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

Abstract:
The investigation reported herein was undertaken to provide experimental data on feeal 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.

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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÷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 direction. 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 exretion 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 Gieseker (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.