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INTERIOR SHEEP STUDIES

by
Wayne Heimer

and

DALL SHEEP DISEASES AND PARASITES

by
Kenneth A. Neiland

Volume II
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-8, Jobs 6.9R, 6.10R, 6.11R and 6.12R

and

Volume XVI
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-8, Job 6.6R

(Printed September 1976)

JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Wayne E. Heimer		
Project No.:	W-17-7		
Job No.:	6.9R	Job Title:	Dynamics of Selected Sheep Populations
Job No.:	6.10R	Job Title:	Assessment of Sheep Populations Occupying Designated Wintering Areas
Job No.:	6.11R	Job Title:	Seasonal Availability of Dall Sheep Range
Job No.:	6.12R	Job Title:	Dall Sheep Condition and Nutritional Profile
Period Covered:	July 1, 1975 through June 30, 1976		

SUMMARY

Sheep populations in the Dry Creek area have declined by about 20 percent since 1970. This decline may be associated with formerly high predator densities, but recent evidence indicates that insufficient production is the proximal cause. Reproductive frequency is low and lactation frequently lasts until lambs are yearlings. This, in turn, has resulted in ewes having lambs only in alternate years at best. Densities of sheep on seasonal ranges are high in these populations, and efforts are underway to determine relationships between range size and quality and sheep populations. Limited data from the Sheep Creek area suggest that a different population-range relationship may exist there.

CONTENTS

BACKGROUND

Previous studies by the Alaska Department of Fish and Game (Heimer and Smith 1975) have shown striking differences in Dall sheep (*Ovis dalli*) ram horn growth in populations along the Alaska Range east of Mount McKinley National Park. The results of these studies were considered by the authors to support the "Quality Hypothesis" of Geist (1971). In part, this hypothesis states that differences in population quality exist among sheep populations and that populations of higher quality are characterized by individuals with more rapid horn growth and larger horns at any given age than are individuals from low quality populations. The studies of Heimer and Smith (1975) also indicated that Dall sheep population quality (as interpreted from ram horn growth and size) is inversely related to population density.

Heimer and Smith (1975) divided the Alaska Range east of Mount McKinley National Park into three areas for purposes of investigating "quality" based on ram horn growth characteristics. These areas, from McKinley Park to the east, are: ARE I, from the Nenana River eastward to the Delta River; ARE II, from the Delta River eastward to the Johnson River and ARE III, from the Johnson River eastward to the Tok-Slana Road. In the quality ranking of Heimer and Smith (1975) ARE I was of very low quality, ARE II was of average quality and ARE III was of very high quality. For these reasons it was decided to pursue a comparative study of Dall sheep ecology in ARE I and ARE III to determine whether different management approaches are necessary in areas of vastly differing sheep quality.

The quality hypothesis of Geist (1971) predicts that the population dynamics of high and low quality populations will be different. His hypothesis specifically states that high quality populations will be characterized by individuals with higher reproductive capability and higher survival to yearling age, more rapid body growth and generally shorter life expectancy than individuals in low quality populations. Past observations have supported this hypothesis by indicating higher reproductive rates and yearling recruitment in high quality populations (Heimer 1975). It is not known, however, whether high quality populations in Alaska are increasing in size as a result of high reproductive rates and lamb survival or whether the postulated higher adult mortality balances the greater numbers of sheep produced. To determine if this occurs in high quality and low quality sheep populations the population dynamics for the high quality (ARE III) population will be investigated and compared with those of the low quality (ARE I) population.

The suggestion of Heimer and Smith (1975) that population quality is inversely related to population density in Dall sheep raises the possibilities that range quality and/or food availability may be major determinants of population quality. Consequently, the relationship of Dall sheep to their seasonal ranges will be investigated by determining sheep density and forage quality on winter range. Nichols (1974) suggested that Dall sheep winter range was limited by snow depth and hardness. This may result in different winter range carrying capacities from year to year. The number of sheep on winter ranges in the Alaska Range is thought to be fairly consistent from year to year. The number of Dall sheep on specific winter ranges in the high quality (ARE III) and low quality (ARE I) populations will be determined. Also, availability of winter range will be determined and densities of sheep will be calculated. These measurements will then be correlated with survival, range quality and sheep condition to clarify management alternatives.

OBJECTIVES

To determine the composition and productivity of sample sheep populations in ARE I and ARE III.

To determine the numbers of sheep wintering on specific areas in ARE I and ARE III.

To determine the availability of winter range to sheep wintering in ARE I and ARE III.

To determine the quality of forage and seasonal body composition of sheep in ARE I and ARE III.

PROCEDURES

Dynamics of selected sheep populations

Mineral lick observations, in which sheep using the mineral lick on Dry Creek were classified as to sex and age, have been carried out since 1968. These data were summarized by Heimer (1975). In 1972 continuous observations were made for 24 hours per day from 19 May through 5 July.

All sheep entering the lick during this period were classified with respect to age (lamb, yearling, adult) and sex, and the number of sheep attracted to the lick during the period of observation was estimated.

Heimer (1973) reported that during periods of continuous observation marked sheep visited the lick an average of four times per licking season. Consequently, the total number of sheep entering the mineral lick was divided by 4 to estimate the number of sheep attracted to the main mineral lick on Dry Creek. Composition data allowed calculation of lamb production (lambs per 100 ewes) and survival of lambs to yearling age.

Since it was not practical to make continuous observations each year, data gathered in 1972 were used to develop a means of estimating the number of sheep attracted to the mineral lick from 12-hour observation days from 0400 to 1600 hours. The total number of sheep entering the lick between 0400 and 1600 hours during 24-hour observation days between 1 June and 30 June were counted. This total was then divided by the estimated population size during that year (1972) and a correction factor determined. This factor, found to be 2.14, was used to estimate the total population size attracted to the main mineral lick on Dry Creek for the years subsequent to 1972. The calculation was made by dividing the total number of incoming sheep for the month of June by 2.14. I believe this factor is applicable to all years because of the demonstrated high fidelity to the Dry Creek mineral lick (Heimer 1973).

