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CARIBOU REPORT

by

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Project Progress Report
Federal Aid in Wildlife Restoration
Projects W-17-4, Jobs 3.3R, 3.5R and 3.8R (2nd half) and 3.9R
and W-17-5, Jobs 3.3R, 3.5R, 3.8R and 3.9R (1st half)

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Robert E. Pegau		
Project Nos.:	W-17-4 & W-17-5	Project Title:	Big Game Investigation
Job No.:	3.3R	Job Title:	Caribou Food Habits
Job No.:	3.5R	Job Title:	Exclosure Construction
Period Covered:	January 1, 1972 to December 31, 1972		

SUMMARY

A one-acre exclosure was constructed on the Arctic caribou herd's calving grounds. Vegetation transects inside and outside the exclosure were established, read and photographed.

Variations in the chemical composition of lichens were greater between species than between the habitat or season in which the lichens were collected. *Cetraria* spp. combined more desirable characteristics than did the *Cladonia* spp. examined. With few exceptions, lichens from all habitats tested, throughout the year, were deficient in crude protein, crude fat, calcium and phosphorus. The value of lichens to caribou is in their abnormally high carbohydrate content which provides large quantities of energy.

Prediction equations have been calculated for use in a microhistological technique of rumen and fecal pellet analysis.

Dry matter digestibility of several plant samples was determined by use of the nylon bag technique in reindeer. Digestibility values of lichens varied from 27 to 93 percent, depending on lichen species and the sex of the digester. Overall, lichens were the most digestible, followed by shrubs, grasses, sedges and mosses in decreasing order of digestibility.

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BACKGROUND

Caribou (*Rangifer tarandus*) are extensively hunted in Alaska for sport and subsistence by local residents. In some remote areas, residents rely extensively on wild animals, especially caribou, for food. A knowledge of caribou-range relationships will aid in formulating management decisions designed to maintain adequate populations of caribou in Alaska.

Accurate diet information and range condition and trend data are essential prerequisites for understanding caribou-range relationships. A microhistological technique for studying food habits of animals that finely masticate their foods has been developed (Bear and Hansen, 1966).

Few tests of the technique have been reported and none of these represented a very heterogeneous diet such as that of caribou. We tested the microhistological technique last year and are making efforts to refine interpretation of its results. There are insufficient reported data to ascertain the value of various plant species to caribou.

OBJECTIVES

To provide reliable data on caribou food habits and to determine the impact of caribou on range vegetation.

PROCEDURES AND FINDINGS

Four separate aspects were investigated to meet the objectives of this project. Each aspect is discussed separately.

Exclosure on the Arctic Caribou Herd's Calving Grounds

A one-acre exclosure was constructed on the calving grounds of the Arctic caribou herd in late August, 1972. The Kaksu Lake exclosure is located on a small hill about one-half mile west of the larger lake at the head of Kaksu River. Coordinates are: latitude 69°15'N; longitude 158°30'W. Caribou use the area primarily during calving but scattered bands may be in the vicinity throughout the summer and fall. This area is seldom used during winter.

Eriophorum vaginatum tussocks are the dominant feature of the vegetation, as is characteristic throughout the calving grounds. A wet sedge stand extends from the saddle of the hill on which the exclosure is located, to the lake. The south quarter of the exclosure lies in the wet sedge stand, the remainder is in tussocks.

In late August permafrost was usually encountered four to eight inches below the surface. Frost boils were common and the soil contained a considerable quantity of clay.

Construction details and the vegetation analysis were identical to those used last year (Pegau and Bos, 1972).

The vegetation readings from the permanent transects have been compiled into association tables (Tables 1 and 2). Mosses, *Eriophorum vaginatum*, *Betula nana* and *Ledum decumbens*, dominate the vegetation. The vascular plants were similar to those of the Selawik exclosure (Hemming and Pegau, 1970), but at Kaksu Lake lichens were scarce in contrast to the common *Cetraria cucullata* at the Selawik exclosure. The primary consideration of this exclosure should be with vascular plants, especially *Eriophorum vaginatum* which is grazed extensively during calving.

Chemical Analysis of Lichens

Certain chemical analyses of plants are often used as indices of their nutritional value. There are abundant published data for the vascular plants, and Sullivan (1964, 1969) prepared a good review correlating various components of vascular plants to nutritional quality and digestibility. Nutritional quality of vascular plants varies according to their growth stages and the habitat in which they are growing.

Lichens, the principal winter forage of caribou and reindeer, have been examined only to a limited extent, however. In Alaska, Spencer and Krumboltz (1929) and Pegau (1968) reported analyses of some lichens but the effects of seasons or habitat usually were not investigated. Scotter (1972) analyzed several plants, including four lichen species, collected on the Reindeer Preserve in the Northwest Territories of Canada at five times during the year. Courtright (1959) reviewed published reports from several countries. Aside from those of Scotter (1972) and Pegau (1968), no efforts have been made to measure seasonal changes and no results of habitat influences have been noted.

Published analyses indicate that within a species there are only slight differences in the crude protein, fat and ash constituents, but the carbohydrate fraction represented by crude fiber and nitrogen-free extract varies considerably. Because the nitrogen-free extract is calculated as the remainder of an analysis it varies inversely with the crude fiber content in lichens.

Table 1. Vegetation analysis inside of Kaksu Lake exclosure by modified Hult-Sernander scale. August 26, 1972.

Species	Transect # 1	2	3	4	5	6	Ave. Species Comp.	Freq. %	No. of Quadrants in which species occurred
Total Cover %	85	100	99	85	76	99	91	-	-
Bare Ground				15	16	1	5	-	-
Water	15		1		8		4	-	-
Moss	5.0	5.2	4.5	4.7	2.5	4.0	4.3	100	24
Eriophorum vaginatum		3.0	4.2	3.7	4.0	4.0	3.2	83	20
E. angustifolium	3.0	2.0	2.0	0.7	0.7		1.4	63	15
Carex aquatilis	4.0	2.2	1.5	0.7		0.5	1.5	58	14
C. lugens						1.0	0.2	12	3
Betula nana	2.2	3.0	2.7	2.2	2.2	2.0	2.4	100	24
Ledum decumbens		2.2	2.7	2.2	2.2	2.7	2.0	83	20
Salix spp.	1.7	1.5	2.0	1.5	1.5		1.4	71	17
Empetrum nigrum			0.5	1.5	1.2	0.7	0.7	38	9
Vaccinium vitis-idaea		0.7	1.2	1.5	1.0	2.0	1.1	71	17
Cassiope tetragona				0.7	0.5	1.5	0.4	29	7
Rubus chamaemorus		1.0	1.7	1.7	0.2		0.8	54	13
Petasites frigidus				0.2	0.5	0.2	0.1	17	4
Rumex arcticus					0.2		t	4	1

Table 2. Vegetation analysis outside of Kaksu Lake exclosure by modified Hult-Sernander scale, August 27, 1972.

Species	Transect # 1	2	3	4	5	6	7	8	Avg. Species Comp.	Freq. %	No. of Quadrants
Total Cover %	90	100	70	100	86	79	96	95	90	–	–
Bare Ground					14	21	4	4	5	–	–
Water	10		30						5	–	–
Moss	4.7	4.7	2.7	5.0	3.2	2.7	3.5	3.2	3.7	100	32
Eriophorum vaginatum	1.0	4.5		1.7	3.7	3.5	4.5	4.5	2.9	88	28
E. angustifolium	0.2	1.0			0.2				0.2	12	4
Carex aquatilis	1.0	0.5	3.5	2.2	0.2				0.9	35	11
C. lugens					1.0		0.5	0.2	0.2	9	3
C. rotundata			1.2						0.1	9	3
Hierochloe alpina			0.2						t	3	1
Arctagrostis latifolia					0.2	1.0	0.5	0.2	0.2	22	7
Betula nana	2.7	2.5	0.7	2.2	2.5	2.5	2.7	3.2	2.4	91	29
Ledum decumbens	1.2	2.2		2.7	3.0	2.5	2.2	3.2	2.1	81	26
Salix spp.		0.7	2.2	1.5	1.5		0.7	0.7	0.9	44	14
Empetrum nigrum		0.5			1.0	1.5	0.5		0.4	22	7
Vaccinium vitis-idaea	2.2	2.0		1.5	2.2	2.0	2.0	2.2	1.8	81	26
Cassiope tetragona		0.5			1.0	2.2	0.5	1.7	0.7	41	13
Rubus chamaemorus	0.7	1.7		1.0		0.2	0.2	1.7	0.7	47	15
Petasites frigidus					1.2	0.7	1.5	1.2	0.6	38	12
Rumex arcticus						0.7			0.1	9	3
Cladonia rangiferina	0.7			0.2					0.1	12	4
C. gracilis	1.0	0.2							0.1	12	4
Cetraria calcullata	0.2	0.2		0.5	0.2	0.2		0.2	0.2	22	7
Dactylina arctica	0.5				0.5	0.5	0.2	0.5	0.3	28	9
Peltigera aphthosa						0.7	0.2		0.1	12	4
Thamnolia vermicularis	0.2								t	3	1

For this study samples of two lichen species and a mixture of two similar species were collected at four sites representing four different habitat types at bimonthly intervals for one year. Insufficient material was collected to enable analysis of a few of the samples so similar samples were collected the following year during the appropriate month and from the site that the incomplete sample was collected. Samples of two additional species were collected bimonthly at one site only, where they represented principal components of the lichen flora. Only one replicate was taken of each sample because of the monetary limitations of the project.

A mixture of *Cladonia rangiferina* and *C. arbuscula* was used as these lichens commonly grow intermingled and some individual plants are difficult to separate visually and require testing with chemical stains for accurate determinations. For management purposes such separation was considered impractical. Two pure samples of each species were collected and analyzed (Table 3) and no significant differences were detected. Descriptions of the four sites have been extensively detailed (Hemming and Pegau, 1970). Briefly they are:

BELTZ, in a stand of *Eriophorum-Carex*-dwarf shrub meadow, nearly level, where snow seldom exceeds two feet in depth; SNAKE RIVER represents the luxuriant lichen growth found on large, sandy knolls where snow accumulates to a depth of over five feet and remains for a prolonged period in the spring; CABIN ROCK #1, representing a Dryas Fell-Field type vegetation on the top of a level ridge that commonly has a hard ice or crusted layer in midwinter; and CABIN ROCK #2 in dwarf shrub-lichen vegetation with a leeward exposure to the prevailing winter winds so snow commonly accumulates to a depth of four or more feet.

The Cabin Rock #1 site represents the site most commonly used by reindeer or caribou in the winter, followed in use by the Beltz site. Lichens at Cabin Rock #2 and Snake River are used extensively until snow cover precludes their use.

Scotter (1972) reported considerably higher levels of crude fiber for the lichens in the Northwest Territories than those found in this study. To ascertain if these were real differences, three lichen species were collected from the Snake River site in late August, 1972. The individual species were sorted to assure purity of each sample, then each was ground into 1 mm particles and thoroughly mixed. Three aliquots were taken of each sample and sent to three different labs for analysis. Laucks Testing Lab, which conducted the analysis reported herein; the Alberta Department of Agriculture, Soil and Feeds Testing Lab, which did the analysis reported by Scotter (1972); and the WARF Institute Lab, which has done analyses for other Departmental projects, were chosen for these analyses.

The three labs reported similar results for crude protein, fat and ash (all of which are less than 3 percent in the lichens tested) but the crude fiber content varied considerably (Table 4). All three labs reported the results as crube fiber; however, in subsequent correspondence

Table 3. Chemical composition of lichens collected at four sites.

Month	Site	Species	Percent composition on dry-weight basis						
			Protein (N x 6.25)	Fat	Crude Fiber	Ash	NFE	Ca	P
Jul	B	*Cladonia arb.-rang.*	2.1	0.6	9.5	7.4	80.4	.39	.052
"	S	"	2.2	1.2	21.2	1.1	74.3	.05	.042
"	C1	"	1.8	1.3	16.2	1.6	79.1	.02	.034
"	C2	"	1.9	0.9	32.7	1.1	63.4	.05	.046
Sep	B	"	1.9	0.7	26.1	5.0	66.3	.17	.038
"	S	"	2.1	0.3	41.3	1.0	55.3	.06	.042
"	C1	"	2.1	0.9	35.0	3.7	58.3	.05	.064
"	C2	"	1.9	0.8	30.6	1.1	65.6	.05	.038
Nov	B	"	2.2	1.0	21.7	5.4	69.7	.25	.040
"	S	"	2.7	0.7	36.7	0.9	59.0	.04	.044
"	C1	"	1.7	0.8	28.5	1.9	67.1	.02	.032
"	C2	"	2.0	1.2	24.4	1.5	70.9	.06	.038
Jan	B	"	2.0	0.6	39.0	3.9	54.5	.14	.046
"	S	"	3.1	0.7	43.3	1.1	51.8	.05	.040
"	C1	"	2.5	1.2	24.5	2.4	69.4	.10	.084
"	C2	"	2.4	2.3	25.3	2.4	67.6	.06	.040
Mar	B	"	2.9	1.1	25.6	2.9	67.5	.15	.060
"	S	"	2.1	0.9	32.8	0.9	63.3	.07	.064
"	C1	"	2.0	1.1	16.9	2.7	77.3	.03	.040
"	C2	"	2.0	0.8	31.0	1.3	64.9	.05	.048
May	B	"	1.9	1.0	26.7	3.3	67.1	.08	.032
"	S	"	2.6	1.0	32.5	1.0	62.9	.02	.042
"	C1	"	2.4	1.2	21.7	2.2	72.5	.05	.058
"	C2	"	2.4	1.4	36.8	1.6	57.8	.07	.058
Jul	B	*Cladonia uncialis*	1.8	0.6	8.2	2.6	86.8	.15	.040
"	S	"	1.8	1.6	23.5	0.8	72.3	.04	.032
"	C1	"	1.7	1.4	14.0	1.8	81.1	.02	.034
"	C2	"	1.8	1.3	10.9	0.7	85.3	.03	.036
Sep	B	"	1.8	1.0	4.5	3.5	89.2	.13	.032
"	S	"	1.9	1.0	14.5	0.9	81.7	.04	.030
"	C1	"	1.8	1.5	14.5	2.1	80.1	.02	.036
"	C2	"	2.0	1.1	23.3	0.7	72.9	.04	.044

Table 3. (cont'd.) Chemical composition of lichens collected at four sites.

Month	Site	Species	Percent composition on dry-weight basis: Protein (N x 6.25)	Fat	Crude Fiber	Ash	NFE	Ca	P
Nov	B	*Cladonia uncialis*	1.9	1.0	15.5	3.0	78.6	.15	.028
"	S	"	2.8	0.9	25.6	0.8	69.9	.04	.040
"	C1	"	1.6	1.2	18.7	2.0	76.5	.02	.034
"	C2	"	1.8	1.5	18.2	1.0	77.5	.05	.032
Jan	B	"	1.8	0.8	27.6	2.4	67.4	.11	.038
"	S	"	2.3	1.1	18.4	0.9	77.3	.04	.030
"	C1	"	2.0	1.4	13.4	3.2	80.0	.04	.034
"	C2	"	2.2	2.0	19.0	2.3	74.5	.07	.034
Mar	B	"	2.0	1.3	16.0	2.0	78.7	.12	.036
"	S	"	2.2	1.8	11.7	1.1	83.2	.06	.068
"	C1	"	2.1	1.4	11.7	2.1	82.7	.04	.048
"	C2	"	1.6	0.8	20.0	0.9	76.7	.04	.040
May	B	"	1.6	1.6	9.4	2.5	84.9	.08	.032
"	S	"	2.5	1.1	19.7	0.9	75.8	.07	.038
"	C1	"	2.1	1.5	23.6	2.0	70.8	.03	.046
"	C2	"	2.2	1.6	19.5	1.2	75.5	.05	.044
Jul	B	*Cetraria islandica*	2.4	0.2	2.4	3.5	91.5	.60	.066
"	S	"	2.4	0.5	5.6	1.1	90.4	.08	.048
"	C1	"	2.6	0.4	1.4	1.7	93.9	.05	.050
"	C2	"	2.4	0.4	4.5	1.3	91.4	.11	.062
Sep	B	"	1.9	0.5	5.6	3.2	88.8	.30	.034
"	S	"	3.1	0.5	4.6	1.1	90.7	.08	.060
"	C1	"	2.2	0.9	18.1	1.6	77.2	.08	.044
"	C2	"	2.6	0.8	4.0	1.3	91.3	.16	.070
Nov	B	"	2.3	1.1	2.2	2.5	91.9	.36	.040
"	S	"	3.6	0.7	5.5	1.0	89.2	.05	.050
"	C1	"	2.0	0.6	10.8	1.6	85.0	.06	.032
"	C2	"	2.4	0.8	5.7	1.1	90.0	.12	.038
Jan	B	"	1.9	0.6	10.3	2.0	85.2	.20	.038
"	S	"	2.9	0.5	3.3	0.8	92.5	.05	.036
"	C1	"	2.1	0.5	1.7	1.5	94.2	.05	.038
"	C2	"	2.5	1.0	6.9	1.8	87.8	.14	.042

Table 3. (cont'd.) Chemical composition of lichens collected at four sites.

