^2 = \frac{(N_1-1)\ S_1^2 + (N_2-1)\ S_2^2}{(N_1 + N_2 - 2)}$$

S_1^2 and S_2^2 can be computed by direct substitution

$$S_j^2 = (SE_j)^2 \cdot N$$

which is a slight manipulation of the definition of the standard error (SE).

$$SE = \frac{S}{\sqrt{N}} = \sqrt{\frac{S^2}{N}}$$

$$(SE)^2 = \frac{S^2}{N}$$

$$S^2 = (SE)^2 \cdot N$$

To calculate S_p^2 the estimates of the sample variance must be calculated for TOTFB for each study area.

$$S_1^2 = (SE_1)^2 \quad N = (.0312)^2 \ (990) = .9637$$

$$S_2^2 = (SE_2)^2 \quad N = (.0366)^2 \ (980) = 1.3128$$

therefore

$$S_p^2 = \frac{(N_1-1)\ S_1^2 + (N_2-1)\ S_2^2}{(N_1 + N_2 - 2)}$$

$$S_p^2 = \frac{(989)\ (.9637) + (979)\ (1.3128)}{1968}$$

$$S_p^2 = \frac{(953.0993 + 1285.2312)}{1968}$$

$$S_p^2 = \frac{2238.3305}{1968} = 1.1374$$

The t value is now a straight-forward substitution of the values previously developed into the formula given previously.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{Sp \sqrt{(\frac{1}{N_1}) + (\frac{1}{N_2})}}$$

$$t = \frac{0.9666 - 1.1694}{\sqrt{1.1374}\sqrt{(\frac{1}{990}) + ((\frac{1}{980})}}$$

$$t = \frac{-.2028}{\sqrt{1.1374} \bullet \sqrt{.001 + .001}}$$

$$t = \frac{-.2028}{\sqrt{1.1374} \cdot \sqrt{.002}} = \frac{-.2028}{(1.0665)(.04472)}$$

$$t = \frac{-.2028}{.0477} = -4.2516$$

The purpose of the t value is to determine if the difference between the two sample means is too negative or too positive after the deviations and the sample size are taken into account. Because we are looking at either negative or positive differences, it is called a two-sided test. Therefore, there is an interval called the critical region outside which a t value will indicate a difference between the two sample means. Thus, looking in the two-sided t table under $t_{.05}$ (1968) (t with a conficence interval of $\alpha = .05$ and 1968 degrees of freedom). The interval is:

$$-1.96 < t < +1.96$$

The same interval can also be obtained by looking in a one-sided table under $t_{.025}$ (1968). (A one-sided table gives the whole interval on one side of the distribution or zero. So, it is necessary to divide the interval in half and place one half on each side of zero). Observe that the calculated t value lies outside the critical region. The conclusion is that the means are statistically different at the $\alpha = .05$ level of conficence. It is possible in this particular comparison to change the confidence level to $\alpha = .001$ and still have an interval for which the calculation t value lies outside.

Significant statistical differences between different plants within each study area and between the same plants from different study areas appear to be much more common than are non-significant differences. This is a reflection upon the technique used in the range survey and the intensity of the sampling effort.

A CHART SHOWING SOME T VALUES FOR FORAGE COMPARISONS BETWEEN THREE DALL SHEEP WINTERING AREAS AT KENAI PENINSULA, ALASKA. THE T VALUES WERE CALCULATED ON THE BASIS OF MEAN OVEN DRY WEIGHT OF ABOVEGROUND HERBAGE PER UNIT OF AREA.

AREAS	One vs. Two		One vs. Three		Two vs. Three	
	t	sig	t	sig	t	sig
TOTGR	- 8.6	α = .001	6.8	α = .001	12.8	α = .001
TOTFB	- 4.3	α = .001	18.6	α = .001	21.6	α = .001
TOTHB	- 6.7	α = .001	19.5	α = .001	24.1	α = .001
DRYAS	- 9.2	α = .001	5.7	α = .001	14.1	α = .001
BENA	14.7	α = .001				
CARE	3.4	α = .001	5.7	α = .001	.9	α = n.s.
HIAL	-10.2	α = .001	6.8	α = .001	12.7	α = .001

LEGEND FOR SYMBOLS USED

Area one = Surprise Mountain, July 28, 1971
Area two = Slaughter Mountain, August 3, 1971
Area three = Crescent Mountain, August 10, 1971

TOTGR = Grasses and grasslike plants
TOTFB = Non-grasslike plants
TOTHB = Total herbage
DRYAS = *Dryas*
BENA = *Betula nana*
CARE = Sedges
HIAL = *Hierochloë alpina*

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{x}_1 - \bar{x}_2}}$$

sig = Level of statistical significance
α = Probability of a larger value (n.s. = not significant)

DIETS OF DALL SHEEP

The composition of recognized plant fragments from the digestive tracts of Dall sheep and the fecal pellets of Dall sheep was quantified by a microscope technique. The frequency of recognized plant fragments in forage fed to domestic sheep and the frequency of recognized plant fragments in the feces indicated that digestion did not greatly change the relative frequency of plant epidermal characteristics (Hansen, 1972).

A microscope identification technique for classifying fragments of plant material eaten by herbivores that thoroughly masticate their food was described by Baumgartner and Martin (1939) and the technique was later refined by Dusi (1949). Sparks and Malechek (1968) found a quantification scheme so that they could predict approximately a 1:1 relationship between relative density of recognized fragments and the dry weights of foodplants in hand compounded mixtures. Recent studies have shown that by using new slide preparation techniques practically all plant fragments passed through a leaf-eating herbivore could be recognized in the feces (Storr, 1961; Williams, 1969; Free, et al. 1970). Since there is no digestion of the epidermis that is encased in cutin and only partial digestion of cellwalls made up of cellulose and lignin-occluded cellulose there are recognizable plant fragments in the feces even though the mass (weight) of a fragment may have been changed during digestion.

Materials and Samples

Rumen samples of Dall sheep were obtained from Surprise Mountain in April 1970; Crescent Mountain in August 1970, November 1970, January 1971, February 1971, March 1971 and April 1971 by the Alaska Fish and Game Department. While the vegetation sampling was being done in July and August 1971 the recently voided feces of Dall sheep were collected in the vicinity of the transects at Crescent Mountain and Slaughter Mountain but not from Surprise Mountain. Two "ages" of sheep pellets were collected at Slaughter Mountain which were: recently dropped symetrical pellets and weathered amorphous Dall sheep pellets believed to represent an early summer (June) period of feeding. In addition, several marmot fecal samples were obtained from each of the three study areas. All the samples are listed in tabular form.

When enough Dall sheep rumen samples were available to make up a composite male and female diet the rumen samples were composited by sex. There were enough males and females to make composited diets by sex for August 1970, March 1971 and April 1971. Both sexes were composited together for the other samples. The compositing was done on an equal weight basis. The fecal pellets were made into a composite sample by date. In collecting pellets in the study areas only one pellet from a pellet group was saved and this tended to be a composite on an approximate equal weight basis.