Because events of the mineral lick use cycle are variable (Heimer 1973) lamb production and survival information was selected from data for incoming sheep from 19 June through 30 June to insure representative sampling. Lambing groups have disbanded and sex and age classes are more randomly mixed during late June than during other periods of the licking season.

In 1975 observations began on 6 June and were made from 0400 to 1600 hours through 19 June. On 20 June high water prevented observers from reaching the lick. Observations were then made from 1200 to 1600 on 22 June, from 0530 to 1130 on 23 June, from 0400 to 1100 on 24 June and from 1100 to 1600 on 25 June. From 26 through 30 June observations were made from 0400 through 1600. Mineral lick observations at Sheep Creek and the Tok Glacier were carried out from 4-6 July and from 10-17 July, respectively. In 1976 the Dry Creek mineral lick was observed from 19-28 June between 0430 and 1100 hours.

An aerial census of the Dry Creek study area, using a Helio Courier 250, was conducted between 28 July and 2 August 1975. Total counting time was 15 hours and conditions for observation were ideal, with calm air, bright days and a high overcast.

Field facilities capable of supporting winter work in the Dry Creek and Sheep Creek study areas were constructed during 1975.

<u>Assessment of sheep populations occupying designated wintering areas</u>

The aerial census noted above was used to determine the size of the wintering population of Dall sheep on the Dry Creek study area. Seasonal movements of these sheep are well known (Heimer 1973), which permitted an estimate of the winter population size from a summer census. No work was accomplished on this job in the Tok Management Area.

Seasonal availability of Dall sheep range

The extent of winter range in the Dry Creek study area was estimated by making late winter surveys by helicopter to determine areas sheep used during the winter. Feeding sites, tracks and presence of sheep indicated winter range use.

Dall sheep condition and nutritional profile

Four Dall ewes were collected from Dry Creek in late October and five in late May, utilizing standard hunting techniques. Rumen samples were collected to determine botanical composition and rumen fermentation rate. Standard body weights and measurements of all specimens were gathered. Carcasses were then taken to Fairbanks and prepared for determination of whole body composition. The viscera were removed, frozen and stored; each carcass was divided by a median sagittal section. One-half was frozen for later fat and water determination and the other half was boned to determine skeletal weight. Bones were cleaned, boiled and blotted dry before weighing (hooves and horns were not included). Carcass halves and viscera will be analyzed in cooperation with the large animal nutrition group at the University of Alaska for whole body fat, water, dry matter and mineral composition. Analysis of nutritional data was not completed in this segment.

FINDINGS

Dynamics of selected sheep populations

Lamb production, survival and total number of sheep using the Dry Creek mineral lick suggest that sheep populations in the Dry Creek area are declining (Table 1, Fig. 1). The total population estimate for 1970 was reconstructed (see below), figures for 1972-1975 are estimates based on mineral lick use, and the figure for 1975 is a total count resulting from an aerial survey. A 1970 count and the 1975 survey were comparable (Table 2). Tony Smith, a veteran sheep observer, directed both flights. The 1970 survey was flown in a PA-18-150 Super Cub, and the counting time for the areas surveyed was about 11 hours. The 1975 survey was flown in a Helio Courier 250. An outstanding survey pilot, Bill Lentsch, flew and T. Smith and W. Heimer were observers. Counting time for the areas surveyed was 15 hours. The 1975 flight covered all territory surveyed in 1970 plus other areas.

The 1975 census included the upper Wood River and the upper drainages of the West Fork of the Little Delta River (Fig. 2). The total count for 1975 was 1,232 sheep, and 24 percent of this total was seen in these 2 areas (Table 2). The upper Wood River and the upper West Fork of the Little Delta River were not surveyed in 1970, and the total count was

Table 1. Productivity, survival and estimated number of Dall sheep influenced by the Dry Creek mineral lick from 1970 through 1975.

Year	Lambs per 100 ewes	Yearlings per 100 ewes	% of last yrs. lambs surviving	Estimated population
1968*	63	13	--	--
1969*	64	31	49	--
1970*	55	31	48	1500
1971*	50	51	93	--
1972	15	16	32	1473
1973	38	11	73	1315
1974	28	25	66	1270
1975	28	23	82	1150
1976	36	16	57	--

*Data gathered at mineral lick using observation schedules not described in procedures (See Heimer 1974).