Month	Site	Species	Protein (N x 6.25)	Fat	Crude Fiber	Ash	NFE	Ca	P
			Percent composition on dry-weight basis						
Mar	B	*Cetraria islandica*	2.1	0.5	7.0	2.0	88.4	.18	.040
"	S	"	2.6	0.4	3.7	0.9	92.4	.05	.065
"	C1	"	2.4	0.6	2.6	1.5	92.9	.05	.046
"	C2	"	2.3	0.5	5.3	1.3	90.6	.08	.070
May	B	"	2.2	1.1	12.6	2.3	81.8	.21	.036
"	S	"	3.6	0.4	23.3	1.0	71.7	.03	.056
"	C1	"	2.7	0.8	4.8	1.7	90.0	.06	.044
"	C2	"	3.2	0.9	9.1	1.5	85.3	.08	.074
Jul	B	*Cetraria cucullata*	2.3	2.3	4.3	4.9	86.2	.51	.050
Sep	B	"	2.0	2.6	5.4	2.5	87.5	.28	.040
Nov	B	"	2.4	3.0	4.4	3.8	86.4	.53	.040
Jan	B	"	1.8	1.6	5.2	2.3	89.1	.26	.048
Mar	B	"	2.0	2.0	5.9	2.4	87.7	.21	.042
May	B	"	2.1	3.0	4.3	2.2	88.4	.14	.034
Jul	S	*Cladonia gracilis*	2.5	0.5	16.4	0.8	79.8	.03	.038
Sep	S	"	3.0	0.3	18.2	0.7	77.8	.02	.038
Nov	S	"	3.1	1.0	22.9	0.8	72.2	.06	.042
Jan	S	"	2.3	0.6	19.3	0.8	77.0	.04	.030
Mar	S	"	2.7	0.5	24.5	1.1	71.2	.06	.046
May	S	"	2.6	0.4	31.0	1.0	65.0	.04	.038
Mar	B	*Cladonia rangiferina*-live	2.7	0.6	33.8	1.7	61.2	.14	.048
Mar	B	" - dead	1.9	0.4	38.9	4.0	54.8	.20	.044
Mar	S	" - live	3.4	0.4	30.5	1.0	64.7	.04	.070
Mar	S	" - dead	2.1	0.3	52.0	1.3	44.3	.10	.048
Jul	S	*Cladonia arbuscula*	2.3	1.3	6.5	0.9	89.0	.04	.030
Sep	S	"	2.1	0.6	22.3	0.8	74.2	.03	.032
Jul	S	*Cladonia rangiferina*	2.1	0.6	10.2	1.0	86.1	.03	.032
Sep	S	"	2.2	0.5	23.5	0.9	72.9	.03	.034

a B = Beltz C1 = Cabin Rock #1
S = Snake C2 = Cabin Rock #2

Table 4. Analyses by three labs of aliquot samples of the same three lichens.

Species	Lab	Protein	Fat	Crude Fiber	NFE	Ash	Ca	P
Cetraria islandica	Laucks	3.2	0.5	10.1	85.4	0.9	.06	.020
Cetraria islandica	WARF	3.0	<0.1	6.7	89.2	1.0	.09	.039
Cetraria islandica	Alberta	3.0	0.4	11.5	84.3	1.0	.10	.070
Cladonia gracilis	Laucks	3.0	0.4	17.5	78.3	0.8	.05	.050
Cladonia gracilis	WARF	2.9	<0.1	32.1	64.2	0.8	.06	.036
Cladonia gracilis	Alberta	2.6	0.3	46.1	51.1	0.8	.08	.040
C. rangiferina	Laucks	2.8	0.5	20.2	75.6	0.9	.07	.047
C. rangiferina	WARF	2.7	<0.1	36.7	59.3	1.1	.09	.047
C. rangiferina	Alberta	2.8	0.4	52.5	43.4	1.1	.10	.040

two labs (Laucks and WARF) reported using procedures outlined by the Association of Official Agricultural Chemist, AOAC 11th ed. (1970). The Alberta lab used a modified technique described by Van Soest (1963).

The Van Soest method measures neutral-detergent fiber which represents cell wall constituents. This is not the same as the typical crude fiber of proximate analyses, as can be seen in the results reported by the lab. It is unfortunate that the Alberta lab has chosen to call their neutral-detergent fiber crude fiber, because it ends up in the literature as such (i.e. Scotter, 1972), thus making comparisons of published reports difficult if not impossible. Still unresolved, however, are the differences reported by the two labs that theoretically used the same technique. Hopefully, the individual labs are consistent and analyses conducted by any one lab are comparable. Such discrepancies between labs were not foreseen so this aspect was not tested.

In analyzing my data percentages were transformed with the arcsine transformation to prevent the variances in the binominal distribution from becoming a function of the mean (Sokal and Rohlf, 1969). The arcsine transformation stretches out both tails of a distribution of percentages which is particularly important in the analysis of crude protein, fat and ash data. Each of the seven attributes listed in Table 3 was compared, using the computer programmed 6x4x3 factorial analysis of variance without replication model illustrated by Dixon (1971) and available at the University of Alaska. Mr. Jim Dunlap of the computer center is thankfully acknowledged for his assistance and discussions concerning these analyses.

Throughout the remainder of this discussion, the four habitats will be abbreviated as follows: Beltz = Beltz site; Snake = Snake River site; CR1 = Cabin Rock #1 site; and CR2 = Cabin Rock #2 site. The species are listed as: CLAR = mixture of *Cladonia arbuscula* and *C. rangiferina*; CLUN = *C. uncialis*; CLGR = *C. gracilis*; CEIS = *Cetraria islandica*; and CECU = *C. cucullata*.

Crude Protein

Crude protein content is widely used as a criterion for assessing forage quality. Apart from being an essential nutrient, it is usually positively correlated with digestibility. In lichens this correlation probably isn't as clearly definable because of their very low protein content. The highest protein content of the lichens examined was the 3.6 percent in CEIS in November and May at Snake. The overall crude protein average was 2.2 percent which is considerably below the 7 to 8 percent recommended minimum for domestic livestock (Morrison, 1959). Although crude protein content in the lichens usually varied less than 1 percent, the differences were consistent as detected by an analysis of variance (Table 5). All main effects (species, habitats and months) had significant differences (>P.001) and there were significant (>P.05) first-order interactions.

Because of their low crude protein content, lichens are often lightly regarded as a protein source for ruminants. However, in view of the fact

Table 5. Analysis of variance of crude protein content.

Source of variation	df	ms	F
Species	2	.00199	49.75**
Habitats	3	.00113	28.25**
Months	5	.00024	6.00**
Species X Habitat	6	.00011	2.75*
Species X Months	10	.00009	2.25*
Habitat X Months	15	.00021	5.25*
Residual	30	.00004	

* p>.05
**p>.001

that reindeer and caribou are able to recycle nitrogen to a considerable degree and usually are in a negative nitrogen balance during the winter (Steen, 1968), relatively small increments in crude protein intake become of greater significance. In feeding trials reported by Nordfeldt et al. (1961) the protein in lichens had a negative digestibility and their reindeer lost approximately 3 grams digestible protein for each kg dry matter of lichens consumed. Efforts are currently being made to analyze protein in a large sample of lichens that were used in digestion trials herein reported, to further clarify the value of lichen crude protein to reindeer.

Seasonal variation was the least marked of the main effects but there were significent seasonal effects noted. There was a general trend of protein being lowest during the snowfree periods and increasing thereafter, reaching a peak in May when there was still considerable snow at all sites except Beltz.

As there was only one repetition of each sample, the six monthly values for each species at each site were combined and a comparison of their means was accomplished using the Student-Newman-Kuels test (Sokal and Rohlf, 1969) to evaluate the role of species and habitat (Table 6).

Protein was highest in CEIS at all sites except Beltz, followed by CLGR, CLAR, and CECU. Lowest protein contents were found in CLUN. All species had their highest content at the Snake site, usually followed by CR2 and CR1. Protein contents were lowest at Beltz except for CLAR, where there was little difference between the last three sites.

There were no significant differences ($p > .05$) detected in the species at Beltz. Usually the only significant differences within a site were between CLUN and CEIS, except at CR2 where CEIS was also significantly different from CLAR. No differences were detected in CLAR at any of the sites and only the CLUN from Beltz and Snake were significantly different.

CEIS and CLGR are usually considered to be of moderate palatability but their protein content is slightly greater than the more palatable CLAR, CLUN and CECU. The habitats with the highest protein content, Snake and CR2, are also the ones with greatest snow accumulations which preclude grazing by reindeer in late winter.

Protein content in perennial vascular plants is normally highest during spring and summer (during periods of growth) and lowest in winter during dormancy (Johnston et al., 1968). It is interesting to note that protein content in the lichens tested was greatest during the period they were covered with snow and being used the most, usually reaching a peak in May, which coincides with calving in most reindeer and caribou.

Crude Fat

Crude fat provides about 2.25 times as much energy as equal amounts of carbohydrates (Morrison, 1959), but not all fats are digestible. The crude fat content in the lichens examined was very low (average, 1.0 percent), and only limited discussion is warranted.

Table 6. Multiple comparisons of the mean monthly protein content by species and habitat.

CEIS		CLAR		CLUN	
Beltz^{a}	2.13	CR1^{a}	2.08	Beltz^{a}	1.82
CR1^{a}	2.33	CR2^{a}	2.10	CR1^{ab}	1.88
CR2^{a}	2.57	Beltz^{a}	2.17	CR2^{ab}	1.93
Snake	3.10	Snake^{a}	2.47	Snake^{b}	2.25
Average	2.52		2.21		1.97

SNAKE		CR2		CR1		BELTZ	
CLUN^{a}	2.25	CLUN^{a}	1.93	CLUN^{a}	1.88	CLUN^{a}	1.82
CLAR^{ab}	2.47	CRAR^{a}	2.10	CLAR^{ab}	2.08	CECU^{a}	2.10
CLGR^{ab}	2.70	CEIS	2.57	CEIS^{b}	2.33	CEIS^{a}	2.13
CEIS^{b}	3.03					CLAR^{a}	2.17
Average	2.61		2.20		2.10		2.06

Values within a group, followed by a common superscript are not significantly different ($P<.05$)

The analysis of variance indicated highly significant ($p>.001$) differences in crude fat content between species and habitat (Table 7); however, in comparison of the means no differences were detected between habitats (Table 8). The crude fat content varied seasonally similar to crude protein, being lowest during the snowfree periods and reaching a peak in May. Crude fat content in the species tested was opposite that of protein: being lowest in CIES and highest in CLUN. Apparently these are not generic differences, as the fat content was considerably higher in *Cetraria cucullata* from the Beltz site and *Cetraria nivalis* reported by Scotter (1972) in the Northwest Territories. *Cladonia alpestris* was also relatively high in crude fat content (Scotter, 1972).

Crude Fiber

Crude fiber content is considered to be inversely proportional to forage digestibility and is widely used as a criterion of forage quality. Nordfeldt et al. (1961) reported that reindeer were able to digest crude fiber to a greater extent than sheep and appeared to digest fiber especially well. We are currently trying to analyze the residues from the digestion trials to ascertain the role of crude fiber.

Crude fiber content varied considerably between species (Table 9) and to a lesser degree between habitats and months. There were no significant first order interactions. The seasonal crude fiber content varied considerably in the different species and especially in the different habitats. It was usually lowest in July with another low in March. Comparisons of the means (Table 10) show that crude fiber content was always highest at the Snake River site and the other three sites varied according to species; however, none were significantly different. Almost all of the difference was due to species. Apparently crude fiber content is generically related, as it was always much lower in the *Cetrarias* than in the *Cladonias*. Other studies report the same trend (Scotter, 1965 and 1972; Courtright, 1959; and Pegau, 1968). In the *Cladonias*, crude fiber was usually significantly lower in CLUN, followed by CLGR, and was always highest in CLAR. Results of the digestion trials tend to support this, except in *Cetraria nivalis* where digestibility was lower than in some *Cladonias*.

Nitrogen-Free Extract

NFE represents the more digestible carbohydrates. It varies inversely with the crude fiber content of lichens because NFE is calculated as the remainder of the analysis. Statistical analyses (Tables 11 and 12) of NFE were almost identical to those of crude fiber only in inverse order, so they are not further discussed.

Ash

Ash and calcium were the only components in which the differences due to habitats were greater than those due to species. The ash content was usually low. There were highly significant differences due to habitat and species (Table 13) and no seasonal trends were detected. However, there was a significant habitats X months interaction. Ash

Table 7. Analyses of variance of crude fat content.

Source of Variation	df	ms	F
Species	2	.00687	85.87**
Habitats	3	.00088	11.00**
Months	5	.00044	5.50*
Species X habitats	6	.00016	2.00 NS
Species X months	10	.00025	3.13*
Habitats X months	15	.00053	6.63**
Residual	30	.00008	

NS = non-significant $p<.05$
* $p>.05$
**$p>.001$

Table 8. Average monthly crude fiber content by species and habitat.

	CLUN		CLAR		CEIS	
	Beltz^{a}	1.05	Snake^{a}	0.80	Snake^{a}	0.50
	Snake^{a}	1.25	Beltz^{a}	0.83	CR1^{a}	0.63
	CR2^{a}	1.38	CR1^{a}	1.08	Beltz^{a}	0.66
	CR1^{a}	1.40	CR2^{a}	1.23	CR2^{a}	0.73
Average		1.27		0.99		0.63

	BELTZ		CR2		CR1		SNAKE	
	CEIS^{a}	0.67	CEIS^{a}	0.73	CEIS	0.63	CEIS^{a}	0.50
	CLAR^{a}	0.83	CLAR^{ab}	1.23	CLAR	1.08	CLGR^{a}	0.55
	CLUN^{a}	1.05	CLUN^{b}	1.38	CLUN	1.40	CLAR^{a}	0.80
	CECU	2.42					CLUN	1.25
Average		1.24		1.11		1.04		0.78

Values, within group, with the same superscript are non-significant ($p<.05$).

Table 9. Analysis of variance of the crude fiber content.

Source of variation	df	ms	F
Species	2	.57518	109.14**
Habitats	3	.01928	3.66*
Months	5	.01959	3.72*
Species X Habitat	6	.00502	.95 NS
Species X Months	10	.00663	1.26 NS
Habitats X Months	15	.01049	1.99 NS
Residual	30	.00527	

NS = nonsignificant p<.05
* = p>.05
** = p>.001

Table 10. Average monthly crude fiber content by species and habitat.

