



Fecal nitrogen of ewes on winter range as affected by varying levels of protein intake and by climatic factors

by Robert Jefferson Springer

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Animal Industry at Montana State College

Montana State University

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Abstract:

The investigation reported herein was undertaken to provide experimental data on fecal nitrogen of ewes on winter range as affected by varying levels of protein intake. In addition, the influence of weather conditions on fecal nitrogen was also studied.

Previous work indicated that a factor or factors other than the level of protein intake influenced fecal nitrogen of ewes more than the protein contained in the supplemental feed.

Approximately 1000 ewes were used in this study. They were randomly divided into eight groups, each group being fed a different level of protein during the winter feeding period.

One group depended on range forage only for maintenance. Another group, typical of a small farm flock, was fed at the Port Ellis farm near Bozeman, Montana; these ewes were subjected to environmental and climatic conditions different from the seven groups remaining on the range.

Ewes fed the pellet containing the greater percentage of protein had higher fecal nitrogen values than the ewes fed pellets containing the lower protein percentage. The variation in fecal nitrogen content among the groups remained consistent throughout the sampling period; however, on different sampling dates, all groups tended to be higher or lower apparently because of environmental factors other than supplemental feed.

During the two years of the study, fecal nitrogen tended to fluctuate with changes in temperature. A lower fecal nitrogen content was evident in all groups when the sampling date was preceded by cold weather; when temperatures rose, fecal nitrogen showed a similar upward trend. Fecal nitrogen levels of the various groups were also compared to wind velocities, but no definite trend was noted.

Grass samples were collected from the winter range and the protein content determined. The shrubs and half-shrubs sampled had a considerably higher protein content than did the grasses. Fringed sagewort (*Artemisia frigida*), a half-shrub, had a high protein content, and was highly utilized by the sheep.

Digestion trials were conducted to determine whether or not fecal nitrogen would vary under controlled conditions in a manner similar to that from range ewes fed the same protein supplements.

A grass hay ration was fed during one trial, and during the second trial, the wether lambs were fed supplements in addition to hay. The addition of the supplements increased the digestibility of each ration.

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### ABSTRACT

The investigation reported herein was undertaken to provide experimental data on fecal nitrogen of ewes on winter range as affected by varying levels of protein intake. In addition, the influence of weather conditions on fecal nitrogen was also studied.

Previous work indicated that a factor or factors other than the level of protein intake influenced fecal nitrogen of ewes more than the protein contained in the supplemental feed.

Approximately 1000 ewes were used in this study. They were randomly divided into eight groups, each group being fed a different level of protein during the winter feeding period.

One group depended on range forage only for maintenance. Another group, typical of a small farm flock, was fed at the Fort Ellis farm near Bozeman, Montana; these ewes were subjected to environmental and climatic conditions different from the seven groups remaining on the range.

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## INTRODUCTION

Range sheep production constitutes one of the major enterprises found in our western states. The range used by these sheep comprises a large acreage of the total area of the West. From the native grasses on these ranges, the sheep gather the major portion of their nourishment for lamb and wool production. The nutritive value of these range forage plants, available to the sheep, is often a controversial subject. Variations in rainfall from one area to another, and often local drought conditions within regions, may lower the nutritive value of the forage to a point where the nutrients are not adequate. When these conditions occur, some form of supplement must be added to the diet, particularly during the winter months, to maintain proper nutritional levels.

Research has a major role in leading to a better understanding of range nutrition. Therefore, with the increased need for full production from every acre, research must play a larger part in the management of western range lands and the livestock that graze these ranges.

At this date, little is known about the actual composition of the range sheep's diet. Obviously, it is vital to understand the nutritional aspects of these western ranges in order to maintain a high level of production of range

forage and sheep numbers.

The reasons for this lack of information are various. There are many complexities involved in the collecting of data, such as the high variability of western range vegetation. Mountain and plains conditions intermingle, soil depths are highly divergent, and accumulations of alkali are found in some of the lower areas. One can find highly variable conditions existing side by side because of soil texture, soil structure, chemical composition of soil and available soil moisture. The seasonal variability of plant growth and different environmental conditions bring about a correspondingly variable chemical composition of forage plants. The foraging sheep's diet may change materially from day to day, depending upon many interrelated factors. The preference and amount consumed may vary with soil, site, vegetation, season, wind velocity, temperature, snow cover, supplemental feed, and intensity of grazing.

The nutritional value of winter range supplements can be determined by complete feed analyses or by determining the digestibility of the supplement by means of a metabolism test with experimental animals under controlled environment. The nutritive value of winter range forage used by the grazing sheep, when provided with complimentary supplementation, is difficult to determine. The amount of protein in range

forage that can be utilized in the complete winter ration is a problem that remains to be solved.

Several methods are available for estimating the summer forage consumption by sheep. Although these methods seem adequate, they are tedious and time consuming. For measuring winter forage consumption, these methods are inadequate for the purpose of determining the quantity and the quality of the forage obtained by the sheep. Methods using the conversion of stubble height to weight removed and stem counts can be used for summer grazing, along with methods based on estimation, such as general reconnaissance and the ocular estimate by plot method. A possible direct method that can be used for winter studies on grazing habits is to follow sheep by foot or by horseback and make observations of the particular plant species upon which they are grazing. However, this method takes considerable time, and it is difficult for the observer to keep track of any particular animal or animals in the flock.

It would be advantageous to have a simple, accurate method of measuring the amount of protein obtained by a ewe from winter range. An approach that may provide an answer to this problem is by fecal nitrogen determinants. The reason for feeding supplements is to complement range forage during critical periods in a sheep's reproduction cycle and

during seasons of the year in which the range forage does not supply ample nutrients for optimum production. By determining or finding an accurate method of determining relationships of fecal nitrogen to protein intake, it would be possible to test sheep on the range and determine whether or not the sheep are receiving the desired level of protein and whether or not protein supplementation would be necessary.

There may be a considerable amount of protein obtained by range sheep from shrubs and half-shrubs. A study, conducted on the sheep range leased by the Animal Industry and Range Management Department, near Livingston, Montana, in 1951, indicated that fringed sagewort (Artemisia frigida) showed a high utilization because of its palatability.

According to chemical analyses, fringed sagewort contained considerably larger amounts of protein than did the major species of range forage plants found on this range. This amount of protein in fringed sagewort could be very important in the animal's diet, as the range grasses are lower in protein during the winter months.

Considering the process of selective grazing by sheep, it is likely that, day by day, the nitrogen content of their feed from a single area will decrease, because they are progressively removing the leafiest, nitrogen-rich growth available and leaving the stemmy part of the growth for subsequent

grazing. A move to fresh range will make available feed of higher nitrogen content, and the protein in the feed should thus exhibit a periodicity with movement from camp to camp. If feed-nitrogen bears a direct relationship to fecal nitrogen, the latter should show a similar periodicity, with the time-lag of approximately two days normally assumed for the feed to pass through the intestinal tract. The amount of selective grazing and the time of selective grazing may possibly be determined then by fecal nitrogen studies.

The Montana Agricultural Experiment Station is, at present, conducting a study to determine the supplemental protein requirements of ewes under winter range conditions. The data presented in this thesis were obtained in conjunction with the experiment involving approximately 1000 ewes fed different levels of protein supplements during the winter. When the most economic and efficient level of supplement has been found for range ewes, it may then be possible to set up an optimum protein fecal level which would indicate the nutritional plane at which the sheep should be fed.

REVIEW OF LITERATURE

Folin (1905) first put forth the theory that fecal nitrogen resulted from two different forms of protein catabolism, essentially independent and quite different from each other; a variable one which he called exogenous--dependent on the level of protein consumed, and a constant type, endogenous, which he states was related to body size and other body factors. With the review of work by Borsook and Dubnoff (1943) and significant studies by Schoeheimer (1942), the sharp distinction between endogenous and exogenous nitrogen as set forth by Folin is no longer valid.

Mitchell (1943) states that fecal nitrogen consists of two fractions: nitrogen of dietary origin and nitrogen of body origin. The latter fraction, commonly referred to as the "metabolic nitrogen of the feces", is related to the dry matter consumed for rations of similar roughage content and for intakes of food sufficient in amount to maintain body weight. It is also related, for equal intakes of dry matter, to the indigestible matter contained in the ration.

Because of these facts, in support of which there is ample evidence (Mendel and Fine, 1912; Mitchell, 1924, 1926, 1934; Schneider, 1934, 1935), the true digestibility of nitrogen (protein) is considerably higher than the apparent digestibility, and the latter, for feeds of different kinds,

is positively correlated with the protein content of the feed on the dry basis.

The metabolism of dietary nitrogen serves two general purposes in the animal body according to Mitchell (1943). It maintains the nitrogen integrity of the tissues, replacing the losses of nitrogen incurred in the endogenous catabolism, and it serves as structural material in the formation of new tissues and secretions in growth, reproduction and lactation.

For the chemical determination of protein, the chemist takes advantage of the fact that nitrogen occurs in the different proteins in a fairly constant percentage. The average nitrogen content of the various proteins has been found to be about 16 percent. To determine the percent of crude protein, one analyzes for nitrogen and multiplies the percent nitrogen by 6.25 ( $100 \div 16$ ).

Brody et al. (1934) stated that within close limits basal metabolism, endogenous nitrogen, and neutral sulfur excretion all increase or tend to increase in the same proportion with increasing body weight of mature animals of different species.

The data of Gallup and Briggs (1948) indicates that fecal nitrogen per 100 grams of dry matter intake increases as the protein percentage of the ration is increased. The work of Forbes (1949) exhibits a tendency in the opposite direc-

tion. This difference in behavior may be explained in part by the fact that the previous data have been obtained with hay in which digestible nutrient content varied to a relatively small extent as compared with the variation in digestible nutrients of the fresh bluegrass used by Forbes. According to Mitchell (1926) the greater the concentration of indigestible, non-nitrogenous material in a ration, the greater the fecal excretion of metabolic nitrogen.

Gallup and Briggs (1948) found higher fecal nitrogen values were obtained and that they tended to vary directly with the protein content of the supplemental rations fed. They suggested that, when conditions permit, the feed consumption of grazing animals can be determined by taking advantage of the relationship between fecal nitrogen excretion and dry matter intake.

In a preliminary report at Cambridge University, Stewart (1930) noted changes in the metabolism of sheep on excessive protein diets and recorded these changes by nitrogen balances and weight curves. Using linseed cake, there were no weight increases the first four months; previous experiments had shown opposite results. He states such results as obtained from these trials show the need of careful investigation in the physiology of protein metabolism during high protein feeding.

Smuts (1935) reported the total endogenous nitrogen output of warm-blooded animals varied more nearly with the body surface than with the body weight. The endogenous catabolism of an animal, regardless of species, could be estimated from its basal heat production as accurately as the latter could be estimated from its body surface or body weight. The estimate of endogenous loss of nitrogen was the basic information required to compute the maintenance requirement of protein. It is now generally accepted that the maintenance requirement of nitrogen of an animal can be measured by the total nitrogen excretion in the urine after the endogenous level is attained. On this basis, the endogenous nitrogen excretion of mature sheep was measured (Smuts and Marais 1939) and the results interpreted in relation to the maintenance requirement of protein.

In this study an effort was made to measure the endogenous nitrogen metabolism of young sheep with a view to establishing their maintenance requirement. Smuts working with mature sheep noticed that after the initial sharp drop in urinary nitrogen excretion on the first day, there was a further prominent decrease up to the eighth day. Thereafter, the decrease was more gradual, and such that the endogenous level was not reached until the fourteenth day. Smuts found different results with young sheep; there was the

first characteristic sharp drop in the nitrogen excretion the first day, with a very gradual reduction up to the fifth or sixth day, when in nearly every case the endogenous level is obtained. Thus, there appears to be a distinct difference in the amount of nitrogen stored by the actively growing sheep and the non-growing or mature sheep. Such a difference may be expected on the basis that the growing animal needs, in addition to its maintenance requirements, a substantial portion of the available nitrogen for tissue synthesis, leaving thus a smaller fraction of the total nitrogen intake for reserves.

Continuing the work of Smuts (1935), Ashworth (1935) conducted a study to determine whether lactalbumin produced more reserve protein than corn gluten when both proteins were fed at the same low level to 20 pairs of young rats. It was found that the nature of the protein fed affected but slightly the nitrogenous nitrogen excretion when short experimental periods were used. When the reserve protein supply of the body was reduced to a low level by long periods on nitrogen-free diets, an effect of the nature of the protein fed on nitrogenous nitrogen excretion did appear.

Ewes fed rations low in protein by Klosterman et al. (1950) had lower serum albumins than those fed a liberal or adequate amount of protein. When fed at an equal level of

protein, there was no difference in blood proteins between ewes fed linseed meal and those fed dried skim milk as the protein supplement.

Kennedy and Dinsmore (1909) in their early work on digestibility of range forage found that controlled feeding experiments with native forage plants did not adequately measure the diet under normal range conditions. They found that sheep when fed under controlled conditions did not show the natural selectivity for plants or portion of plants and they frequently did not eat adequate amounts for even a maintenance ration.

Using mature range grasses, McCall (1940) found the addition of supplements, particularly in large amounts, materially increased the digestibility of crude protein and crude fat. The addition of linseed cake to the range grass mixture more than doubled the nitrogen intake over that from range grass mixtures and barley.

Digestion trials conducted during grazing periods by Hobbs et al. (1945) gave some evidence that fecal excretion of nitrogen and ether-soluble material is greater in steers on pasture than in steers in dry lot.

Titus (1927) introduced a technique with steers involving the plotting of the total nitrogen intake as a function of the total nitrogen excretion, with rations of varying

protein content but of constant total food intake.

Blaxter and Mitchell (1947) found that, in the immature ruminant, in which the growth of new tissues is at its highest rate, some 20 percent of the requirement of truly digestible (metabolizable) protein is used in the replacement of the metabolic fecal loss, whereas, at maturity, over 60 percent of the total requirement is determined by this factor.