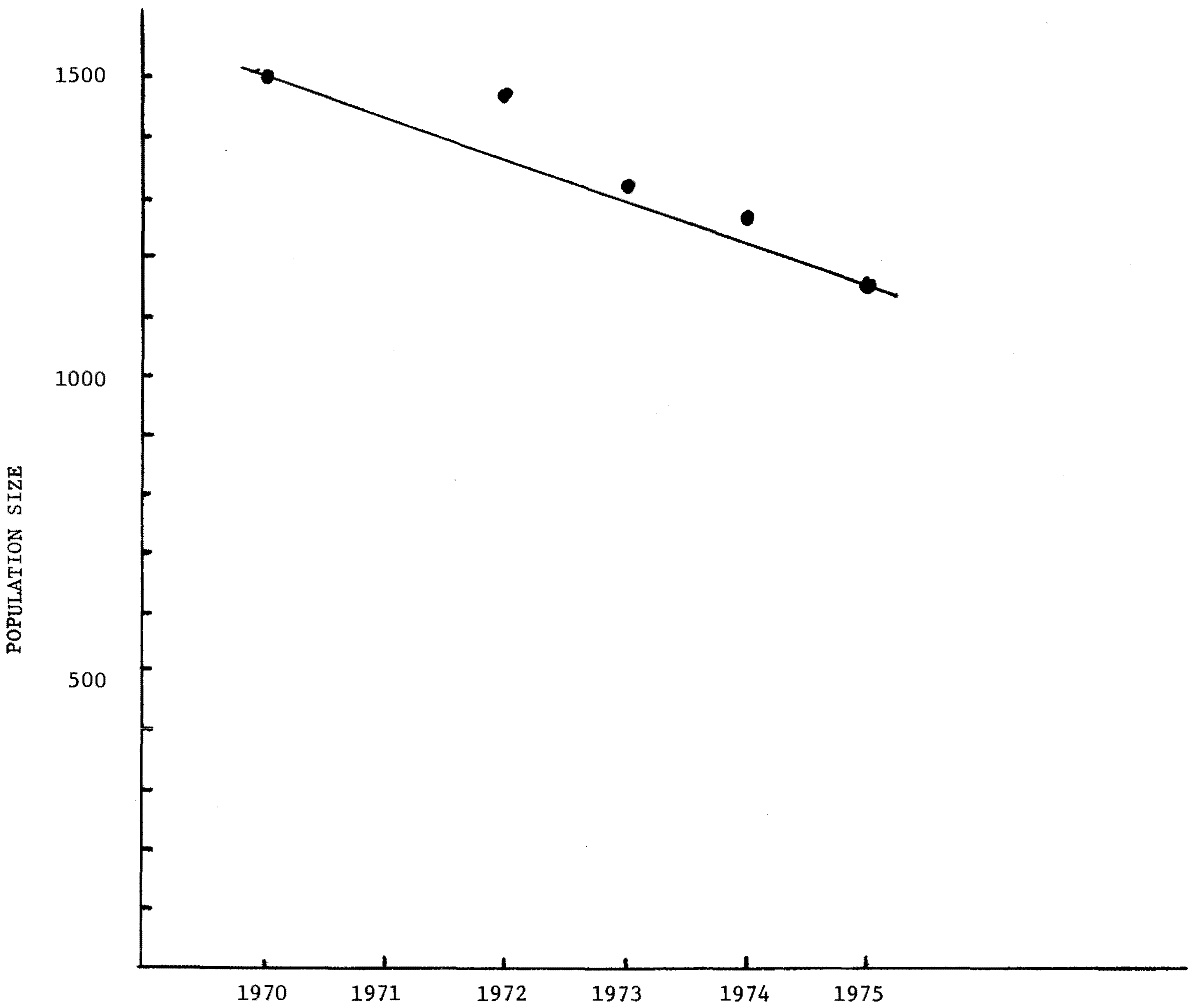

Figure 1. Estimated population size of Dall sheep in Dry Creek study area.

Table 2. Sheep counts from 1970 and 1975 from Dry Creek, Alaska Range.

Area surveyed	1970 count	Time	1975 count	Time
1	315 sheep	*	250 sheep	3 hrs
2	485 sheep	*	347 sheep	2 hrs 25 min
3	332 sheep	*	341 sheep	3 hrs
4	not surveyed		133 sheep	2 hrs 46 min
5	not surveyed	out	161 sheep	3 hrs 10 min

* specific time per area not available; total time was 11 hours.

Fig. 2. Areas surveyed for Dall sheep in Dry Creek study area, 1975.

1,132 sheep. If the relative distribution of sheep was unchanged from 1970 to 1975 (both surveys took place in early August) the expected number of countable sheep, had these areas been surveyed in 1970, can be calculated (1132 = [1.000.24]X or 0.76 X, where X = the expected number of sheep) to be about 1,500 sheep. This was the method of reconstructing the estimated population in 1970.

The population estimate for 1972 (Heimer 1973) was slightly less than 1,500 sheep. Mineral lick estimates of population numbers declined after 1972 (Table 1). The 1975 population estimate was 1,130 animals counted during the aerial survey, and no estimate has yet been made for 1976. No correction was made for sheep not seen during aerial counts. For purposes of establishing trends this comparison is adequate. Estimated population sizes in 1972, 1973 and 1974 were close to the line connecting the population counts of 1970 and 1975 (Fig. 1). The estimate for 1972 was 7 percent greater, that of 1973 was 2 percent greater and that of 1974 was 4 percent greater than the interpolated line. If these estimates are accurate they may indicate that carefully conducted aerial counts in well-known terrain may allow highly motivated, experienced observers to see from 93 to 98 percent of the sheep present.

Approximately 2 more hours were spent in areas 1, 2 and 3 (Table 2) during 1970 than in 1975. This may represent an approximately equal effort during these 2 years because of greater aircraft efficiency with the Helio Courier (much time is saved in climbing) and the presence of two observers in the aircraft. If any difference in counting efficiency existed, I believe the 1975 survey was more complete than the 1970 survey. In any case, the decreasing numbers of sheep counted and estimated over the last 5 years indicate that the Dry Creek sheep populations are presently declining. The magnitude of this decline has been about 17 to 20 percent since 1970, although some populations appear to be declining more than others. The decline appears to be linear, and may be due to several factors.

Survival to yearling age has averaged about 65 percent since 1970, and lamb production has been lower than before 1971 (Table 1). This lower production may be due to different sampling schemes. Heimer (1973, 1975) showed that the number of lambs per 100 ewes seen at the mineral lick was variable with time and should be estimated from a long observation period in late June. If a short period is used to estimate initial production and survival of sheep at mineral licks biased data can result because ewes with lambs form aggregations (particularly immediately following lambing) which generally do not include lone ewes. Short observation periods may have been responsible for high initial production figures seen in the late 1960's and early 1970's, since the main objective in those years was not to observe sheep, but to trap and tag. Observation schedules during those years were reported by Heimer (1973).

Two other possible causes for the decline may be insufficient production to compensate for "normal" mortality or an unusually high adult mortality. The latter possibility might result from predator pressure. Murie (1944) concluded that wolves (*Canis lupus*) mainly utilized the old and weak (diseased or young) classes of Dall sheep in McKinley Park. This conclusion was based on the assumption that sheep with skulls having evidence of lump jaw were diseased and consequently weak.