CLAR		CLUN		CEIS	
CR1[a]	23.80	Beltz[a]	13.53	CR2[a]	5.92
Beltz[a]	24.77	CR1[a]	15.98	CR1[a]	6.57
CR2[a]	30.13	CR2[a]	18.48	Beltz[a]	6.68
Snake[a]	34.63	Snake[a]	18.90	Snake[a]	7.67
Average	28.33		16.72		6.71

SNAKE		CR2		CR1		BELTZ	
CEIS	7.67	CEIS	5.92	CEIS	6.56	CECU[a]	4.92
CLUN[a]	18.90	CLUN	18.48	CLUN	15.98	CEIS[a]	6.68
CLGR[a]	22.05	CLAR	30.13	CLAR	23.80	CLUN[a]	13.53
CLAR	34.63					CLAR	24.77
Average	20.81		18.18		15.45		12.48

Values, within a group, with the same superscript are nonsignificant (p<.05).

Table 11. Analysis of variance of nitrogen-free extract content.

Source of variation	df	ms	F
Species	2	.45714	112.59**
Habitats	3	.00721	1.77 NS
Months	5	.01432	3.53*
Species X Habitats	6	.00488	1.20 NS
Species X Months	10	.00572	1.41 NS
Habitats X Months	15	.00619	1.52 NS
Residual	30	.00406	

NS = nonsignificant p<.05
* = p>.05
** = p>.001

Table 12. Average monthly nitrogen-free extract content by species and habitat.

CEIS		CLUN		CLAR	
Beltz[a]	86.93	Snake[a]	76.70	Snake[a]	61.10
Snake[a]	87.82	CR2[a]	77.07	CR2[a]	65.03
CR1[a]	88.87	CR1[a]	78.53	Beltz[a]	67.58
CR2[a]	89.40	Beltz[a]	80.93	CR1[a]	70.62
Average	88.26		78.31		66.08

BELTZ		CR1		CR2		SNAKE	
CLAR	67.58	CLAR	70.62	CLAR	65.03	CLAR	61.10
CLUN[a]	80.93	CLUN	78.53	CLUN	77.07	CLGR[a]	73.83
CEIS[a]	86.93	CEIS	88.87	CEIS	89.40	CLUN[a]	76.70
CECU[a]	87.55					CEIS	87.82
Average	80.75		79.43		77.17		74.86

Values, within a group, with the same superscript are nonsignificant (p<.05).

Table 13. Analysis of variance of ash content.

Source of variation	df	ms	F
Species	2	.00277	8.94*
Habitats	3	.02703	87.19**
Months	5	.00064	2.06 NS
Species X Habitats	6	.00104	3.35*
Species X Months	10	.00061	1.97 NS
Habitats X Months	15	.00146	4.71**
Residual	30	.00031	

NS = nonsignificant $p<.05$
* = $p>.05$
** = $p>.001$

content of all species was significantly greater at the Beltz site (Table 14); but within the Beltz site there were no significant differences between species. For all species, ash content was lowest at Snake (where there was very little variation between species) followed by CR2 and CR1. It was highest at Beltz, which also had the highest variability. Only CEIS and CLAR at CR1 had significant differences within the different habitats. Ash was highest in CLAR at all four sites. With habitat having such marked influence on ash content, comparisons of like species from different areas should be done cautiously or when the habitats can be compared.

Calcium

Calcium in the lichens was below the recommended minimums for livestock (Morrison, 1959), except during the summer and fall in the two *Cetraria* species at Beltz. Calcium was similar to ash in that habitats accounted for the greatest part of the variability within species (Table 15). Again there were no general seasonal trends, but in all species at Beltz and in CEIS at all sites calcium was much higher during July and September and reduced during the remainder of the year. Calcium was highest in all species at the Beltz site (Table 16). It did not vary significantly at the three other sites. It was highest in CEIS followed by CECU, CLAR and CLUN at all sites, but only at CR2 was the difference significant.

Phosphorus

Phosphorus was the only component in which there were no statistical differences due to species, habitats or months. The only general trend noted was that CLUN always had the lowest phosphorus content. Phosphorus was lowest during November and January and its high was usually in March. The phosphorus content of all lichens examined was considerably below that recommended for domestic livestock (Morrison, 1959).

Calcium and phosphorus compounds make up about three-fourths of the mineral matter in the bodies of most domestic livestock and over 90 percent of that in their skeletons (Morrison, 1959). Large amounts of calcium and phosphorus are needed by growing animals and pregnant and lactating females. Apparently lichens are inadequate to even meet maintenance requirements.

Discussion

Table 17 summarizes all analysis of variance tests. The relative magnitude of the effects of species, habitat and season can be compared by the size of the F value. For all values except ash and calcium, species variations accounted for the greatest share of differences noted. Phosphorus content in the lichens examined was unique in that it was not significantly affected by species, habitat or season. Ash and calcium content varied most in relationship to habitat differences, being especially high in the lichens collected in the *Eriphorum-Carex*-dwarf - shrub meadow at the Beltz site. Almost all of the variability in the principal constituents of lichens (crude fiber and nitrogen-free extract)

Table 14. Average monthly ash content by species and habitat.

CLAR		CEIS		CLUN	
Snake[a]	1.00	Snake[a]	0.98	Snake	0.90
CR2[ab]	1.50	CR2[a]	1.38	CR2	1.13
CR1[b]	2.42	CR1[a]	1.60	CR1	2.20
Beltz	4.65	Beltz	3.58	Beltz	2.67
Average	2.39		1.89		1.73

BELTZ		CR1		CR2		SNAKE	
CLUN[a]	2.67	CEIS[a]	1.60	CLUN[a]	1.13	CLGR[a]	0.87
CECU[a]	3.02	CLUN[ab]	2.20	CEIS[a]	1.38	CLUN[a]	0.90
CEIS[a]	3.58	CLAR[b]	2.42	CLAR[a]	1.50	CEIS[a]	0.98
CLAR[a]	4.65					CLAR[a]	1.00
Average	3.48		2.07		1.34		0.94

Values, within a group, with the same superscript are nonsignificant ($p<.05$).

Table 15. Analysis of variance of calcium content.

Source of variation	df	ms	F
Species	2	.00089	17.80**
Habitats	3	.00257	51.40**
Months	5	.00012	2.40 NS
Species X Habitat	6	.00017	3.40*
Species X Month	10	.00009	1.80 NS
Habitats X Months	15	.00018	3.60*
Residual	30	.00005	

NS = nonsignificant $p<.05$
* = $p>.05$
** = $p>.001$

Table 16. Average monthly calcium content by species and habitat.

CEIS		CLAR		CLUN	
Snake[a]	.057	CR1[a]	.045	CR1[a]	.028
CR1[a]	.058	Snake[a]	.048	CR2[a]	.047
CR2[a]	.115	CR2[a]	.057	Snake[a]	.048
Beltz	.442	Beltz	.197	Beltz	.123
Average	.168		.087		.062

BELTZ		CR2		SNAKE		CR1	
CLUN[a]	.123	CLUN[a]	.047	CLGR[a]	.042	CLUN[a]	.028
CLAR[a]	.197	CLAR[a]	.057	CLAR[a]	.048	CLAR[ab]	.045
CECU[a]	.437	CEIS	.115	CLUN[a]	.048	CEIS[b]	.058
CEIS[a]	.442			CEIS[a]	.057		
Average	.300		.073		.049		.044

Values, within a group, with the same superscript are nonsignificant ($p<.05$).

Table 17. Summary of the analysis of variance for the components tested in three lichens from four habitats at bimonthly intervals through one year.

Source of Variation	df	F value: Protein	Crude Fat	Crude Fiber	NFE	Ash	C	P
Species	2	49.75**	85.87**	109.14**	112.59**	8.94**	17.80**	1.22 NS
Habitats	3	28.25**	11.00**	3.66*	1.77 NS	87.19**	51.40**	.87 NS
Months	5	6.00**	5.50*	3.72*	3.53*	2.06*	2.40 NS	1.00 NS
Species X Habitats	6	2.75*	2.00 NS	.95 NS	1.20 NS	3.35*	3.40*	.94 NS
Species X Months	10	2.25*	3.13*	1.26 NS	1.41 NS	1.97 NS	1.80 NS	1.03 NS
Habitats X Months	15	5.25**	6.63**	1.99 NS	1.52 NS	4.71**	3.60*	1.05 NS
Residual	30							

NS = nonsignificant
* = p>.05
** = p>.001

was related to species, with the *Cetraria* species having much lower crude fiber and conversely higher NFE contents than the *Cladonia* species. There was a slight seasonal trend that varied somewhat according to species and habitat. There were significant first-order interactions in crude protein, crude fat, ash and calcium, in which main effects were also all significant.

In Table 18 the grand mean of the three main species is ranked according to species and habitat for each of the seven components. Based on these lichens, CEIS combines the most desirable traits. This may be a generic characteristic as the composition of CECU, collected at Beltz only, and *C. nivalis*, *C. hiascens* and *C. delisei* (Scotter, 1965 and 1972 and Courtright, 1959) are usually similar; in fact these other *Cetrarias* usually have a higher fat content than CEIS. Fat was the only beneficial component in which CEIS was not superior to the two *Cladonias*. Evaluating the habitats is not as clear-cut, as the lichens collected from the Snake site had the highest overall protein content but they were also highest in crude fiber. The lichens at the Beltz site came closest to meeting the recommended minimum calcium content but none approached the recommended phosphorus content.

It is clear that, with few exceptions, all of the lichens examined from all habitats throughout the year are deficient in crude protein, crude fat, calcium and phosphorus. The value of lichens to caribou and reindeer clearly lies in their abnormally high carbohydrate content and apparently high digestibility which provide large quantities of energy that is so vital for maintenance during the cold winters of the far north. A mixed forage diet is necessary to compensate for the deficiencies in lichens. Shrubs, and to a lesser degree sedges and grasses, with high protein, calcium and phosphorus contents (Scotter, 1965 and 1972; Courtright, 1959; and Pegau, 1968) would complement the high carbohydrate content of lichens.

Rumen Analysis

An evaluation of the microhistological technique for analysis of complex diets was undertaken in cooperation with Dr. Richard Hansen of Colorado State University. A general review of the technique was presented in last year's progress report (Pegau and Bos, 1972). Because the microhistological technique appears to overcome the most serious pitfall of previous caribou rumen analysis, that of the bulk of the material in the rumen being too fragmented to identify, it was tested extensively. It has been used to investigate the diets of grasshoppers and crickets (Ueckert, 1968; Mulkern and Anderson, 1959; Brusven and Mulkern et al., 1962), squirrels and pocket gophers (Baumgartner and Martin, 1939; Myers and Vaughan, 1964; Vaughan, 1967; Ward, 1970; Ward and Keith, 1962), rabbits (Bear and Hansen, 1966; Dusi, 1949; Hayden, 1966; Sparks, 1968), sheep (Croker, 1959; Storr, 1968; Hansen, 1972; Todd and Hansen, in press), African herbivores (Casebeer and Koss, 1970; Field, 1968; Kiley, 1966; Stewart and Stewart, 1970 and 1971; Stewart, 1971), and Australian marsupials (Storr, 1961 and 1964).

Table 18. Ranking of the grand means for the three species and four habitats.

	SPECIES		HABITAT	
	CEIS	2.52	Snake	2.58
Crude Protein	CLAR	2.21	CR2	2.20
	CLUN	1.97	CR1	2.10
			Beltz	2.06
	CLUN	1.27	CR2	1.11
Crude Fat	CLAR	0.99	CR1	1.04
	CEIS	0.63	Snake	1.03
			Beltz	0.85
	CLAR	28.33	Snake	20.40
Crude Fiber	CLUN	16.72	CR2	18.18
	CEIS	6.71	CR1	15.45
			Beltz	14.99
	CEIS	88.26	CR1	79.34
NFE	CLUN	78.31	Beltz	78.48
	CLAR	66.08	CR2	77.17
			Snake	75.21
	CLAR	2.39	Beltz	3.63
Ash	CEIS	1.89	CR1	2.07
	CLUN	1.73	CR2	1.34
			Snake	0.96
	CEIS	.168	Beltz	.254
Calcium	CLAR	.087	CR2	.073
	CLUN	.062	Snake	.051
			CR1	.044
	CEIS	.052	Snake	.049
Phosphorus	CLAR	.047	CR2	.048
	CLUN	.038	CR1	.044
			Beltz	.040

Storr (1961), Heady and Van Dyne (1965) and Theurer (1970) reported that weight of plant material per unit area was not consistent at different stages of maturity or between all species. Although the microhistological technique has been widely adopted, it has been subjected to only limited testing. Sparks and Malechek (1968) demonstrated a direct relationship between percent relative density (estimated dry weight) and actual dry weight in hand-compounded mixtures of grass only, forb only and grass-forb combinations.

We contracted with Dr. Hansen at Colorado State University because of his expertise with the microhistological technique. Eight hand-compounded mixtures approximating caribou diets were examined, utilizing the microhistological technique to determine its applicability in assessing caribou diets. A report was prepared by Hansen, "Actual percent dry weight=f (estimated percent dry weight) for nineteen species of Alaskan plants, by a microscopic technique, March 1, 1972." and it has been filed with the caribou progress reports in Fairbanks and Nome.

Plant species, dates and locations of collection used to evaluate the technique are given in Table 19. Species composition and percent dry weights of the hand-compounded mixtures are shown in Table 20, which also shows the frequency of occurrence of discerned fragments at 20 fields per slide for 10 slides recorded by the three technicians.

The principal points of Hansen's report are presented herein. Interested persons should consult the entire report on file in Fairbanks and Nome.

> Correction factors were calculated for three species of grasses, four species of sedges, two species of mosses, four species of shrubs, two species of forbs and four species of lichens. These factors can be used to determine the percent dry weight of each species contained in a mixture of plant species when the sample is examined by a high power microscope technique. The plant species used were from Alaska and are important in big game forage species. This work, in part, validates the microscope technique.
>
> Hypothesis "Y = f (X)"
>
> This report is a comparison of an estimated percent dry weight with a known, or actual percent dry weight of plant species in mixtures.
>
> The estimated percent dry weight is calculated as a function of the frequency of discerned fragments of a given species in a sample. A primary relationship of frequency to density is determined by the formula:
>
> $$F = 100\ (1 - e^{-D}).$$
>
> This is, for a given frequency (F), a mean density (D) of discerned particles of a species per microscope field (location) can be determined. The density of particles per

Table 19. Species, dates and locations of collection of plant materials used in hand-compounded mixtures for testing relationship of actual dry weights to estimated dry weights.

Species	Location	Date
Grasses		
CACA *Calamagrostis canadensis*	Nome	Sept. 1971
HIAL *Hierchloe alpina*	Slaughter Creek	August 1971
FEAL *Festuca altaica*	Nome	Sept. 1971
Sedges		
CAAQ *Carex aquatilis*	Farewell	July 1971
CABI *C. bigelowii*	Nome	Sept. 1971
ERAN *Eriophorum angustifolium*	Nome	Sept. 1971
ERBR *E. brachyantherum*	Nome	Sept. 1971
Forbs		
EPAN *Epilobium angustifolium*	Nome	Sept. 1971
EQFL *Equisetum fluviatile*	Farewell	July 1971
Shrubs		
BENA *Betula nana*	Nome	Sept. 1971
SAPU *Salix pulchra*	Nome	Sept. 1971
DROC *Dryas octopetala*	Nome	Sept. 1971
VAVI *Vaccinium vitis-idaea*	Nome	Sept. 1971
Mosses		
POJU *Polytrichum juniperinum*	Nome	Sept. 1971
PLSC *Pleurozium schrieberi*	Nome	Sept. 1971
Lichens		
CLRA *Cladonia rangiferina*	Nome	Sept. 1971
STGR *Stereocaulon grande*	Nome	Sept. 1971
CEIS *Cetraria islandica*	Nome	Sept. 1971
PEAP *Peltigera apthosa*	Nome	June 1971

Table 20. Species composition, percent dry weight and frequency of occurrence of discerned fragments recorded by three technicians on ten slides each, 20 fields per slide.