A procedure was suggested by Gallup and Hobbs (1944) for the analysis of fresh feces which gave results in good agreement with those obtained on ground air-dry samples. This procedure which may prove to have practical value, merits further study under other experimental conditions. A modified procedure using iron as an additive to the ration was suggested by Gallup and Kuhlman (1931). Their results indicated that the silica naturally contained in the feed served as a better index of the digestibility of other substances in the ration than did the iron which had been added for that purpose.

Berger (1903) fed sheep rations consisting of hay alone, hay plus peanut oil, hay plus straw, a fat-free mixed ration, and a mixed ration containing oil. The amount of digestible protein in the fresh and the dried feces was determined by the pepsin-hydrochloric acid method. Berger found that considerably higher values were obtained with the fresh than

with the dried feces. He believed that it was best, therefore, to retain the usual method and use fresh feces for the determination of the nitrogenous material insoluble in pepsin-hydrochloric acid. This is especially important in determining the coefficients of digestibility of a mixed ration.

A number of other workers have explored the possibility of including a known amount of a completely indigestible material in the feed and, by determining its subsequent concentration in the feces, allowing this material to serve as an index of digestibility of that feed. The use of chromic oxide as such an index substance was first proposed by Edin (1918). This method was found satisfactory by Schurch *et al.* (1950, 1952) and also by Crampton and Lloyd (1951). It was concluded by Cook and Harris (1951) that the chromogen method was not suited for determining digestibility of winter range forage because, in some cases, there was considerably less chromogen material recovered in the feces than was actually consumed. A rapid and efficient method of extraction and determination of small amounts of a dye in the feces was tested by Corbin and Forbes (1951). By a comparison of the density obtained with a calibrated density-concentration curve, the amount of dye extracted can be measured.

Patton and Giesecker (1942) report that lignin in forage plants is not only practically unavailable to the ruminant,

but also has an adverse effect on the digestibility of other constituents as well. Hale, Duncan and Huffman (1940) found lignin varied in digestibility from -5.1 to 23.7 percent, but none of the digestion took place in the rumen. Crampton (1940) stated that lignin probably serves no useful dietary function in the animal, since the small amounts absorbed are re-excreted in the urine.

A difference in digestive capacities of cattle and sheep was demonstrated by Forbes (1950). Sheep are apparently more efficient digesters of forage low in protein than are cattle. Digestion coefficients secured from trials by Jordan and Staples (1951) indicated that lambs tend to show greater variation on digestibility trials than do steers.

Catlin (1925) summarized reports on digestibility of various range grasses and other forages from several stations, principally from the Texas Station. He concluded that in general their feeding value is much less than that of alfalfa hay. Watkins (1933) of the New Mexico station conducted digestion experiments with growing steers fed native hay; he found that a positive nitrogen balance is usually accompanied by a daily gain of approximately one-half pound in live weight.

A method used by Cook et al. (1948) to determine digestibility consists of collecting a predetermined number of

plant units before grazing, and a similar number after grazing. Each plant species is sampled both before and after grazing and each sample is weighed and chemically analyzed. The difference in weight and chemical composition between the before-grazing sample and the after-grazing sample serves as a measure of the nutrient content of the ingested forage.

A field method by Cook et al. (1952) for determining the digestibility and metabolizable energy of native forage under range conditions was developed and used on the winter ranges of Utah. The method consisted of grazing wether sheep equipped with fecal bags and urinals in temporary enclosures on pure stands of important desert plants. It was indicated in this study that an accurate appraisal of the nutritive energy furnished by many range forage plants can be assessed only by determining their metabolizable energy values.

According to Armsby (1917), the amount of feed consumed has little effect on its digestibility as long as the kind of feed consumed remains the same and the experimental animals are similar. Schneider (1950) concluded that the practice of applying average digestion co-efficients of that feed is warranted despite the fact that a high within-feed variability in digestibility is very common.

Many possibilities other than the digestibility of the

ration may affect the quantity of the fecal nitrogen that is excreted. Lofgreen et al. (1947) suggest that the quality of protein as fed in the ration may influence the nitrogen retention ability of lambs in the feed lot. The addition of 0.2 percent methionine to a ration containing 10 percent protein with urea furnishing 40 percent of the total nitrogen, significantly increased the nitrogen retained by the lambs on the trial. These same lambs utilized egg protein significantly better than linseed meal protein or that synthesized from urea. McKinney (1951) found some factor or factors other than the level of protein supplementation was the most important in changing the level of fecal protein; significant differences of fecal protein were attributed to sampling dates, and environmental factors operative between dates. Raymond (1948) attributes the rise and fall of fecal nitrogen in his trial to fresh pasture. A move to fresh range will make feed of higher nitrogen available at the beginning of a grazing period.

Lee and Phillips (1948) state the intestinal functions tend to be disturbed by heat; during cold weather, the intestinal tract tends to show no effect or change. Atmospheric temperature and precipitation data for three seasons were recorded by Garrigus and Rusk (1939) but these factors had no effect on the rate of forage consumption by steers.

On this experiment with steers they discovered no relationship between the size of the steer and the relative rate of forage consumption when rate of consumption was measured either in percent of maintenance requirement or in pounds of dry forage per unit of live weight. Because of the limited number of steers in each weight division, however, the data were not considered to be conclusive.

### CONDITIONS OF THE EXPERIMENT

The fecal protein study was a part of the range nutrition experiment involving approximately 1000 ewes on different levels of protein supplement. The ewes were all grade ewes consisting of Columbias, Targhees and Rambouillets varying in age from two to six years. They were typical of the range sheep found on most Montana ranges.

The range land on which the sheep grazed during the winter months is located on the east slope of the Bridger Mountains, west of the Shields River about seven miles north of Livingston, Montana. This range is mostly of the foothill grassland type such as shown in Figure 1. The topography of the area is typical of foothill regions; however, steady winds sweep most of the ridges clean after a snow storm. During the winter of 1951-52, a large amount of snow fell, but some forage was still available. The low areas are covered with snow during most winters; however, the winter of 1952-53 was a mild winter and had only a small amount of snowfall as compared to the previous winter.

During January of 1952, there was snow or a trace of snow recorded each day of the month. The largest amount of snowfall recorded was 11 inches. February had only 21 days of snow or a trace of snow. There was snow or a trace of snow recorded for 27 days in March. In the month of January 1953, there were 21 days of snow or a trace of snow, with



Figure 1. The nutrition band being moved toward camp, the Shields River and the Crazy Mountains are visible in the background. Bluebunch wheatgrass and june grass upon which the sheep were grazing can be observed in the foreground.

February having 24 days showing snow or a trace of snow.

March had only 15 days of snow or a trace of snow. The heaviest snowfall recorded for January, February, and March was 1.2 inches, 6.4 inches and 2.9 inches, respectively.

All ewes were kept in one band during the experimental period except for group 5 which was taken to the Fort Ellis farm after the breeding period. All ewes on the range were separated into the various feeding groups each morning by means of a five and a three-way cutting chute. The cutting and feeding period took approximately one hour and a half and required the time of two men. The ewes of each group had a group number painted on the back with scourable paint; each group had a different color paint brand, and this paint was also daubed on the poll of all ewes in each group to facilitate cutting during snowy weather.

The amount and kind of supplemental pellets fed the ewes during the winter of 1951-52 is given in Table I. The composition of these pellets is shown in Table II. The ewes of Group 0 did not receive supplemental rations during the winter feeding period, except for seven days during the first year the trial was conducted when weather conditions made it a necessity. Groups 1, 2, 3 and 4 received  $1/3$  pound of supplemental pellets containing 10 percent, 20 percent, 30 percent and 40 percent protein, respectively. Group 6 received

TABLE I. SUPPLEMENTAL RATIONS FED EWES ON WINTER RANGE  
(1951-1952)

Group No.	No. Sheep on Experiment	Amount of Supplement	Amount Protein in Pellet	Roughage
		Lbs.	%	
0	70	None	----	Range Forage
1	200	1/3	11.8	Range Forage
2	200	1/3	20.1	Range Forage
3	200	1/3	30.6	Range Forage
4	200	1/3	39.2	Range Forage
5	70	1/3 1/3	20.0 18.9 <sup>1</sup>	Mixed Grass and Alfalfa Hay
6	70	2/3	11.4	Range Forage
7	70	2/3	16.6	Range Forage

<sup>1</sup>A dehydrated alfalfa pellet.

TABLE II. FEED COMPOSITION OF SUPPLEMENTAL CONCENTRATES  
(1951-1952)

Group No.	I	II	III	IV	VI	VII
	%	%	%	%	%	%
Barley	62.8	41.7	20.7	----	64.3	48.5
Wheat	26.5	17.7	8.9	----	27.4	19.7
Cane molasses	6.0	6.0	6.0	6.0	6.0	6.0
Cottonseed meal	----	10.1	20.3	30.3	----	7.3
Linseed meal	----	10.1	20.2	30.3	----	7.3
Soybean oil meal	----	10.2	20.3	30.3	----	7.3
Monosodium phosphate	3.3	2.6	1.9	1.2	1.6	3.0
Limestone <sup>1</sup>	0.0	0.2	0.3	0.5	0.0	0.2
Salt (iodized)	1.0	1.0	1.0	1.0	0.5	0.5
Trace mineral mixture <sup>2</sup>	0.3	0.3	0.3	0.3	0.15	0.15
A-D supplement <sup>3</sup>	0.1	0.1	0.1	0.1	0.05	0.05
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
% Crude Protein	11.8	20.1	30.6	39.2	11.4	16.6

<sup>1</sup>Additional calcium added to equalize calcium content of the four pellets.

<sup>2</sup>"Tra-Min" furnished gratis by Midland-Western, Inc., Madison, Wisconsin. Contains iodine, manganese, copper, cobalt, iron and zinc.

<sup>3</sup>"AD-SEAL-IN" furnished gratis by Dawe's Laboratories, Inc., Chicago, Illinois. Contains 10,000 units vitamin A and 1,000 units vitamin D per gram.

2/3 pound 10 percent supplement or the amount of protein fed Group 2, but the ration for the former contained approximately twice the energy value. Group 7 received 2/3 pound of 15 percent protein pellet or half the amount of protein fed Group 3, but containing twice the energy value of Group 3.

Ewes of Group 5 at Fort Ellis were fed at a rate in excess of the nutritional requirements for range ewes, 1/3 pound of 20 percent protein pellet and 1/3 pound of a dehydrated alfalfa pellet plus all the good quality hay they could consume. The objective was to try to obtain maximum production irrespective of feed costs. This group could be used as a positive control group with those groups on the range. Climatic, forage and feeding conditions at Fort Ellis were different from those on the range. During the latter part of March, because of a hay shortage at Fort Ellis, the ewes were trucked to the Chadbourne Ranch north of Livingston. The ration fed at the Chadbourne Ranch remained the same as that fed at Fort Ellis.

Groups 0 through 7 (except Group 5) grazed on the range during the day. At night, they were bedded near the camp and then were separated each morning into groups to be fed their respective supplemental rations. The ewes of Group 0 passed through the chute and received no supplement. After the sheep were fed the supplemental pellets, they were grouped into one band for grazing.

Baled hay was stored at the winter range camps for emergency feeding during conditions when the sheep were unable to obtain range forage. When the snow cover was too deep for grazing, the hay would be scattered near the camp, and all the groups were fed hay.

The procedure remained much the same for the year 1952-53, except that the amount fed and composition of supplemental pellets were changed in the various groups as shown in Tables III and IV, respectively. Group 0 remained a control group, as during the previous year, and depended only on range forage for their maintenance, receiving no hay during the second year of the experiment. The feed treatment for Group 1, which received the 10 percent pellet the previous year, also remained the same. Group 2 received  $\frac{1}{3}$  pound of dehydrated alfalfa pellets during the entire feeding trial. Group 3 received  $\frac{1}{3}$  pound of a 10 percent protein pellet for the first half of the feeding trial and then  $\frac{2}{3}$  of a pound of 30 percent protein pellets were fed for the last half. Group 4 received  $\frac{2}{3}$  of a pound of 30 percent protein pellet for the first half of the feeding period. This was replaced the last half by  $\frac{1}{3}$  of a pound of 10 percent protein pellet.

The ration for Group 5, the heavily fed group during 1951-52, was changed slightly from  $\frac{1}{3}$  pound of 20 percent pellet plus  $\frac{1}{3}$  pound dehydrated alfalfa pellets plus hay to

TABLE III. SUPPLEMENTAL RATIONS FED RANGE EWES ON WINTER RANGE  
(1952-1953)

Group No.	No. of Sheep on Expt.	Amount Protein Supplement Fed		Amount of Protein in Supplemental Pellet		Roughage
		1st Half Winter	2nd Half Winter	1st Half Winter	2nd Half Winter	
		Lbs.	Lbs.	%	%	
0	125	None	None	None	None	Range Forage
1	125	1/3	1/3	12.5	12.5	Range Forage
2	125	1/3	1/3	18.3 <sup>1</sup>	18.3 <sup>1</sup>	Range Forage
3	125	1/3	2/3	12.5	31.1	Range Forage
4	125	2/3	1/3	31.1	12.5	Range Forage
5	125	2/3	2/3	31.1	31.1	Hay
6	125	2/3	2/3	31.1	31.1	Range Forage
7	125	Depending on weather		Depending on weather		Range Forage

<sup>1</sup>A dehydrated alfalfa pellet.

TABLE IV. FEED COMPOSITION OF SUPPLEMENTAL CONCENTRATES  
(1952-1953)

Pellet No.	1	2
Ingredient:	%	%
Barley	63.4	11.8
Wheat	22.5	-----
Cane molasses	6.0	6.0
Cottonseed meal	-----	20.3
Linseed meal	-----	20.3
Soybean meal	-----	20.4
Dehydrated alfalfa meal	-----	20.0
Monosodium phosphate	4.3	-----
Limestone	2.4	-----
Salt	1.0	1.0
Trace mineral <sup>1</sup>	0.3	0.15
A-D-Seal-In <sup>2</sup>	0.1	0.05
	<u>100.0</u>	<u>100.00</u>
% crude protein	12.5	31.1

<sup>1</sup>"Tra-Min" furnished by Whitmoyer Laboratories.