The rumen samples and the fecal samples were ground in a Wiley mill through a 1.0 mm screen. Each sample was thoroughly mixed to develop randomness for subsampling. The grinding appears to reduce any species differences for fragmentation due to chewing and digestion so that the mean size of particles of different species of plants were similar in each sample. The material used for microscope slides was washed over a 0.1 mm screen to insure mixing and to remove the small fragments. Twenty microscope slides were prepared for each sample according to procedure outlined by Sparks and Malechek (1968). The material used for making slides was not stained and was only treated with clearing (Hertwig's) and mounting (Hoyer's) mediums. The microscope slides were examined for the frequency of recognizable plant fragments for estimating the relative percent density (RD) of each species of plant fragment for each kind of composite sample.

A reference collection was made that included the lichens, mosses, grasses, sedges, forbs and shrubs collected from the three study areas. The appropriate slides of leaf, stem, flower and seed were prepared for each species. The separate parts of each plant were placed in a Waring blender with enough hot water to at least cover the blades. After two minutes at high speed, the contents of the blender were poured into a 0.1 mm mesh screen and washed. Reference slides were made directly from this material, following the same procedure as for the fecal samples, but applying more material to the slides.

Each species of plant was identified in the sample when a fragment was observed that matched the material on a reference slide.

The relative percent density of recognized fragments of plants in each of the rumen and fecal composited samples was estimated by observing 20 systematically located fields on each of the 20 slides per composited sample with a compound binocular microscope at about 100 power magnification. The occurrence of each recognized species of plant in each field was recorded. Average percent frequency was computed for all plant species present in the samples. The relative percent density, calculated as the number of recognized fragments of a species expressed as a percentage of the total number of fragments of all species (Curtis and McIntosh, 1950) was calculated for each plant species or category of forage.

Dall Sheep Foods

At least 45 species of plants can be found in the diets of Dall sheep. There were at least nine kinds of grasses and grasslikes, 30 species of forbs and shrubs, and six categories of cryptograms. Certain plants made up the major percentage of the dry weight ingested. The major foods were sedges, hierochloe, festuca, dryas, berries, willows and lichens. Dall sheep diets in winter contained small amounts of hemlock. Hemlock did not occur on any of the transects and its presence firmly shows that the sheep feed an unknown percentage of their time on areas not sampled. The common occurrence of berries and seeds (possibly bearberry) indicates that sheep can recognize and seek out such high-energy goods when they are available. Reference plants on hand did not permit the identification of a few "unknowns", such as the fruits.

It is common knowledge that the variety and abundance of foods strongly influences the diet selected by big game animals, and we assume that it occurs this way in Dall sheep. Because plant composition and production between each study area were significantly different, it is almost a certainty that the diets of Dall sheep will reflect this difference. The variety of plants eaten shows that the sheep do not always restrict their diet even though a few kinds make up large amounts. In winter their diets may be more restricted to the plants available than in summer. This may be the reason why cladonia-type lichens which are poorly digested are so common in the winter diets of sheep. It is beyond the scope of the data to attempt to make detailed comparisons between study areas based on the data on hand. A listing of the diets determined is included.

FORAGE QUALITY

Two herford cows and two bison had been accustomed to intensive handling. These animals were rumen fistulated to enable their use for nylon bag digestion studies.

The nylon bag procedure was similar to that of Van Dyne (1962). Bags (5 mm x 10 mm in size) were constructed of parachute nylon. Two grams (oven-dried at 60°C 48 hours) of forage were digested for a 48-hour period. Nylon bags were attached to a 1 kg metal plate so that all bags were in the ventral portion and within the same strata of the rumen.

The plate and bags were washed with tap water as soon as they were removed from the rumen. They were washed in successive rinses until the wash-water became relatively clear. Each bag was then washed separately and subsequently dried 48 hours at 60°C.

The cows and bison were being maintained on a standard hay diet of western wheatgrass and the percent residue was averaged for bison and cows in order to obtain a mean ± SD for each of the 35 kinds of samples tested.

Forages used inside the nylon bags varied in composition from single species at specific stages of growth to comples mixtures of plants. The forages had been ground over a 1 mm screen. The percentage residues in dry weights averaged (over all tests) from about 93% to 16%. *Anemone* was the most (84.3%) digestible and *Cladonia gracillis* was least digestible (7.1%), (Digestion = 100 - % residue). The forages tested are ranked from most to least digestible on the next page. The values, in part reflect species differences as well as stage of maturity at the time when samples were collected. Mature plants do not digest as readily as do plants in an early stage of growth. We believe the samples might digest in Dall sheep in a similar ranking sequence.

Percent residue in nylon bag after 48 hours digestion in large herbivore rumens.

SYMBOL	SCIENTIFIC NAME	MEAN ± SD	DATE	LOCALITY
ANNA	Anemone narcissiflora	15.7 ± 9.3	8-14-71	Crescent Mtn.
ARAR	Artemesia arctica	16.0 ± 5.3	8-13-71	Crescent Mtn.
EQFL	Equisetum fluviatile	26.6 ± 11.9	9-71	Nome, Alaska
SAPU	Salix pulchra	27.9 ± 2.3	9-71	Nome, Alaska
SALI	Salix spp.	31.0 ± 14.7	8-14-71	Crescent Mtn.
CARE	Carex spp.	31.2 ± 8.6	8-13-71	Crescent Mtn.
CEIS	Cetraria islandica	31.3 ± 26.5	9-71	Nome, Alaska
SALI	Salix spp.	31.8 ± 13.3	8-1-71	Slaughter Gulch
POAS	Poa spp.	32.3 ± 10.2	8-13-71	Crescent Mtn.
HIAL	Hierochloë alpina	34.7 ± 18.7	8-13-71	Crescent Mtn.
DRIN	Dryas integrifolia	34.9 ± 9.9	7-27-71	Surprise Mtn.
DROC	Dryas octopetala	38.4 ± 8.4	8-13-71	Crescent Mtn.
EPAN	Epilobium angustifolium	38.9 ± 6.9	9-71	Nome, Alaska
TRSP	Trisetum spicatum	39.3 ± 12.7	8-13-71	Crescent Mtn.
HIAL	Hierochloë alpina	39.8 ± 17.6	8-1-71	Slaughter Gulch
POUN	Potentilla uniflora	40.7 ± 7.0	8-13-71	Crescent Mtn.
CACA	Calamagrostis canadensis	45.8 ± 7.1	9-71	Nome, Alaska
FEBR	Festuca brachyphylla	45.9 ± 17.3	8-13-71	Crescent Mtn.
ERBR	Eriophorum brachyantheram	47.0 ± 8.0	9-71	Nome, Alaska
ERAN	Eriophorum angustifolium	47.0 ± 6.6	9-71	Nome, Alaska
MHAO	Standard Meadow Hay	47.7 ± 10.7	1969	North Park
FEAL	Festuca altaica	49.6 ± 10.7	9-71	Nome, Alaska
SALB	Salix bronchialis	51.0 ± 9.5	8-14-71	Crescent Mtn.
LUSP	Luzula spp.	51.9 ± 15.6	8-71	Crescent Mtn.
CAAQ	Carex aquatilis	54.0 ± 9.5	9-71	Nome, Alaska
DROC	Dryas octopetala	55.3 ± 3.0	9-71	Nome, Alaska
CABI	Carex bigelowii	56.0 ± 11.2	9-71	Nome, Alaska
SRHO	Standard Reindeer Hay	73.3 ± 8.0	1-1-72	Nome, Alaska
STSP	Stereocaulon spp.	74.4 ± 6.8	9-71	Nome, Alaska
CENI	Cetraria nivalis	76.6 ± 6.6	8-13-71	Crescent Mtn.
STRI	Stereocaulon rivulorum	78.3 ± 3.7	8-71	Crescent Mtn.
CLAL	Cladonia alpestris	84.8 ± 1.6	8-71	Crescent Mtn.
MOSS	Species of Mosses	85.4 ± 3.9	8-14-71	Crescent Mtn.
CLRA	Cladonia rangiferina	92.0 ± 2.2	9-71	Nome, Alaska
CLGR	Cladonia gracillis	92.9 ± 0.9	9-71	Nome, Alaska