Using this criterion, 24 percent of the sheep in Murie's death assemblage were defined as old and diseased. A more correct interpretation could have been made if the incidence of lump jaw in the living population were known. Over the last 5 years 32 percent of the living animals taken from the Dry Creek populations have shown the lump jaw condition (Nielsen pers. comm.). Hence, a more correct interpretation of Murie's death assemblage data may be that the old and young were represented as they may have occurred in the population, and that disease and weakness were not factors. In Dry Creek it is unlikely that predators have been selecting for lambs because survival to yearling age has been high. If wolves are a factor in the decline of sheep populations, predation is probably directed at adults as well as lambs.

Predators have been abundant in the area during the recent past, but removal of about 40 wolves from the area by trapping and aerial shooting has left a minimum of 10 wolves in the area as of spring 1976 (Buchholtz pers. comm.). No evidence of Dall sheep was seen in stomachs of wolves killed in the area. Prior to this reduction in wolf numbers I estimated that wolves killed a maximum of 5 percent of the sheep population per year. This estimate was based on observations of wolves taking sheep, time spent observing and area viewable by observers. Here it is interesting to note the mean annual decline over the last 5 years has been 3 to 5 percent. If wolf predation were the major cause of this decline, elimination of most wolves should lessen or stop the decline.

While predators have certainly contributed to the decline, evidence indicates that the decline is due primarily to production below that necessary to compensate for "normal" adult mortality. Over the last 5 years 15 ewes have been collected after the rut when a fetus would be visible (Heimer 1973). Of these 15 ewes, 7 have been pregnant. Of the eight nonpregnant ewes, six were lactating strongly and two showed evidence of having resorbed a fetus. The low pregnancy rate in this admittedly small sample of ewes, frequent observations of lambs nursing in April, typically low initial production and observations of yearlings nursing at the mineral lick, indicate that the rate of reproduction may be lowered to enhance survival of lambs through their first winter.

This hypothesis is supported by mineral lick observations of collared ewes from 1972 through 1976. During periods of mineral lick observations all collared ewes were carefully observed to determine whether they were leading a lamb (Appendix I). The criterion for defining a ewe with a lamb was the observation of suckling. This criterion is admittedly strict, but was necessary because some observers were unable to accurately recognize a ewe-lamb pair by behavioral displays and contact patterns. In all years except 1975 the number of collared ewes with lambs determined with this strict criterion was similar to that determined for the population by traditional counting methods at the mineral lick (Heimer 1975 and Appendix I). Hence, use of this strict criterion did not underestimate lamb production. Because of inexperienced observers in 1975, poor agreement in lamb:ewe ratios resulted. Consequently data from 1975 were disregarded. This reduced the sample size from 101 to 99 ewes of breeding age, the total number of observations from 247 to 206, and the total number of ewes seen in two successive years from 127 to 86. These deletions did not alter the results significantly. All instances of successive annual sightings of each individual ewe were tabulated (Table 3). In 6 percent of the paired observations the ewes were seen to lead a lamb in 2 successive years, in 50 percent of the observations ewes were seen to lead a lamb every other year, and in 44 percent of the observations ewes were never observed leading lambs.

Table 3. Successive annual resightings of collared ewes with and without lambs for 86 paired observations at Dry Creek mineral lick.

Total successive sightings	Total With-With	Total Without-With	Total With-Without	Total Without-Without
86	5 (6%)	22 (26%)	21 (24%)	38 (44%)

The low percentage of observations of ewes reproducing in successive years, the low pregnancy rate, and the high incidence of extended lactation by nonpregnant ewes raises the possibility that when a ewe leads lambs in 2 successive years early summer mortality may have occurred during the first year. Certainly, annual production of lambs in Dry Creek is the exception rather than the rule. The most common pattern is biennial reproduction. That is, a lamb is born in June, the ewe does not breed during the rut of the following December or she may breed and then resorb the fetus, the lamb is weaned at about 1 year of age, and the ewe regains her decreased energy reserves before breeding again in December. The mean reproductive interval in the paired observations calculates to be 39 lambs per 172 ewe-years or 0.23 lambs per ewe year. This is one lamb every 4.4 years. If this were indeed the average reproductive rate the maximum number of lambs would be 23 per 100 ewes. This figure is, of course, unreasonably low since the observed mean is about 30 lambs per 100 ewes.

Some theoretical calculations may be based on this alternate year reproductive strategy. The average initial production observed over the last 5 years in Dry Creek was 30 lambs per 100 ewes. Hence, the percentage of ewes capable of reproduction in December (those without a lamb in summer) was 70 percent. If all of these animals breed and produce a lamb, the mean survival rate following parturition must be 30 percent of the ewes with lambs divided by 70 percent of the ewes that breed, or 43 percent. This represents 57 percent mortality. This is the maximum possible parturition-associated mortality since it assumes that all breeding ewes will carry their lambs to delivery. However, severe winters as well as other factors probably result in some *in utero* mortality.

In the collected ewes, fetal death occurred in 2 of 8 or in 25 percent of the ewes taken near term. If this figure is incorporated into the above calculation, 70 percent of the ewes breed each year, minus 25 percent of this number, or 53 percent of the ewes carry lambs to term. This calculates to a parturition-associated mortality of 43 percent.

Throughout the last 5 years bad weather was recorded during the lambing seasons of 1972, 1973, 1974 and 1975. Here, bad weather is defined as a 24- to 36-hour period of snow, freezing rain, rain accompanied by wind or subfreezing temperatures. The effects of this weather on parturition mortality are unknown for Dall sheep but are highly significant in domestic sheep neonate death (Watson et al. 1968). In winter 1975-76 snow was minimal, temperatures were generally mild and no unusually adverse weather was measured during the 1976 lambing season. Still the production was well below the theoretical maximum of 72 lambs per 100 ewes (100%-28% lambs in 1975). One case of fetal resorption was documented from five ewes collected in late May. If fetal death in winter of 1975-76 is assumed to have been 20 percent, parturition-associated mortality would have been 38 percent (given 72% of the ewes capable of breeding; 20% fetal death; 36% of the ewes seen with lambs in 1976). This may represent parturition-associated mortality under favorable conditions. Lambing mortality associated with parturition when unfavorable conditions occur may range between 40 and 60 percent. However, fetal death under extremely difficult winter conditions may be much higher, as during the severe winter and spring of 1971 when lamb production reached a record low of 15 lambs per 100 ewes and survival to yearling age was only 32 percent (Table 1).