<sup>2</sup>"AD-SEAL-IN" furnished by Dawes Laboratories, Inc.

a ration of  $\frac{2}{3}$  pound 30 percent protein plus all the hay they could consume. Group 6 was fed the  $\frac{2}{3}$  of a pound of 30 percent protein supplement throughout the entire period. The amount of supplement fed to ewes of Group 7 varied according to wind velocity and temperature. Weather instruments were obtained for the camp site during the year 1952-53 to study climatic factors that might affect certain nutritional factors.

Samples of range forage were collected during the two years of the study and analyzed for protein content.

PROCEDURE

1951-1952

Twenty ewes were selected at random from each of the eight groups receiving the different protein supplements, making a total of 160 ewes. Fecal samples were obtained from each ewe approximately every 14 days, depending on weather conditions. Samples were taken from ewes two years of age or older because the yearlings in the band might have higher or lower protein needs than the mature ewe producing a lamb.

The experimental animals were put on the supplemental feeding trial December 27, 1951. The winter feeding trial was terminated on March 24, 1952. At this time, the ewes were near lambing time, and it was thought unwise to continue running them through the cutting chutes. The sheep were changed from camp number 2 to camp number 3 on February 2, 1952. No fecal samples were obtained for analysis at camp number 1.

After the sheep were removed from the range, a range survey was made; this survey estimated the percent of range forage utilized by the sheep during the winter.

After the ewes had eaten their supplemental rations, the band was then run through the cutting chutes again to cut out those ewes from which fecal samples were to be obtained; these ewes were easily identified by a blue paint mark on their left

shoulders. A small pen was constructed from panels, and the ewes to be tested were driven into this enclosure in groups of 25 to 30. Four persons worked the sheep, two holding the ewes up against the panels and the other two persons collecting the fecal material. It was found that the collections were easier to obtain when two persons obtained samples. The longer the ewes had to remain penned, the harder it was to secure sufficient amounts of fecal material. The fecal sample was obtained by inserting the first two fingers in the rectum and removing 8 to 10 fecal pellets or an equal amount of unpeletted material. Rubber gloves were worn to protect the sheep and for sanitary reasons. After sampling, each ewe was chalked on the nose to prevent a repeat sampling. The fecal material from each ewe was placed in an individually labeled bottle; the ewe's ear tag number and group number was written on the label.

After air-drying for one week, the samples were ground in a Wiley Mill, then chemical analyses were made to determine crude protein (Kjeldahl method) and moisture. A two-gram sample of air-dry fecal material collected from each ewe made up the composite sample for each respective group. Individual samples in Groups 0 and 7 were analyzed separately in order to determine the variation that might occur within groups.

1952-1953

The procedure used in 1952-53 was similar to that used during the previous year. The nutrition band was separated into eight randomized groups of 125 ewes according to age and breed. Fecal samples were collected from 20 randomly selected ewes in each group. These samples were individually bottled and were analyzed for each individual ewe from Group 0 and Group 6. Composite samples were analyzed for fecal nitrogen for all groups including Group 0 and Group 6 at each sampling period and before the beginning of the experiment and after the completion of the supplemental feeding period.

Because significant differences were found between dates as well as between groups the first year, a study was undertaken to determine the influence of weather conditions on fecal nitrogen. Weather recording instruments, a hygro-thermograph, and an anemometer were placed near the winter feeding sites. The chart on the hygro-thermograph which recorded temperature and humidity was changed once weekly. Wind velocity was recorded at 7:00 a.m. and 4:00 p.m. Moisture readings were obtained whenever precipitation occurred.

Figure 2 shows the physical set-up of the winter feeding operations at camp number 3.

The nutrition study began December 11, 1952, and continued until March 22, 1953, at which time the ewes were removed to the lambing sheds. The ewes were moved from camp number 2

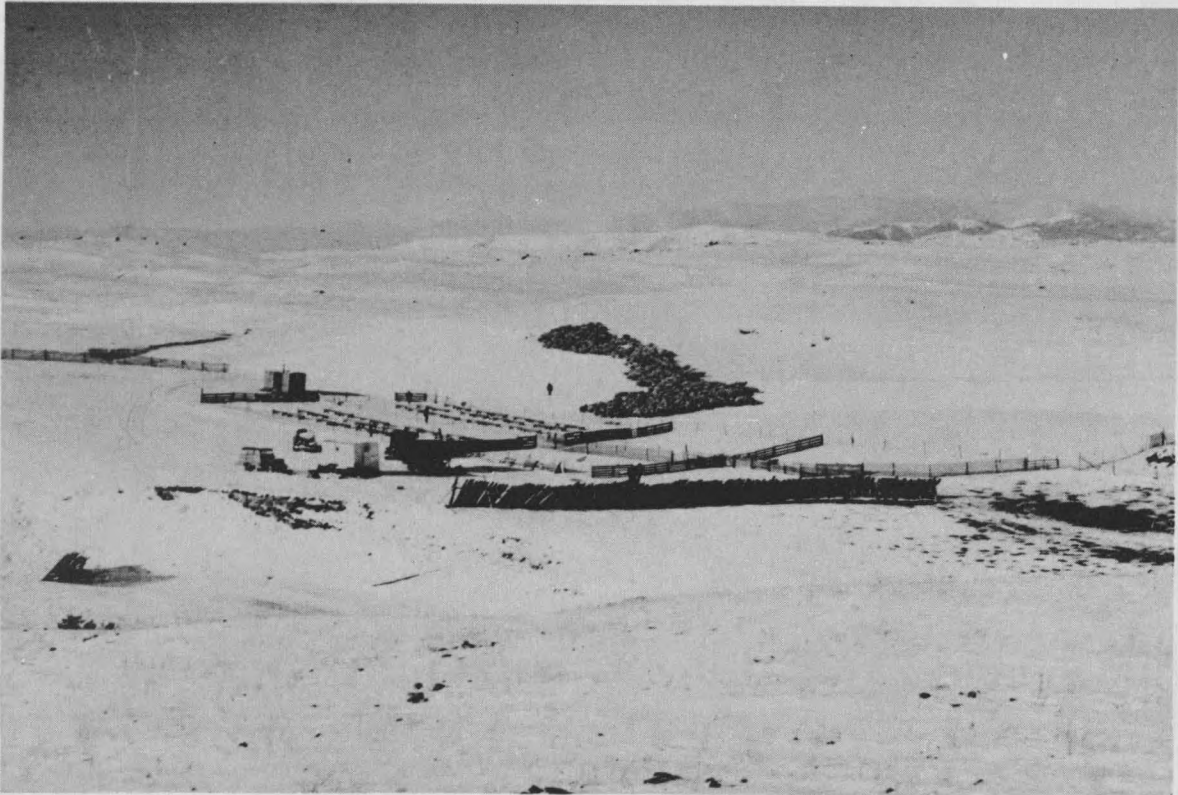


Figure 2. The experimental facilities used consisting of cutting chutes, corrals and feed troughs at camp site number 3. The range shown in the photograph is typical of the area used by the sheep on the winter nutrition experiment.

to fresh range at camp number 3 on February 7, 1953. The first fecal samples were obtained at camp number 1 before the ewes were fed their respective supplements. The next five sampling periods were at camp number 2 and camp number 3, and the final sampling was done March 31 at the lambing area.

A range survey determined the percent of utilization of forage on the winter range by the nutrition band and the percent composition of the forage of the major grass species.

A metabolism trial, using wether lambs as the experimental animals, was conducted during the last year of the fecal nitrogen studies. The lambs were fed only grass hay during the first trial, and for the second metabolism trial, they were fed hay supplemented with the same protein pellets fed the ewes on the nutritional range studies. The digestibility of the pellets and the loss of fecal nitrogen by the wethers under controlled environments was obtained in order to compare the results with those obtained from the range ewes receiving the same supplements.

All chemical analyses in this study were determined by the Chemistry Research Department at Montana State College.

### RANGE FORAGE SAMPLING

Weaver and Clements (1938) described the foothills area of Montana as a transition between the Palouse prairie of the Northwest and the mixed prairie of the Great Plains.

Daubenmire (1942) and Tisdale (1947) described three elevational zones of the Palouse prairie. The lowest and driest zone was dominated by sagebrush and wheatgrasses, the middle zone by wheatgrasses and bluegrasses, and the upper zone by fescues and wheatgrasses.

The range area, described in this thesis and grazed by the range ewes for the nutrition study, is in the second elevational classification zone characterized by Daubenmire and Tisdale.

Figure 3 shows a typical scene on the winter sheep range. The ewes had received their daily amounts of supplemental pellets and were grazing on the native forage available after a five-inch snowfall during the previous night.

Various species of grass are found on this winter range. The principal forage species are bluebunch wheatgrass (Agropyron spicatum), needle-and-thread (Stipa comata), june grass (Koeleria cristata), western wheat (Agropyron smithii), and sandberg bluegrass (Poa secunda). The percent composition of the total forage on the range as determined by a range survey for major forage species was as follows: June grass 27 percent, bluebunch wheatgrass 26 percent,



Figure 3. Typical scene on the winter sheep range of ewes grazing on native forage after receiving their daily ration of protein supplements.

needle-and-thread 15 percent, sandberg bluegrass 13 percent, western wheatgrass 11 percent, fringed sagewort (Artemisia frigida) 1 percent, threadleaf sedge (Carex filifolia) 1 percent and miscellaneous grasses 4 percent.

There were small amounts of big sage (Artemisia tridentata) and rabbitbrush (Chrysothamus sp.) found over most of the range, but in limited amounts. Phlox (Phlox sp.) and club moss (Selaginella sp.) were observed on some sites but these probably had little influence on the forage eaten by the sheep.

During the winter grazing season, samples of the more abundant range plants were clipped and analyzed for crude protein, phosphorus, calcium and moisture. The percent of utilization by the sheep and the occurrence of the major species was also determined. The utilization work was confined to the range used from camp number 3. The utilization survey was based on the conversion of stubble height to weight of grass eaten (Lommasson method).

Samples of major species of grass were collected at only one date for crude protein analyses during the winter grazing period of 1951-52. Further collections of samples were made impossible by the snow cover which remained on the sampling area the entire time during the grazing period. For the year 1952-53, the grass samples were collected every two weeks at the first of the grazing season and later at

monthly intervals.

Collections of forage samples and the utilization survey were made by members of the Range Management staff of Montana State College.

The grass samples, after the species were determined, were cut approximately one-half inch from the ground. Grass samples were also collected and used for sorted sampling. The sorted samples consisted of the fine leaves and stems that would appear to be more palatable to a sheep. After the finer material was carefully selected from the range sample, it was then analyzed for protein content.

## RESULTS AND DISCUSSION

The amount of fecal nitrogen obtained in the composite sampling collections for the first year of the study is shown in Table V. These results are in agreement with previous work reported by McKinney (1951), the figures showing a significant difference<sup>1</sup> between treatments, which might be expected because of the varying levels of protein intake in the rations. It is interesting to note that sampling dates also show highly significant differences. This clearly indicates that although group protein levels show significant differences, some factor or factors other than the varying amounts of protein in the supplemental pellets have a decided effect on the fecal nitrogen level found in a ewe on winter range. Significant differences due to sampling dates were reported by McKinney; he states a change in dietary protein percentage will cause a corresponding but smaller change in the fecal protein percentage. A separate statistical analysis (Table VI) is presented; the group representing a typical farm flock is deleted as this group was subjected to environmental and climatic conditions different from the seven remaining groups on range forage and added supplements. Viewing the results of analyses (Group 5 deleted), significant differences were evident in both treatments and sampling dates.

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<sup>1</sup>All statistical analyses presented in this thesis are according to methods described by Snedecor (1946).

TABLE V. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES ON PROTEIN NUTRITION TRIAL 1951-1952.

Groups	0	1	2	3	4	5	6	7	Mean
Jan. 7	7.7	8.2	8.8	8.8	7.8	9.2	8.4	9.1	8.5
Jan. 25	7.1	7.7	7.6	8.3	8.1	11.4	7.7	9.6	8.3
Feb. 12	9.5	9.7	10.1	9.7	10.2	13.7	9.9	11.4	10.5
Feb. 26	8.2	7.9	8.3	8.8	8.6	11.0	9.0	9.5	8.9
Mar. 8	8.3	7.7	8.4	8.7	8.8	9.1	9.6	10.0	8.8
Mar. 22	7.5	8.2	8.9	8.6	8.8	11.2	8.4	8.9	8.8
Mean	8.1	8.2	8.7	8.8	8.7	10.9	8.8	9.6	

Analysis of Variance

Variance Due To:	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	7	34.84	4.98	14.23**	2.38	3.18
Dates	5	24.95	4.99	14.26**	2.48	3.58
Error	35	12.30	0.35			
Total	47	72.09				

TABLE VI. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES ON PROTEIN NUTRITION TRIAL 1951-1952.<sup>1</sup>

Groups	0	1	2	3	4	6	7	Mean
Jan. 7	7.7	8.2	8.8	8.8	7.8	8.4	9.1	8.4
Jan. 25	7.1	7.7	7.6	8.3	8.1	7.7	8.6	7.9
Feb. 12	9.5	9.7	10.1	9.7	10.2	9.9	11.4	10.7
Feb. 26	8.2	7.9	8.3	8.8	8.6	9.0	9.5	8.6
Mar. 8	8.3	7.7	8.4	8.7	8.8	9.6	10.0	8.8
Mar. 22	7.5	8.2	8.9	8.6	8.8	8.4	8.9	8.5
Mean	8.1	8.2	8.7	8.8	8.7	8.8	9.6	

Analysis of Variance

Variance Due To:	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	6	8.72	1.45	11.15**	2.42	3.47
Dates	5	19.07	3.81	29.31**	2.53	3.70
Error	30	3.86	.13			
Total	41	31.65				

<sup>1</sup>Same as Table V except that Group 5 is deleted.