A description of the specimens and samples used to determine the diets of Dall Sheep from Alaska

Diet Category	Sample type	Locality	Date	Sex	Specimen Number	Collector
A	Dall Sheep rumens	Surprise Mtn.	4-28-70	F	LN#1 62051	Nichols
			4-28-70	F	LN#3 62053	Nichols
			4-28-70	F	#1 62054	Nichols
B	Dall Sheep rumens	Crescent Mtn.	8-11-70	M	5	Lynn Vennes
			8-11-70	M	6	D. Dearing
			8-10-70	M	8	Colin Holme
			8-11-70	M	11	Louie Edwards
			8-23-70	M	14	Duane LeVan
C	Dall Sheep rumens	Crescent Mtn.	8-10-70	F	1	Karns
			8-10-70	F	2	Jim Blake
			8-10-70	F	3	John Bonner
			8-10-70	F	4	M. Smith
			8-10-70	F	7	Bob Wolf
			8-10-70	F	9	Hardel Crawl
			8-13-70	F	10	Fred Delany III
			8-13-70	F	12	Koning
			8-17-70	F	13	John Widener
			8-23-70	F	15	E. Joyce Thompson
D	Dall Sheep rumens	Crescent Mtn.	11-13-70	F	62075	Nichols
			11-13-70	F	62076	Nichols
			11-13-70	M	62077	Nichols
			11-13-70	F	62078	Nichols
			11-13-70	F	62079	Nichols
			11-13-70	M	62080	Nichols
			11-13-70	F	62081	Nichols
			11-13-70	F	62082	Nichols
			11-13-70	M	62083	Nichols
E	Dall Sheep rumens	Crescent Mtn.	1-14-71	F	62085	Nichols
			1-14-71	M	62086	Nichols
			1-14-71	M	62087	Nichols
			1-14-71	F	62088	Nichols
			1-14-71	F	62090	Nichols
			1-14-71	M	62091	Nichols
			1-14-71	F	62092	Nichols
F	Dall Sheep rumens	Crescent Mtn.	2-26-71	F	62089	Nichols
			2-26-71	M	62094	Nichols
			2-26-71	F	62095	Nichols
			2-26-71	F	62097	Nichols
			2-26-71	F	62099	Nichols
			2-26-71	F	62100	Nichols
			2-26-71	M	62103	Nichols
			2-26-71	M	62104	Nichols
			2-26-71	F	62105	Nichols
			2-26-71	F	62110	Nichols
G	Dall Sheep rumens	Crescent Mtn.	3-18-71	M	62096	Nichols
			3-18-71	M	62106	Nichols
			3-18-71	M	62109	Nichols
			3-18-71	M	62114	Nichols
H	Dall Sheep rumens	Crescent Mtn.	3-18-71	F	62093	Nichols
			3-18-71	F	62098	Nichols
			3-18-71	F	62101	Nichols
			3-18-71	F	62102	Nichols
			3-18-71	F	62107	Nichols
			3-18-71	F	62108	Nichols
			3-18-71	F	62112	Nichols

A description of the specimens and samples used to determine the diets of Dall Sheep and Marmots from Alaska

Diet Category	Sample type	Locality	Date	Sex	Specimen Number	Collector
I	Dall Sheep rumens	Crescent Mtn.	4-27-71	M	62117	Nichols
			4-27-71	M	62121	Nichols
			4-27-71	M	62124	Nichols
J	Dall Sheep rumens	Crescent Mtn.	4-27-71	F	62113	Nichols
			4-27-71	F	62116	Nichols
			4-27-71	F	62118	Nichols
			4-27-71	F	62119	Nichols
			4-27-71	F	62120	Nichols
			4-27-71	F	62123	Nichols
			4-27-71	F	62125	Nichols
K	Dall Sheep fecals	Crescent Mtn.	8-11-71		Composite	Hansen
L	Dall Sheep fecals	Slaughter Gulch	6- -71		Composite	Hansen
M	Dall Sheep fecal	Slaughter Gulch	8-03-71		Composite	Hansen
N	Marmots fecals	Crescent Mtn.	8-10-71		Composite	Hansen
O	Marmot fecals	Surprise Mtn.	7-28-71		Composite	Hansen
P	Marmot fecals	Slaughter Gulch	8-03-71		Composite	Hansen

Symbols and names of categories used in classifying the discerned fragments in Dall sheep and marmot diets.

Symbol		Symbol	
Grasses and Sedges		**Forbs and Shrubs**	
Agro	*Agropyron* species	Anna	*Anemone narcissiflora*
Brsp	*Bromus* species	Arar	*Artemesia arctica*
Caca	*Calamagrostis canadensis*	Aral	*Arctostaphylos alpina*
Care	*Carex* species	Bena	*Betula nana*
Febr	*Festuca brachyphylla*	Cala	*Campanula lasiocarpa*
Hial	*Hierochloë alpina*	Dila	*Diapensia lapponica*
Lusp	*Luzula* species	Drin	*Dryas integrifolia*
Poas	*Poa* species	Droc	*Dryas octopetala*
Trsp	*Trisetum spicatum*	Drsp	*Dryas* species
		Emni	*Empetrum nigrum*
		Epan	*Epilobium angustifolium*
		Epsp	*Epilobium* species
		Geer	*Geranium erianthum*
		Mypa	*Myosotis palustris*
Mosses & Lichens		Oxyt	*Oxytropis* species
Moss	Mosses	Tsme	*Tsuga mertensiana*
Clad	*Cladonia* species	Popu	*Polemonium pulcherrimum*
Pelt	*Peltigera* species	Poun	*Potentilla uniflora*
Unkl	Unknown lichen	Sali	*Salix* species
Others		Satr	*Saxifraga tricuspidata*
Endo	Endogone (Fungus) unknown	Seed	Seed, identification unknown
Arth	Arthropod parts unknown	Shr 1	Unknown shrub number 1
		Vavi	*Vaccinium vitis-idaea*
		Com 1	Composite number 1, *Aster*-like
		Com 2	Composite number 2, *Iva*-like
		Com 3	Unknown Composite Number 3
		Unkf	Unknown forb
		Unkf 2	Unknown forb number 2
		Ber 1	Unknown Berry number 1
		Ber 2	Unknown Berry number 2

Percent relative density (= dry weight %) of discernable fragments of plants found in diet samples for Dall sheep and marmots.