In summary, data indicate that rates of initial lamb production in the Dry Creek populations may be sacrificed to enhance survival of lambs. This is accomplished by extended lactation which leads to breeding in alternate years. Weather probably influences initial production by affecting *in utero* and neonate mortality. The decline in numbers of sheep in Dry Creek is thought to be due to relatively low reproductive rates, rather than high yearling and adult mortality. Parasitic fauna and burdens have been described (Nielsen and Neiland 1974), but their actual effects on condition and reproduction of Dall sheep are unknown.

The reason for low reproductive rates and the decline of Dry Creek sheep populations is unclear. The suspected cause is insufficient energy availability in winter. Comparative range studies, high sheep population densities, slow horn growth rates for rams, small body size of ewes and subjective determinations of range utilization made in numerous field trips suggest that range conditions are relatively poor. Further work will be needed to test this hypothesis.

Data gathered on productivity and survival at the Sheep Creek mineral lick are given in Table 4.

Table 4. Rate of reproduction and survival and sample size of Dall sheep lambs using the Sheep Creek mineral lick from 1974 through 1975.

Year	Lambs per 100 ewes	Yearlings per 100 ewes	Sample size
1974	56	21	116
1975	43	37	273

A lick at the head of the Tok River was also observed from 0400 through 1200 hours from 10-17 July. The observed lamb:ewe ratio was 36 lambs per 100 ewes, the yearling:ewe ratio was 29 yearlings per 100 ewes and the total number of sheep classified was 331. This mineral lick is in an area of high population quality in the general vicinity of the Sheep Creek study area. Combining data from these two observation sites for 1975 provides a good approximation of production and survival for this high quality area (Heimer and Smith 1975).

Only limited data are now available for the high quality sheep populations which use the Sheep Creek mineral lick. These data indicate that rates of production may be higher than in Dry Creek. Survival to yearling age was also higher than in Dry Creek for 1974. Unfortunately, enumeration of the sheep in these populations must await marking and movement studies, and is not yet possible. Consequently, it is not known whether these populations are expanding, stable or declining.

Assessment of sheep populations occupying designated wintering areas

A knowledge of sheep movement patterns in the Dry Creek study area (Heimer 1973) made it possible to use a summer census to determine the number of animals which would winter in some areas. One such area, lying between Dry Creek and the West Fork of the Little Delta River, contained at least 350 sheep in 1975 (Table 2). The sheep of this area spend winter and summer in the same general location (Heimer 1973).

The total area available to Dall sheep between the West Fork of the Little Delta River and Dry Creek is about 69 km^2 (Fig. 3). This results in a density of about five Dall sheep per map square kilometer.

Determination of the population density of sheep in the Sheep Creek area awaits marking and movement studies.

Seasonal availability of Dall sheep range

The density of sheep on summer range in the Dry Creek study area was a minimum of five Dall sheep per map square kilometer. This figure assumes that all areas within the study unit are suitable sheep habitat, which is an oversimplification. However, even within the constraints of using map square kilometers as an index of sheep habitat the extent of habitat reduction by winter snow can be estimated. A helicopter survey during the last week of April indicated that only about 32 map km^2 of this area were available to sheep. This resulted in a minimum winter range density of 350 sheep in 32 map km^2 or 11 Dall sheep per map square kilometer (Fig. 3).

Dall sheep condition and nutritional profile

Measurements, body weights and weights of component parts of Dall ewes collected in fall 1975 and spring 1976 from the Dry Creek study area are given in Table 5. Complete analyses of carcass data and rumen fermentation rates have not been completed.