Although samples from ewes receiving supplements with high percentages of protein had a correspondingly high fecal protein throughout the feeding period, it will be noted in Table V that there were highly noticeable variations in fecal samples on different dates.

To determine if there was variation of fecal nitrogen in ewes within a group, the fecal nitrogen samples from the 20 ewes randomly selected for sampling in Groups 0 and 7 were analyzed separately, as shown in Table VII. Significant differences were obtained for groups and dates, but treatment and date interactions were not significant. It was concluded from these results that there was little variation in fecal nitrogen of the ewes fed a similar ration during the winter feeding trial.

The results of the second year of the experiment were similar to those obtained in the first winter's feeding study. One of the factors that tended to complicate observations the second year was the change of supplements fed two groups (Table III) half-way through the winter feeding trial. The ration fed to Group 3 and Group 4 was interchanged midway through the winter feeding period.

Significant differences (Tables VIII and IX) were found during the two collection periods before Group 3 and Group 4 rations were interchanged. These analyses indicated that groups and dates were significantly different during both

TABLE VII. FECAL PROTEIN LEVELS OF RANGE EWES ON PROTEIN NUTRITION TEST (1951-1952). EACH FIGURE IN THE TABLE IS THE AVERAGE VALUE OF SAMPLES FROM TWENTY EWES. STATISTICAL ANALYSIS WAS OF THE INDIVIDUAL SAMPLES.

Group	Jan. 7	Jan. 25	Feb. 2	Feb. 26	Mar. 3	Mar. 22
0	7.9	6.4	9.6	8.1	8.0	7.4
7	9.1	7.7	11.2	9.3	9.6	8.9

Analysis of Variance						
Variance Due To:	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	1	115.04	115.04	143.80**	3.89	6.76
Dates	5	226.96	45.39	56.73**	2.26	3.11
Treatment x dates	5	5.07	1.01	1.26	2.26	3.11
Error	220	175.61	.80			
Total	231	522.68				

TABLE VIII. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES DURING FIRST HALF OF SUPPLEMENTAL FEEDING TRIAL (1952-1953)

Group	0	1	2	3	4	5	6	7	Mean
Jan. 13	8.9	9.2	9.2	9.0	9.7	10.0	10.0	8.7	9.3
Jan. 29	8.1	8.1	8.3	8.0	9.1	9.6	9.2	8.1	8.6
Mean	8.5	8.7	8.8	8.5	9.4	9.8	9.6	8.4	

Analysis of Variance

Variance Due To	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	7	4.37	.624	13.3*	6.09	14.98
Dates	4	2.40	.600	12.8*		
Error	4	.19	.047			
Total	15	6.96				

TABLE IX. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES DURING FIRST HALF OF SUPPLEMENTAL FEEDING TRIAL (1952-1953)<sup>1</sup>

Group	0	1	2	3	4	6	7	Mean
Jan. 13	8.9	9.2	9.2	9.0	9.7	10.0	8.7	9.2
Jan. 29	8.1	8.1	8.3	8.0	9.1	9.2	8.1	8.4
Mean	8.5	8.7	8.8	8.5	9.4	9.6	8.4	

Analysis of Variance

Variance Due To	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	6	2.72	.45	25.17**	4.28	8.47
Dates	1	2.40	2.40	133.33**	5.99	13.74
Error	6	.11	.018			
Total	13	5.23				

<sup>1</sup>Same as Table XIII except that Group 5 is deleted.

sampling periods.

Groups and dates (Table X) were found to be highly significant during the second half of the second year's trial; however, when Group 5 was deleted, as shown in Table XI, no significant differences were obtained. It would appear that the groups were more comparable in fecal nitrogen content during this second period when Group 5 was deleted from the analyses.

Treatments x dates, groups and dates were found to be significant (Table XII) for the individual nitrogen samples the second year. Group 7 was replaced by Group 6 for the individual sampling the second year of the fecal collections. The amount of protein supplement Group 7 was scheduled to receive was based on temperature, wind velocity and amount of snow on the ground. Because of an unusually mild winter and light snowfall the ewes of this group received little additional supplement; in appearance at the close of the trial the ewes of Group 7 were similar to those receiving only range forage.

#### Temperature

The date differences indicate that factors other than the quantity or the quality of the protein supplements fed may affect fecal nitrogen percentages as much or more than the feeding of the supplement. Environmental factors which

TABLE X. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES DURING SECOND HALF OF SUPPLEMENTAL FEEDING TRIAL. (1952-1953)

Group	0	1	2	3	4	5	6	7	Mean
Feb. 12	8.6	9.8	9.3	9.0	9.7	11.4	10.2	8.8	9.6
Feb. 26	8.6	8.7	9.1	9.2	9.0	11.1	10.1	9.1	9.4
Mar. 12	9.5	9.3	10.0	10.7	7.4	10.7	11.0	9.4	9.8
Mean	8.9	9.3	9.5	9.6	8.7	11.0	10.4	9.1	

Analysis of Variance

Variance Due To	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	7	13.56	1.94	29.8**	2.77	4.28
Dates	2	6.10	3.05	46.9**	3.74	5.61
Error	14	.91	.065			
Total	23	20.57				

TABLE XI. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES DURING SECOND HALF OF SUPPLEMENTAL FEEDING TRIAL (1952-1953)<sup>1</sup>

Group	0	1	2	3	4	6	7	Mean
Feb. 12	8.6	9.8	9.3	9.0	9.7	10.2	8.8	9.3
Feb. 26	8.6	8.7	9.1	9.2	9.0	10.1	9.1	9.1
Mar. 12	9.5	9.3	10.0	10.7	7.4	11.0	9.4	9.6
Mean	8.9	9.3	9.5	9.6	8.7	10.4	9.1	

Analysis of Variance

Variance Due To	D.F.	S.S.	M.S.	Significant F. Ratio		
				F. Ratio	5% Level	1% Level
Groups	6	5.88	.98	2.00	3.00	4.82
Dates	2	.88	.44	.90	19.41	99.42
Error	12	5.89	.49			
Total	20	12.65				

<sup>1</sup>Same as Table X except that Group 5 is deleted.

TABLE XII. FECAL PROTEIN LEVELS<sup>1</sup> OF RANGE EWES ON SUPPLEMENTAL FEEDING TRIAL (1952-1953).

Group	Jan. 13	Jan. 29	Feb. 12	Feb. 26	Mar. 12
0	8.8	7.8	8.6	8.7	9.0
6	9.8	9.0	9.5	9.5	10.6

Analysis of Variance

Variance Due To	D.F.	S.S.	M.S.	F. Ratio	5% Level	1% Level
Groups	1	8.05	8.05	16.43**	3.91	6.81
Dates	4	35.14	8.79	17.94**	2.43	3.44
Treatment x Dates	4	45.35	11.34	23.14**	2.43	3.44
Error	149	73.51	.49			
Total	158	162.05				

<sup>1</sup> Each figure in the table is the average fecal protein value of samples collected from 20 ewes on five different dates.

could contribute to these variations in fecal nitrogen are snow cover, temperature, wind, species and quality of range forage, fetal growth and possibly other undetermined factors.

An attempt was made to determine the influence of weather on the fluctuation of fecal nitrogen. Temperature changes show trends in the rise and fall of fecal nitrogen that are similar to weekly average temperature for the first year of the study. As the temperature rose, fecal samples had a tendency to increase in nitrogen; as the temperature fell, fecal nitrogen decreased. The means of fecal nitrogen for sampling dates are illustrated in Figure 4 for all groups, Group 0 and Group 5. There was only a short period during the first winter of the study when the average weekly temperature was above freezing. February 1 to approximately February 18, the temperature was above the freezing point as denoted by the broken line across the graph in Figure 4. The group at Fort Ellis showed a more marked rise and fall in fecal nitrogen than was found in the range groups, however, in the range groups the amount of fecal protein on successive dates showed more short term fluctuations in trend. In Figure 5 a more complete picture of the relationship of fecal nitrogen to temperature for the range band is presented; the fecal nitrogen is charted of the group receiving only range forage; also included are

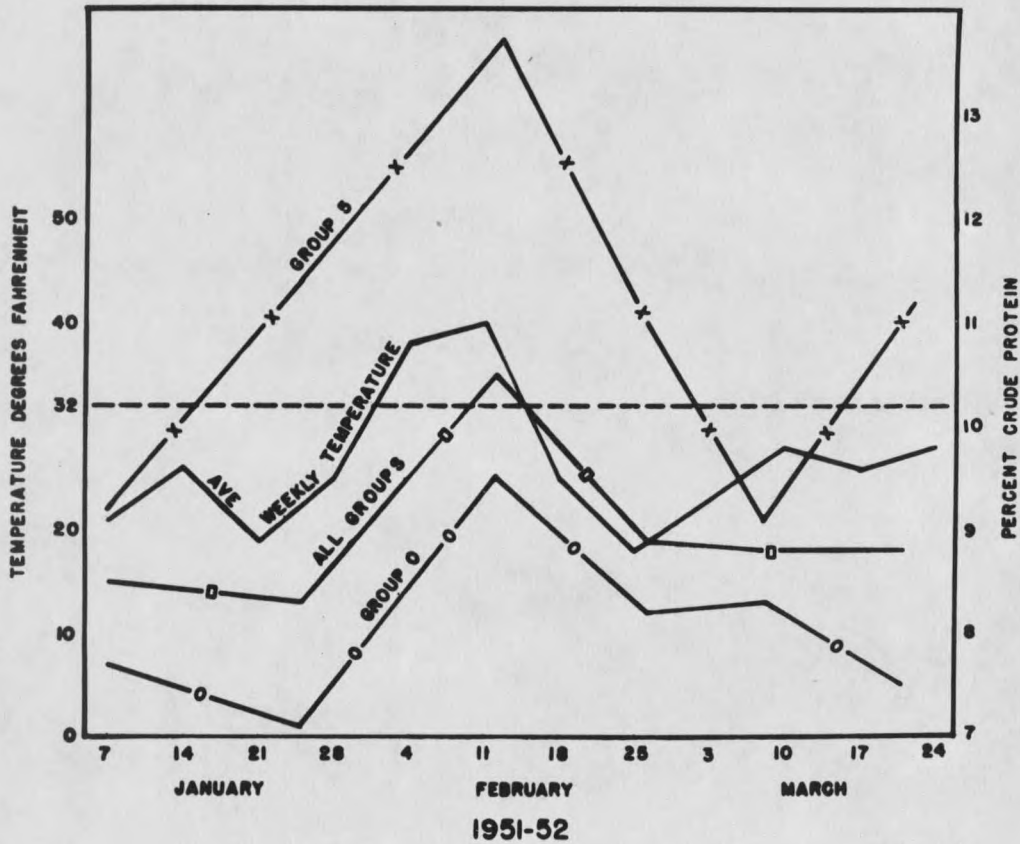


Figure 4. Average weekly temperatures are graphed showing the relationship between temperature and the level of fecal protein on the various sampling dates of 1951-1952. Group 5 (Fort Ellis), Group 0 and the average fecal protein of all groups are shown. The broken line denotes the freezing point.

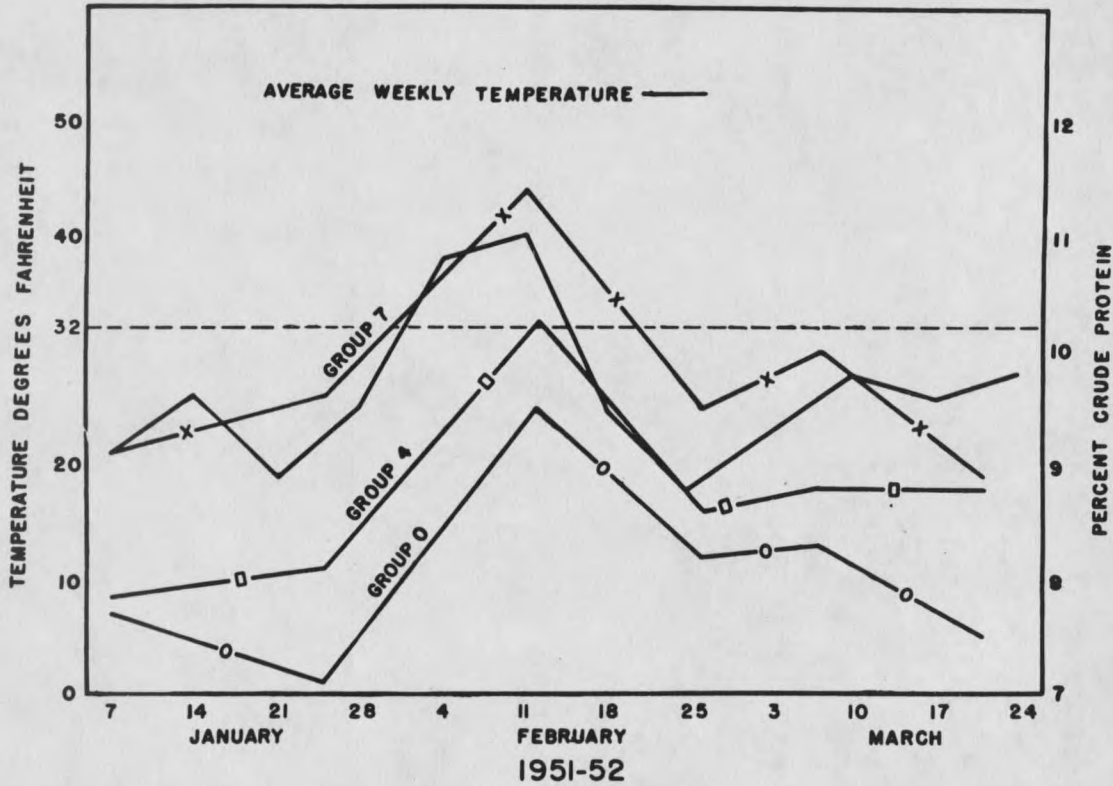


Figure 5. Average weekly temperatures showing the relationship of fecal nitrogen of three range groups with temperature change. Group 0 getting only range forage, Group 4 receiving 1/3 pound 40 percent protein pellet and Group 7 receiving 2/3 pound 15 percent protein pellet, showing the corresponding level of fecal nitrogen which each group maintained during the winter supplementation period of 1951-1952.

the fecal nitrogen levels for Group 4 receiving a moderately high protein supplement and Group 7, a group on a higher energy level than any of the other groups. Figure 5, showing only range groups, illustrates clearly that the level of protein supplementation sets a definite level of fecal nitrogen between the groups, while other factors determine the actual amount of fecal nitrogen on any sampling date. Studying the trend of fecal nitrogen and temperature for the first year, it seems that weather can be a major factor in determining the amount of fecal nitrogen. Lee and Phillips (1948) reported results which indicated that the intestinal functions of experimental animals tend to be disturbed by heat; however, they reported that during cold weather the intestinal tract tends to show no effect or change. It will be noted in Figure 5 that with a rise in temperature the nitrogen voided by the sheep increased and with a drop in temperature the fecal nitrogen in the samples decreased.