Plant Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
AGRO		.08									.08					
BRSP												.09				
CACA				3.22									.08			
CARE	2.07	53.75	54.13	3.22	14.80	13.39	9.73	8.79	2.67	1.66	53.62	9.25	8.46	23.65	13.26	13.50
FEBR		4.46	8.21	46.12	9.68	4.35	4.02	10.42	14.03	8.13	4.87			.66	3.33	
HIAL	33.24	22.98	23.90	22.02	29.10	42.37	41.17	43.68	55.04	25.06	30.14	38.75	50.21	1.33	5.34	23.70
LUSP			.09													
POAS	.22				.21							1.51	2.13	.16	.09	1.39
TRSP									.23	2.21	.08	.17				
ANNA					.41				.11				1.48			
ARAR			.09										1.97	1.24	13.79	.21
ARAL	.11						.48	.55	.56	.20						
BENA					.10								.23			.29
CALA		.93	2.05													
DILA		.25	1.11	.76												
DRIN	4.24											2.54	4.40			
DROC		.59			10.21	4.45	5.76	4.96	1.49	13.04				2.20	.57	
DRSP									.23				.31	.25	.38	2.07
EMNI	24.89											.09	.69			
EPAN												.44				
EPSP														.08		
GEER												.98		.75	5.23	.07
MYPA											.17	.09			1.34	
OXYT			.45	1.08					.34		1.63			44.66	29.49	28.89

Plant Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
TSME	.22					.11		.11		.10			.08			
POPU			1.86	.22										.25		
POUN																.65
SALI	3.26	7.35	1.39	7.33				2.70	3.52		3.26	40.10	8.76	.33		
SATR															.47	.43
SEED	.11				12.23	1.89	1.46	4.24	.34	4.43						.07
SHR 1						1.27										
VAVI	8.65				.73	2.01	.87	.11	.56	1.14	.08	3.49				3.24
COM 1	.91	.34			2.54	.21	.29		1.26	.10			1.24	21.53	36.33	.79
COM 2				.11											.19	
COM 3													.08			
UNKF				.32						.10						
UNKF 2													.15			
BER 1	.22			5.10	.51				7.20	5.82						
BER 2						.31										
MOSS	4.49	.76	.55	.43	1.46	3.32	5.76	3.05	1.95	5.71	1.20	.26	14.69	.33	.19	10.26
CLAD	17.35	8.51	4.02	10.08	18.01	26.35	30.47	21.39	10.49	32.27	4.87	2.25	5.04	.83		10.98
PELT																3.32
UNKL			2.15													
ENDO																.07
ARTH														1.76		.07

LEGEND FOR DIET CATEGORIES OF DALL SHEEP AND MARMOTS

A– Rumens-Surprise Mtn.-Apr. 70
B– Female Rumens-Crescent Mtn.-Aug. 70
C– Male Rumens-Crescent Mtn.-Aug. 70
D– Rumens-Crescent Mtn.-Nov. 20
E– Rumens-Crescent Mtn.-Jan. 71
F– Rumens-Crescent Mtn.-Feb. 71
G– Male Rumens-Crescent Mtn.-Mar. 71
H– Female Rumens-Crescent Mtn.-Mar. 71
I– Male Rumens Crescent Mtn.-Apr. 71
J– Female Rumens-Crescent Mtn.-Apr. 71
K– Feces-Crescent Mtn.-Aug. 71
L– Feces-Slaughter Gulch-Jun. 71
M– Feces-Slaughter Gulch-Aug. 71
N– Marmot Feces-Crescent Mtn.-Aug. 71
O– Marmot Feces-Surprise Mtn.-Jul. 71
P– Marmot Feces-Slaughter Gulch-Aug.

DIET PREFERENCES OF DALL SHEEP

Values of dietary preference do more than indicate those plants most highly preferred as foods. They also indicate the relative amounts of energy expended by Dall sheep in searching for the foods in their diets. The mean preference index for plants is calculated by the formula:

$$PI = \frac{\%\text{ dry weight of a plant in the }\bar{X}\text{ diet}}{\%\text{ dry weight of a plant in the }\bar{X}\text{ habitat}}$$

and

$$\text{Mean } PI = \frac{\Sigma(PI_1 + PI_2 \ldots\ldots + PI_n)}{n}$$

The mean preference index for a herd of sheep is the sum of all the indexes for all the forage categories making up at least one percent of the mean diet divided by the number of forage categories making up at least one percent of the mean diet.

As an example, if the mean index of dietary preference of a herd of sheep equaled "one" this would mean that these animals were choosing plants as food in the same proportion as they occurred in their habitat. They would be in balance with their habitat and expending a minimal amount of energy searching for food. The mean preference index of a sheep herd must logically be directly proportional to a modified version of Lindeman's (1942) equations of ecological efficiencies (EE):

$$EE = \frac{R_e}{I_e}$$

where I_e equals the amount of digestible energy in the plants selected as food, and R_e equals the amount of energy respired by the animal in gathering or searching for these foods. As R_e increases, more of the energy derived from food source is used in activities related to work of food seeking. When this quotient approaches "one" the animal is in a food stress situation that can only be alleviated by reducing this quotient. As the mean index of dietary preference increases above "one" this indicates increasing energy devoted to searching for food. The upper critical limits of preference that would indicate starvation conditions of stress are unknown, but the relative magnitude of the mean indexes of dietary preference indicates the relative efficiency of two Dall sheep herds in gathering food. This would be true only if the nutritive content of the diets as well as the metabolic requirements of the two herds were taken into account.

If enough good data were available the mean food preference of Dall sheep herds for each study area could be compared and useful knowledge could be obtained as to which herd might be working the most to obtain food. The two sets of data obtained that lend themselves to analyses (to illustrate the concept) are the diets of female Dall sheep from Surprise Mountain of April 1970 (Diet Category A) and female Dall sheep from Crescent Mountain of April 1971 (Diet Category J). Mean herd diet preferences of the two female herds are comparable if we assume:

1. The seasons of 1970 and 1971 are similar;
2. The sheep population attributes are similar;
3. The quantity of forage plants growing in the summer of 1971 on wintering sites is an index to the amount of food available to the sheep in March of the years when the diets were collected;
4. The percentage of dry weight of *Cladonia* was one-half percent for both areas.