Mix.	Species	% dry wt.	Tech.	1	2	3	4	5	6	7	8	9	10	Avg.
1	POJU	20	A	11	11	12	16	14	12	13	16	17	14	13.6
1	POJU	20	B	12	14	12	10	14	15	15	12	12	17	13.3
1	POJU	20	C	12	14	13	8	14	10	12	8	11	15	11.7
1	CACA	20	A	10	11	17	13	14	13	12	10	11	13	12.4
1	CACA	20	B	12	11	8	10	9	7	8	8	8	8	8.9
1	CACA	20	C	9	11	9	10	6	12	10	5	10	10	9.2
1	CAAQ	20	A	12	12	14	13	17	15	15	14	19	14	14.5
1	CAAQ	20	B	9	14	13	13	17	9	14	10	16	14	12.9
1	CAAQ	20	C	15	12	9	13	16	13	13	13	12	15	13.1
1	BENA	20	A	11	8	10	9	10	12	9	12	9	12	10.2
1	BENA	20	B	10	12	9	7	9	7	9	10	10	10	9.3
1	BENA	20	C	14	10	10	9	13	12	9	8	10	12	10.7
1	CLRA	20	A	12	11	9	13	14	15	10	13	10	8	11.5
1	CLRA	20	B	14	13	13	17	12	17	15	10	15	14	14.0
1	CLRA	20	C	7	12	12	9	10	9	8	8	12	14	10.1
2	HIAL[a]	20	A	9	10	7	9	11	12	14	10	9	12	10.3
2	HIAL[a]	20	B	7	4	9	6	6	8	8	5	5	6	6.4
2	HIAL[a]	20	C	13	9	8	9	7	10	9	6	10	9	9.0
2	ERAN	20	A	14	11	13	14	14	13	15	13	14	15	13.6
2	ERAN	20	B	7	7	6	9	9	7	7	12	5	10	7.9
2	ERAN	20	C	12	9	7	8	9	15	12	8	9	10	9.9
2	PLSC	20	A	14	16	15	15	12	19	16	15	15	15	15.2
2	PLSC	20	B	17	12	14	16	18	18	16	13	15	18	15.7
2	PLSC	20	C	19	18	16	19	16	20	18	17	20	18	18.1
2	DROC	20	A	6	13	10	12	15	15	12	12	15	16	12.6
2	DROC	20	B	16	11	11	12	12	15	13	12	12	13	12.7
2	DROC	20	C	12	11	9	11	8	15	11	9	9	11	10.6
2	STGR	20	A	11	14	13	11	14	16	13	12	9	16	12.9
2	STGR	20	B	17	8	7	9	15	16	7	11	11	13	11.4
2	STGR	20	C	12	7	10	9	11	11	7	11	9	13	10.0
3	CACA	10	A	6	7	5	5	4	3	3	5	6	6	5.0
3	CACA	10	B	3	5	6	4	3	5	2	5	6	3	4.2
3	CACA	10	C	6	2	3	4	6	3	3	3	3	2	3.5
3	CAAQ	10	A	10	6	10	12	13	10	8	7	8	10	9.4
3	CAAQ	10	B	4	6	4	6	5	3	6	5	9	8	5.6
3	CAAQ	10	C	9	6	4	11	10	7	6	4	6	10	7.3
3	HIAL[a]	10	A	9	10	11	7	9	10	5	7	11	10	8.9
3	HIAL[a]	10	B	3	2	3	8	5	3	3	4	3	2	3.6
3	HIAL[a]	10	C	5	10	7	7	9	7	3	8	6	7	6.9
3	POJU	10	A	10	7	9	6	8	9	9	7	8	9	7.9
3	POJU	10	B	8	12	12	9	9	6	17	14	9	7	10.3
3	POJU	10	C	8	10	8	11	4	9	4	5	7	5	7.1
3	PLSC	10	A	13	14	11	15	9	15	18	13	14	11	13.3
3	PLSC	10	B	11	14	9	9	11	8	10	11	10		10.3
3	PLSC	10	C	15	15	16	12	15	14	13	16	15	14	14.5

Table 20. (cont'd.)

Mix.	Species	% dry wt.	Tech.	1	2	3	4	5	6	7	8	9	10	Avg.
3	BENA	10	A	6	5	4	9	3	2	1	3	6	3	4.2
3	BENA	10	B	3	4	2	8	4	5	5	3	2	6	4.2
3	BENA	10	C	4	2	4	1	4	8	3	3	3	2	3.4
3	DROC	10	A	9	6	7	8	5	5	8	6	9	6	6.9
3	DROC	10	B	9	7	5	4	5	7	7	5	5	5	5.9
3	DROC	10	C	8	4	3	4	5	6	4	2	5	8	4.9
3	CLRA	10	A	9	5	8	17	16	11	9	8	5	10	9.8
3	CLRA	10	B	5	10	8	7	8	7	4	8	10	7	6.7
3	CLRA	10	C	10	5	6	5	8	6	9	5	6	8	6.8
3	STGR	10	A	7	9	4	3	5	4	7	5	8	6	5.8
3	STGR	10	B	4	4	2	2	8	7	7	7	5	5	5.1
3	STGR	10	C	3	2	2	4	2	2	1	4	4	3	2.7
3	ERAN	10	A	14	2	9	9	3	7	5	7	8	5	6.9
3	ERAN	10	B	4	4	4	5	2	6	7	2	4	8	4.6
3	ERAN	10	C	7	2	4	4	5	2	6	3	8	4	4.5
4	CACA	6.7	A	7	4	2	2	5	2	3	2	1	3	3.1
4	CACA	6.7	B	2	5	2	4	4	4	2	4	7	2	3.6
4	CACA	6.7	C	1	1	1	2	2	4	2	1	1	4	1.9
4	CAAQ	6.7	A	5	2	6	3	2	3	7	5	2	8	4.3
4	CAAQ	6.7	B	2	7	2	4	3	3	3	3	5	2	3.4
4	CAAQ	6.7	C	3	8	7	5	5	3	3	8	5	3	5.0
4	HIAL[a]	13.3	A	5	11	9	10	8	7	8	9	11	6	8.4
4	HIAL[a]	13.3	B	2	5	3	11	5	5	5	7	8	5	5.6
4	HIAL[a]	13.3	C	8	5	5	6	7	6	7	9	6	6	6.5
4	POJU	6.7	A	6	6	8	7	11	10	12	8	13	9	9.0
4	POJU	6.7	B	7	6	8	7	8	10	10	6	7	7	7.6
4	POJU	6.7	C	5	4	5	8	4	4	4	7	4	5	5.0
4	PLSC	13.3	A	13	12	10	10	13	8	8	8	14	13	10.9
4	PLSC	13.3	B	13	15	8	13	13	9	11	9	11	9	11.1
4	PLSC	13.3	C	17	18	13	14	17	13	18	15	17	12	15.4
4	BENA	6.7	A	5	2	2	5	6	4	2	2	5	6	3.9
4	BENA	6.7	B	2	5	3	4	5	4	6	5	5	2	4.0
4	BENA	6.7	C	2	1	3	3	2	1	1	3	1	2	1.9
4	DROC	13.3	A	7	6	2	6	6	11	9	7	6	9	6.9
4	DROC	13.3	B	6	7	4	3	6	6	3	6	6	2	4.9
4	DROC	13.3	C	7	7	5	5	4	8	8	3	7	4	5.8
4	CLRA	6.7	A	2	6	6	8	8	4	7	4	8	3	5.6
4	CLRA	6.7	B	7	8	2	7	2	3	4	6	7	3	4.9
4	CLRA	6.7	C	5	3	1	8	2	5	3	4	5	5	4.1
4	STGR	13.3	A	7	8	8	7	7	6	6	4	8	1	6.2
4	STGR	13.3	B	5	9	4	6	6	4	4	3	9	5	5.5
4	STGR	13.3	C	4	4	3	2	1	2	1	3	6	2	2.8
4	ERAN	13.3	A	4	5	4	9	7	6	7	6	6	6	6.0
4	ERAN	13.3	B	5	7	6	5	5	3	5	4	4	6	5.0
4	ERAN	13.3	C	7	4	5	7	5	5	5	10	5	5	5.8
5	CACA	13.3	A	5	3	7	5	2	5	3	5	3	3	4.1
5	CACA	13.3	B	6	5	6	3	4	6	4	7	5	3	4.9
5	CACA	13.3	C	6	5	3	4	4	4	3	7	5	9	5.0

Table 20. (cont'd.)

Mix.	Species	% dry wt.	Tech.	1	2	3	4	5	6	7	8	9	10	Avg.
5	CAAQ	13.3	A	13	11	10	13	12	7	13	11	11	9	11.0
5	CAAQ	13.3	B	2	5	3	7	6	5	10	6	9	5	5.8
5	CAAQ	13.3	C	14	8	7	10	10	10	10	8	8	5	9.0
5	HIAL[a]	6.7	A	7	7	13	9	8	12	9	9	6	6	8.6
5	HIAL[a]	6.7	B	3	3	7	3	4	4	3	4	4	5	4.0
5	HIAL[a]	6.7	C	5	4	3	2	5	4	4	6	7	3	4.3
5	POJU	13.3	A	13	12	8	12	11	11	8	5	11	9	10.0
5	POJU	13.3	B	8	13	5	12	8	11	7	9	9	10	9.2
5	POJU	13.3	C	7	10	6	12	12	12	9	5	8	9	9.0
5	PLSC	6.7	A	10	9	8	7	13	12	9	9	14	9	10.0
5	PLSC	6.7	B	8	7	9	9	6	12	10	5	6	10	8.2
5	PLSC	6.7	C	15	15	8	11	13	11	12	12	13	10	12.0
5	BENA	13.3	A	7	9	10	11	8	9	12	7	7	10	9.0
5	BENA	13.3	B	9	4	4	5	7	7	5	4	4	3	5.2
5	BENA	13.3	C	2	8	6	8	8	3	5	6	7	5	5.8
5	DROC	6.7	A	3	2	7	7	1	2	3	1	4	1	3.1
5	DROC	6.7	B	4	5	6	3	4	4	5	6	4	5	4.6
5	DROC	6.7	C	2	8	4	1	2	3	5	2	2	4	3.3
5	CLRA	13.3	A	9	9	6	11	8	11	11	8	9	7	9.1
5	CLRA	13.3	B	8	8	12	12	6	9	6	8	8	10	8.7
5	CLRA	13.3	C	4	8	9	10	5	10	6	9	7	9	7.7
5	STGR	6.7	A	5	6	2	6	2	6	4	3	6	1	4.1
5	STGR	6.7	B	7	7	4	5	5	7	7	6	4	6	5.8
5	STGR	6.7	C	2	1	1	3	1	2	1	1	2	2	1.6
5	ERAN	6.7	A	2	6	1	7	2	2	8	5	7	3	4.3
5	ERAN	6.7	B	4	3	4	3	3	3	3	3	5	6	3.7
5	ERAN	6.7	C	4	2	4	1	4	3	8	2	2	3	3.3
6	FEAL	14.3	A	10	11	12	8	9	5	12	7	5	9	8.8
6	FEAL	14.3	B	9	4	2	5	5	6	3	5	7	8	5.4
6	FEAL	14.3[b]	C	2	6	5	1	8	4	2	6	6	6	4.8
6	ERBR	14.3	A	12	12	10	10	14	12	13	16	7	9	11.5
6	ERBR	14.3	B	10	9	5	4	6	10	8	7	5	6	7.0
6	ERBR	14.3	C	10	6	7	4	11	13	9	10	7	8	8.5
6	EQFL	14.3	A	13	8	9	8	8	8	7	10	6	7	8.4
6	EQFL	14.3	B	5	5	10	5	7	6	8	8	3	5	6.2
6	EQFL	14.3	C	6	11	9	8	9	7	11	9	5	11	8.6
6	SAPU	14.3	A	11	11	16	9	9	13	11	13	10	13	11.6
6	SAPU	14.3	B	8	6	5	3	3	3	7	8	5	6	5.4
6	SAPU	14.3	C	6	7	4	3	3	6	8	5	5	5	5.2
6	VAVI	14.3	A[c]	-	-	-	-	-	-	-	-	-	-	
6	VAVI	14.3	B	2	7	2	2	3	6	4	3	5	5	3.9
6	VAVI	14.3	C	3	3	5	5	5	3	6	4	6	8	4.8
6	PEAP	14.3	A	12	12	13	10	8	10	13	12	9	9	10.8
6	PEAP	14.3	B	12	14	14	11	11	13	12	16	14	14	14.3
6	PEAP	14.3	C	16	10	14	11	10	13	7	12	8	8	10.9
6	CLRA	14.3	A	7	10	10	10	11	8	12	13	6	10	9.7
6	CLRA	14.3	B	11	12	7	10	8	8	11	11	12	5	9.5
6	CLRA	14.3	C	8	4	7	8	5	8	7	9	6	3	6.5

Table 20. (cont'd.)

Mix.	Species	% dry wt.	Tech.	1	2	3	4	5	6	7	8	9	10	Avg.
6	PLSC	0	B	2	1	0	0	0	0	0	0	0	0	0.3
6	PLSC	0	C	2	0	0	0	0	0	0	1	0	1	0.4
6	BENA	0	B	0	0	0	0	0	0	0	0	0	2	0.2
6	CACA	0	C	1	0	1	0	0	0	0	0	0	0	0.2
7	CABI	20	A	6	11	11	13	14	12	9	11	8	14	10.9
7	CABI	20	B[d]	4	3	3	3	4	2	3	4	2	7	3.5
7	CABI	20	C[d]	3	0	0	0	0	2	0	1	0	3	0.9
7	ERBR	20	A	4	4	9	7	5	5	11	12	10	12	7.9
7	ERBR	20	B	10	6	13	9	14	17	9	10	6	5	9.9
7	ERBR	20	C	12	11	15	14	13	15	12	12	10	10	12.4
7	EPAN	20	A	14	10	15	9	14	13	14	11	10	8	11.8
7	EPAN	20	B	5	5	3	9	3	5	5	3	4	4	4.6
7	EPAN	20	C	9	11	7	6	6	5	10	6	8	5	7.3
7	CEIS	20	A	8	8	7	10	7	13	3	7	7	4	7.4
7	CEIS	20	B	8	6	4	12	11	7	5	7	12	7	7.9
7	CEIS	20	C	5	5	6	10	9	6	3	4	9	6	6.3
7	PLSC	20	A	9	8	19	18	19	17	18	19	16	17	16.0
7	PLSC	20	B	12	16	17	19	20	18	20	20	18	15	17.5
7	PLSC	20	C	19	17	20	15	19	19	20	20	18	19	16.7
7	CACA	0	A	1	0	0	0	0	0	0	0	0	0	0.1
7	VAVI	0	A	2	0	0	1	0	2	0	0	1	0	0.6
7	FEAL	0	A	1	0	0	0	0	0	0	0	0	0	0.1
8	FEAL	8.6	A	7	10	4	3	7	3	8	5	3	4	5.4
8	FEAL	8.6	B	2	4	5	4	3	4	4	5	2	2	3.5
8	FEAL[b]	8.6	C	2	5	6	6	2	5	2	5	3	5	4.1
8	ERBR	16.6	A	7	10	9	7	7	5	10	7	12	3	7.7
8	ERBR	16.6	B	8	10	8	6	6	8	3	4	5	4	6.2
8	ERBR	16.6	C	8	11	9	8	9	6	8	11	10	11	9.1
8	CABI	8	A	5	6	8	8	5	6	6	5	3	5	5.7
8	CABI	8	B	2	0	0	2	1	2	3	1	1	1	1.3
8	CABI	8	C[d]	1	1	2	0	0	3	2	0	1	0	1.0
8	EQFL	8.6	A	7	6	4	5	7	6	4	4	3	9	5.5
8	EQFL	8.6	B	4	2	3	4	2	2	4	4	6	3	3.4
8	EQFL	8.6	C	6	7	3	6	2	2	4	1	3	4	3.8
8	EPAN	8	A	7	7	4	7	7	5	5	1	2	6	5.1
8	EPAN	8	B	4	3	7	3	2	3	4	6	3	4	3.9
8	EPAN	8	C	6	5	2	6	6	8	10	5	4	4	5.6
8	SAPU	8.6	A	3	2	0	2	4	1	1	2	3	4	2.2
8	SAPU	8.6	B	2	2	1	5	1	2	2	1	1	3	2.0
8	SAPU	8.6	C	0	2	0	1	3	1	3	1	2	0	1.3
8	VAVI	8.6	A	4	3	5	7	3	5	8	8	2	3	4.8
8	VAVI	8.6	B	3	5	4	4	2	4	5	2	3	1	3.3
8	VAVI	8.6	C	1	4	2	4	1	0	3	3	1	2	2.1
8	PEAP	8.6	A	7	7	9	6	10	9	9	5	7	11	7.9
8	PEAP	8.6	B	11	10	10	9	8	8	10	10	6	8	9.0
8	PEAP	8.6	C	11	8	7	10	8	12	5	8	9	12	9.0

Table 20. (cont'd.)