The trend was similar when comparing the relationship of fecal nitrogen to temperature during the first year of the study, with results obtained the second year; however, because the sampling dates happened to fall midway between the high and low temperatures the overall effect of temperature is lessened. If the sampling dates had been one week earlier (Figure 6) the results would correspond to the

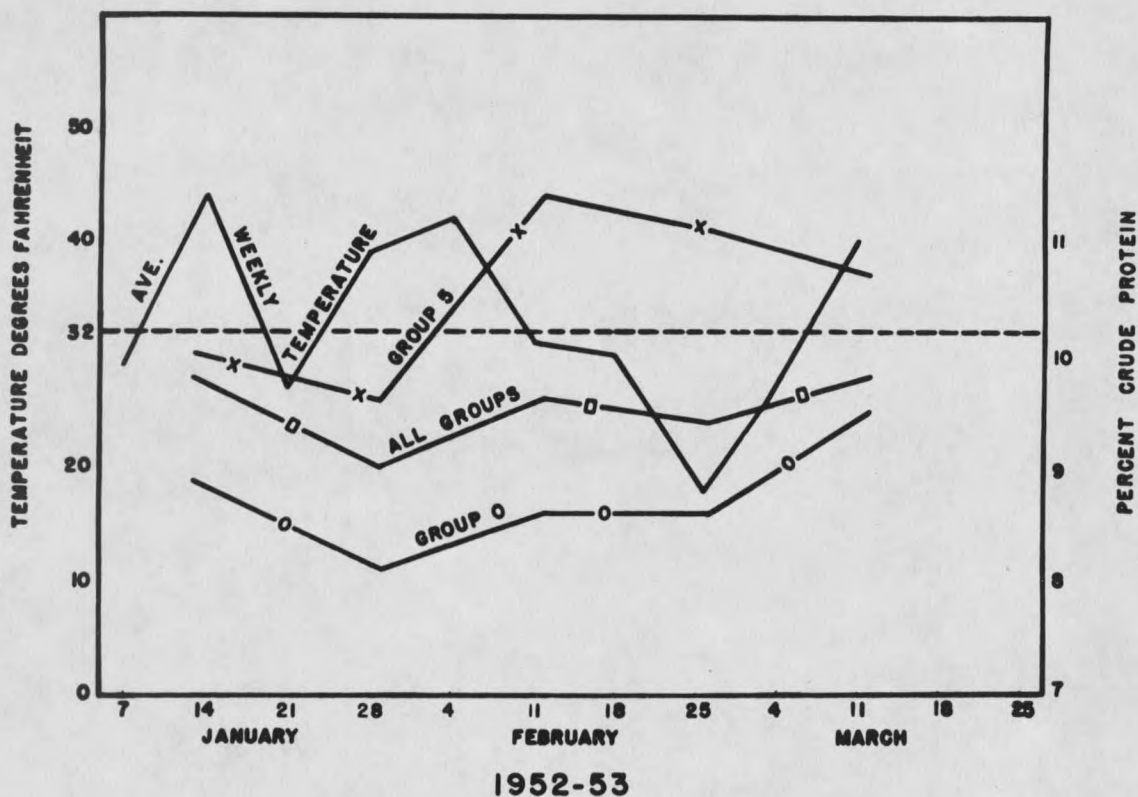


Figure 6. Average weekly temperature is compared with fecal protein levels on different sampling dates. The average fecal nitrogen for all groups, Group 5 and Group 0 are shown for the 1952-1953 study.

results of the first year. When the temperature went up, fecal nitrogen showed a slight upward trend; both fecal nitrogen and temperature had less marked fluctuations the second year than the previous year. This is attributed to warmer weather for the winter feeding period of 1952-1953.

The ewes of all groups seemed to have the ability to digest more of the protein in the body during the cooler temperatures. With the event of warmer temperatures the loss of protein from the forage and supplements in the body became greater as indicated by the higher protein content of the fecal samples at this time. The amount of influence the weather appeared to have on the fecal nitrogen in this study may indicate that it would be important to put more emphasis on studies where animals are fed according to changes in weather during winter feeding periods. These studies with fecal nitrogen in relationship to temperature should be conducted under closely controlled environment. The trial should be initiated under conditions where the temperature could be controlled; this method might then give information valuable to range sheep operations during the wintering period.

#### Wind

In Figure 7 it will be noted that the fecal nitrogen levels of the different groups show a decided tendency to

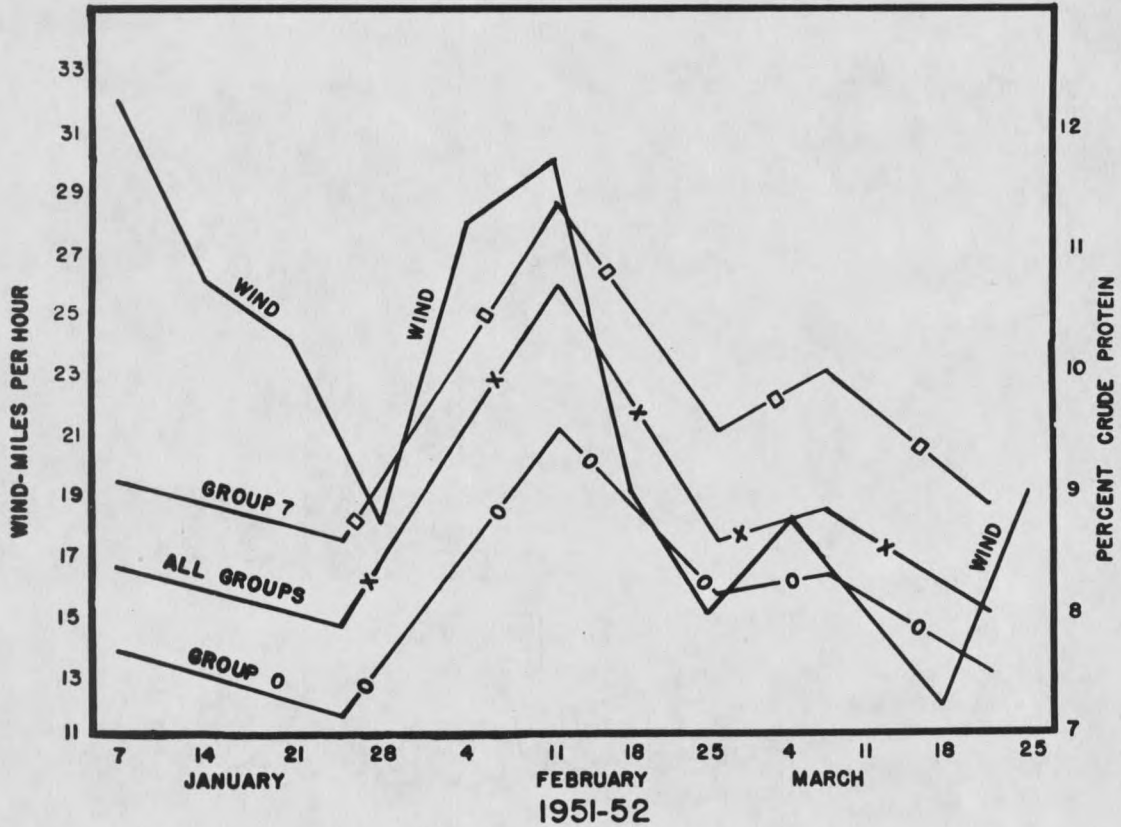


Figure 7. Showing the relationship of average weekly wind velocity with the different levels of fecal nitrogen from Groups 0 and 7; also the average fecal protein for all groups on the 1951-1952 sampling dates.

fluctuate according to the average wind velocity. On the first sampling date, January 7, 1952, all the groups had a higher fecal protein level than on the following sampling date, January 25. Studying the graph, one can see the sharp drop in wind velocity from a weekly average of 32 miles per hour on the first date to 17 miles per hour on the second sampling date. On the third sampling date, February 12, the fecal nitrogen showed a sharp upward trend in all groups; correspondingly, wind velocity rose from 17 miles per hour to 30 miles per hour during that period. On the fourth sampling date of February 26, wind velocity dropped from 30 miles per hour to 15 miles per hour. March 8, wind velocity averaged 18 miles per hour compared to 15 miles per hour on the last sampling date of February 26; fecal nitrogen showed an upward trend also for this period. On the last sampling date of the first year, fecal nitrogen was lower than on the fifth sampling date, with average wind velocity at its lowest point for the year with an average of 12 miles per hour. Group 5, although located at Fort Ellis, where there is relatively little wind, as compared to that experienced on the range, had a high point in fecal nitrogen of 13.7 percent crude protein in composite sampling on February 12, 1952. This was also the date that the fecal nitrogen content of all the range groups was at a maximum for the first study

period of the 1951-52 feeding period.

These observations from the first year of the experiment would tend to show that both wind and temperature had a definite effect on the amount of fecal nitrogen.

For the time of fecal collection in 1952-53, fecal nitrogen tended to show an inverse relation to wind velocity from the feeding period of the first year. Wind data was not available at as early a date for 1952-53; the first readings were taken approximately ten days later than in 1952. In Figure 8, a peak in average weekly wind velocity was again reached between February 24 and March 4; the time between these dates also had shown a similar peak the previous year. In contrast to the first year of the apparent trend of fecal nitrogen to follow wind velocity, the opposite trend was evident. With high wind velocity in 1952-53, there was some lowering of the fecal nitrogen. The point of highest wind velocity was reached during the week of February 28 and on this sampling date the amount of fecal nitrogen was the lowest obtained during the feeding experiment. February 24 was another period of higher wind velocity; the wind reading was 9 miles per hour February 17; on the fifth sampling date, February 26, it had risen to 14 miles per hour. This higher velocity had little effect on the nitrogen content of the fecal samples from Group 0; however, Group 6 and

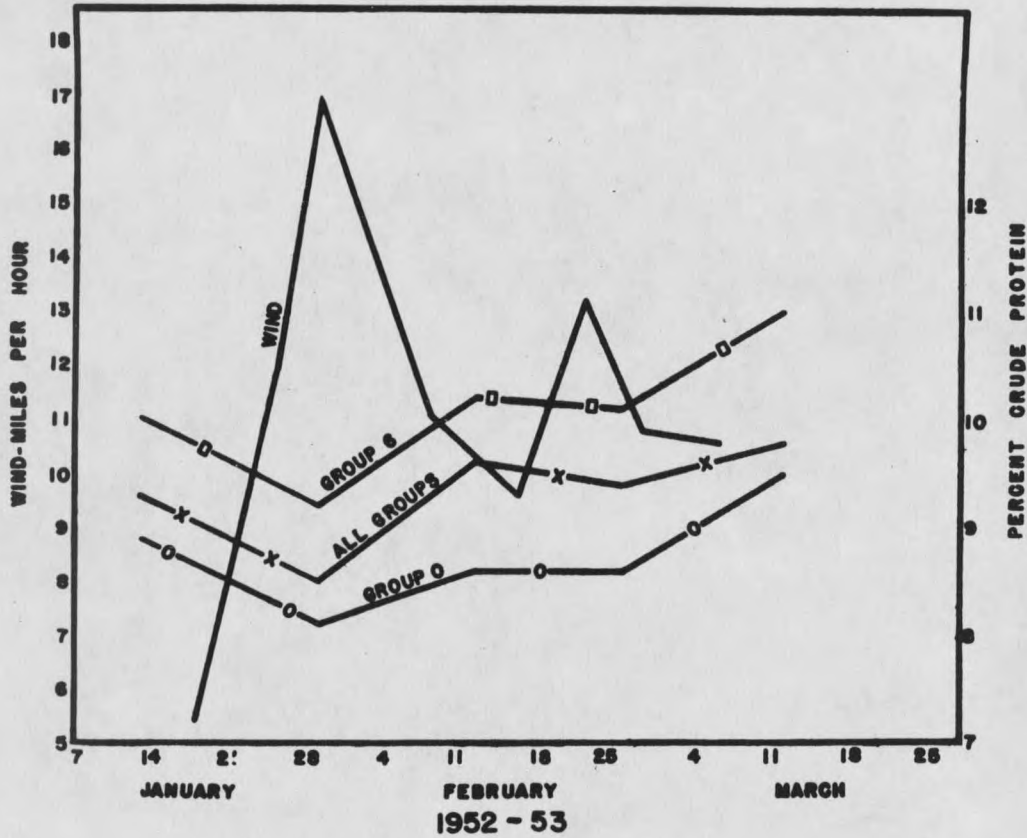


Figure 8. This graph shows the relationship of average weekly wind velocity with the fecal protein levels of Groups 0 and 6 and the average fecal protein level of all groups combined for the 1952-1953 sampling dates.