Controversy could occur because of the lack of good data, or too narrow a viewpoint, but these are the "best" comparable data available for mean herd diet preferences for all three study areas.

There were eight forages which each constituted one percent or more in the diet. The mean and ± one standard deviation for the herd diet preference index was 7 ± 11 for Surprise Mountain sheep. The comparable value was 11 ± 20 for 10 forage categories for Crescent Mountain sheep. The mean indexes were not statistically different at $\alpha = 0.05$ but if more samples showed the same values it would show that sheep from Surprise Mountain expended less energy in April to obtain food than do sheep at Crescent Mountain. What are actually needed are simultaneously collected data on diets and habitats of sheep from all three areas.

HABITAT SUITABILITY INDEX

Indexes of similarity between diets and feeding habitats are comparisons that indicate the percent suitability or compatability of plant compositions in the sheep diets to the plant composition of the habitats. The similarity index is expressed by the ratio of the percentages of dry weights of food items shared between mean diet and the mean habitat. It is calculated by the formula:

$$SI = \frac{2\ W}{a + b} \times 100$$

where

w = the lowest of the pair of plant percentages
a = the mean percentage of a plant in the diet
b = the mean percentage of that same plant in the habitat

and

$$\text{Mean SI} = \frac{\Sigma(SI_1 + SI_2 \ldots\ldots + SI_n)}{n}$$

The mean suitability index is obtained by summing all of the $\frac{2W}{a+b}$ values and dividing by the number of food items making up at least one percent of the mean diet.

When reliable data are available for the quantity of each forage plant available and the quantity of each forage plant consumed by Dall sheep it will be useful to calculate mean suitability indexes for each Dall sheep herd area.

Data sets available that can be used to illustrate how to make these comparisons are those of female Dall sheep from Surprise Mountain of April 1970 and those of female Dall sheep from Crescent Mountain of 1971. Mean herd habitat suitability indexes can be calculated and compared if we assume they are suitable for comparisons. If we assume they are comparable, it is calculated that the mean suitablility index ± one standard deviation for Surprise Mountain female sheep is 45 ± 27 and the comparable value for Crescent Mountain is 45 ± 29. If these are representatitve it must be assumed that the two suitability indexes are identical or nearly so in April. Simultaneously collected data on diets and habitats of sheep from all three areas on a seasonal basis are needed.

SHEEP POPULATION ATTRIBUTES AND CARRYING CAPACITY

In practice, the sheep populations are simply all of the sheep found occupying each of the three management areas. The more important sheep population characteristics, or group attributes, are as follows:

Density = number of sheep (N) per area

Realized population growth = the rate at which new sheep are added to each area (by births and by immigration)

Realized population decrease = the rate at which resident sheep are lost from each area (by death or immigration)

Sex and age distribution = the proportion of individuals of different sexes and ages in the population of the area

Population dispersion = the way in which individuals are distributed in the area

Since it is generally believed (without proof) that Dall sheep populations are regulated by factors (food, weather, predators) outside the sheep population itself their population growth is assumed to be density independent for the three management areas. Controversy stems mostly from the lack of good data, but sometimes from too narrow a viewpoint. Until substantial evidence to the contrary is available it seems better to consider Dall sheep "density independent" so that firm research objectives can be tested.

The Dall sheep population growth form is sigmoid and we can assume that environmental resistance is more or less in equilibrium with sheep populations. This form may be represented by the simple logistic model (Odum, 1971):

$$\frac{dN}{dt} = rN \frac{(K-N)}{K}$$

where

N = Dall sheep population of an area

$\frac{dN}{dt}$ = the rate of change in number of sheep per time

rN = growth rate under unlimited environmental conditions

K = the carrying capacity constant for an area

It is assumed that the relatively unrestricted sheep population growth is (yearly) suddenly halted when the sheep population runs out of some resource (such as food and/or places to avoid predators), or when hunting or any other seasonal factor intervenes, or when the reproductive capacity suddenly drops.

Temporary changes in carrying capacity may be brought about by weather. It has been assumed that carrying capacity of an area might be changed effectively by management.

Because each of the three winter habitats is significantly different from each other in plant composition and forage production we can assume that most plant composition and production changes caused by increases or decreases in Dall sheep use would not be the same for any two areas.

The plants now present on the exposed ridges used in winter by Dall sheep are without doubt those that are most successful in living under the average conditions that exist.

Reduced use of these wind-swept ridges probably occurs in winters with higher than average snow and higher than average crusting of snow. This would force sheep to move to less favored sites and even some might die of starvation. Open areas resulting from below average snow and crusting would permit Dall sheep to use more area and this would tend to reduce the concentration of use on the wind-swept ridges.

To reduce Dall sheep density, to reduce winter use of plants on wind-swept ridges, to permit plants to revegetate exposed ridges might result in a temporary (one-two years) increase in winter habitat carrying capacity. However, I believe that protecting plants on wind-swept ridges from Dall sheep use in winter will not result in a significant Dall sheep population increase nor will it result in any increase in the number of Dall sheep that can be harvested.

(Note: The purpose of the Crescent Mountain herd reduction is <u>not</u> to increase the carrying capacity of the winter range nor the herd size, but to attempt to maintain a smaller herd over a long period of time without the large natural decreases which periodically occur. If practicable, this would in effect produce more sheep over a period of time but not in any given year. Lyman Nichols)

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Appendix 2

Section B. Discerned Plant Fragments from Rumens and Large Intestines of Dall Sheep

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This is an addendum to the Final Report on Service Contracts for diet studies of Dall sheep on Crescent Mountain of the Kenai Peninsula, Alaska. March 13, 1972.

ABSTRACT OF COMPARISONS

Chi-square tests were used to determine statistical significance for the relative percent density of discerned fragments of species of plants in appropriately paired rumen samples and large intestine samples of Dall sheep. When botanical composition was determined by the microscope technique (Sparks and Malechek, 1968) for plant fragments discerned in the feces from the large intestine and contents from the rumens of Dall sheep, there were statistically significant differences for percentages of some plant species. Plants suspected to have low digestibility appeared to make up a higher percentage of the fragments discerned in feces than they did in the rumen contents. The magnitude of difference between the percentages of a plant in paired rumen and in the large intestine samples appeared to be influenced more by what the sheep had been eating than upon the discernability of the fragments.

PLANT FRAGMENTS IN FECES

The occurrence of recognizable plant fragments in the feces of livestock and wild herbivores has been used in the literature (Dusi, 1949; Storr, 1968) for describing the botanical composition of diets. Whether or not this information is quantitatively useful depends upon the magnitude of the deviations from the true dry weights, caused by differential digestion and fragmentation. Normally the relative discernibility of plant fragments in the feces decreases as the digestibility increases (Casebeer and Koss, 1970; Free, et al., 1970; Grenet, 1966; Hansen, et al., 1972; Regal, 1960; Stewart, 1967). The degree of digestion primarily influences the mean weight lost per plant fragment but not their relative numbers. The difference in thickness of the plant cell walls before and after digestion in steers can be used to estimate the plant's digestibility (Regal, 1960).