Mix.	Species	% dry wt.	Tech.	1	2	3	4	5	6	7	8	9	10	Avg.
8	CLRA	8.6	A	4	5	6	10	7	5	5	4	7	6	5.9
8	CLRA	8.6	B	4	7	5	7	6	7	8	6	8	7	6.3
8	CLRA	8.6	C	7	6	3	3	4	6	6	5	5	6	5.1
8	CEIS	8	A	2	3	4	4	1	2	2	2	4	0	2.4
8	CEIS	8	B	6	4	7	3	3	5	4	5	3	3	4.3
8	CEIS	8	C	3	3	4	3	4	3	3	5	1	2	3.1
8	PLSC	8	A	16	6	10	10	14	9	10	9	15	11	11.0
8	PLSC	8	B	15	12	12	16	15	13	9	16	11	12	13.1
8	PLSC	8	C	16	8	16	11	14	11	12	14	14	11	12.7
8	BENA	0	A	0	0	0	0	1	0	0	0	0	0	0.1
8	BENA	0	B	2	0	0	1	0	0	0	0	0	1	0.4
8	STGR	0	A	2	1	3	2	1	2	2	2	0	0	1.5
8	ERAN	0	B	0	0	0	1	1	0	2	0	2	2	0.8

a = identified as FEAL by all three technicians
b = identified as HIAL
c = lumped with SAPU
d = identified as CAAQ

field is then converted to percent relative density by:

$$RD = \frac{\text{Density of discerned fragments for a species}}{\text{Total density of discerned fragments for all species}} \times 100.$$

This relative percent density is then used as an estimate of the percent dry weight of that species in the mixture.

Method comparisons are through regression equations expressing the relationship between the estimated and actual percents dry weight, where Actual Percent Dry Weight = f (Estimated Percent Dry Weight).

The hand-compounded mixtures were prepared in the normal manner utilized in analyzing rumen or fecal samples.

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

The RD of recognized fragments of plants in each of the samples was estimated by observing 20 systematically located fields on each of the slides 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 RD, 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 species of plant.

Validation Procedures

Some simple mixtures containing two or three species of easily recognized plants were used to validate the hypothesis that:

Dry weight of a monocot or dicot = f (RD).

The testing techniques on these simple mixtures is not part of the Alaskan contract agreement but since it is a basic preliminary procedure to validation of the complex mixtures of Alaskan plant species we have included it within this report. The validation of the hypothesis Y = f (X) for the simple mixtures simulates optimum technique conditions which are seldom seen under natural conditions when big game diets are being determined. The results of these tests on simple mixtures did show that we can expect to occasionally find an "outlier" species of plant which deviated enough from the hypothesis that dry weight = estimated dry weight that if such a plant is a major constituent in a diet its RD value should be multiplied by a correction factor to obtain the "best" estimate of percent dry weight.

Some very complex mixtures of Alaskan plants, each containing from five to twelve species of big game forage plants, were used to validate the microscopic technique and obtain correction factors (f) for each of 19 plant species. The hand-compounded mixtures were made so each contained at least one lichen, one moss, one sedge, one grass and one forb or shrub. The actual percentages of dry weights used in the complex mixture were chosen so that the correction factors obtained would be within an anticipated range that might be encountered in a big game diet. Higher coefficients of correlation for X = Y could have been obtained if some of the mixtures had been made to simulate the "unlikely" types of big game diets. However, the correction factors obtained will be accurate, useful and typical of natural conditions.

Quantifications in Simple Mixtures

Twenty-four samples were hand-compounded so they contained known dry weight percentages of: 1) grasses and grasslikes and 2) forbs or shrubs. These mixtures were made up of forage species having distinctly different cellular patterns and primarily contained two or three species each. There were 10 species of grasses or grasslikes (=monocots) and 15 species of non-grasses (=dicots) in the mixture. The technicians were trained to correctly identify species of plants used in the mixtures and they practiced recording frequency on slides made from mixtures of plants. The dry weight compositions of "practice slides" were known by the technicians.

The species of plants in the 24 hand-made mixtures were unknown to the four technicians who recorded the frequency of the fragments they discerned. All plants were correctly identified for each mixture used in these tests.

Plant species are considered in three groups for the regressions: monocots (=grasses and grasslikes); dicots (=forbs and shrubs); and monocots + dicots. The results are the following:

		R^2	Sy.x	Sb_1
Monocots	Y = .594 + .951 X	.9644	4.1633	.0270
Dicots	Y = 3.834 + .941 X	.9748	4.0860	.0315
Monocots + Dicots	Y = 1.936 + .941 X	.9649	4.3134	.0213

Means and variances of the <u>estimated (X)</u> and <u>actual (Y)</u> percents dry weight are:

	n	$\bar{X}$	$\bar{Y}$	Sx^2	Sy^2	$S\bar{x}$	$S\bar{y}$
Monocots	48	34.637	33.540	507.247	475.889	3.251	3.149
Dicots	25	29.500	31.600	699.250	635.500	5.289	5.042
Monocots + Dicots	73	32.877	32.875	570.228	523.342	2.795	2.678

From the above two charts, it can be seen that the best linear regression fit is for the dicot grouping (R^2 = .9748) even though the variances for this group are greater than for either of the other two groups (possibly due to the smaller sample size). Examination of the group means shows an overall estimation of the actual percent dry weight for monocots and an overall underestimation for the dicots. The differences between these means are not significant (P>.10 t-test).

Statistical tests were made of the means and of the regression line to: 1) see if the slope of the line equaled 1; 2) see if the intercept equaled 0; 3) see that the slopes of the monocot and dicot equations were not significantly different from each other; and 4) determine the 95 percent confidence limits about the regression line. The statistical tests and graphs of the results are presented in Hansen's report. The results of tests were: 1) all three regression equations had a slope significantly (p>.10) different from 1. (Hansen points out that this discrepancy and the fact that the means were non-significant might be attributed to the adjustments due to the intercepts); 2) only the equation for monocots had an intercept not significantly (P>.10) different from 0; 3) there was no difference (P>.10) in the slopes of the regression equation for the monocots and dicots; and 4) the 95 percent confidence limits about the regression equation gives..

> ...a confidence interval for a single observed X value and is correct for this single prediction. This is not the same as a confidence interval for the mean of all Y values (actual percent dry weight) of all plant species having a particular X value (estimated % dry weight). There is one outlier for each of the two functional groups. The outlier for the monocot group is an overestimation while the outlier for the dicot group is an underestimation. There are four observations outside the confidence band for the monocot-dicot combination in that there is an additional extreme dicot underestimation, and an additional extreme monocot overestimation.
>
> In conclusion, the predictive equations each show a high correlation between the estimated and actual percents dry weight. This relationship, however, is not strictly 1:1, as indicated by the t tests about the slopes and intercepts. In practice, however, one would observe little difference in a corrected or uncorrected mean estimate of dry weight. It appears that trained technicians can accurately discern the frequency of fragments in simple mixtures containing plants that have distinctive cellular patterns.

Quantification in Complex Mixtures

Nineteen species were considered individually and in functionally classified groups (grasses, sedges, forbs, shrubs, mosses and lichens). Eight mixtures were made so each contained at least one grass, one sedge, one lichen, one moss and one forb or shrub. The plants used in the mixtures are listed on page 29. Ten microscope slides were prepared for each of the eight mixtures and each microscope slide was read by three different technicians at the rate of 20 systematic-random fields per slide. This resulted in a total of 24 independently developed tests for "Y = f (X)".

The reference slides of each plant were studied and then "practice slides" of simple mixtures were read by each technician before the reference slides were studied again. About 40 hours was spent by each technician in the study of reference slides and in practice estimation of RD from simple mixtures of Alaskan plants. Some combinations were not made into "practice slides" and this resulted in a higher than expected variance between such species when they occurred together during the testing.

The behavior of the technicians was more carefully controlled than in a normal laboratory program for the microscope technique. The technicians normally help each other with identification but during the tests they were not permitted to exchange information about the problems they encountered with the unknown mixtures of slides. The technicians are normally permitted to search through reference slides when they are working but they were not permitted to use reference slides once the testing of the unknown mixtures had started. Although both of these restraints are believed to have introduced higher than usual errors into the observed results it was felt this was more desirable than to have obtained greater accuracy at the possibility of some bias.

Regression estimates were made on ten slide averages (200 microscope fields) of three laboratory technicians. The regression equations are generally "better" when the data is treated by species rather than by functional groups. That is, the r^2 values, a value relating the percent of variability explained by the equation, are higher by species than by groups. These analyses are of the form of (a) testing for differences between the means (actual vs. estimated) (b) and tests about the regression equation.

The differences between means are tested for with the use of a two-sample t-test.

The statistics involved and calculated t values for means, slopes and intercepts are all given in Hansen's report. Table 21 summarizes the significance test p>.10.

For the CACA, ERAN, PLSC, VAVI, CEIS, and PEAP species, the estimated and actual percent means are significantly different from each other. This difference is also true of the grass, moss and shrub functional groups. There do not tend to be any subjective comparisons between the significances of the functional groups and the species of these functional groups; for example, where there are no differences between means for p = .10. Likewise where there is no difference between the means for the lichens as a group the ERAN species show a significant difference between the means for the lichens

Table 21. Summary of t-tests about the means, about the slopes, and about the intercepts.

Species	Means	Slope	Intercept
CACA	*	NS	*
HIAL	NS	NS	NS
FEAL	NS	NS	NS
CAAQ	NS	*	*
CABI	NS	NS	NS
ERAN	*	NS	*
ERBR	NS	NS	NS
POJU	NS	NS	NS
PLSC	*	*	*
BENA	NS	NS	*
SAPU	NS	NS	*
DROC	NS	NS	*
VAVI	*	NS	NS
EPAN	NS	NS	NS
EQFL	NS	*	*
CLRA	NS	*	NS
STGR	NS	NS	*
CEIS	*	NS	NS
PEAP	*	*	NS
GRASSES	*	NS	*
SEDGES	NS	*	*
MOSSES	*	*	*
SHRUBS	*	*	*
FORBS	NS	NS	*
LICHENS	NS	*	*

* = significance P>.10
NS = nonsignificant

as a group, the CEIS and PEAP species show significant differences between means for p = .10. It should be noted here that a significant difference between means should not be used as a criterion for judgment of the respective regression equations. It is merely a statement of similarity between the mean estimates. In testing the fit of the regression slope to equal 1 Hansen found that there seems to be considerable difference in the frequency of significances when the data are viewed with respect to species as opposed to when they are viewed with respect to functional groups (5/19 as opposed to 4/6, respectively).

There is again a lack of subjective comparison between the significances of the functional groups and the species of the functional groups. That is, none of the species of the shrubs (BENA, SAPU, DROC, VAVI) show a slope significantly different from 1 whereas, as a whole, the shrub group does show a slope significantly different from 1. On the other hand, the forb group as a whole displays a slope not different from 1 while the EQFL species displays a slope different from 1, for P = .10. The species with slopes significantly different from 1 are CAAQ, PLSC, EQFL, CLARA, and PEAP; the functional groups with slopes significantly different from 1 are sedges, mosses, shrubs, and lichens.

It should be noted here that the results of testing the means and slope should not necessarily yield similar results when viewed simultaneously. An equation with a slope equal to 1 may, in fact, have independent and dependent variable means significantly different from each other due to a "large" y intercept value. Likewise, independent and dependent variable means which are not significantly different do not insure a 45° slope.

Simultaneous comparisons of the functional group categories with the species of the categories show that at least one species of each category displays an intercept significantly different from zero while, at the same time, each category displays an intercept significantly different from zero. The individual species which show an intercept significantly different from zero are CACA, CAAO, ERAN, PLSC, BENA, SAPU, DROC, EQFL, and STGR.

Because it is ultimately hoped that a one to one relationship will hold between the estimated percent and the actual percent, it is interesting to note for which species the slopes are not different from one while the intercepts are not different from zero.

This is not to say that the function Y = X is the proper relationship between the two variables; it is merely to say that the regression estimates, b_0 and b_1, are not significantly different from 0 and 1, respectively. These species are HIAL, FEAL, CABI, ERBR, POJU, VAVI, EPAN, and CEIS.

Table 21 summarizes the results of the three preceding t tests about the means, about the slopes, and about the intercepts.

Six of the eight species previously mentioned which reportedly have slopes not different from one and intercepts not different from zero also have actual and estimated percent means not significantly different from each other (HIAL, FEAL, CABI, ERBR, POJU, and EPAN.

Hansen presents graphs of the regression equations and their 95 percent confidence limits for all of the species and the functional groups which pictorially aid in explaining why either the means, slope or intercepts could be significantly different and the other two components could be non-significant for a species.

To fully evaluate the results of the t-tests you should view the graphs. Slope comparisons of selected pairs of species were made according to Hansen because...

> ...it is noted that the HIAL-FEAL, SAPU-VAVI, and CAAQ-CABI slope comparisons are made due to initial technician failures to distinguish between the respective grasses, shrubs, and sedges. In actual work HIAL-FEAL and SAPU-VAVI can be discerned but during the training period the technicians were not trained on practice slides containing mixtures of these species. Before the tests on these species had ended each technician was aware that they had "lumped" the species together for the first few slides. To be consistent they "called" the discerned fragments the same for all slides. The similarity of some characters of CAAO and CABI suggests that these two species, if they occur together in a big game animal's diet, should be "lumped" together in a single category.
>
> The calculated t values are: p>.10:

HIAL-FEAL	0.162	NS
SAPU-VAVI	0.463	NS
CAAQ-CABI	0.439	NS

Hansen also tested the slopes of various similar functional groups to see if the groups appeared similar. Comparisons were made between the grasses and sedges, lichens and mosses, and forbs with shrubs. The calculated t values for slope differences between groups were all significant (p>.10).

Regression equations were developed for the nineteen species and six functional groups based on the recordings of the three technicians. Each point of a technician represents 200 observations (i.e. 10 slides with 20 fields per slide). Each species occurred in at least two mixtures which resulted in six points (three technicians x two mixtures) being used to develop the regression equations. Most species were in four and some were in six mixtures which resulted in 12 and 18 points, respectively. Table 22 summarizes the regression values.