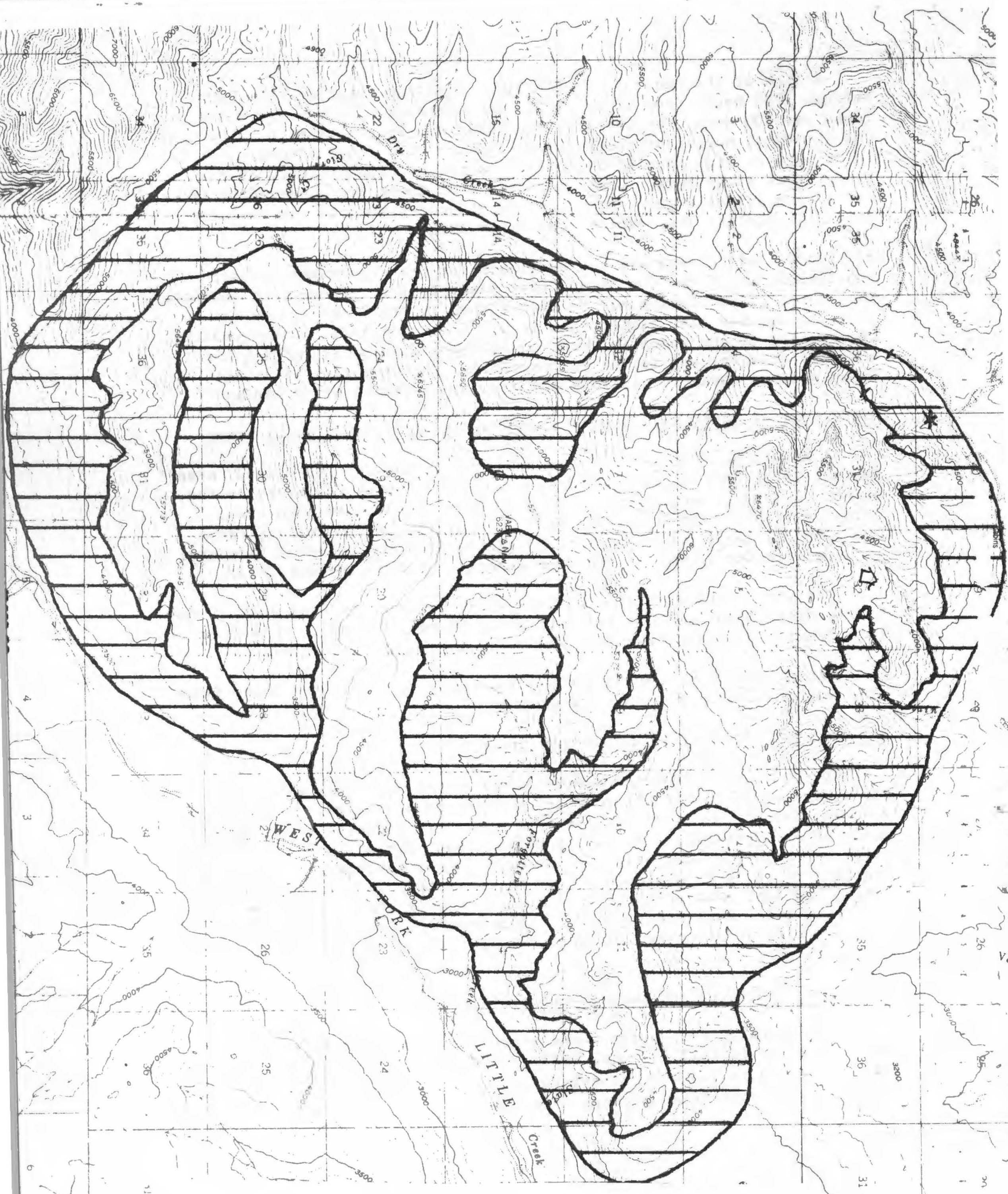

Fig. 3. Areas Available to Dall sheep in summer (enclosed) and late winter (hatched area) in Dry Creek study area.

Table 5. Weights and measurements of Dall ewes collected in October 1975 and May 1976.

Accession Number	Date Collected	Age	Body Weight (kg)	Half Carcass Weight (kg)	Rumen and Contents Weight (kg)	Weight of Viscera without Rumen (kg)	Weight of bones (kg)	Length (cm)	Height (cm)	Pregnant	Lactating
4331	10-28-75	11	62.27	--	8.18	--	4.42	142	84	No	No
4332	10-28-75	7	55.91	20.00	7.73	8.18	4.10	139	73	No	No
4333	10-29-75	8	61.36	20.45	9.55	9.55	4.40	131	72.5	No	No
4334	10-30-75	9	53.18	18.36	10.50	8.64	4.69	141	76	No	Yes*
4384	5-25-76	6	51.36	14.55	6.36	7.73	n.a.	--	--	Yes	No
4385	5-25-76	10	42.27	13.40	7.73	5.91	n.a.	--	--	No	Yes
4386	5-25-76	5	42.27	14.09	8.18	5.00	n.a.	137	81	No	Yes
4387	5-25-76	5	42.27	14.55	lost	4.77	n.a.	136	81	No	Yes
4388	5-25-76	7	41.36	13.18	8.64	5.45	n.a.	128	82	No	Yes

Lost = lost when helicopter crew mishandled carcass

n.a. = not available at this time

* = ewe accompanied by lamb

Sheep from the late October collection had a mean age of 8.6 years and a mean whole body weight of 58.2 kg. Animals have deposited their maximum amount of fat in preparation for winter at this time, and these figures are considered to be yearly maximum weights.

Sheep collected in late May had a mean age of 6.6 years and mean body weight for nonpregnant ewes was 42.04 kg. Heimer (1973) has shown that the weight gain between 6 and 8.5 years of age for ewes may average about 1.5 kg. If this correction is made the body weights from both collections should be comparable. Calculations indicated that over the winter of 1975-76 nonpregnant, lactating ewes in the Dry Creek study area lost 25 percent of their peak fall weight. This was in a winter of light snow and moderate temperatures. Complete analyses of carcass data and rumen function are not yet completed.

No animals were collected from Sheep Creek during this segment.

MANAGEMENT RECOMMENDATIONS

The finding of low reproductive frequency in a low quality, high density and declining sheep population in the Dry Creek study area indicates that many nonproductive ewes may occur on the range. Range quality and quantity may be insufficient to maintain annual reproduction among most ewes, but this has not been substantiated. However, if this hypothesis is correct a reduction in population size may be beneficial, resulting in increased reproductive frequency. However, range recovery and increased reproductive frequency would probably be gradual. I recommend that range relationships be clearly defined before any population manipulation is attempted.

LITERATURE CITED

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

Heimer, W. 1973. Dall sheep movements and mineral lick use. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-17-2 through W-17-5, Job 6.1R.

__________. 1975. Study area selection in the Tok Management Area. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-17-7, Job 6.8R.

__________ and A. C. Smith. 1975. Dall ram horn growth and population quality and their significance to Dall sheep management in Alaska. Alaska Department Fish & Game. Tech. Bull. 5. 41pp.

Murie, A. 1944. The Wolves of Mt. McKinley. U. S. Nat. Park Serv., Fauna Series No. 5. 283pp.

Nichols, L. 1974. Sheep report. Fed. Aid in Wildl. Rest. Annu. Proj. Prog. Rep. Vol. XV.

Nielsen, C. and K. A. Neiland. 1974. Sheep Disease Report. Fed. Aid in Wildl. Rest. Annu. Proj. Prog. Rep. Vol. XIV.

Watson, R. H., G. Alexander, I. A. Cumming, J. W. MacDonald, J. W. McLaughlin, D. J. Rizzoli and D. Williams. 1968. Reduction of perinatal loss of lambs in winter in western Victoria by lambing in sheltered individual pens. Aust. Soc. for Animal Production. 7:243-249.