Group O, Figure 8 show a slight downward trend. This lowering of fecal nitrogen was very small, averaging about 0.1 of one percent. Group O maintained an even level of fecal nitrogen from February 12 to February 26, the change in wind velocity apparently showing no effect. March 7 wind velocity was lower than on the last sampling date; fecal nitrogen was approximately 0.1 percent higher. A lack of any definite trend in fecal nitrogen in the second year, in either wind or temperature, could be attributed to less abrupt changes and smaller changes in wind and temperature. Five and one-half miles per hour and 17 miles per hour were the lowest and highest of the average weekly wind velocities for the second year of the study. In contrast, the first year had colder weather and more snow and had a low wind velocity of only 12 miles per hour. This was only 5 miles per hour below the maximum for the second year. The highest peak of wind velocity the first year was 32 miles per hour, approximately double the reading for the second winter of the fecal nitrogen study.

#### Forage Sampling

Selective grazing as demonstrated by Raymond (1948) may be a factor which cannot be overlooked in determining influences upon fecal nitrogen levels. Raymond states that the results obtained from fecal nitrogen analyses of grazing

sheep may give a more accurate figure for nitrogen in the feed grazed, than that obtained by analysis of cut herbage. This theory should be true of winter ranges but is more difficult to evaluate. The ewes were moved to a new camp and to fresh range on February 7, 1952. In Figures 4 and 5 this date corresponds closely to the high point for fecal nitrogen in all groups which occurred on the 12th of February. Fringed sagewort was readily eaten at this time for a short period and it contained a higher percentage of protein than available grasses. It may have helped in raising the amount of protein in the fecal samples. However, it is obvious that Group 5 at Fort Ellis could not have been influenced by this change; yet they show an increase in fecal nitrogen on this sampling date that is more pronounced than that of those groups fed on the range. If fresh range had any influence upon fecal nitrogen at the February 12 sampling date, it was a minor factor. Some other factor, obviously weather, had much more effect as is shown in fecal protein levels of the heavily fed group at Fort Ellis. These were comparable in trend of fecal nitrogen to that of groups on the range.

The percent protein determined in three of the major species of grass found on the winter range is illustrated in Figure 9; also included in the graph is one shrub, big

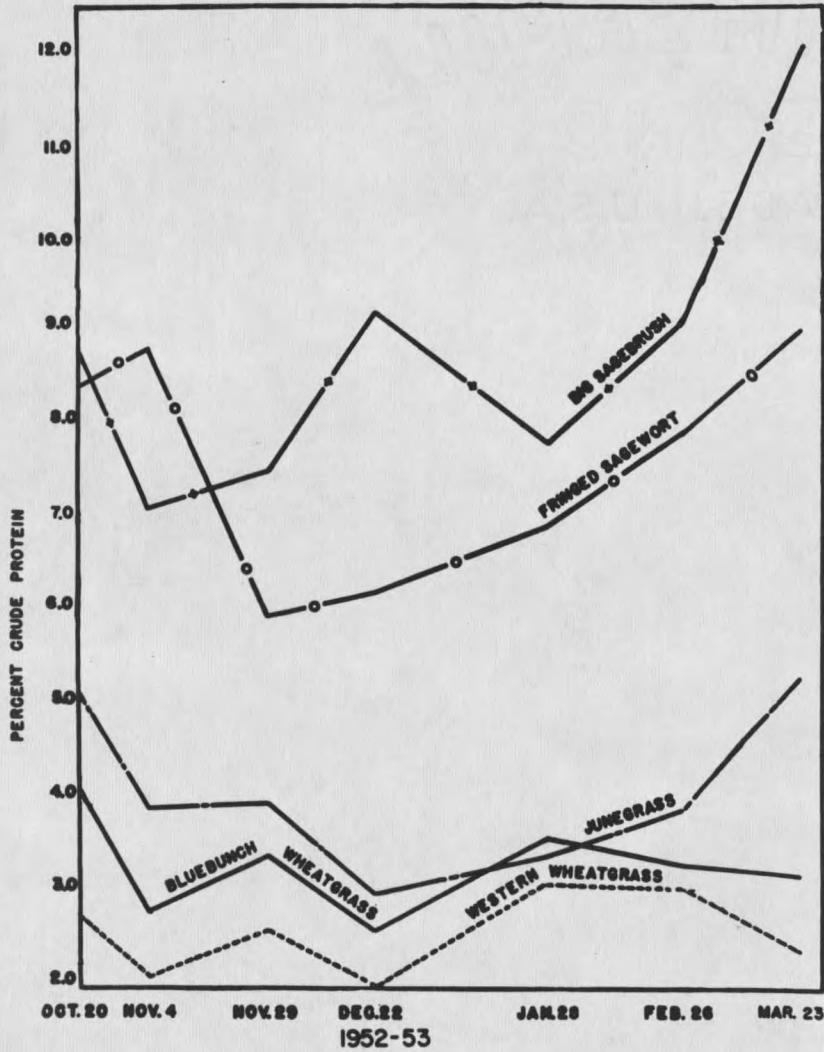


Figure 9. This graph shows the amount of protein found in the forage that was clipped and analyzed for the winter grazing period of 1952-1953. It demonstrates that the shrubs and half-shrubs are much higher in protein than the common grasses found on the sheep range.

sagebrush (Artemisia tridentata), and a half shrub, fringed sagewort (Artemisia frigida). A noticeable difference in the amount of protein contained in the big sagebrush and fringed sagewort in comparison with that found in the three species of grass can readily be observed. Jameson (1952) found shrubby plants contained considerable amounts of various nutrients, protein being quite high in greasewood (Sarcobatus vermiculatus) and schadscale (Atriplex confertifolia). The big sagebrush and fringed sagewort had considerably more variation in percent of protein during the winter than did the grasses. Percent protein in fringed sagewort (Figure 9) dropped from 8.7 on November 4, 1952 to 6.0 on November 29, 1952. From November 29 it had an upward trend on through the grazing period, the protein content reaching 9 percent on the March 23 sampling date. Clarke (1945) working with the chemical composition of range forage found fringed sagewort contained 7.8 percent protein, which is comparable to the analyses of fringed sagewort for crude protein in this study. Clarke states, in addition to a high percentage of protein, fringed sagewort and sagebrush have an exceptionally high fat content, even when in the cured stage. The western wheatgrass (Agropyron smithii) contained 2 to 3 percent protein during the winter grazing period; only at one period, from the January 28 sampling date to the February

sampling date, did it rise over the 3 percent protein level. Bluebunch wheatgrass (Agropyron spicatum) showed a decline in protein during the winter, going from 4 percent on October 20, 1952, to a low of 2.6 percent on December 22, 1952, and being back up to 3.2 percent on the March 23, 1953, sampling date. The grass containing the largest amount of protein was junegrass (Koeleria cristata) of which had a high protein content of 5.3 percent on March 23, 1953, sampling date and a low of 3.0 percent protein on December 22, 1952. In the middle of the winter trial, February 26, 1953, junegrass contained 4 percent protein. On the final sampling date of 1953, big sagebrush and fringed sagewort had reached their highest protein content of 12.1 percent and 9.0 percent respectively.

Junegrass, bluebunch wheatgrass, western wheatgrass, Kentucky bluegrass, timothy and sheep fescue were used as sorted samples. Junegrass was the only grass that had a higher non-sorted protein content. The sorted samples in the remaining grasses contained more protein than the non-sorted species. This indicates a range ewe would be getting more protein than is frequently determined by the usual method of clipping grass to find the protein content.

The utilization of the range forage by the sheep is illustrated in Figure 10. The first year of the study showed a much higher utilization figure because of lower forage

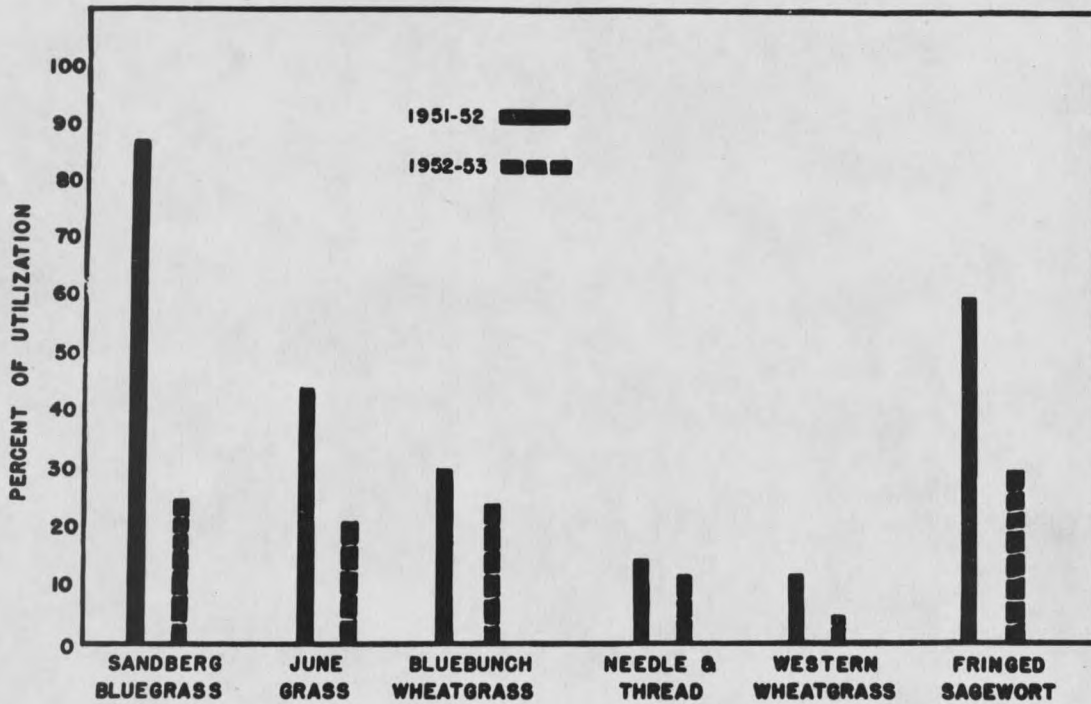


Figure 10. The percent of utilization for the winter grazing periods during 1951-1952 and 1952-1953 are illustrated. Note that the year 1952-1953 utilization was much lower, probably because of a milder winter and better distribution over the entire winter range.

production during the summer of 1951. Another view to consider is that the grass was shorter and thus utilized more fully. The mild winter of 1953 allowed more complete grazing and better distribution over the entire winter range. Sandberg bluegrass (Poa secunda) had the highest utilization of 86 percent for the 1951-1952 study; in the following year sandberg bluegrass and bluebunch wheatgrass were the two major species utilized, with about the same utilization figure, approximately 26 percent. For the entire study of two years, fringed sagewort was consistent in having a higher utilization figure than the grasses found on the range. The results obtained with fringed sagewort on this range suggest that it is far more important as a forage for range sheep than has been determined in the past. It is generally thought of as an increaser on most ranges of the West.

Table XIII gives the percent of average protein and percent of occurrence for the major forage species during the first year of the trial. Cook and Harris (1950) found bluebunch wheatgrass to have a utilization figure of 26.6 percent under Utah range wintering conditions. This figure is in close agreement with the figure for bluebunch wheatgrass contained in this thesis. Conflicting results, however, were obtained with browse plants. Cook and Harris found browse plants fluctuated least in chemical composi-

TABLE XIII. THE PERCENT USE, OCCURRENCE AND PROTEIN IN CONTENT OF THE MAJOR PLANTS ON WINTER RANGE (1951-1952)

Species	Percent of Use at End of the Season	Occurrence <sup>1</sup> %	Average Protein Content for Winter Grazing Period (%)
June grass ( <u>Koeleria cristata</u> )	43.87	26.17	5.4
Needle & thread ( <u>Stipa comata</u> )	14.75	18.97	4.5
Bluebunch wheatgrass ( <u>Agropyron spicatum</u> )	27.94	21.52	2.9
Western wheatgrass ( <u>Agropyron smithii</u> )	11.37	14.89	Not determined
Sandberg bluegrass ( <u>Poa secunda</u> )	86.97	10.53	7.1
Threadleaf sedge ( <u>Carex filifolia</u> )	12.59	2.11	Not determined
Blue grama ( <u>Bouteloua gracilis</u> )	10.18	.61	Not determined
Cheatgrass ( <u>Bromus tectorum</u> )	-----	1.84	3.0
Others	-----	3.64	Not determined
Fringed sage ( <u>Artemisia frigida</u> )	59.4 <sup>2</sup>	-----	8.54

<sup>1</sup>These figures are based on the number of times each kind of plant was encountered on sampling lines. This does not directly represent pounds per acre of each kind of plant.

<sup>2</sup>Based on weights of 275 plants collected before and after grazing by sheep.

tion during the season while grass analyses indicated wide variations in composition.

The twenty ewes in the group receiving only range forage reached a high point in fecal nitrogen of 9.5 percent during both years. However, the peak was reached by the O Group one month later the second year.

Fecal samples were collected before the supplemental feeding period (Table XIV) and after the completion of the winter nutritional studies. After the supplementation period, the fecal nitrogen of all groups was considerably higher because of the three months of additional protein pellets and the ewes were all fed hay at this time. Also, the weather being warmer, the nitrogen retention might be lower. Warmer weather with some green growth of forage would contribute to the higher fecal nitrogen content.

TABLE XIV. FECAL PROTEIN LEVELS<sup>1</sup> IN SAMPLES COLLECTED FROM RANGE EWES BEFORE AND AFTER THE SUPPLEMENTAL FEEDING TRIAL<sup>2</sup> (1952-1953).

Group	0	1	2	3	4	5	6	7
Nov. 22, 1952	8.7	9.1	8.9	8.6	9.0	8.6	9.1	8.8
Mar. 31, 1953	10.3	10.1	10.7	9.9	9.5	11.9	11.0	10.7

<sup>1</sup>Each figure in the table represents the amount of protein from a composite sample of 20 ewes.

<sup>2</sup>All ewes had been fed hay nine days previous to March 31 sampling date.