In summary, and contrary to what Sparks and Malechek (1968) found with simple diets, the dry weight of complex diets apparently is not a 1 to 1 relationship with percent relative density, and correction factors

Table 22. Summary of regression analyses, by species and by functional groups.

	n	Y = a + bX	$\bar{X}$	$\bar{Y}$	r^2	s_x^2	s_y^2	$s_{y.x}$	s_{b_1}
CACA	12	Y = 4.002 + 1.115X	7.64	12.52	.85	17.982	26.132	2.043	.145
HIAL	12	Y = 2.761 + .883X	9.90	12.50	.21	6.967	26.421	4.806	.549
FEAL	6	Y = 4.474 + .819X	8.49	11.43	.55	8.001	9.781	2.351	.372
CAAQ	12	Y = 3.290 + .655X	14.05	12.49	.92	57.953	27.039	1.5463	.061
CABI	5	Y = 8.004 + .724X	6.63	12.80	.41	34.021	43.200	5.8169	.499
ERAN	12	Y = 3.938 + .952X	8.99	12.50	.73	21.421	26.421	2.7783	.181
ERBR	9	Y = 9.887 + .616X	15.07	19.17	.08	14.143	65.984	8.3234	.783
POJU	12	Y = .865 + .838X	15.97	12.51	.68	25.282	26.092	3.0321	.182
PLSC	18	Y = 3.920 + .290X	31.31	12.99	.62	223.404	30.286	3.4996	.057
BENA	12	Y = 4.622 + .851X	9.26	12.51	.84	30.637	26.585	2.1947	.120
SAPU	6	Y = 5.391 + 1.087X	7.74	13.81	.98	50.116	60.134	1.0821	.068
DROC	12	Y = 4.383 + .792X	10.24	12.49	.80	34.012	26.631	2.4195	.125
VAVI	5	Y = 5.180 + .940X	6.04	10.86	.43	4.781	9.816	2.7294	.624
EPAN	6	Y = 8.281 + .629X	9.10	14.00	.18	19.700	43.200	6.6535	.670
EQFL	6	Y = 5.631 + .571X	10.17	11.44	.75	22.818	9.850	1.7377	.163
CLRA	18	Y = 2.082 + .774X	13.01	12.15	.75	25.367	20.275	2.3268	.112
STGR	12	Y = 5.708 + .765X	8.87	12.49	.69	31.36	26.63	3.0178	.162
CEIS	6	Y = 1.580 + 2.022X	7.70	14.00	.75	7.946	43.128	3.6475	.579
PEAP	6	Y = 4.574 + .342X	20.00	11.42	.58	48.304	9.747	2.2601	.145
GRASSES	30	Y = 4.167 + .932X	8.71	12.29	.47	11.910	21.814	3.4453	.185
SEDGES	38	Y = 6.316 + .666X	11.72	14.11	.42	40.738	42.974	5.0614	.130
MOSSES	30	Y = 6.751 + .240X	25.18	12.80	.41	198.974	27.708	4.0986	.054
SHRUBS	35	Y = 5.005 + .843X	8.88	12.49	.79	30.970	27.913	2.4664	.076
FORBS	12	Y = 7.421 + .550X	9.63	12.72	.23	19.639	25.908	4.6868	.319
LICHENS	42	Y = 7.657 + .394X	12.07	12.41	.28	41.176	22.543	4.0708	.099

then must be developed such as the prediction equations developed for the nineteen species.

Reasons for this departure from the expected could be any one or a combination of the following:

1) The weight per fragment might vary between species so that a given unit of weight of one species would produce more plant fragments of the same size than would an equal weight of a different species.

2) Plant fragments of one species might be more "identifiable" than fragments of another species. A basic assumption of the technique is that the undiscernable fragments occur in the same proportions as the recognizable fragments.

3) The regression equations were computed from percentages, therefore if one plant species in a mixture were over or underestimated it then affected the estimation of all other species in that mixture.

4) Frequency of occurrence was used rather than counting the number of fragments per species. However, frequency of occurrence is converted to density and, according to Fracker and Brischle (1944), this provides a better estimate.

Analyses have been made of caribou rumen samples, muskox (*Ovibos moschatus*) and Arctic hare (*Lepus othus*) fecal pellets and Arctic hare stomach samples (Tables 23 through 28). Attempts to convert percent relative density to percent dry weight utilizing the prediction equations have been mostly unsatisfactory (Table 29). The data from the hand-compounded mixtures are being reexamined and efforts will be made to develop independent prediction equations so that the estimate of one species will not affect the estimate of other species in the same sample. For the present percent dry weights of complex diets should not be calculated but rather should be postponed until one or two "technical problems" have been overcome; the microhistological method has potential for use in studying animals with complex diets.

Digestion Trials

An expanded series of digestion trials using rumen fistulated reindeer were conducted in late November and early December. The reindeer were both adults, one a bull, the other a cow, belonging to the Institute of Arctic Biology, University of Alaska. Drs. Jack Luick and Robert White and especially Mr. Steve Person of the Institute are thankfully acknowledged for their assistance, comments and cooperation. The reindeer had been accustomed to the facilities and to intensive handling and were quite docile. The trials were conducted similar to those of last year, using the nylon bag technique (Pegau and Bos, 1972) with a few modifications.

Six trials were completed with the bull and five with the cow.

Table 23. Symbols and names for plant fragments identified in rumen or fecal samples.

SYMBOLS	NAME OF DISCERNED PLANT
GRASS AND GRASSLIKE	
UNG 1	Unidentified grass
ARLA	*Arctagrostis latifolia*
CAAO	*Carex aquatilis*
CABI	*Carex bigelowii*
CASP	*Carex* spp.
ERSP	*Eriophorum brachyantherum*, *E. vaginatum*
EQFL	*Equestum fluviatile*
FESP	*Festuca* spp.
HIAL	*Hierochloe alpina*
FORBS AND SHRUBS	
UNF 1	Unidentified forb
ARAR	*Artemisia arctica*
ARRU	*Arctostaphylos rubra*
BENA	*Betula nana*
DROC	*Dryas octopetala*
EMNI	*Empetrum nigrum*
EPAN	*Epilobium angustifolium*
SASP	*Salix* spp.
SAPU	*Salix pulchra*
VIVI	*Vaccinium vitis-idaea*
PISP	*Picea* spp.
MOSSES	
MOSS	Unidentified moss
MOSI	Unknown moss number one
MOSA	*Pleurozium schreberi*, *Hylocomium splendens*
MOSB	*Polytrichum juniperinum*, *Oncophorus wahlenbergii*
MOSC	*Sphagnum centrale*, *S. fimbriatum*, *S. fuscum*, *S. magellanicum*, *Drepanocladus fluitans*, *D. elongatum*
LICHENS	
CESP	*Cetraria cucullata*, *C. andrejevii*, *C. islandica*
CLSP	*Cladonia arbuscula*, *C. gracilis*, *C. rangiferina*, *C. uncialis*, *C. alpestris*, *C. amaurocraea*
LICH	Unknown lichens
LICB	*Nephroma arcticum*, *Lobraia linita*
PEAP	*Peltigera aphthosa*
LICA	*Stereocaulon grande*, *S. rivulorum*, *S. pachale*, *S. tomentosum*, *Alectoria ochronleuca*
LICC	*Thamnolia vermicularis*, *Cetraria tilesii*

Table 24. Percent relative density for discerned plant fragments in rumen samples of caribou in the Arctic and Adak herds. Derived from five slides of 20 fields per slide per animal.

	54371 June/69 Female NoLuck Lake	54361 June/69 Female NoLuck Lake	54366 June/69 Female NoLuck Lake	#2-69 Dec/69 Male Ambler	#4-69 Dec/69 Male Ambler	1-69 Dec/69 Female Ambler	5-69 Dec/69 Female Ambler	53,549 Sept/68 Adak	53,548 Sept/68 Adak
GRASSLIKE									
CAAQ	.69	.45		2.28	.94		.80		
CABI								1.03	1.93
ERSP	82.58	47.95	35.18	3.48		4.22	2.89	1.03	
HIAL			.47					.51	6.27
FORBS									
ARAR			.94						
DROC		.45	.94		.47				
EMNI			1.42	.57					
SASP			.47						
UNFI								9.47	14.15
VAVI			.94						
MOSSES									
MOSI	.69	9.92	8.69	.57				1.03	16.58
MOSS	10.79	28.22	20.80	2.88	8.11	4.22	11.46	.51	1.93
MOSA	1.05	6.70	4.60	1.14	.47		1.21		
MOSB	.35								
LICHENS									
CESP		1.36	2.88	.57	3.38	.51	.40		
CLSP	1.39	1.80	6.49	46.14	26.96	66.28	45.37	7.08	12.59
LICB		.90							
PEAP	1.76	1.80	11.58	23.34	38.18	8.83	14.78		
LICA		.45	4.60	18.46	21.49	15.93	23.09	79.34	46.55
LICC				.57					

Table 25. Percent relative density for discerned plant fragments in rumen samples of adult cow caribou collected during early June, 1971 on the calving grounds of the Arctic herd. Derived from 10 slides with 20 fields per slide per sample.

	Composit of rumen samples from 18 cows	Composit from the cows to the right	45050	45044	45052	45037	45036
GRASSLIKE							
ARLA							
CAAQ	6.16	0.20	1.60	0.11	3.10	4.80	0.59
CABI					0.50		
ERSP	60.44	82.43	77.41	81.28	53.74	83.98	90.72
HIAL		0.20		0.56	1.17		0.11
FORBS							
DROC					0.16		
EMNI						0.21	
SASP	0.22	0.29			1.17		
SAPU			0.13	0.11			
VAVI	1.35			0.67	0.33		
EPAN						0.21	
MOSSES							
MOSS	18.38	6.78	8.67	5.90	11.26	0.42	3.77
MOSA	9.59	5.42	7.09	5.62	18.19	5.97	2.19
MOSB		0.20	0.26		0.33	2.55	
MOSC		0.58	0.39	0.11	0.83		
LICHENS							
CESP	1.12	0.78	2.29	2.58	3.28		1.07
CLSP	2.74	3.03	2.16	3.07	5.93	1.26	1.44
LICH						0.21	
LICB		0.20					
LICA						0.42	0.11

Table 26. Frequency, density and percent relative density for discerned plant fragments in rumen samples from caribou collected near the Nabesna Road in February, 1972. Sex unknown.

Plant Symbol	C - 1 - 72 one caribou			C - 2 - 72 one caribou			C - 3 - 72 one caribou			C - 4 - 72 one caribou		
	f.	d.	% RD	f.	d.	% RD	f.	d.	% RD	f.	d.	% RD
GRASS & GRASSLIKES												
UNG 1	5	.0513	1.69	2	.0202	0.90	2	.0202	0.77	3	.0305	1.51
UNG 2	2	.0202	0.66							1	.0101	0.50
HIAL	2	.0202	0.66	1	.0101	0.45	2	.0202	0.77	2	.0202	1.00
EQFL	3	.0305	1.00	3	.0305	1.36	1	.0101	0.38			
FESP							5	.0513	1.95	1	.0101	0.50
CAAQ							5	.0513	1.95			
FORBS & SHRUBS												
UNF 1	3	.0305	1.00	2	.0202	0.90	3	.0305	1.16	1	.0101	0.50
UNF 2	3	.0305	1.00	2	.0202	0.90	5	.0513	1.95	23	.2614	12.97
EMNI	1	.0101	0.33									
BENA	5	.0513	1.69	3	.0305	1.36	5	.0513	1.95	1	.0101	0.50
PISP	3	.0305	1.00	1	.0101	0.45	1	.0101	0.38	2	.0202	1.00
SASP				3	.0305	1.36	1	.0101	0.38	1	.0101	0.50
VAVI				1	.0101	0.45	1	.0101	0.38			
MOSSES												
UNM 1	1	.0101	0.33	2	.0202	0.90				1	.0101	0.50
Moss	25	.2877	9.46	18	.1985	8.84	18	.1985	7.53	37	.4620	22.93
LICHENS												
CLSP	91	2.4075	79.15	83	1.7720	78.91	88	2.1203	80.48	67	1.1087	55.03
STSP	5	.0513	1.69									
PEAP	1	.0101	0.33	7	.0726	3.23	5	.0513	1.95	5	.0513	2.55
TOTALS	150	3.0418	0.9999	128	2.2457	1.0001	137	2.6347	1.0000	145	2.0149	0.9999
No. of Fields	100			100			100			100		

f = frequency of occurrence per sample (at 100 fields)
d = density of discerned fragments per field
% RD = percentage relative density of discerned fragments per sample

Table 26. (cont'd.)

Plant Symbol	C - 5 - 72 one caribou			C - 6 - 72 one caribou			C - 7 - 72 one caribou			C - 8 - 72 Composite of C - 1 thru C - 7 - 72		
	f.	d.	% RD	f.	d.	% RD	f.	d.	% RD	f.	c.	% RD
<u>GRASS & GRASSLIKES</u>												
HIAL	2	.0202	0.45	3	.0305	1.27	9	.0988	4.39	4	.0101	0.36
EQFL	1	.0101	0.22									
FESP				2	.0202	0.84				2	.0050	0.18
CAAQ	1	.0101	0.22									
CASP				2	.0202	0.84						
<u>FORBS & SHRUBS</u>												
UNF 1	1	.0101	0.22	6	.0619	2.57	1	.0101	0.45	10	.0253	0.91
UNF 2	3	.0305	0.67	9	.0988	4.10	15	.1625	7.22	52	.1393	5.01
BENA										3	.0075	0.27
PISP	1	.0101	0.22	13	.1393	5.78	6	.0619	2.75	10	.0253	0.91
SASP	1	.0101	0.22	5	.0513	2.13				5	.0125	0.45
VAVI				1	.0101	0.42				2	.0050	0.18
EPAN				1	.0101	0.42	1	.0101	0.45			
<u>MOSSES</u>												
UNM 1	1	.0101	0.22	1	.0101	0.42	1	.0101	0.45	5	.0125	0.45
Moss	30	.3567	7.86	17	.1863	7.73	40	.5108	22.68	115	.3390	12.19
<u>LICHENS</u>												
CLSP	97	3.9120	86.22	83	1.7720	73.50	74	1.3471	59.82	352	2.1203	76.21
PEAP	11	.1165	2.57				3	.0305	1.35	29	.0753	2.71
LICA	4	.0406	0.89				1	.0101	0.45	2	.0050	0.18
TOTALS	153	4.5511	0.9998	143	2.4108	1.0002	151	2.2520	1.0001	591	2.7821	1.0001
No. of Fields	100			100			100			400		

f = frequency of occurrence per sample (at 100 and 400 fields)
d = density of discerned fragments per field
% RD = percentage relative density of discerned fragments per sample

Table 26. (cont'd.)

Plant Symbol	C - 9 - 72 Composite of seven other caribou f.	d.	% RD	C - 10 - 72 Composite of seven other caribou f.	d.	% RD
GRASS & GRASSLIKES						
HIAL	7	.0177	0.58			
EQFL	1	.0025	0.08			
FESP	21	.0539	1.75	4	.0101	0.48
CAAQ	3	.0075	0.24			
FORBS & SHRUBS						
UNF 1	21	.0539	1.75	28	.0726	3.49
UNF 2	45	.1193	3.88	33	.0861	4.13
BENA	1	.0025	0.08	3	.0075	0.36
PISP	20	.0513	1.67	32	.0834	4.00
SASP	2	.0050	0.16	2	.0050	0.24
MOSSES						
UNM 1	3	.0075	0.24	6	.0151	0.73
Moss	163	.5234	17.02	100	.2877	13.81
LICHENS						
CLSP	353	2.1413	69.61	306	1.4482	69.53
PEAP	28	.0726	2.36	25	.0645	3.10
LICA	7	.0177	0.58	1	.0025	0.12
TOTALS	675	3.0761	1.0000	534	2.0827	0.9999
No. of Fields	400			400		

f = frequency of occurrence per sample (at 400 fields)
d = density of discerned fragments per field
% RD = percentage relative density of discerned fragments per sample

Table 27. Percent relative density for discerned plant fragments in musk-oxen pellets. Derived from 20 slides for M-1-72 and M-2-72, 10 slides for M-4-71 and five slides for M-1-70 and M-2-71, with 20 fields on each slide.