Use of a polarizing microscope and new slide preparation techniques permits recogniztion of virtually all epidermal fragments (Storr, 1961 and 1968; Williams, 1969). The potential of discerned fragments when applied to Dall sheep fecal pellets is the purpose of this paper.

The motivation for this approach lies in the desire to overcome the difficulties in both observing feeding behavior and in the slaughter of these herbivores in order to describe their seasonal diets. A comprehensive diet sample for a herd can be obtained from fecal pellets that is not as likely to be biased as would be the case when small sample sizes come from slaughtered Dall sheep.

MATERIALS AND TECHNIQUE

The composition of recognized plant fragments from the contents of rumens of Dall sheep and the fecal pellets in the large intestines of Dall sheep was quantified by a microscope technique. The frequency of recognized plant fragments in forage fed to domestic sheep and the frequency of recognized plant fragments in the feces indicated that digestion did not greatly change the relative frequency of plant epidermal characteristics (Hansen, 1972).

A microscope identification technique for classifying fragments of plant material eaten by herbivores that thoroughly masticate their food was described by Baumgartner and Martin (1939) and the technique was later refined by Dusi (1949). Sparks and Malechek (1968) found a quantification scheme so that they could predict approximately a 1:1 relationship between relative density of recognized fragments and the dry weights of foodplants in hand compounded mixtures. Recent studies have shown that by using new slide preparation techniques practically all plant fragments passed through a herbivore could be recognized in the feces (Storr, 1961; Williams, 1969; Free, et al., 1970). Since there is no digestion of the epidermis that is encased in cutin and only partial digestion of cellwalls made up of cellulose and lignin-occluded cellulose there are recognizable plant fragments in the feces even though the mass (weight) of a fragment may have been changed during digestion.

Rumen samples and pellets from the large intestines of Dall sheep were obtained from Crescent Mountain, Alaska in February 1971, March 1971 and April 1971 by the Alaska Fish and Game Department. The rumen samples and the fecal samples were ground in a Wiley mill through a 1.0 mm screen. Each sample was thoroughly mixed to develop randomness for subsampling. The grinding appears to reduce any species differences for fragmentation due to chewing and digestion so that the mean size of particles of different species of plants were similar in each sample. The material used for microscope slides was washed over a 0.1 mm screen to insure mixing and to remove the small fragments. Twenty microscope slides were prepared for each sample according to procedure outlined by Sparks and Malechek (1968). The diet samples were not stained and were only treated with clearing (Hertwig's) and mounting (Hoyer's) mediums.

It is common knowledge that the variety and abundance of foods strongly influences the diet selected by big game animals, and we assume that it is also true for Dall sheep. Even though the rumen contents are being well mixed during digestion it is common knowledge that the solid excreta defecated within any given hour or two roughly represents a sequence of ingestion. The fragments in pellets might represent a time lag of about 36 hours, from the time when the plants had been ingested. Therefore, if there is day-to-day variation between places where sheep eat there is likely to be a very large variance in the percentage of plant fragments discerned between the rumen contents and the pellets, unless the plants available were similar throughout the times when Dall sheep were feeding.

Dall sheep rumen samples and pellet samples were "paired" for each specimen and date. Five "herd composites" were made so that statistical tests could be made for the mean percentages of each kind of plant occurring in rumens and large intestines. The compositing was done on an equal weight basis.

STATISTICAL PROCEDURES

Let us assume that the mean percentage of a plant determined by the microscopic analysis of Dall sheep rumens is approximately correct. Even though there will have been a significant amount of energy and dry weight solubilized from most fragments of plants found in the rumen it is unlikely that any natural food in a rumen would have lost its "identity". Accordingly the formula for chi-square,

$$\chi^2 = \Sigma\ (f - F)^2/F,$$

where

$f_1 = \bar{X}$ % of a kind of discerned fragment in rumens for 26 Feb. 1971

$f_2 = \bar{X}$ % of a kind of discerned fragment in rumens for 4 males for 18 March 1971

$f_3 = \bar{X}$ % of a kind of discerned fragment in rumens for 7 females for 18 March 1971

$f_4 = \bar{X}$ % of a kind of discerned fragment in rumens for 3 males for 27 April 1971

$f_5 = \bar{X}$ % of a kind of discerned fragment in rumens for 7 males for 27 April 1971 and

$F_1 = \bar{X}$ % of a kind of discerned fragment in feces for 26 Feb. 1971

$F_2 = \bar{X}$ % of a kind of discerned fragment in feces for 4 males for 18 March 1971

$F_3 = \bar{X}$ % of a kind of discerned fragment in feces for 7 females for 18 March 1971

$F_4 = \bar{X}$ % of a kind of discerned fragment in feces for 3 males for 27 April 1971

$F_5 = \bar{X}$ % of a kind of discerned fragment in feces for 7 females for 27 April 1971

therefore,

$$X^2 = \Sigma \frac{(\delta_1 - F_1)^2}{\delta_1} + \frac{(\delta_2 - F_2)^2}{\delta_2} + \frac{(\delta_3 - F_3)^2}{\delta_3} + \frac{(\delta_4 - F_4)^2}{\delta_4} + \frac{(\delta_5 - F_5)^2}{\delta_5}$$

with five minus one = 4 degrees of freedom.

Let us use data for sedges from the included table to illustrate the chi-square test.

$$\chi^2 = \frac{(\delta_1 - F_1)^2}{\delta_1} + \frac{(\delta_2 - F_2)^2}{\delta_2} + \frac{(\delta_3 - F_3)^2}{\delta_3} + \frac{(\delta_4 - F_4)^2}{\delta_4} + \frac{(\delta_5 - F_5)^2}{\delta_5}$$

substituting the values for CARE,

$$\chi^2 = \frac{(13.39-8.04)^2}{13.39} + \frac{(9.73-11.87)^2}{9.73} + \frac{(8.79-9.26)^2}{8.79} + \frac{(2.67-3.65)^2}{2.67} + \frac{(1.66-1.18)^2}{1.66}$$

or,

$$\chi^2 = 2.14 + .47 + .03 + .36 + .14 = 3.14$$

At four degrees of freedom the χ^2 value would have to be 9.49 to be significant at the 5% level ($\alpha = .05$), and we therefore, conclude that the percentage of fragments discerned in rumens and large intestines was about the same for sedges.

Ten composite samples were made into five composite pairs.

f	5 Samples from Rumens	5 Samples from Large Intestines	Sexes and Date of Collection
First pair =	F_1	F_2	7 females & 3 males 26 Feb. 1971
Second pair =	G_1	G_2	7 females, 18 March 1971
Third pair =	H_1	H_2	4 males, 18 March 1971
Fourth pair =	I_1	I_2	7 females, 27 April 1971
Fifth pair =	J_1	J_2	3 males, 27 April 1971

A reference collection of the foods available was made that included the lichens, mosses, grasses, sedges, forbs and shrubs from the study area. The appropriate slides of leaf, stem, flower and seed were prepared for each species. The separate parts of each plant were placed in a Waring blender with enough hot water to at least cover the blades. After two minutes at high speed, the contents of the blender were poured into a 0.1 mm mesh screen and washed. Reference slides were made directly from this material. The same procedure for making slides for the rumen samples and pellet samples was followed but less material was applied to the slides.