DIGESTIBILITY TRIALS WITH WETHER LAMBS FED GRASS HAY  
AND FED HAY PLUS PROTEIN PELLETS IDENTICAL TO  
THOSE FED THE EWES ON WINTER RANGE

Introduction

This trial was conducted as a supplementary division of the fecal nitrogen study with the range ewes on the various levels of protein supplementation.

The purpose of the trial was to study the various protein supplements fed the range ewes on winter range under more closely controlled environment. By controlling the food intake of the lambs in the metabolism battery, the amount of digestible nutrients in the rations fed could be computed. A comparison of protein intake and the amount of nitrogen lost in the feces from the rations fed could then be determined.

Procedure

Metabolism cages and fecal collection bags described by McCall et al. (1943) were used. Six wether lambs were selected, comparable as far as possible in weight and size. The lambs were put into the metabolism cages for 10 days during the preliminary trial. This period allowed the lambs to become accustomed to the cages and fecal collection bags; also the ration was adjusted during this 10-day period. The metabolism cages were placed (because of freezing conditions outside) in the stock judging pavillion at Montana State College.

Figure 11 shows a front view of the experimental animals during the fecal collection period of trial 1 on a hay ration. The temperature was kept at about 50 degrees Fahrenheit.

The lambs were weighed at the beginning of the preliminary trial period of 10 days, weighed at the end of the preliminary period, and at the end of the collection period or 20 days after the initial weighing. The lambs were fed twice daily, receiving half of the total ration at each feeding. Water was available at all time, and 5 grams of salt was placed before each lamb every morning. Fecal bags were emptied morning and evening. At each feeding period, a one-tenth aliquot of the total fecal collection was weighed out. The aliquots were put in paper envelopes, carefully labeled and placed over a radiator for drying. At the end of the 10-day collection period, daily aliquots of each lamb were composited and analyzed for protein content. Urine samples were collected once daily, measured in a graduated cylinder; the total volume was then recorded, after pouring back and forth several times from one cylinder to the other to suspend the sediment. A smaller cylinder was then used to measure out a one-tenth aliquot. The aliquot was tested with litmus paper and, if necessary, enough concentrated hydrochloric acid (dropwise) was added to make it turn litmus paper from blue to red. The one-tenth aliquot was



Figure 11. A front view of the metabolism cages.

then transferred to a glass one-gallon container bearing the ear tag and stall number of the lamb. Bacterial decomposition of the urine was prevented by adding 50 milliliters of toluene to each urine container. This provided a quarter-inch cover of toluene for each sample. After the addition of each daily aliquot, the total aliquot was tested and acid added if necessary. At the end of the 10-day collection period, an eight-ounce bottle was filled from the total aliquot and sent in for analyses by the chemistry department. Each lamb had one pound of the hay placed before it in each respective feed container morning and night.

A running sample of the hay was taken daily during the 10-day preliminary period and the final collection period. All hay not consumed by each lamb was collected and the weight recorded. A sample of the daily orts on the final 10-day period was also kept for analysis during the collection period. The hay was locally grown grass hay, a mixture of timothy (Phleum pratense), red top (Agrostis sp.), rush (Juncus sp.), sedge (Carex sp.), a small amount of foxtail (Hordeum jubatum) was present in the hay along with small amounts of other wet meadow species.

The rush seemed to be the only part of the hay ration that was refused. Chopping the hay would have facilitated the handling, but little was wasted because of the construc-

tion of the metabolism crates. The chemical composition of the hay fed to the lambs is shown in Table XV.

TABLE XV. CHEMICAL COMPOSITION OF HAY FED LAMBS DURING NITROGEN METABOLISM TRIALS (Dry Matter Basis)

Good Quality Grass Hay	%
Dry Matter	94.3
Crude Protein	6.7
Ether Extract	5.1
Crude Fiber	34.9
Nitrogen	46.2
Ash	7.1
Calcium <sup>1</sup>	.78
Phosphorus	1.18

<sup>1</sup>Calcium and phosphorus listed as micrograms per gram.

Results and Discussion of Trial 1.

Weights and feed consumption of the lambs during the 10-day fecal collection period on the hay ration are shown in Table XVI. At the start of the preliminary trial, some diffi-

TABLE XVI. WEIGHTS AND FEED CONSUMPTION OF LAMBS DURING TEN-DAY FECAL COLLECTION PERIOD ON HAY TRIAL (Feb. 9-18 incl., 1953)

Lamb No.	Initial Weight	Change in Weight	Total Ration of Hay
	Lbs.	Lbs.	Grams
1	102	-1	9040
2	94	-1	8009
3	93	-1	6190
4	97	0	7758
5	96	-4	7550
6	87	-2	5889

culty was experienced in getting the lambs to consume the grass hay, because of the unpalatability of the species of carex and juncus that made up a considerable portion of the hay fed. These species when mature are highly unpalatable, but make fair to good forage for sheep, when the

leaves are tender, according to Booth (1950). The wire rush was the species left untouched if the entire ration was not eaten. Dinsmore (1907) found hay composed largely of water-grass, sedges and rushes proved to be of fair quality in studies at the Nevada Experiment Station.

The consumption and retention by the lambs of nutrients from the hay are shown in Table XVII.

At the end of the preliminary trial, all the lambs were eating fairly consistently except lamb 6. This lamb, eating a smaller amount of hay per day, showed a total digestible nutrient figure comparable to the figures of T.D.N. for the other five wether lambs, as shown in Table XVIII. This data is in complete agreement with Armsby (1917).

There was a loss in body weight by three lambs (Table XVI); two lambs gained a pound each and the remaining lamb maintained its body weight. Results of other trials (Burkitt, 1951; McCall, 1943) indicate that lambs consuming cut grasses show similar losses in body weight.

Similar to the work of Forbes (1950), the protein digestibility of the forage decreased at nearly the same rate as did the total digestible nutrient content; however, in the experiment of Gallup and Briggs (1948), the protein digestibility decreased much more rapidly than did the total digestible nutrient content.

TABLE XVII. CONSUMPTION AND RETENTION OF NUTRIENTS BY THE SIX LAMBS FED  
HAY IN TRIAL 1.  
(Grams-Dry Matter Basis)

Nutrients in Hay					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	8524.72	571.16	434.76	2975.13	3938.42
2	7552.49	506.02	385.18	2635.82	3489.25
3	5837.17	391.09	297.70	2037.82	2696.77
4	7315.79	490.16	373.11	2553.21	3379.89
5	7119.65	477.02	363.10	2484.76	3289.28
6	5553.32	372.07	283.22	1938.11	2565.63

Nutrients in Feces					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	3040.22	276.66	118.56	845.18	1371.14
2	2892.55	300.82	170.66	789.66	1200.40
3	2154.96	187.48	81.18	622.78	954.64
4	2874.74	258.72	172.48	804.92	1227.51
5	2816.66	250.68	123.93	794.30	1236.51
6	2386.30	217.15	112.16	656.23	1045.20

Nutrients Retained by Lambs					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	5484.50	240.50	316.20	2129.95	2567.28
2	4659.94	205.20	214.52	1846.16	2288.85
3	3682.21	203.61	216.52	1414.39	1742.13
4	4441.05	231.44	200.63	1748.29	2152.38
5	4302.99	226.34	239.17	1690.46	2052.38
6	3166.92	154.92	171.06	1231.88	1520.43

TABLE XVIII. COEFFICIENTS OF APPARENT DIGESTIBILITY AND DIGESTIBLE NUTRIENTS IN THE DRY MATTER OF HAY FED IN TRIAL 1.

Coefficients of Digestibility					
Lamb No.	D.M.	Protein	E.E.	Crude Fiber	N.F.E.
1	64.3	42.1	72.7	71.6	65.2
2	61.7	40.6	55.7	70.0	65.6
3	63.1	52.1	72.7	69.4	64.6
4	60.7	47.2	53.8	68.5	63.7
5	60.4	47.5	65.9	68.0	62.4
6	57.0	41.6	60.4	66.1	59.3

Percent Digestible Nutrients in the Hay					
Lamb No.	D.M.	Protein	E.E.	Crude Fiber	N.F.E.
1	60.64	2.8	3.7	25.0	30.1
2	58.2	2.7	2.8	24.4	30.3
3	59.5	3.5	3.7	24.2	29.9
4	57.2	3.2	2.7	23.9	29.4
5	57.0	3.2	3.4	23.7	28.8
6	53.8	2.8	3.1	23.1	27.4

Total Digestible Nutrients <sup>1</sup> of the Hay		
Lamb No.		
1	T.D.N.	66.5
2	T.D.N.	64.2
3	T.D.N.	66.2
4	T.D.N.	63.0
5	T.D.N.	63.6
6	T.D.N.	60.5

<sup>1</sup>Average T.D.N. 64.0

The percent of fecal nitrogen excreted by five of the lambs was comparable to the average, differing less than one percent. Lamb 2 had a variation of one and one-tenth percent from the average. This compares favorably with the work done on the range; the ewes within a group were all near the average, the deviation of only an animal or two being more than one percent or below the average for the group of twenty animals.

The widest variations in percent of nutrients digested occurred in ether extract (Table XVIII), which varied from a low of 53.8 percent to a high of 72.7 percent. Jordan (1951) found lambs tended to show a wide variation on feeding trials in the digestion of a single ration. The percent crude fiber digested in the trial by each of the six lambs was similar, having a spread of only 5.5 percent among all the lambs.

Except for the adding of supplemental protein pellets to the hay ration, the experimental procedure with trial 2 was similar to trial 1; the supplemental pellets were identical to those fed the range ewes. The lambs were placed on a 10-day preliminary feeding period before the collection of fecal and urine samples was initiated. The amount of hay placed before the lambs remained the same as that fed in trial 1. The lambs in this study are referred to

by number. Also, the protein pellets are referred to by number. The 10 percent protein pellet is designated as pellet No. 1, the 30 percent protein pellet, as No. 2, and the dehydrated alfalfa pellet, as No. 3.

The hay ration of lambs one and two was supplemented daily with  $\frac{2}{3}$  of a pound of pellet No. 1. A  $\frac{1}{3}$  pound of pellet No. 2 was added daily to the ration fed to lambs 3 and 4, and lambs 5 and 6 received  $\frac{1}{3}$  pound of pellet No. 3 per day. The chemical composition of these supplemental pellets is shown in Table XIX. The percentage of the nitrogen free extract digested varied by only 6.3 percent in the ration of the six lambs. These results agree favorably with work done by Burkitt (1951).

#### Results and Discussion of Trial 2.

The changes in body weight and the amount of hay, plus protein supplement each lamb consumed during the 10-day fecal collection period of trial 2, are shown in Table XX.

The quantity of hay consumed by each lamb increased with the feeding of supplements, with the exception of lamb 3 which consumed 654 grams less hay. The lambs ate the protein supplements readily; one-half of the daily amount was fed at each feeding period.

The two lambs fed  $\frac{2}{3}$  of a pound of pellet No. 1

TABLE XIX. CHEMICAL COMPOSITION OF PROTEIN SUPPLEMENTS FED LAMBS DURING NITROGEN METABOLISM TRIAL (Dry Matter Basis)

Pellet No. <sup>1</sup>	1	2	3
Percent Crude Protein	10%	30%	100% dehydrated alfalfa pellet
Dry Matter	93.9	93.8	93.1
Crude Protein	13.3	33.2	19.7
Ether Extract	1.7	2.8	4.0
Crude Fiber	6.1	11.2	21.1
Nitrogen Free Extract	71.1	44.5	41.5
Ash	7.6	8.3	13.9
Calcium	1.31	.70	.23
Phosphorus	2.80	.57	1.56

<sup>1</sup>Composition of protein pellet No. 1 and protein pellet No. 2 is shown in Table IV.

gained two pounds per head during trial 2. Lambs 1 and 2 on the hay trial had exhibited an average gain of zero, just maintaining their body weight when fed hay. The only lamb to lose weight in trial 2 was lamb 3; this loss in weight was

TABLE XX. WEIGHTS AND FEED CONSUMPTION OF LAMBS DURING TEN-DAY FECAL COLLECTION PERIOD ON PROTEIN SUPPLEMENT TRIAL (March 4--14 incl., 1953)

Lamb No.	Initial Weight	Change in Weight	Total Ration (grams)	
	Lbs.	Lbs.	Hay	Supplement
1	100	<del>/</del> 2	9080	3000
2	94	<del>/</del> 2	9080	3000
3	89	-2	5536	1500
4	92	<del>/</del> 2	9080	1500
5	85	0	7940	1500
6	85	<del>/</del> 1	9040	1500

probably due to the low hay consumption of this lamb, inasmuch as lamb 4 had a gain similar to lambs 1 and 2. The lambs fed the dehydrated alfalfa had a one-half pound gain for an average on the trial. Lambs 5 and 6 had the least amount of gain for the six wether lambs fed the added supplements. The extra gain of lambs 1 and 2 can be attributed to

the fact that they were receiving  $2/3$  of a pound more supplement per day and consuming their entire hay ration. It is also shown in Table XX that the initial body weights of lambs 1 and 2 were approximately 10 pounds heavier per animal than lambs 5 and 6. The recommended daily nutrient allowances for sheep, published by the National Research Council, are shown in Table XXI.

The consumption and retention by the lambs of nutrients from the hay and the supplemental pellets, in trial 2, are shown in Table XXII.

A comparison of Tables XVIII and XXIII shows that the total digestible nutrients of the two rations varied from an average of 64 percent with hay to 70 percent with the addition of a protein supplement. These results indicate that protein supplements fed with a hay ration result in a higher total digestible nutrient figure than a hay ration fed without supplementation. This data agrees with a trial by Briggs et al. (1946) conducted with steers. His results show that digestibility of all the nutrients were higher in the supplemented rations than in the unsupplemented hay ration. Morrison (1951) states that when lambs are fed 0.16 of a pound of linseed or cottonseed supplement, one can expect an increased gain of 0.05 pound on the average per head per day over a ration of alfalfa hay, corn silage and grain.