Species	M-1-70 May 1970 Sinuk River Hills	M-2-71 Jan. 1971 Sinuk River Flats	M-4-71 Dec. 1971 Brevig Mission	M-1-72 Feb. 1972 Nuluk River Hill	M-2-72 Feb. 1972 Point Hope Flats
GRASSLIKE					
ARLA		15.34	.22	30.73	.88
CAAQ	3.51	.46	1.53	.87	2.19
CABI	4.12		1.31	19.36	7.74
ERSP	6.61	2.31	3.36	17.10	.17
FESP			2.44	5.62	8.68
HIAL		2.31	1.09		.50
FORBS					
ARAR	16.32		12.11		2.19
ARRU	.57	1.83	.22		.17
DROC			.22		
SASP			1.75	3.21	5.18
UNF					34.59
MOSSES					
MOSI	11.26		13.86		18.68
MOSS	40.47	51.35	32.10	1.30	9.56
MOSA	4.73	3.76	21.30	1.04	2.70
MOSB			1.74	5.25	6.63
MOSC				0.70	
LICHENS					
CESP	2.91	1.37	4.30		.33
CLSP	5.98	16.72	6.75	14.05	.33
LICB			.22		.50
PEAP			.44		
LICA	3.51	4.45	4.06	0.17	1.68

Table 28. Percent relative density for discerned plant fragments in diets of arctic hares collected during April and May, 1971 on the Seward Peninsula. Derived from 10 slides with 20 fields per slide per date.

	AH-1-71 Composite of 19 Males Stomach Arctic River	AH-2-71 Composite of 19 Males Fecal Arctic River	AH-3-71 Composite of 12 Females Stomach Arctic River	AH-4-71 Composite of 12 Females Fecal Arctic River	AH-5-71 Composite of 2 Males Stom & Fec Serpentine River	AH-6-71 Composite of 2 Females Stom & Fec Serpentine River	AH-7-71 one female Stom & Fec Serpentine River
GRASSLIKE							
ERSP					0.23		
EQFL		0.20					
HIAL					0.91		
FORBS							
BENA				0.23			
DROC	0.39			0.46			0.69
EMNI	7.84	6.80	27.39	15.03	67.19	49.15	1.20
SASP	90.21	93.00	72.41	83.82	31.67	50.54	98.11
SAPU	1.57						
VAVI				0.23		0.31	
LICHENS							
CESP				0.23			

Table 29. Conversion of percent relative density to estimated percent dry weight using regression equations derived from hand-compounded mixtures (Table 22).

Species	y=a+bx	M-4-71 Muskox pellets Dec. 1971 % RD	M-4-71 Muskox pellets Dec. 1971 % dry weight	54371 Caribou rumen June 1969 % RD	54371 Caribou rumen June 1969 % dry weight	2-69 Caribou rumen Dec. 1969 % RD	2-69 Caribou rumen Dec. 1969 % dry weight
GRASSLIKE							
CAAO	3.290+ .655x	1.53	4.3	.69	3.2	2.28	4.7
CABI	8.004+ .724x	1.31	9.0				
ERSP	9.887+ .616x	3.36	12.0	82.58	60.7	3.48	12.0
HIAL	3.761+ .883x	1.09	4.7				
FESP	4.474+ .819x	2.44	6.5				
ARLA	4.002+1.115x	.22	4.2				
FORBS & SHRUBS							
ARAR	8.281+ .629x	12.11	15.9				
ARRU	4.383+ .792x	.22	4.6				
DROC	4.383+ .792x	.22	4.6				
SASP	5.391+1.087x	1.75	7.3				
MOSSES							
MOSI	6.751+ .240x	13.86	7.9	.69	6.7	.57	6.7
MOSS	6.751+ .240x	23.10	10.6	10.79	9.3	2.88	7.4
MOSA	3.920+ .290x	21.30	10.1	1.05	4.2	1.14	4.3
MOSB	.865+ .838x	1.74	2.3	.35	1.0		
LICHENS							
CESP	1.580+2.022x	4.30	10.3			.57	1.6
CLSP	2.082+ .774x	6.75	7.3	1.39	3.2	46.14	37.8
LICB	4.574+ .342x	.22	4.6				
PEAP	4.574+ .342x	.44	4.7	1.76	4.6	23.34	12.6
LICA	5.708+ .765x	4.06	8.8			18.46	19.8
TOTALS		100.00	139.7	99.30	92.9	98.8	106.9

Trial number three was not conducted in the cow as it was necessary to modify the size of the nylon bags, making them narrower and longer (≃ 3 x 7 cm), due to the small size of the fistula opening.

The reindeer were placed on a diet of 67 percent (dry weight) lichens (mostly *Cladonia arbuscula, C. rangiferina* and to a lesser extent other *Cladonias* and *Cetraria islandica*), 8 percent *Carex aquatilis* and 25 percent Brome hay from the University experiment station. The feed was ground in a hammer mill and then thoroughly mixed to insure its complete consumption by the reindeer.

A mixture of several of the species used in the trials was used as a control and all dry matter disappearance rates were adjusted to the average digestibility of this Standard Reindeer Forage (SRF) by each reindeer (Table 30). Therefore any change in digestibility of the SRF was assumed to represent a change in digestibility by the reindeer and all plant species in that trial were adjusted accordingly. This provides a method for comparison of plant species used in different trials and in different digesters.

The SRF was composed of the following:

Lichens - 40%	
Cetraria islandica	10%
Cladonia arbuscula	10%
Stereocaulon alpinum	20%
Grass - 20%	
Festuca altaica	20%
Shrub - 10%	
Salix pulchra	10%
Sedges - 25%	
Eriophorum vaginatum	15%
Carex aquatilis	10%
Moss - 5%	
Sphagnum magellanicum	5%

Stained samples of lichens and Brome hay and individual samples of *Stereocaulon alpinum* and *Carex lyngbyaei* were fed to the reindeer. Rumen and fecal pellet samples were collected to determine rate of passage and to evaluate the microhistological technique for reindeer and caribou diet studies. These samples are presently being analyzed and will be reported in next year's progress report.

All plant samples were collected in September, 1972 near Nome, mostly at Cabin Rock No. 2 area (Hemming and Pegau, 1970) except three lichens collected by Dr. Hansen on the Kenai sheep study area and a grass from Colorado and one from Oklahoma. Table 31 lists the plants and parts that were used.

The same plant species were run in both reindeer trials 1 and 2. In subsequent trials, a plant sample was used in only one reindeer to facilitate examining as many species as possible within the period that the reindeer could be used. Steve Person conducted *in vitro* trials using rumen liquor from the two reindeer with most of the same plant samples for comparison.

Table 30. Mean percent *in vivo* dry matter disappearance in reindeer.

Species	Sex	Trial	Means and standard deviation: Unadjusted percent	Adjusted percent	St. Dev.
Standard Reindeer Forage	M	1	55.5	52.4	1.81
" " "	F	1	43.0	44.4	2.48
" " "	M	2	50.1	52.4	1.19
" " "	F	2	45.4	44.4	3.04
" " "	M	3[a]	48.2	52.4	2.12
" " "	M	4	48.2	52.4	.37
" " "	F	4	36.1	44.4	.90
" " "	M	5	54.5	52.4	2.33
" " "	F	5	45.5	44.4	.63
" " "	M	6	57.9	52.4	4.70
" " "	F	6	51.9	44.4	1.60
Purina Cattle Starter #1 - 1971	M	2	71.1	68.8-	1.25
" " " - 1971	F	2	69.8	68.8-	.22
Feed Mixture	M	1[b]	46.2	43.1-	5.11
" "	F	1[b]	28.7	30.1-	1.78
" "	M	2	56.0	58.3-	2.91
" "	F	2	42.4	41.4-	2.96
" "	M	6	61.5	56.0-	4.59
" "	F	6	47.1	39.6-	.95
Feed Components					
Lichens	M	2	47.1	49.4-	3.15
Lichens	F	2	36.7	35.7-	7.10
Carex aquatilis	M	2	45.7	48.0-	1.81
" "	F	2	47.3	46.3-	4.35
Brome hay	M	2[a]	59.7	62.0-	.16
" "	F	2	60.2	59.2-	3.14
Mosses					
Hylocomium splendens	M	3	5.8	10.0-	2.35
Polytrichum juniperinum	M	4	13.1	17.3-	.42
Sphagnum magellanicum	F	5	+ 3.2		1.65
Lichens					
Cladonia alpestris - Nome	F	4	39.1	47.4-	1.64
C. alpestris - Kenai	F	4	31.7	40.0-	2.25
C. arbuscula	M	1	73.2	70.1-	2.88
" "	F	1	28.3	29.7-	4.86
C. arb.-rang. - 1971	M	2	54.7	57.0-	5.17
" " "	F	2	46.0	45.0-	1.25
C. uncialis	F	5	33.0	31.9-	2.50

Table 30. (cont'd.)

Species	Sex	Trial	Means and standard deviation Unadjusted percent	Adjusted percent	St. Dev.
C. rangiferina					
First stage of growth only	M	5	58.1	56.0-	2.14
Entire podetia	M	5	45.4	43.3-	2.50
Decadent portions only	M	5	22.8	20.7-	.63
Live portions only:					
from Beltz	M	5	47.7	45.6-	6.81
from Snake	M	5	44.0	41.9-	4.67
from Cabin Rock #1	M	5	60.9	58.8-	5.27
from Cabin Rock #2	M	5[a]	46.9	44.8-	3.82
Cetraria islandica	F	5	57.6	56.5-	2.47
" " from 1971	F	2	61.4	60.4-	2.49
" " " "	M	2	83.1	85.4-	6.15
C. nivalis - Nome	F	4	30.7	39.0-	.95
" " - Kenai	F	4	38.1	46.4-	1.28
C. cucullata	M	3	89.1	93.3-	3.43
Alectoria nigricans	F	5	88.6	87.5-	4.14
Thamnolia vermicularis	M	4	70.2	74.4-	7.18
Stereocaulon alpinum	M	1	55.9	52.8-	5.99
" "	F	1	26.3	27.7-	2.78
S. rivulorum - Kenai	F	4	32.8	41.1-	5.31
Peltigera aphthosa	M	1	50.7	47.6-	2.08
" "	F	1	47.6	49.0-	1.53
Lobaria linita	M	4	45.9	50.1-	1.13
Sedges					
Carex aquatilis					
live leaves	M	6	63.2	57.7-	2.20
dead leaves	M	6	37.7	32.2-	1.40
culms	M	6	42.3	36.8-	1.49
bases	M	6	31.6	26.1-	3.15
inflorescences	M	6	51.4	45.9-	3.11
C. lyngbyaei					
live leaves	F	6	60.3	52.8-	2.60
dead leaves	F	6	51.9	44.4-	3.72
culms	F	6	56.7	49.2-	3.85
inflorescences	F	6	51.1	43.6-	2.21
C. bigelowii	M	3	32.5	36.7-	.83
Eriophorum vaginatum	M	1	32.0	28.9-	1.05
" "	F	1	29.9	31.3-	1.33
E. angustifolium	M	4	35.0	39.2-	3.75
Grasses					
Festuca altaica	M	3[a]	43.0	47.2	2.54

Table 30. (cont'd.)

Species	Sex	Trial	Unadjusted percent	Adjusted percent	St. Dev.
		Means and standard deviation			
Hierochloe alpina	M	4	63.1	67.3-	7.78
Calamagrostis canadensis	M	4	35.8	40.0-	1.28
Bluestem	M	3	46.3	50.5-	5.18
Bluegrama	M	3	56.9	61.1-	4.44
Shrubs					
Salix pulchra	M	1	68.0	64.9-	.46
" "	F	1	64.8	66.2-	.80
Betula nana	M	3	56.6	60.8-	1.95
Vaccinium vitis-idaea	F	4[a]	47.7	56.0-	1.34
Dryas octopetala	M	4	53.7	57.9-	2.46
Ledum decumbens	F	5	44.5	43.4-	4.19
Loiseleuria procumbens	F	5	54.4	53.3-	1.25

[a] = two replicates only
[b] = same as fed to reindeer, not ground as rest of samples.

Table 31. Plant species and parts used for dry matter digestion trials in reindeer, collected September 1972, near Nome unless otherwise noted.

Species	Habitat	Parts Used
<u>Lichens</u>		
Cladonia alpestris - Nome	Dwarf shrub-lichen	living podetium
" " - Kenai		" "
C. arbuscula	Dwarf shrub-lichen	" "
C. rangiferina	" " "	living podetium except as otherwise noted
C. uncialis	" " "	" "
Cetraria islandica	" " "	Entire thallus
C. nivalis - Nome	Alpine dryas	" "
" " - Kenai		" "
C. culcullata	Alpine dryas	" "
Alectoria nigricans	" "	" " and branches
Thamnolia vermicularis	" "	" "
Stereocaulon alpinum	Exposed gravel beds	Pseudopodentia and cephalodia
S. rivulorim - Kenai		" "
Peltigera aphthosa	Dwarf shrub-lichen	living lobes
Lobaria linita	" " "	" "
<u>Mosses</u>		
Hylocomium splendens	" " "	almost entirely gametophytes
Polytrichum juniperinum	" " "	" " "
Sphagnum magellanicum	Wet bog	" " "
<u>Sedges</u>		
Carex aquatilis	Periphery of ponds	as noted; mature but still mostly green
C. lyngbyaei	" "	as noted; mature - no green material

Table 31. (cont'd.)

Species	Habitat	Parts Used
C. bigelowii	Dwarf shrub-lichen	culms, spikes and mostly leaves mature with some green material
Eriophorum vaginatum	Sedge tussock	culms, spikes and mostly leaves mature but still mostly green
E. angustifolium	Sedge meadow	culms, spikes and mostly leaves mature - no green material
<u>Grasses</u>		
Festuca altaica	Dwarf shrub-lichen	culms, spikes and mostly leaves mature - no green material
Hierochloe alpina	" " "	" " " "
Calamagrostis canadensis	" " "	" " " "
Bluestem	Osage, Oklahoma	Summer 1969 - culms, spikes and mostly leaves
Bluegrama	Nunn, Colorado	June, 1969 - culms, spikes and mostly leaves
Brome hay	Cultivated fields	Green bales
<u>Shrubs</u>		
Salix pulchra	Willow stands	mature leaves - some green material
Betula nana	Dwarf shrub-lichen	mature leaves - no green material
Vaccinium vitis-idaea	" " "	green leaves and attached stems
Ledum decumbens	" " "	" " " " "
Loiseleuria procumbens	Alpine dryas	" " " " "
Dryas octopetala	" "	" " " " "

Every feed mixture was weighed each day and provided in excess to what the reindeer would eat. The weight of the uneaten portion was subtracted from that fed the previous day to determine daily consumption. The feed contained 35 percent moisture; supplemental water was also provided. Live weight of the bull during the trials was 268 pounds and the cow weighed 218 pounds. The bull consumed 2.80 pounds of dry weight feed per 100 pounds live weight per day. The cow consumed 2.68 pounds dry weight of feed per 100 pounds live weight per day. Although both reindeer were on the same diet there were highly significant differences in their digestibility of the control, SRF (Table 32). There were also differences between trials. The bull had a higher rate of digestion of the SRF in all trials. In all of the paired comparisons (except in trials with Brome hay and *Carex aquatilis* used in the feed, where the cow was slightly higher) (Table 33), the bull exhibited a greater degree of digestion. Trial 2 was primarily a test of the two reindeers' digestion of the feed and its components. Based on these results, the bull's greater digestion of the feed was due primarily to the lichens in the feed.

By taking the percent digestion of the components of the feed the probable digestion of the feed can be modeled as follows:

Feed Composition		Male Digestion	Probable Digestion	Female Digestion	Probable Digestion
Lichens	66.3	47.1	31.2	36.7	24.3
Carex aquatilis	8.7	45.8	4.0	47.3	4.1
Brome hay	25.0	59.7	14.9	60.2	15.1
Calculated digestion of feed			50.1		43.5
Actual digestion of feed			56.0		42.4

It is interesting to note that the bull not only ate more than the cow but was also able to digest the feed to a greater extent. Both animals digested the Brome hay to a greater extent than either the sedge or lichens. This is very likely due to a higher nitrogen content of the green Brome compared to the cured sedge and the lichens which have very low nitrogen contents.

Another check of the determined digestibility rates can be provided by breaking down the Standard Reindeer Forage into its components and determining the digestion of the components by each reindeer. Since not all species in the SRF were run in both reindeer, estimates have to be made based on their performance with similar samples.

1) The *Cetraria islandica* used in the SRF was only run in the cow; however another sample of *C. islandica* was used in both reindeer and the bull digested it at 85 percent (Table 30). The cow was able to digest the 1971 *C. islandica* sample 4 percentage points more than the sample used in the SRF so 4 was subtracted from 84 to give an estimate of 81 percent for the bull.