Each species of plant was identified in the sample when a fragment was observed that matched the material on a reference slide.

The relative percent density of recognized fragments of plants in each of the rumen and fecal composited samples was estimated by observing 20 systematically located fields on each of the 20 slides per composited sample with a compound binocular microscope at about 100 power magnification. The occurrence of each recognized species of plant in each field was recorded. Average percent frequency was computed for all plant species present in the samples. The relative percent density, calculated as the number of recognized fragments of a species expressed as a percentage of the total number of fragments of all species (Curtis and McIntosh, 1950) was calculated for each plant species or category of forage.

RESULTS

The same plants were discerned in the rumen samples and in the pellet samples whenever a significant percentage occurred in either composite sample of the pair. When a plant fragment made up two percent or more of the rumen composition it was discerned in the fecal composition except on two pairs of composites when seeds occurred in the rumens but were not recorded in the pellets.

	5 Samples from Rumens	5 Samples from Large Intestines	Sexes and Date of Collection
First pair =	F_1	F_2	7 females & 3 males 26 Feb. 1971
Second pair =	G_1	G_2	7 females, 18 March 1971
Third pair =	H_1	H_2	4 males, 18 March 1971
Fourth pair =	I_1	I_2	7 females, 27 April 1971
Fifth pair =	J_1	J_2	3 males, 27 April 1971

A reference collection of the foods available was made that included the lichens, mosses, grasses, sedges, forbs and shrubs from the study area. The appropriate slides of leaf, stem, flower and seed were prepared for each species. The separate parts of each plant were placed in a Waring blender with enough hot water to at least cover the blades. After two minutes at high speed, the contents of the blender were poured into a 0.1 mm mesh screen and washed. Reference slides were made directly from this material. The same procedure for making slides for the rumen samples and pellet samples was followed but less material was applied to the slides.

Each species of plant was identified in the sample when a fragment was observed that matched the material on a reference slide.

The relative percent density of recognized fragments of plants in each of the rumen and fecal composited samples was estimated by observing 20 systematically located fields on each of the 20 slides per composited sample with a compound binocular microscope at about 100 power magnification. The occurrence of each recognized species of plant in each field was recorded. Average percent frequency was computed for all plant species present in the samples. The relative percent density, calculated as the number of recognized fragments of a species expressed as a percentage of the total number of fragments of all species (Curtis and McIntosh 1950) was calculated for each plant species or category of forage.

There were seven forages that consistently occurred in each of the five pairs of composite samples. Chi-square tests showed that there were statistically significant differences for the percentages between the rumen samples and fecal samples for four plants (FEBR, DROC, MOSS and CLAD), and the percentages in the rumens and pellets were not different for three kinds of discerned plant fragments (CARE, HIAL, and VAVI).

Although there was a statistically significant difference over all five composite pairs for festuca, dryas, moss and cladonia lichens the differences within all sample pairs were not consistent. For example, only two of the five pairs for cladonia lichens showed a statistical difference and three did not (see the following tabular material).

The chi-square values were computed for each pair of percentages and for all of the percentages of a discerned plant fragment. The significant chi-square values are indicated by an asterisk.

	F_1 vs F_2	G_1 vs G_2	H_1 vs H_2	I_1 vs I_2	J_1 vs J_2	Overall Chi-square
CARE	2.14	.47	.03	.36	.14	3.14
FEBR	2.34	2.96	8.14*	9.86*	7.07*	29.47*
HIAL	2.18	4.26*	.09	.15	1.05	7.73
DROC	.14	1.76	9.88*	.53	12.23*	24.54*
VAVI	.14	1.88	.93	1.75	.74	5.44
MOSS	.21	21.47*	18.00*	.304	.96	43.68*
CLAD	.01	14.54*	1.44	2.23	26.69*	44.91*
Degrees of Freedom	1	1	1	1	1	4

LEGEND FOR SYMBOLS OF COMPOSIT SAMPLES AND PLANTS

F_1 = rumens, and F_2 = pellets from 7 females and 3 males, 26 Feb. 1971

G_1 = rumens, and G_2 = pellets from 7 females, 18 Mar. 1971

H_1 = rumens, and H_2 = pellets from 4 males, 18 Mar. 1971

I_1 = rumens, and I_2 = pellets from 7 females, 27 Apr. 1971

J_1 = rumens, and J_2 = pellets from 3 males, 27 Apr. 1971

CARE = species of sedges
FEBR = *Festuca brachyphylla*
HIAL = *Hierochloe alpina*
DROC = *Dryas octopetala*
VAVI = *Vaccinium vitis-idaea*
MOSS = species of mosses
CLAD = species of *Cladonia*

Symbols and names of categories used in classifying the discerned fragments in Dall Sheep diets in late winter from Crescent Mountain, Alaska, 1971.

Symbol	Scientific Name	Symbol	Scientific Name
Grasses and Sedges		Forbs and Shrubs	
Care	*Carex* species	Anna	*Anemone narcissiflora*
Febr	*Festuca brachyphylla*	Aral	*Arctostaphylos alpina*
Hial	*Hierochloë alpina*	Droc	*Dryas octopetala*
Trsp	*Trisetum spicatum*	Drsp	*Dryas* species
		Oxyt	*Oxytropis* species
Mosses and Lichens		Tsme	*Tsuga mertensiana*
Moss	Mosses	Sali	*Salix* species
Clad	*Cladonia* species	Seed	Seed, identification unknown
Pelt	*Peltigera* species	Shrl	Unknown shrub number 1
		Vavi	*Vaccinium vitis-idaea*
		Coml	Composite number 1, *Aster*-like
		Unkf	Unknown forb
		Ber 1	Unknown Berry number 1
		Ber 2	Unknown Berry number 2

Percent relative density (≈% dry weight) of discerned plant fragments found in contents from the rumen and pellets from the large intestine of Dall sheep specimens from Crescent Mountain, Alaska