PREPARED BY:

Wayne E. Heimer
Game Biologist

APPROVED BY:

Director, Division of Game

SUBMITTED BY:

John Coady
Regional Research Coordinator

Donald E McKnight
Research Chief, Division of Game

Appendix I. Marked ewe reproductive history, "Yes" or "No" indicates presence of lamb in any given year, (-) indicates ewe not seen.

Ear Tag	1972	1973	1974	1975	1976
501	--	yes	--	--	--
502	--	--	--	no	--
511	--	--	no	no	--
513	no	--	--	--	--
514	no	no	--	--	--
518	no	no	--	--	--
522	no	no	no	no	no
525	no	no	no	no	--
527	--	no	--	--	yes
528	no	--	--	--	--
531	yes	no	no	--	--
532	no	no	yes	no	yes
533	yes	no	no	--	--
534	no	no	no	--	--
535	no	yes	yes	--	--
536	--	no	--	no	--
538	no	no	yes	--	--
542	yes	yes	no	--	--
544	no	no	--	no	no
545	--	no	--	no	--
546	--	no	no	--	--
553	--	no	yes	--	--

Ear Tag	1972	1973	1974	1975	1976
557	no	--	--	--	--
559	yes	no	yes	--	--
561	yes	yes	--	no	no
563	--	yes	--	--	--
567	--	no	--	--	--
569	--	no	--	no	no
572	no	--	--	--	--
573	--	no	--	--	--
574	--	no	yes	--	--
578	--	no	--	--	--
584	--	no	--	--	--
586	--	no	--	--	--
589	no	yes	no	no	yes
611	--	no	no	no	yes
612	--	yes	--	--	--
614	--	no	no	--	--
616	--	yes	--	--	--
620	--	--	yes	--	--
623	--	no	no	--	--
625	no	no	no	no	--
627	no	no	--	--	--
629	--	no	--	no	--
637	no	yes	--	--	--
638	no	no	--	--	--
639	--	--	--	no	--
644	--	no	--	no	--

Ear Tag	1972	1973	1974	1975	1976
646	yes	--	--	--	--
649	--	no	no	no	--
650	--	yes	no	no	--
664	--	yes	--	no	no
665	--	no	--	--	--
666	--	no	--	no	--
667	--	yes	no	no	no
668	no	no	no	--	--
671	no	no	no	no	--
674	--	no	no	--	--
679	no	no	--	no	--
685	--	yes	no	no	yes
687	--	no	no	--	--
689	no	yes	--	no	--
690	no	no	--	no	--
693	--	yes	no	no	no
695	no	no	yes	no	no
699	yes	yes	no	no	--
703	--	yes	no	no	yes
706	--	no	no	no	no
707	--	no	no	no	--
708	no	yes	no	--	--
710	--	no	--	no	--
712	--	--	no	yes	yes
713	no	yes	no	--	--

Ear Tag	1972	1973	1974	1975	1976
714	yes	--	--	--	--
716	--	no	--	--	--
727	no	yes	no	--	no
729	--	yes	--	no	yes
730	--	no	yes	yes	no
731	--	--	no	no	no
738	no	no	--	--	--
743	no	yes	--	--	--
744	--	no	yes	no	yes
746	no	no	--	yes	--
748	--	yes	--	--	--
749	no	--	--	--	--
750	yes	no	no	no	--

Collar #	1972	1973	1974	1975	1976
5	no	yes	no	no	--
7	no	yes	no	no	--
22	yes	no	no	--	--
32	no	no	--	--	--
50	no	yes	--	--	--
56	no	--	--	--	--
57	no	--	--	--	--
63	--	no	--	--	--
72	no	--	--	--	--
96	no	--	--	--	--
194	no	yes	no	--	--

Collar #	1972	1973	1974	1975	1976
202	no	--	--	--	--
G-2	no	yes	no	--	--
G-4	yes	yes	no	--	--
G-6	yes	no	--	--	--
Marked sample lamb: ewe ratio	22:100	35:100	21:100	7:100	41:100
			$\bar{x}$ = 26:100		
Population lamb:ewe ratio	15:100	38:100	28:100	28:100	36:100
			$\bar{x}$ = 29:100		

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Kenneth A. Neiland

Project No.: W-17-8 Project Title: Big Game Investigations

Job No.: 6.6R Job Title: Dall Sheep Diseases and Parasites

Period Covered: July 1, 1975 to June 30, 1976

SUMMARY

Four species of trichostrongylid nematodes are reported from two specimens of *Ovis nivicola* (yearling and lamb) collected 200 kilometers northeast of Magadan, Eastern Siberia, U.S.S.R.

The presence of well-developed lesions caused by adults and myriads of larvae of an apparently unnamed species of lungworm, *Protostrongylus* sp., in the 40-60 day old lamb strongly supports the concept of "prenatal infection" as suggested by others for infections of *P. stilesi* in the North American bighorn.

BACKGROUND

Over the past several years we have engaged in a detailed survey of the diseases and parasites of Dall sheep (*Ovis dalli*) in Alaska. Our attention has chiefly focused on three potential problem areas: gastro-intestinal nematodes, lungworms and "lumpy jaw." Extensive information on our findings on these conditions in sheep collected on the Kenai Peninsula and at the Dry Creek study area in the Alaska Range have been presented in earlier reports in this series.

During the period covered by this report our activities on sheep disease and parasites took a new turn. We had the opportunity as the U.S. Coordinator of Subproject A-3 (Diseases and Parasites of Northern Animals) of Area V of the Environmental Protection Treaty with the Soviet government to do some work on a close relative and ecological equivalent of the North American Dall sheep. We spent most of August 1975 in eastern Siberia near Magadan, where we had the opportunity to collect and examine two snow sheep (*Ovis nivicola*). Our observations are reported below.