2) *Festuca altaica* was run only in the bull. Brome hay is the only grass that was digested by both reindeer; its digestion was

Table 32. Analysis of variance of unadjusted dry matter digestion to Standard Reindeer Forage.

Trial #	Bull	Cow	Σ
1	53.6	44.3	
	57.2	40.1	
	55.7	44.5	
	166.5	128.9	295.4
2	49.6	47.9	
	49.1	42.0	
	51.4	46.2	
	150.1	136.1	286.2
4	47.9	36.1	
	48.0	37.0	
	48.6	35.2	
	144.5	108.3	252.8
5	56.6	45.3	
	54.9	45.0	
	52.0	46.2	
	163.5	136.5	300.0
6	52.9	53.7	
	62.2	50.8	
	58.7	51.1	
	173.8	155.6	329.4
Σ	798.4	665.4	1463.8

Source of variation	df	SS	MS	F
Subgroups	9	1170.36	130.04	
Sex	1	589.63	589.63	114.49***
Trials	4	506.95	126.74	24.61***
Sex x trial interaction	4	73.78	18.45	3.58*
Within subgroups (Error)	20	102.98	5.15	

* p>.05
***p>.001

Table 33. Digestion comparisons of paired samples in the two reindeer.

	Male		Female			
	unadjusted mean	St. Dev.	unadjusted mean	St. Dev.	$\bar{Y}M - \bar{Y}F$	t
SRF - trial 1	55.5	1.81	43.0	2.48	12.5	3.971*
SRF - trial 2	50.1	1.19	45.4	3.04	4.7	1.320 NS
SRF - trial 4	48.2	.37	36.1	.90	12.1	38.050***
SRF - trial 5	54.5	2.33	45.5	.63	9.0	4.656*
SRF - trial 6	57.9	4.70	51.9	1.60	6.0	.731 NS
Purina Cattle Starter	71.1	1.25	69.9	.22	1.2	2.308 NS
Feed mixture - trial 1[a]	46.2	5.11	28.7	1.78	17.5	1.789 NS
Feed mixture - trial 2	56.0	2.91	42.4	2.96	13.6	2.372 NS
Feed mixture - trial 6	61.5	4.59	47.1	.95	14.4	1.960 NS
Lichens in feed	47.1	3.15	36.7	7.10	10.3	.531 NS
Cladonia arbuscula	73.2	2.88	28.3	4.86	45.0	4.209*
C. arbuscula & *C. rangiferina* mixture from 1971	54.7	5.17	46.0	1.25	8.7	.926 NS
Cetraria islandica -- 1971	83.1	2.49	61.4	6.15	21.7	1.827 NS
Stereocaulon alpinum	55.9	5.99	26.3	2.78	29.6	2.980*
Peltigera aphthosa	50.7	2.08	47.6	1.53	3.1	1.417 NS
Carex aquatilis in feed	45.8	1.81	47.3	4.35	-1.5	-.207 NS
Eriophorum vaginatum	32.0	1.05	29.9	1.33	2.1	4.386*
Brome hay in feed	59.7	.16	60.2	3.14	-.5	-.151 NS
Salix pulchra	68.0	.46	64.8	.80	3.23	11.333***

[a] = material as feed to the reindeer, not ground to 1 mm
NS = nonsignificant
* = p>.05
*** = p>.001

almost identical, so the same rate of digestion of *Festuca altaica* was used in both reindeer.

3) The sample of live leaves of *Carex aquatilis* was used in the SRF and it was run only in the bull. An estimate for the cow is provided from their digestion of *C. aquatilis* in the feed. The cow digested it about 2 percentage points greater than the bull, so 2 points were added to the 58 percent which the bull digested the live leaves for the cow.

4) It is assumed that the bull was unable to digest the moss *Sphagnum magellanicum* as was the case with the cow.

The breakdown of the digestion of the Standard Reindeer Forage is then calculated as follows:

Species	% Composition	% Digestion	Male	Female Digestion	Female %
Cetraria islandica	10	81*	8.1	57	5.7
Cladonia arbuscula	10	70	7.0	30	3.0
Stereocaulon alpinum	20	53	10.6	28	5.6
Festuca altaica	20	47	9.4	47*	9.4
Eriophorum vaginatum	15	37	5.6	29	4.4
Carex aquatilis	10	58	5.8	60*	6.0
Salix pulchra	10	65	6.5	66	6.6
Sphagnum magellanicum	5	0*	0.0	0	0.0
			53.0%		40.7

* = Estimate

Overall digestibility of SRF by the bull during the six trials was 54.4 percent which compares very well with the calculated 53.0 percent. In the cow it was 44.4 percent, compared to a calculated 40.7 percent.

There was slightly more variability in some of the samples this year (Table 30) than last year (Pegau and Bos, 1972). This year, more bags per trial were suspended in the rumen (21 to 27 compared to the 18 of last year). A section of flexible plastic tubing was used this year instead of a rigid plexiglass block, and the tubing was longer than the block (approximately 25 cm compared to 15 cm). The use of the longer flexible tubing made it easier to get the bags into and out of the rumen. There would, however, be a greater chance that the bags could be in a different strata of the rumen which might account for some of the greater variability. This should be minimized, however, by the normal churning of the rumen contents.

The greater digestibility of most plants by the bull is not so apparent in the t-test (Table 33), because of the variances. The differences between means, however, are usually quite large, especially in the lichens and in the feed. Additional repetitions would be required to obtain greater statistical differences.

Since published digestion rates in reindeer are very limited, priority was given to ascertaining digestion rates for more species thereby sacrificing precision for quantity. The bull had a much higher rate of digestion of the lichens, except for the foliose lichen *Peltigera aphthosa* which he digested only slightly more. This was especially true with *Cladonia arbuscula* which he digested at 73.2 percent compared to only 28.3 percent in the cow.

Standard Reindeer Forage

The bull digested the SRF significantly greater than the cow in all trials. As seen in the breakdown of the digestion components of the SRF, this increased digestibility is due primarily to the lichens, particularly *Cladonia arbuscula* and *Stereocaulon alpinum*. There were significant differences between trials (Table 32), with a general trend (with exceptions, of course) of lowering digestibility from trial 1 to 3 and then with an upswing to trial 6. The reindeer may not have been completely adjusted to their diet, environment or handling. By adjusting all means to the control, SRF, these effects were minimized.

Lichens

The adjusted dry matter digestibility of lichens ranged from 27.7 percent for *Stereocaulon alpinum* by the cow to 93.3 percent for *Cetraria cucullata* by the bull. The differences in digestibility of the same species by the two reindeer were more marked in the lichens than any other group of plants. The bull had a much higher rate of digestibility except with the foliose lichen *Peltigera aphthosa*. The cow did, however, digest *Alectoria nigricans* to a very high degree (87.5%). The means are ranked and compared using a Student-Newman-Kuells test in Table 34. The *Cetrarias* except *C. nivalis* normally were highly digestible as were *Alectoria nigricans* and *Thamnolia vermicularis*. It is worthy of note that some of the less palatable lichens such as the latter two are so much more digestible than the more palatable *Cladonias*.

Two lichen samples used in the digestion trials last year (*Cetraria islandica* and a mixture of *Cladonia arbuscula* and *C. rangiferina*) were also used in the digestion trials this year. The digestibility of both samples was lower this year than in the reindeer last year.

Cladonia rangiferina samples from the four habitats, and of the three different growth stages, were digested in the bull in trial 5. The digestibility of the three growth stages differed significantly. The digestibility of the decadent podetia only, was the lowest of all the samples (20.7%). The sample of the entire podetia comprised of both living and decadent material had an intermediate digestibility (43.3%). Digestibility was highest, 56.0 percent, in the sample of young podetia. The digestibility rates of the samples collected from three habitats, Snake, Cabin Rock 2, and Beltz were similar, 41.9, 44.8, and 45.6 percent, respectively, but the sample from Cabin Rock 1 was significantly higher (58.8%). This was the highest of all samples of *C. rangiferina* tested, including the sample of young podetia. Cabin Rock 1 is on the top of a

Table 34. Ranked mean digestibility of all lichens tested.

Species	Digester Sex	Mean %	Species	Digester Sex	Mean %
Stereocaulon alpinum^{a}	F	27.7	*Peltigera aphthosa*^{def}	M	47.6
Cladonia arbuscula^{a}	F	29.7	" " ^{def}	F	49.0
Cladonia uncialis^{ab}	F	31.9	Lichens in feed^{def}	M	49.4
Lichens in feed^{abc}	F	35.7	*Lobaria linita*^{def}	M	50.1
Cetraria nivalis-Nome^{abcd}	F	39.0	*Stereocaulon alpinum*^{efg}	M	52.8
Cladonia alpestris-Kenai^{bcd}	F	40.0	*Cetraria islandica*^{fg}	F	56.5
Stereocaulon rivulorum^{bcd}	F	41.1	*Cladonia arb.-rang.*-1971^{fg}	M	57.0
Cladonia rangiferina-CR2^{cde}	M	44.8	*Cetraria islandica*-1971^{g}	F	60.4
Cladonia arb.-rang.-1971^{cde}	F	45.0	*Cladonia arbuscula*^{h}	M	70.1
Cetraria nivalis-Kenai^{def}	F	46.4	*Thamnolia vermicularis*^{h}	M	74.4
Cladonia alpestris-Nome^{def}	F	47.4	*Cetraria islandica*-1971^{i}	M	85.4
			Alectoria nigricans^{i}	F	87.5
			Cetraria cucullata^{i}	M	93.3

Species followed by a common superscript are not significantly different ($P<.05$)

windswept ridge and most of the growth was small, probably due to the severity of the climate and also heavier grazing use.

Mosses

Mosses, quite simply, are very poor reindeer forage. *Sphagnum magellanicum* was the only forage tested that was totally indigestible. The three moss species used had the lowest digestibility rates of all the forages used.

Sedges

Most of the sedges tested had a moderate digestibility. As seen in Table 35, the *Carex* spp. usually had a higher digestibility rate than the *Eriophorum* spp. All of the sedge samples were mature and cured with exception that some of the live leaves of *C. aquatilis* still had some chlorophyll.

Samples of different parts of *C. aquatilis* and of *C. lyngbyaei* were digested in trial 6 (Table 36). The differences between each part of *C. aquatilis* were significant, but in *C. lyngbyaei* only the digestibility of the live leaves was significantly different from the dead leaves and seed heads.

Grasses

The mean digestibilities are compared in Table 37. All grass samples from Nome were mature and cured. The bluegrama, bluestem, and Brome hay were collected in the summer and were green. The grasses were usually more digestible than the sedges. The coarser grasses, *Calamagrostis canadensis* and *Festuca altaica*, were the least digestible.

Shrubs

Interestingly, the evergreen shrubs had lower digestibility rates than the leaves of deciduous shrubs (Table 38). There was very little green material in the leaves of the deciduous shrubs.

The residues from the digested samples have been sent out for analysis of cell walls, fiber, lignin, nitrogen and gross energy. Further discussion of the digestion trials will be deferred until not only the dry matter digestibilities can be compared but the digestibilities of the various components can be compared simultaneously.

RECOMMENDATIONS

Transects of the Kaksu Lake exclosure should be reexamined in 1977. The exclosure should be checked periodically as all of the posts are in frozen ground and may tend to heave when the ground thaws.

Rumen and fecal pellets collected while the reindeer were on a controlled diet should be examined by the microhistological technique to test the accuracy of the results.

Table 35. Ranked mean digestibility of sedges.

Species	Digester Sex	Mean %
Eriophorum vaginatum[a]	M	28.9
Eriophorum vaginatum[a]	F	31.3
Carex bigelowii[b]	M	36.7
Eriophorum angustifolium[b]	M	39.2
Carex aquatilis in feed[c]	F	46.3
Carex aquatilis in feed[c]	M	48.0
C. lyngbyaei - live leaves	F	52.8
C. aquatilis - live leaves	M	57.7

Species followed by a common superscript are not significantly different ($P<.05$).

Table 36. Mean digestibility of different parts of *Carex aquatilis* and *C. lyngbyaei*.

Part	*C. aquatilis*	*C. lyngbyaei*
Live leaves	57.7	52.8[a]
Inflorescences	45.9	43.6[b]
Culms	36.8	49.2[ab]
Dead leaves	32.2	44.4[b]
Bases	26.1	not tested

Values followed by a common superscript are not significantly different ($P<.05$).

Table 37. Ranked mean digestibility of grasses.

Species	Digester Sex	Mean %
Calamagrostis canadensis[a]	M	40.0
Festuca altaica[ab]	M	47.2
Bluestem[b]	M	50.5
Brome hay[c]	F	59.2
Bluegrama[c]	M	61.1
Brome hay[c]	M	62.0
Hierochloe alpina[c]	M	67.3

Species followed by a common superscript are not significantly different ($P<.05$).

Table 38. Ranked mean digestibility of shrubs.

Species	Digester Sex	Mean %
Ledum decumbens	F	43.4
Loiseleuria procumbens[a]	F	53.3
Vaccinium vitis-idaea[ab]	F	56.0
Dryas octopetala[b]	M	57.9
Betula nana[b]	M	60.8
Salix pulchra[c]	M	64.9
Salix pulchra[c]	F	66.2

Species followed by a common superscript are not significantly different ($P<.05$).

Residues from the digestion trials should be analyzed for nitrogen, cell walls, lignin, fiber and energy and compared with the pre-digested samples to determine their digestibility.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Gregory N. Bos

Project Nos.: W-17-4 & W-17-5

Project Title: Big Game Investigations

Job No.: 3.8R

Job Title: Computerized Population Models for Use in Projected Caribou Management Plans

Period Covered: January 1, 1972 to December 31, 1972

SUMMARY

No work was accomplished during this reporting period aside from review of past studies and of the literature. Results of initial testing and application of computerized models developed by other investigators will be reported in a subsequent report.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

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Project Nos.: W-17-4 & W-17-5 Project Title: Big Game Investigations

Job No.: 3.9R Job Title: Caribou Disease Studies

Period Covered: July 1, 1971 to December 31, 1972

SUMMARY

The retained-placenta condition was observed for the first time in the Porcupine caribou herd. An instance of lightning-caused mortality to caribou was investigated and documented and a manuscript entitled "Electrocution of a caribou herd caused by lightning in Central Alaska" was submitted for publication.

BACKGROUND

Relatively little work has been done on the diseases and parasites of the Porcupine caribou (*Rangifer tarandus*) herd which calves in Alaska and winters in Canada. In response to a request by the Canadian Wildlife Service, a joint project on this herd was initiated. The Porcupine herd is one of the major wildlife resources in eastern Alaska and western Canadian Arctic where much of the oil development is taking place. Accordingly, information pertaining to factors which are potential sources of population decline is of particular importance.

FINDINGS

The field work attempted during the report period met with only limited success. No effort had ever been made to closely survey the Porcupine caribou herd for the retained placenta condition via helicopter. A combination of severe weather, delayed caribou movements and mechanical problems greatly interfered with our attempts to make a daily survey, each of five days, during the presumed peak of calving. We were able to operate effectively only on the afternoon of the fourth day. At that time we collected and necropsied two animals displaying the condition. Neither showed antibody titers for rangiferine brucellosis. Attempts to isolate infectious agents from selected tissues were also not successful. This is our first exact knowledge that this reproductive problem of as yet unknown etiology, actually occurs in the Porcupine herd. However, we have no idea of the prevalence of the condition.

In mid-July, 1972 we were notified of a major dieoff of caribou in the Delta herd. Subsequent investigations led to the conclusion that 53 animals had been struck by lightning and killed during early summer 1972. A manuscript entitled "Electrocution of a caribou herd caused by lightning in Central Alaska" has been submitted for publication in the Journal of Wildlife Diseases. Authors are Dr. Glenn E. Shaw, Geophysical Institute, University of Alaska and Kenneth A. Neiland.

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