Plant Symbol	F_1	F_2	G_1	G_2	H_1	H_2	I_1	I_2	J_1	J_2
CARE	13.39	8.04	9.73	11.87	8.79	9.26	2.67	3.65	1.66	1.18
FEBR	4.35	1.16	4.02	.57	10.42	1.21	14.03	2.27	8.13	.55
HIAL	42.37	51.99	41.17	54.42	43.68	44.29	55.04	57.88	25.06	19.93
TRSP							.23	.68	2.21	.21
ANNA		.21					.11			
ARAL			.48		.55		.56		.20	
DROC	4.45	5.24	5.76	2.58	4.96	11.96	1.49	.60	13.04	.41
DRSP				.08			.23	.42		
OXYT							.34	.17		.21
TSME	.11	.29			.11	.09		.08	.10	
SALI				.81	2.70	4.08	3.52	2.00		.55
SEED	1.89	.14	1.46		4.24		.34		4.43	
SHR 1	1.27									
VAVI	2.01	2.54	.87	2.15	.11	1.12	.56	1.55	1.14	2.06
COM 1	.21	.21	.29	.98		.65	1.26	8.71	.10	1.99
UNKF									.10	
BER 1							7.20	3.93	5.82	2.88
BER 2	.31									
MOSS	3.32	4.15	5.76	16.88	3.05	10.46	1.95	2.72	5.71	8.05
CLAD	26.35	25.86	30.47	9.42	21.39	15.85	10.49	15.33	32.27	61.62
PELT		.14		.24		1.03				.21

LEGEND FOR

F_1 = rumens and F_2 = pellets from 7 females and 3 males, 26 Feb. 1971

G_1 = rumens and G_2 = pellets from 7 females, 18 Mar. 1971

H_1 = rumens and H_2 = pellets from 4 males, 18 Mar. 1971

I_1 = rumens and I_2 = pellets from 7 females, 27 Apr. 1971

J_1 = rumens and J_2 = pellets from 3 males, 27 Apr. 1971

Percent residue in nylon bag after 48 hours digestion in large herbivore rumens.

SYMBOL	SCIENTIFIC NAME	MEAN ± SD	DATE	LOCALITY
ANNA	Anemone narcissiflora	15.7 ± 9.3	8-14-71	Crescent Mtn.
ARAR	Artemesia arctica	16.0 ± 5.3	8-13-71	Crescent Mtn.
EQFL	Equisetum fluviatile	26.6 ± 11.9	9-71	Nome, Alaska
SAPU	Salix pulchra	27.9 ± 2.3	9-71	Nome, Alaska
SALI	Salix spp.	31.0 ± 14.7	8-14-71	Crescent Mtn.
CARE	Carex spp.	31.2 ± 8.6	8-13-71	Crescent Mtn.
CEIS	Cetraria islandica	31.3 ± 26.5	9-71	Nome, Alaska
SALI	Salix spp.	31.8 ± 13.3	8-1-71	Slaughter Gulch
POAS	Poa spp.	32.3 ± 10.2	8-13-71	Crescent Mtn.
HIAL	Hierochloë alpina	34.7 ± 18.7	8-13-71	Crescent Mtn.
DRIN	Dryas integrifolia	34.9 ± 9.9	7-27-71	Surprise Mtn.
DROC	Dryas octopetala	38.4 ± 8.4	8-13-71	Crescent Mtn.
EPAN	Epilobium angustifolium	38.9 ± 6.9	9-71	Nome, Alaska
TRSP	Trisetum spicatum	39.3 ± 12.7	8-13-71	Crescent Mtn.
HIAL	Hierochloë alpina	39.8 ± 17.6	8-1-71	Slaughter Gulch
POUN	Potentilla uniflora	40.7 ± 7.0	8-13-71	Crescent Mtn.
CACA	Calamagrostis canadensis	45.8 ± 7.1	9-71	Nome, Alaska
FEBR	Festuca brachyphylla	45.9 ± 17.3	8-13-71	Crescent Mtn.
ERBR	Eriophorum brachyantheram	47.0 ± 8.0	9-71	Nome, Alaska
ERAN	Eriophorum angustifolium	47.0 ± 6.6	9-71	Nome, Alaska
MHAO	Standard Meadow Hay	47.7 ± 10.7	1969	North Park
FEAL	Festuca altaica	49.6 ± 10.7	9-71	Nome, Alaska
SALB	Salix bronchialis	51.0 ± 9.5	8-14-71	Crescent Mtn.
LUSP	Luzula spp.	51.9 ± 15.6	8-71	Crescent Mtn.
CAAQ	Carex aquatilis	54.0 ± 9.5	9-71	Nome, Alaska
DROC	Dryas octopetala	55.3 ± 3.0	9-71	Nome, Alaska
CABI	Carex bigelowii	56.0 ± 11.2	9-71	Nome, Alaska
SRHO	Standard Reindeer Hay	73.3 ± 8.0	1-1-72	Nome, Alaska
STGR	Stereocaulon grande	74.4 ± 6.8	9-71	Nome, Alaska
CENI	Cetraria nivalis	76.6 ± 6.6	8-13-71	Crescent Mtn.
STRI	Stereocaulon rivulorum	78.3 ± 3.7	8-71	Crescent Mtn.
CLAL	Cladonia alpestris	84.8 ± 1.6	8-71	Crescent Mtn.
MOSS	Species of Mosses	85.4 ± 3.9	8-14-71	Crescent Mtn.
CLRA	Cladonia rangiferina	92.0 ± 2.2	9-71	Nome, Alaska
CLGR	Cladonia gracillis	92.9 ± 0.9	9-71	Nome, Alaska

DISCUSSION

If the pellets in the large intestines were residues from the same proportions of plants occcurring in the rumens of Dall sheep, I would expect the magnitude of percentage relative density of a fragment of a given species to correlate for the pellets and the rumen contents. Fragments of plants did not show a significant correlation for percentages in rumens and large intestines. I've recently tested the technicians and found them consistent in the way they discern fragments of Alaskan plants. There is no possibility that the species of plants digested greatly different from one period to another or between male and female sheep. Therefore, I must conclude that the residues in the rumens and large intestines were commonly not from the same foods. The residues in rumen composites and paired pellet composites were not coming from the same "statistical population" of plants. This suggests that an average diet that represents a herd of Dall sheep would require (on a given day) more than seven slaughtered sheep. I believe the data also suggests that large day to day variations in diet can be expected and if a choice can be made one should obtain diet samples at frequent, regular intervals rather than collect all samples on the same day. The regular sampling schedule is feasible for collections of fecal pellets but is not practical when samples must come from slaughtered Dall sheep.

From the nylon bag digestion tests it is suggested that mosses and cladonia lichens are not digestible. Some additional chemical tests show that these lichens were deficient in minerals and protein. Although I did not test the moss sample for protein and mineral it may also be low in minerals and nitrogen. However, the data suggests that mosses and cladonia are more discernable in the pellets than they were in the rumens. *Festuca* was consistently less common in the pellets than in the rumens. It would be interesting to see if festuca is a highly digestible plant in winter. If it is highly digestible in winter it might be a "key winter plant."

I would suggest some more research on the "changes in discernability that are caused by digestion" in Dall sheep. The best way to do this would be with tame Dall sheep but other less expensive techniques might be satisfactory.

These data suggest that a validation test needs to be run to see how plant fragment discernability is influenced by digestion. These arctic plants need a great deal of additional study before we can predict how Dall sheep digestion affects discernability. However, I believe that in spite of the many short-comings for determining diet composition from pellets, it is the best procedure now available. The method should be used, anticipating the strong liklihood that refined validation coefficients can be obtained when the need becomes urgent.

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