TABLE XXI. RECOMMENDED DAILY NUTRIENT ALLOWANCE FOR SHEEP<sup>1</sup>

Live Weight	Expected Daily Gain or Loss	Total Feed, Air Dry Basis	Total Digestible Protein	Total Digestible Nutrients	Calcium	Phosphorus	Salt
Lb.	Lb.	Lb.	Lb.	Lb.	Gm.	Gm.	Lb.
Bred Ewes First 100 Days of Gestation							
100	0.12	3.5	0.17	1.7	3.2	2.5	0.03
110	0.12	3.6	0.18	1.8	3.2	2.6	0.03
120	0.12	3.7	0.19	1.9	3.3	2.7	0.03
130	0.12	3.8	0.20	2.0	3.4	2.7	0.03
Bred Ewes Last 6 Weeks Before Lambing							
110	0.25	4.0	0.21	2.1	4.3	3.2	0.03
120	0.25	4.1	0.22	2.2	4.4	3.3	0.03
130	0.25	4.2	0.23	2.3	4.5	3.4	0.03
140	0.25	4.3	0.24	2.4	4.7	3.5	0.03
150	0.25	4.4	0.25	2.5	4.8	3.6	0.03
Ewes in Lactation							
100	-0.10	4.5	0.27	2.5	6.1	4.5	0.03
100	-0.10	4.6	0.28	2.6	6.2	4.6	0.03
120	-0.10	4.7	0.28	2.7	6.4	4.7	0.03
130	-0.10	4.8	0.30	2.8	6.5	4.8	0.03
140	-0.10	4.9	0.30	2.9	6.6	4.9	0.03
150	-0.10	5.0	0.31	3.0	6.8	5.0	0.03

<sup>1</sup>National Research Council, August 1949.

TABLE XXI. (Continued) RECOMMENDED DAILY NUTRIENT ALLOWANCE FOR SHEEP<sup>1</sup>

Live Weight	Expected Daily Gain or Loss	Total Feed, Air Dry Basis	Total Digestible Protein	Total Digestible Nutrients	Calcium	Phosphorus	Salt
Lb.	Lb.	Lb.	Lb.	Lb.	Gm.	Gm.	Lb.
Ewes--Lambs and Yearlings							
70	0.35	3.0	0.22	1.8	3.0	2.7	0.02
90	0.30	3.2	0.22	1.9	3.0	2.7	0.02
110	0.20	3.5	0.20	1.9	3.2	2.8	0.03
130	0.10	3.8	0.20	2.0	3.1	2.7	0.03
Rams--Lambs and Yearlings							
75	0.45	3.5	0.24	2.1	3.8	3.2	0.02
100	0.40	4.0	0.24	2.3	4.0	3.4	0.03
125	0.35	4.0	0.24	2.4	3.6	3.3	0.03
150	0.30	4.3	0.23	2.6	3.7	3.3	0.03
175	0.20	4.5	0.23	2.6	3.7	3.3	0.03
Fattening Lambs							
50	0.25	2.1	0.17	1.2	2.5	2.1	0.02
60	0.30	2.3	0.18	1.4	2.6	2.2	0.02
70	0.35	2.7	0.19	1.7	2.9	2.4	0.02
80	0.35	2.9	0.20	1.9	2.9	2.4	0.02
90	0.25	3.0	0.20	2.0	2.7	2.3	0.02

<sup>1</sup>National Research Council, August 1949.

TABLE XXII. CONSUMPTION AND RETENTION OF NUTRIENTS BY THE SIX LAMBS FED HAY PLUS SUPPLEMENTS IN TRIAL 2.  
(Grams-Dry Matter Basis)

Nutrients in Ration					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	11376.44	1507.93	515.47	3303.46	5208.09
2	11376.44	1507.93	515.47	3303.46	5208.09
3	6628.95	537.10	290.18	1907.86	3413.30
4	9970.94	761.01	460.62	3074.21	4957.31
5	8888.92	776.77	437.72	2907.77	4038.74
6	9921.22	846.27	490.62	3276.07	4517.97

Nutrients in Feces					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	3510.24	379.11	122.86	1063.60	1428.67
2	3704.81	418.64	137.09	1092.92	1537.50
3	1969.01	175.24	66.95	543.45	829.95
4	3213.13	269.90	131.74	918.96	1365.58
5	3161.12	281.34	110.64	1011.56	1289.74
6	3577.07	289.74	128.78	1198.32	1423.67

Nutrients Retained by Lambs					
Lamb No.	D.M.	Protein	Ether Extract	Crude Fiber	N.F.E.
1	7866.20	1128.82	392.61	2239.86	3779.42
2	7671.63	1089.29	378.38	2210.54	3670.59
3	4659.94	361.86	223.23	1364.41	2583.35
4	6757.81	491.92	328.88	2155.25	3591.73
5	5722.80	495.43	327.08	1896.21	2749.00
6	6344.15	556.53	361.84	2077.75	3094.30

TABLE XXIII. COEFFICIENTS OF APPARENT DIGESTIBILITY AND DIGESTIBLE NUTRIENTS IN THE DRY MATTER OF HAY AND SUPPLEMENTS FED IN TRIAL 2.

Coefficients of Digestibility					
Lamb No.	D.M.	Protein	E.E.	Crude Fiber	N.F.E.
1	69.1	74.9	76.17	67.8	72.6
2	67.4	72.2	73.4	66.9	70.5
3	70.3	67.4	76.9	71.5	75.7
4	67.8	64.5	71.4	70.1	72.5
5	64.4	63.8	74.7	65.2	68.1
6	63.9	65.8	73.8	63.4	68.5

Percent Digestible Nutrients in the Rations					
Lamb No.	D.M.	Protein	E.E.	Crude Fiber	N.F.E.
1	64.0	9.96	7.6	19.6	33.3
2	84.0	9.6	7.4	19.4	32.3
3	70.0	5.5	7.6	20.6	38.9
4	68.0	4.9	7.4	26.6	36.0
5	64.0	5.5	8.3	21.3	31.0
6	64.0	5.4	8.1	20.9	31.2

Total Digestible Nutrients <sup>1</sup> of the Ration					
Lamb No.					
1	T.D.N.				70.5
2	T.D.N.				68.7
3	T.D.N.				72.7
4	T.D.N.				74.9
5	T.D.N.				66.1
6	T.D.N.				65.6

<sup>1</sup>Average T.D.N. 70.0

The total digestible nutrients of lambs 1 and 2 fed on the 30 percent protein pellet averaged 4.2 percent below the total digestible nutrients of the lambs fed the 10 percent protein pellet. The total digestible nutrients of the lambs fed the dehydrated alfalfa averaged 3.8 percent less than the average figure of total digestible nutrients for the lambs fed the 10 percent protein pellet. Pellet No. 1 contains more carbohydrates and energy than the No. 2 pellet, thus giving it a smaller total digestible nutrient figure. Ritzman (1930) indicates that the energy requirements of growing sheep are greater than those of mature sheep.

The amount of fecal nitrogen obtained from the lambs on the varying levels of protein intake are illustrated in Figure 12. Pellet No. 1, when fed with hay to lambs, gave a much higher fecal nitrogen content than hay fed alone or pellet 2 or 3 when fed with hay. This may be accounted for in several ways. Pellet No. 1 may have contained too large an amount of protein for satisfactory utilization. Another factor that can be considered is that pellets 2 and 3 contained more total digestible nutrients, whereas, less nitrogen was excreted by the animals. Pellets 2 and 3 evidently helped the retention of nitrogen in the hay also, because both of these pellets, when fed with hay, indicated a lower nitrogen fecal loss. Maynard (1947) states that

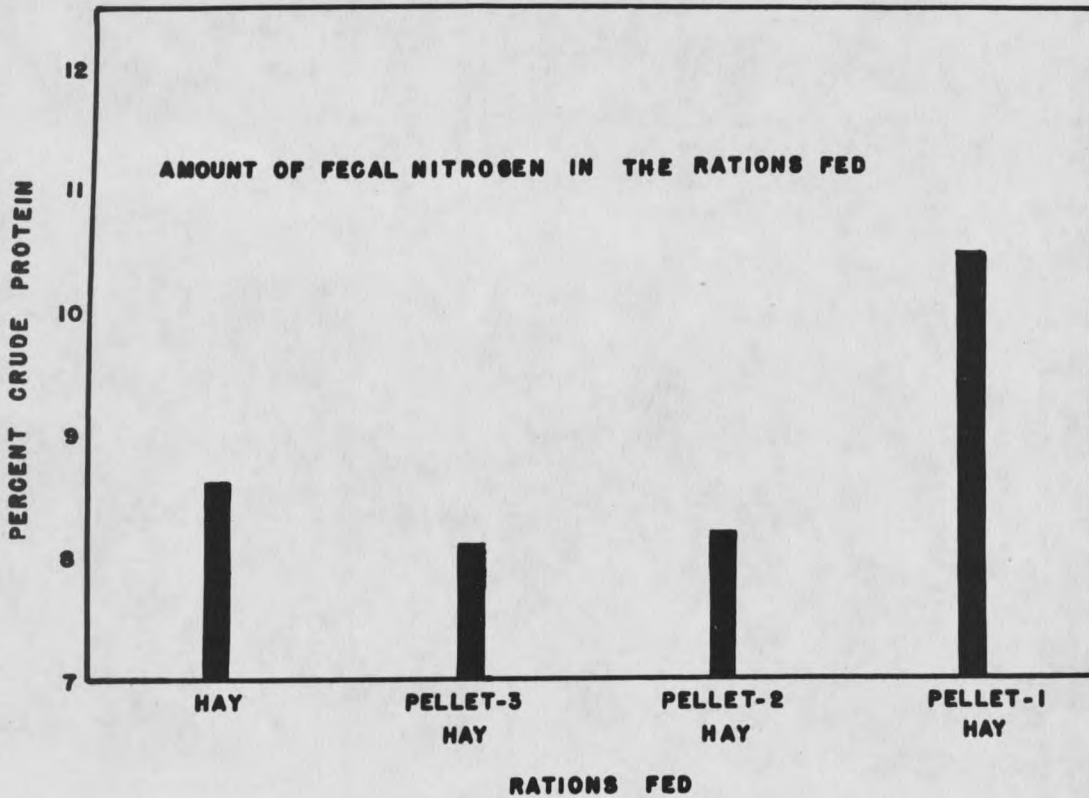


Figure 12. The fecal nitrogen of the hay is compared to the fecal nitrogen obtained from hay plus the three supplemental pellets. Note that pellet No. 3 appears to be more digestible than either pellet No. 1 or 2.

some of the differences of opinion, relative to the optimum level of protein intake, have doubtless arisen from failure to recognize the bearings of variations in protein quality. The minimum intake which proves adequate for a specific combination of proteins will neither be adequate nor optimum for a combination of lower biological value.

Urine samples were collected during the metabolism trial and analyzed; because this study was directly related with fecal nitrogen studies, the information from the urine data will not be presented.

SUMMARY

The investigation reported herein was undertaken to provide experimental data on fecal nitrogen of ewes on winter range as affected by varying levels of protein intake. In addition, the influence of weather conditions on fecal nitrogen was also studied.

Range ewes typical of the sheep grazing Montana ranges were used in the trial conducted near Livingston, Montana.

Previous work indicated that a factor or factors other than the level of protein intake influenced fecal nitrogen of ewes more than the protein contained in the supplemental feed.

Approximately 1000 ewes were used in this study. They were randomly divided into eight groups, each group being fed a different level of protein during the winter feeding period.

One group depended on range forage only for maintenance. Another group, typical of a small farm flock, was fed at the Fort Ellis farm near Bozeman, Montana; these ewes were subjected to environmental and climatic conditions different from the seven groups remaining on the range. All groups on the range grazed in one band except for the short time that they were separated each day for the feeding of supplemental pellets. The rations fed dur-

ing the two years of the study were similar, except for slight changes the second year.

Fecal samples were taken approximately every 14 days during the winter feeding period for two years. Composite samples were obtained for each group, and the protein content determined chemically.

Ewes fed the pellet containing the greater percentage of protein had higher fecal nitrogen values than the ewes fed pellets containing the lower protein percentage. The variation in fecal nitrogen content among the groups remained consistent throughout the sampling period; however, on different sampling dates, all groups tended to be higher or lower apparently because of environmental factors other than supplemental feed.

Individual samples were taken from ewes in two groups each year to determine the variation in fecal nitrogen within a group; variations were found to be negligible.

During the two years of the study, fecal nitrogen tended to fluctuate with changes in temperature. A lower fecal nitrogen content was evident in all groups when the sampling date was preceded by cold weather; when temperatures rose, fecal nitrogen showed a similar upward trend. Fecal nitrogen levels of the various groups were also compared to wind velocities, but no definite trend was noted.

Grass samples were collected from the winter range and the protein content determined. June grass (Koeleria cristata) contained 5.3 percent protein the second year, the highest protein content found in any of the range grass samples. Fringed sagewort (Artemisia frigida), a half-shrub, contained 9.0 percent protein and was highly utilized by the sheep. The shrubs and half-shrubs sampled had a considerably higher protein content than did the grasses.

Digestion trials were conducted to determine whether or not fecal nitrogen would vary under controlled conditions in a manner similar to that from range ewes fed the same protein supplements.

A grass hay ration was fed during one trial, and during the second trial, the wether lambs were fed the following daily supplements in addition to hay. Two-thirds pound of a 30 percent protein pellet was fed to two lambs, one-third pound of a 10 percent protein pellet to two lambs and one-third pound of a dehydrated alfalfa pellet to two lambs. The addition of the supplement increased the digestibility of each ration. There was a higher nitrogen content in the feces when the lambs were fed only hay than when fed either the 10 percent protein pellet or the dehydrated alfalfa pellet. The lambs fed two-thirds pound of 30 percent protein had a considerably higher fecal nitrogen content than

the other lambs.

The amount of protein obtained by range ewes determined the percent nitrogen found in the feces; however, climatic conditions appeared to have more influence on the fluctuations in fecal nitrogen between sampling dates than the amount of protein intake from supplemental feed.

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