We have on hand, in frozen storage, the lungs from a number of the Dall sheep collected at the Dry Creek study area. We plan to analyze the lungworm condition in these using a quantitative procedure currently under development. The press of other activities during the past year has not permitted us to complete our technique development. We expect to accomplish this task, and the analysis of stored lungs during the coming year.

FINDINGS

A. Parasites of *Ovis nivicola*

Two snow sheep, a yearling and a lamb, both females, were collected on August 4 and 6, 1975, respectively, at the Basandra Sheep Preserve near Atka, about 200 kilometers northeast of Magadan. Several species of common gastro-intestinal nematodes, and what appears to be an undescribed species of lungworm, were recovered at necropsy from both animals. These are separately considered below.

1. Gastro-intestinal Nematodes

The trichostrongylid nematodes recovered from the abomasa and intestines of the two sheep are shown in Tables 1 and 2.

Two other species of nematodes were encountered in addition to the trichostrongylids. Seven individuals of a species of whipworm, *Trichuris* sp. (?), were found in the caecum of the yearling. This animal also harbored five specimens of the pinworm, *Skrjabinema* sp. (?). We did not recover these species of nematodes from the lamb.

Table 1. Some abomasal parasites[1] of the snow sheep, *Ovis nivicola*.

Parasite Species	Host	Number[2]
Marshallagia marshalli	yearling	42
	lamb	1
Nematodirus oiratianus	yearling	14
	lamb	0
Ostertaigia occidentalis	yearling	23
	lamb	0

1 Two hundred two and three trichostrongylids, respectively, were recovered from the yearling and lamb. Of these, 125 were females.

2 Only males were enumerated to species since only they can be identified with certainty.

Table 2. Some intestinal parasites[1] of the snow sheep, *Ovis nivicola*.

Parasite Species	Host	Number[2]
Marshallagia marshalli	yearling	5
	lamb	0
Nematodirus archari	yearling	3
	lamb	0
N. davtiani	yearling	7
	lamb	0
N. oiratianus	yearling	297
	lamb	13

1 One thousand seventy five and twenty five trichostrongylid nematodes, respectively, were found in the yearling and lamb. Seven hundred sixty three were *Nematodirus* females.

2 Only males were enumerated to species since only they can be identified with certainty.

2. Lungworms

Our observations on the lungworms in our two necropsy specimens are of considerable interest. Both animals had patent infections of a species of *Protostrongylus* that apparently has not been previously named. The yearling had four well developed, typical lungworm lesions packed with numerous adult worms and thousands of characteristic, first-stage larvae. The lamb, which was approximately 40-60 days old, had 8 discrete nodules similarly packed with adults and larvae.

DISCUSSION

All of the trichostrongylids reported above are more or less commonly found in wild sheep, and in some instances in domestic sheep. All have been found in Alaskan Dall sheep. However, while *Nematodirus oiratianus* was the most common form we found in the two *Ovis nivicola* it has been comparatively rare in about 100 *Ovis dalli* that we have examined over the past several years. Whether this apparent difference in the nematode faunas of *O. nivicola* and *O. dalli* would be true of larger samples of sheep collected over prolonged periods of time in both areas is unknown. Many factors can affect the occurrence and abundance of parasitic forms, and our sample of *Ovis nivicola* was obviously limited.

While there is always a certain amount of interest in the discovery of new species of life, the most interesting aspect of the lungworm infections we saw in *Ovis nivicola* involved the fully developed character of the infection in the lamb. That is, fully mature adults and thousands of first-stage larvae, presumably produced by the adults, were present. It has long been thought that species of *Protostrongylus* follow a life cycle in which the first-stage larvae migrate up the bronchioles, are coughed up, swallowed and passed out in the fecal pellets. They next find their way into certain land snails where in 40-60 days they mature into infective larvae. When infected snails are accidentally ingested by sheep, the infective larvae migrate into the peripheral margins of the lungs and mature into fertile adults. The production of thousands of larvae result in the formation of typical nodules of inactivated lung tissue. If the life cycle of the lungworm we found in *Ovis nivicola* follows the above plan and time scale (as does the life cycle of *P. stilesi*, the common lungworm of the North American big horn [*Ovis canadensis*]) we can only conclude that the well developed, patent infection we saw in the lamb was established prenatally, probably following ingestion of infected snails by the ewe. It appears unlikely that enough time had elapsed following the birth of the lamb for well developed, patent lesions to have developed even if the first, post-natal act of the lamb was to eat infected snails.

Others have conjectured with weaker evidence that patent infections can take place prenatally. However, they have only seen first-stage larvae in presumably prenatally infected lambs and in no case known to me have they seen fully developed patent infections of adults and myriads of larvae. No doubt first-stage larvae sometimes "lose their way" and invade fetal tissues in pregnant ewes rather than pass out of the digestive tract of the ewe in fecal pellets. If, as apparently is the case, a 40-60 day sojourn in certain land snails is indispensible for maturation of larvae which can subsequently develop into fertile adults, then prenatal infections of even a few hundred first-stage larvae probably never leads to nodulation which requires thousands of larvae produced by adults *in situ*. We believe we have reported above the first unequivocal evidence of the prenatal initiation of a patent lungworm infection in wild sheep. We do not know whether prenatal, patent lungworm infections have been seen in non-ovids. Prenatal, patent infections of *ascarid* nematodes in dogs are well known.

ACKNOWLEDGMENTS

Dr. Nina Stepanovna Nazarova, Skrjabin Institute of Helminthology, Moscow, assisted us in processing the helminths in the field. Mrs. Carol Nielsen, on the staff of our Fairbanks laboratory, identified the trichostrongylids. Dr. Vytautas Kontrimavichus, Director, Institute for Biological Problems of the North, Magadan, U.S.S.R., and his staff provided the political, logistic, scientific and linguistic support without which this work could never have been accomplished.

PREPARED BY:

Kenneth A. Neiland
Game Biologist

SUBMITTED BY:

John Coady
Regional Research Coordinator

APPROVED BY:

Director, Division of Game

Donald E McKnight
Research Chief, Division of Game